National Park Service
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Natural Resource Program Center

Vegetation Classification and Mapping Project Report

Great Sand Dunes National Park and Preserve

Natural Resource Report NPS/ROMN/NRR—2010/179

ON THE COVER
Dunefield and Sangre de Cristo Mountains
Photograph by: Steve Chaney

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David Salas
Bureau of Reclamation
Remote Sensing and GIS Group
Mail Code 86-68260
Denver Federal Center Building 67
Denver, Colorado 80225

Joe Stevens
Colorado Natural Heritage Program,
Colorado State University
254 General Services Bldg.
Fort Collins, Colorado 80523

Keith Schulz
NatureServe
4001 Discovery Drive, Suite 2110
Boulder, Colorado 134 Union Blvd
Lakewood, Colorado 80228

Mike Artmann
U.S. Fish and Wildlife Service
Division of Refuge Planning
134 Union Blvd
Lakewood, Colorado 80228

Beverly Freisen / Steve Blauer
U.S.Geological Survey
Rocky Mountain Geographic Science
Center,
P.O. Box 25046, MS 516
Lakewood, Colorado 80225

E.William Schweiger
National Park Service
Rocky Mountain Network
Natural Resources Program Center
1201 Oakridge Drive, Suite 200
Fort Collins, Colorado 80525

Andrew D. Valdez
National Park Service
Great Sand Dunes National Monument
11500 Hwy 150
Mosca, Colorado 81146

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National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Contents

Page

Figures ix

Tables xi

List of Abbreviations and Acronyms xii

List of Contacts and Contributors xiii

Executive Summary xv

Acknowledgments xvii

Introduction 1

USGS-NPS Park Vegetation Characterization Program 1

Great Sand Dunes National Park and Preserve Vegetation Mapping Project 1

Spatial Data *2*

Vegetation Information *2*

The National Vegetation Classification (NVC) and Standard (NVCS) 3

Biological Diversity 5

Project Area Description 7

Location and Setting 7

Physiographic Setting and Topography 9

Climate 10

Geology 11

Soils 13

Hydrology and Water Resources 14

Flora and Fauna 15

Vegetation Patterns *15*

Vascular Plants *16*

Non-native and Invasive Plants ... *17*

Benthic Macroinvertebrates ... *17*

Terrestrial Invertebrates ... *18*

Fish ... *18*

Herpetiles ... *19*

Birds ... *19*

Mammals ... *20*

Methods ... 21

Planning and Scoping ... 21

BOR Responsibilities and Deliverables: ... *21*

USGS Responsibilities and Deliverables: ... *22*

CNHP Responsibilities and Deliverables: ... *22*

NatureServe Responsibilities and Deliverables: ... *23*

Scoping Meetings ... *23*

Project 'Kick-Off' and Scoping Meeting: ... 23

Field Preparation Meetings: ... 24

Map Class and Interim Status Meetings: ... 26

Accuracy Assessment Meeting: ... 26

Episodic Planning Meetings: ... 26

Preliminary Data Collection and Review of Existing Information ... 26

Vegetation Studies ... *26*

Digital Data ... *27*

Classification Phase Sample Design ... 28

Design Specifications ... *29*

Sample Frame ... *29*

Southwest ReGAP Source Data and Processing *32*
Accessibility: Cost Surface *36*
Strata and Subpopulations *37*
Sample size *37*
Opportunistic Sampling *37*
Field Survey Methods 39
Data Collection: Vegetation Data *39*
Data Collection: Forest Fuels Data *40*
Data Collection: Accuracy Assessment Data *41*
Plot Data Management and Classification Analysis 41
Vegetation Classification 42
Image Processing & Analysis 42
Image Processing – Baca NWR *43*
Image Processing – Remaining Areas: *43*
Map Classes 43
Polygon Attribution *53*
Map Verification 54
Accuracy Assessment Phase Sample Design 54
Sample Design *54*
Design Specifications *55*
Sample Frame *55*
Dissolving by density class 56
Internal polygon buffering 56
Cost Surface 58
Strata and subpopulations *61*

Sample size *61*

Sample size per cost class *61*

Oversample *61*

Buffering among AA points *61*

Data Collection – AA Points *62*

AA Metrics *65*

Binary accuracy assessment *65*

Fuzzy Accuracy Assessment *66*

Results 68

Field Data Collection 68

Vegetation Classification 68

Vegetation Alliances and Associations 70

Potential New Vegetation Types *70*

Forest and Woodland *71*

Shrubland *74*

Herbaceous Vegetation *76*

Sparse Vegetation *80*

Photographic Database 81

Vegetation Map 81

Accuracy Assessment 85

Map Class adjustments *85*

Map Adjustments *86*

Discussion 93

NVC Classification 93

Global Rarity 94

Non-native species ... 94

Image-interpretation ... 95

Map Classes ... 96

Map Accuracy ... 96

Recommendations and Usage ... 98

Improving and Learning ... 99

Project Boundary and Stakeholder Involvement ... 99

Sample Design ... 99

Vegetation Classification ... 100

Field Operations ... 101

Mapping ... 102

Accuracy Assessment ... 103

Updating ... 103

PLOTS database ... 103

Grow the Map Forward ... 104

Applications ... 105

Vegetation Keys and Descriptions ... 105

Plot Photos ... 105

Wetland and Alpine Monitoring ... 105

Effects of Climate Change ... 106

Elk Modeling ... 107

Pika Niche Models and Monitoring ... 107

Fire ... 107

Natural Resource Condition Assessment ... 107

Literature Cited ... 109

Appendix A: Baca National Wildlife Refuge Vegetation Mapping Effort................................ 117

Crosswalk Between Initial USFWS Classes and Final Map Classes 137

Appendix B: National Vegatation Classification, Version 2 Hierarchy with GRSA Map Classes Crosswalked to Group Level 141

Appendix C: The Natural Heritage Network Ranking System and Biological Diversity 145

Appendix D: Preliminary Classification List.. 153

Appendix E: Sampling Design Implementation 159

Classification Phase 159

Accuracy Assessment Phase 161

Appendix F: Field Methods - Field Manual and Forms 165

Appendix G: Biophysical Modeling and Image Interpretation.. 275

Appendix H: Keys to the Vegetation Types and Map Classes 295

Dichotomous Key to the Plant Associations of Great Sand Dunes National Park and Preserve.. 295

Field Key to Map Classes of Great Sand Dunes National Park and Preserve.................... 329

Appendix I: Plant Association Descriptions for Great Sand Dunes National Park and Preserve.. 349

Appendix J: Great Sand Dunes National Park Vegetation Map Class Crosswalk to USFS Vegetation Maps (R2Veg Geodatabase) and USFWS National Wetland Inventory Units........ 563

Figures

Page

Figure 1. Location of GRSA in southern Colorado. 7

Figure 2. Map of GRSA Vegetation Mapping boundary and land ownership in the vicinity 8

Figure 3. Viewshed of project area looking from southeast. 10

Figure 4. Climate data for NWS weather station at GRSA 11

Figure 5. Geology map of GRSA. 13

Figure 6. GRSA Kick Off Meeting Participants, February 22-23, 2005 24

Figure 7. GRSA Vegetation Mapping boundary and major landcover types from the 2001 National Landcover Dataset. 25

Figure 8. Southwest Regional Gap Analysis Project landform layers. 30

Figure 9a. Southwest Regional Gap Analysis Project Ecological Systems (landcover) and landform layers. 31

Figure 9b. Legend for Ecological Systems (landcover) map. 32

Figure 10. Example of editing applied to incorrect Rocky Mountain Ponderosa Pine Woodland types on the sand sheet of GRSA. 34

Figure 11a. Final Ecoloigical Systems as used in the classification sample frame 35

Figure 11b. Legend for final Ecological Systems map. 36

Figure 12. Classification phase strata from NPS and non NPS ownership. 38

Figure 13. Basis for the AA design sample frame, the final draft GRSA Vegetation Map. 57

Figure 14. 2005/06 plot mean slope in a small support area around each sites vs. the cost to access each site 59

Figure 15. Final AA cost surface. 60

Figure 16. Locations of AA points at GRSA. 64

Figure 17. Location of vegetation plots collected at GRSA. 69

Figure 18. Example of post-processed project photo. 81

Figure 19. Example of Vegetation Map products applied to a possible survey design for long term monitoring alpine sites at GRSA. 106

Tables

Page

Table 1. The 1997 U.S. National Vegetation Classification physiognomic-floristic hierarchy for terrestrial vegetation (FGDC 1997;Grossman et al. 1998) with a supplemental Alliance Group level.......... 5

Table 2. National Vegetation Classification hierarchy for terrestrial vegetation following the FGDC (2008) standard.......... 6

Table 3. Land ownership in GRSA footprint.......... 9

Table 4. Specific attributes collected on the vegetation plot form.......... 39

Table 5. Final map unit descriptions for GRSA.......... 44

Table 6. Frequency and extent summary of relevant AA design aspects.......... 63

Table 7. Fuzzy set accuracy ranks (Gopal and Woodcock, 1994).......... 67

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.......... 71

Table 9. Spatial statistics for map units.......... 83

Table 10. Overall map accuracies.......... 85

Table 11. Summary statistics for errors of omission and commission at fuzzy level 5.......... 87

Table 12. Summary statistics for errors of omission and commission at fuzzy level 4.......... 89

Table 13. Summary statistics for errors of omission and commission at fuzzy level 3.......... 91

Table 14 . Mean errors for Omission and Commission.......... 92

Table 15. Natural Heritage Elements Identified from Plot Data.......... 95

Table 16. Mean fuzzy accuracy values for several national parks.......... 98

List of Abbreviations and Acronyms

BOR	Bureau of Reclamation (also USBR)
BRD	Biological Resource Division (of the USGS)
CBI	Center for Biological Informatics (of the USGS/BRD)
cm	Centimeter(s)
CNHP	Colorado Natural Heritage Program
F	Fahrenheit
FGDC	Federal Geographic Data Committee
ft	Foot/Ft
GIS	Geographic Information System
GPS	Global Positioning System
GRSA	Great Sand Dunes National Park and Preserve
ha	Hectare(s)
in	Inch(es)
m	Meter(s)
MMU	Minimum mapping unit
NAIP	National Agricultural Imagery Program
NPS	U.S. National Park Service
NRCS	Natural Resources Conservation Service (formerly the Soil Conservation Service - SCS)
NVC	National Vegetation Classification
NVCS	National Vegetation Classification Standard
PARK	GRSA
RSGIG	Remote Sensing and Geographic Information Group
ROMN	Rocky Mountain I&M Network
TNC	The Nature Conservancy
USBR	United States Bureau of Reclamation (also BOR)
USDA-SCS	U.S. Dept. Of Agriculture – Soil Conservation Service
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey

List of Contacts and Contributors

U. S. Department of the Interior
United States Geological Survey - Biological Resources Division

Mike Mulligan
Program Coordinator, USGS-NPS Vegetation Mapping Program
U.S. Geological Survey
Center for Biological Informatics
P.O. Box 25046
Denver, CO 80225-0046
Phone (303) 202-4242
E-mail: mike_mulligan@usgs.gov
Website: http://biology.usgs.gov/cbi

U. S. Department of the Interior
National Park Service

Karl Brown, Ph.D.
Vegetation Mapping Program Manager, DOI PPS/GPS Coordinator
NPS-WASO Natural Resource Program Center
1201 Oakridge Drive, Suite 200
Fort Collins, CO 80525
Phone: (970) 225-3591
E-mail: karl_brown@nps.gov
Website: http://biology.usgs.gov/npsveg

Chris Lea
NPS Botanist / Ecologist
P.O. Box 25287
Denver, CO 80225-0287
Phone: (303) 969-2807
E-mail: Chris_Lea@nps.gov

Mike Britten
Program Manager
Rocky Mountain Inventory & Monitoring Network
1201 Oakridge Drive, Suite 200
Fort Collins, CO 80525
Phone: 970-267-2150
E-mail: mike_britten@nps.gov

Art Hutchinson
Superintendent
11500 Highway 150
Mosca, CO 81146-9798
Phone: 719-378-6300
E-mail: grsa_superintendent@nps.gov

U. S. Department of the Interior
National Park Service

Fred Bunch
Chief of Resources
11500 Highway 150
Mosca, CO 81146-9798
Phone: 719-378-2312 ext. 223
E-mail: fred_bunch@nps.gov

U. S. Department of the Interior
Bureau of Reclamation

Michael Pucherelli
Group Manager
Remote Sensing and Geographic Information Group
Mail Code 86-68260
Denver Federal Center, Building 56
Denver, CO 80225
Phone: (303) 445-2267
E-mail: mpucherelli@do.usbr.gov

NatureServe

Marion S. Reid
Senior Regional Ecologist
NatureServe, 4001 Discovery, Suite 2110
Boulder, CO 80303 Boulder, CO 80306
Phone: (703) 797-4805
E-mail: marion_reid@natureserve.org

Executive Summary

This vegetation classification and mapping effort encompasses 167,148 ha(413,031 acres) within the San Luis Valley, west of the Sangre de Cristo Mountains in south central Colorado. The mapping boundary is made up of several management units from a variety of government and private agencies (and a small amount of private property). These include the National Park Service (Great Sand Dunes National Park and Preserve – 60,354 ha, 149,137 acres), U.S. Fish & Wildlife Service (Baca National Wildlife Refuge – 37,483 ha, 92,623 acres), U.S. Forest Service, Bureau of Land Management (Blanca Wetlands), and the Nature Conservancy (Medano-Zapata Ranch – 13,243 ha, 32,725 acres). The mapped area includes portions of Saguache and Alamosa Counties. The actual mapping boundary reflects the U.S. Forest Service fire management plan area and is thus an effort by the NPS-USGS mapping program to encompass not only lands within the NPS but also those that are in proximity and that have some type of ecological or management cohesiveness.

This mapping effort is part of the National Park Service national inventory and monitoring program and will provide core or 'baseline' information that park managers need to effectively manage and protect park resources. This vegetation inventory was conducted in accordance with specified protocols and quality assurance standards. Data obtained through this inventory are compatible with other efforts, allowing for synthesis and analysis at broader levels (http://www1.nature.nps.gov/protectingrestoring/IM/resourceinventories.cfm).

The final map product was produced in two parts. The USFWS Baca National Wildlife Refuge was produced by USFWS personnel and the remaining portion by NatureServe, Colorado Natural Heritage Program, USGS, Bureau of Reclamation, and National Park Service staff. Constant communication between these parallel efforts allowed for consistency in both accuracy and classification.

These data comply with standards and protocols of the USGS-NPS Vegetation Mapping Program.

Specifically these include the following:

- Nationally defined standards
    - National Vegetation Classification Standard
    - Spatial Data Transfer Standard
    - Metadata Standard
    - Taxonomy
- Additional Program Standards
    - Classification Accuracy
    - Minimum Mapping Unit

To effectively classify and map the wide range of vegetation within the mapping boundary required a multi-year approach and consisted of several linked phases: (1) vegetation classification using field data and the National Vegetation Classification (NVC), (2) digital vegetation map production, and (3) map accuracy assessment.

To classify the vegetation, we sampled 603 representative plots and 208 observation points during the summers of 2005 and 2006 over the entire mapping area. Analysis of the plot data using ordination and clustering techniques produced 198 distinct plant associations, 22 of which are newly described. These associations were then combined into 51 vegetated map units. Other map units not derived from plot data include sparsely vegetated, non-vegetated, and various cultural features such as roads, urban and farmed lands.

The digital vegetation map was produced using a combination of machine processing and visual interpretation. We used two primary image sources. These included 2006 1:12,000-scale infrared aerial photography for the areas west of the Sangre de Cristo Mountain range that was subsequently processed by the USFWS and 2006 National Agricultural Imagery Program (NAIP) imagery, and ground-truthing to interpret the complex patterns of vegetation and landuse at GRSA. Other referenced imagery included 2006 and 2007 Quickbird imagery which covered portions of the project area.

All of the interpreted and remotely sensed data were converted to Geographic Information System (GIS) databases using ArcInfo© software. Draft maps created from the vegetation classification were field-tested and revised before independent ecologists completed an assessment of the map's accuracy during 2008. During the summer of 2008 we sampled 1,537 accuracy assessment points to establish a final overall accuracy of 73.7%. This metric is subject to considerable interpretation and is discussed in detail in the results section.

Products developed for GRSA are described and presented in this report and are stored on the accompanying DVD, and include:

- A Final Report that includes a vegetation key, and accuracy assessment information
- A Geodatabase containing digital vegetation map, plots, and accuracy assessment layers
- Digital Photos of each vegetation type along with representative ground photos and miscellaneous park views;
- Field key for association identification and a list of associations present in the mapping area;
- Federal Geographic Data Committee-compliant metadata for all spatial database coverages and field data.

In addition, the NPS and the USGS Center for Biological Informatics (CBI) both received copies of:

- Digital data files and hard copy data sheets of the observation points, vegetation field plots, and accuracy assessment sites;
- Hardcopy, paper vegetation maps.

The DVD attached to this report contains nine Appendices, metadata files, keys, lists, field data, spatial data, the vegetation map, graphics, and ground photos. The USGS will post this project on its website: http://biology.usgs.gov/npsveg/index.html

Acknowledgments

A project of this size, complexity, expanse and onerous logistics necessarily required the enthusiasm and energy of many people over several years. The dedication of all involved helped to produce a product that we, the authors, gratefully acknowledge. The combination of ecologists, geographers, botanists and natural resource professionals in all the cooperating agencies and organizations allowed for a phenomenal work environment that greatly reduced the stresses one might imagine for a project of this size.

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Introduction

USGS-NPS Park Vegetation Characterization Program

In 1994, the U.S. Geological Survey (USGS) and National Park Service (NPS) formed a partnership to map National Parks in the United States using the National Vegetation Classification Standard (NVCS). The goals of the USGS-NPS Vegetation Characterization Program are to provide baseline ecological data for park resource managers, create data in a regional and national context, and provide opportunities for future inventory, monitoring, and research activities (FGDC 1997, Grossman et al. 1998, http://biology.usgs.gov/npsveg/index.html). The extent of the program is to provide these data for approximately 270 national park units across the United States and territories.

Central to fulfilling the goals of this national program is the use of the National Vegetation Classification (NVC) as the standard vegetation classification. This classification:

- is based upon current vegetation;
- uses a systematic approach to classify vegetation communities across environmental continuums;
- emphasizes natural and existing vegetation;
- uses a combined physiognomic-floristic hierarchy;
- identifies vegetation units based on both qualitative and quantitative data;
- is appropriate for mapping at multiple scales.

The use of standard national vegetation classification and mapping protocols (TNC and ESRI 1994b) facilitate effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as well as by other federal and state agencies. These vegetation maps and associated information support a wide variety of resource assessment, park management and planning needs. In addition, the associated information provide a structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental processes across the landscape.

Great Sand Dunes National Park and Preserve Vegetation Mapping Project

The vegetation at GRSA has been mapped as an integral part of the U.S. Vegetation Characterization Program. The mapping forms the basis for much of the NPS Natural Resources Inventory and Monitoring Guidelines issued in 1992. Because this Park is immediately adjacent to a number of other ecological preserves and other agency-managed lands we expanded the extent of the mapping area to include Baca National Wildlife Refuge (USFWS), new additions to the Rio Grande National Forest (USFS), Blanca Wetlands (BLM), and the Medano-Zapata Ranch (Nature Conservancy), and various small parcels of state and private land within the collection of these units.

In 2006, the Vegetation Inventory Program Manager, Dr. Karl Brown, in coordination with the Rocky Mountain Network, asked the U.S. Bureau of Reclamation's Remote Sensing and Geographic Information Group (RSGIG) and the USGS Rocky Mountain Geographic Science Center to undertake the mapping portion of this project. At this time Colorado Natural Heritage Program and NatureServe were also contracted to conduct both stages of fieldwork (initial classification and accuracy assessment) and classification stages. Considerable support and analysis was also provided by the NPS Rocky Mountain Network.

Colorado Natural Heritage Program (CNHP), NatureServe, BOR RSGIS, and the Park ultimately formed a four-part vegetation team each responsible for a specific portion of the project. CNHP and NatureServe became primarily responsible for collecting standardized field samples and using them to classify GRSA's vegetation types and also to provide data for an accuracy assessment on the final vegetation map. Finally, GRSA staff provided logistical and technical support, helped coordinate fieldwork, and reviewed and evaluated draft data.

Our objectives were to produce final products consistent with the USGS-NPS National Vegetation Mapping Program mandated standards as follows:

- National Vegetation Classification Standard (FGDC 1997)
- Spatial Data Transfer Standard (FGDC 1998a)
- Content Standard for Digital Geospatial Metadata (FGDC 1998b)
- United States National Map Accuracy Standards (USGS 1999)
- Integrated Taxonomic Information System
- NPS-USGS Program-defined standards for map attribute accuracy and MMU

The products derived from these efforts include:

Spatial Data
- Map classification/descriptions
- Spatial database of vegetation communities
- Over 2000 locations with classification or accuracy assessment data
- Hardcopy maps of vegetation communities
- Metadata for spatial databases
- Complete accuracy assessment of spatial data

Vegetation Information
- Vegetation classification
- Dichotomous field key of vegetation classes
- Formal description for each vegetation class
- Ground photos of vegetation classes
- Field data in database format

Vegetation at GRSA was mapped and classified using a combination of plot and observation point data collected for the purposes of this project, several field visits and photo/image interpretation. The protocols and standards used are those for large parks and are described in the NPS/BRD program documents (TNC and ESRI 1994a, section 5.1). CNHP, NatureServe, USGS, and BOR were contracted by the Rocky Mountain I&M Network in 2005 to map and classify the vegetation for approximately 129,702 ha (320,500 acres) of Great Sand Dunes National Park and Preserve and environs. This work was to be seamlessly combined with the U.S. Fish and Wildlife Services vegetation classification and mapping for the Baca National Wildlife Refuge (Appendix A).

The National Vegetation Classification (NVC) and Standard (NVCS)

In 1994, the U.S. Geological Survey - National Park Service (USGS - NPS) Vegetation Mapping Program (VMP) adopted the U.S. National Vegetation Classification (USNVC) (TNC and ESRI 1994a, Grossman et al. 1998) as a basis for the a priori definition of vegetation units to be inventoried. The Federal Geographic Data Committee (FGDC) adopted a modified version of the upper (physiognomic) levels as a federal standard (FGDC-STD-005, FGDC 1997). This standard is hereafter termed the National Vegetation Classification Standard (NVCS)[1]. The NVCS established a federal standard for a complete taxonomic treatment of vegetation in the United States at physiognomic levels. It also established conceptual taxonomic levels for the floristic units of alliance and association, largely following the USNVC, but did not offer a taxonomic treatment for the floristic levels because of the immense scope of establishing robust floristic units for the entire United States. The FGDC standard requires that federally funded vegetation classification efforts collect data in a manner that enables crosswalking the data to the NVCS (i.e., the physiognomic levels) and sharing between agencies, but does not require use of that standard by agencies for internal mission needs.

NatureServe maintains a treatment of floristic units (alliances and associations), which, though not a federal standard, are used as classification and mapping units by the VMP whenever feasible. This database is available online through NatureServe Explorer http://www.natureserve.org/explorer/), which provides public access to regularly updated versions of the USNVC plant community listings and descriptions. NatureServe's documentation of alliances and associations is the most accessible national listing currently available. However, the plant communities within the NVC are not complete, and projects such as the one described in this report constantly add to the documentation and listing of NVC types.

For purposes of this document, the federal standard (FGDC 1997) is denoted as the National Vegetation Classification Standard (NVCS); the U.S. National Vegetation Classification (USNVC) will refer exclusively to NatureServe's treatment for vegetation floristic units (alliances and associations only). Alliances and associations are based on both the dominant (greatest canopy cover) species in the upper strata of a stand as well as on diagnostic species (those consistently found in some types but not others). Associations are the most specific classification unit and are hierarchically subsumed in the alliances. Each association is included in only one alliance, while each alliance typically includes many associations. Alliance names are generally based on the dominant/diagnostic species in the uppermost stratum of the vegetation, though up to four species may be used if necessary to define the type. Associations define a distinct plant composition which repeats across the landscape and are generally named using both the dominant species in the uppermost stratum of the vegetation and one or more dominant species in lower strata, or a diagnostic species in any stratum. The species nomenclature for all alliances and associations follows that of Kartesz (1999). Documentation from NatureServe (2006) describes the naming and syntax for all NVC names:

- A hyphen ("-") separates names of species occurring in the same stratum.
- A slash ("/") separates names of species occurring in different strata.

[1] The VMP program standards refer to the National Vegetation Classification System (also NVCS). Because of nomenclatural and acronym confusion with the federal (FGDC) National Vegetation Classification Standard, this term is no longer used by the VMP.

- Species that occur in the uppermost stratum are listed first, followed successively by those in lower strata.
- Order of species names generally reflects decreasing levels of dominance, constancy, or indicator value.
- Parentheses around a species name indicates the species is less consistently found either in all associations of an alliance, or in all occurrences of an association.
- Association names include the dominant species of the significant strata, followed by the class in which they are classified (e.g., "Forest," "Woodland," or "Herbaceous Vegetation").
- Alliance names also include the class in which they are classified (e.g., "Forest," "Woodland," "Herbaceous"), but are followed by the word "Alliance" to distinguish them from associations.

Examples of alliance names from GRSA:

- *Achnatherum hymenoides* Herbaceous Alliance (Indian Ricegrass Herbaceous Alliance)
- *Sarcobatus vermiculatus* Intermittently Flooded Shrubland Alliance (Greasewood Intermittently Flooded Shrubland Alliance)
- *Pinus edulis* - (*Juniperus* spp.) Woodland Alliance (Two-needle Pinyon - (Juniper species) Woodland Alliance)

Examples of association names from GRSA:

- *Achnatherum hymenoides* - *Psoralidium lanceolatum* Herbaceous Vegetation (Indian Ricegrass - Lemon Scurfpea Herbaceous Vegetation)
- *Sarcobatus vermiculatus / Distichlis spicata* Shrubland (Greasewood / Inland Saltgrass Shrubland)
- *Pinus edulis* - *Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrubs Woodland (Two-needle Pinyon - Juniper species / Mountain-mahogany - Mixed Shrubs Woodland)

The 2008 NVCS revision (Version 2; FGDC 2008) was adopted by the FGDC in February 2008. The revised NVCS is also hierarchical but has eight levels instead of seven (**Table 1** and **Table 2**). The upper three levels, which are a reorganization of the five upper physiognomic levels from Version 1, indicate physiognomic characteristics that reflect geographically widespread (global) topographic and edaphic factors. The middle three levels are new to the NVCS hierarchy and focus on largely biogeographic and habitat factors along very broad, continental-to-regional topographic, edaphic, and disturbance gradients. The lower two levels, the alliance and association, are used in park mapping and are currently the same in the first and second versions. Substantial future revisions of the Version 2 alliances are expected to improve concordance through the hierarchy, however, for the purposes of this report, they have not been revised. This GRSA report will use the NVCS, version 1 as its standard because version 2, although it provides a new framework for levels of classification, does not yet provide descriptions of vegetation types at all levels.

For more information on the NVC see Grossman et al. 1998 and the USGS-NPS Vegetation Mapping Programmatic standards (http://biology.usgs.gov/npsveg/standards.html). Additional information is available at the FGDC (Federal Geographic Data Committee), National

Vegetation Classification Standard website: http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation.

In addition to the USNVC, NatureServe has created a standardized Terrestrial Ecological Systems Classification for describing sites based on both the vegetation and the ecological processes that drive them. Ecological systems are mid-scale biological communities that occur in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding (Comer et al. 2003). They are not conceptually a unit within the NVC and do not occupy a place in the NVC hierarchy. However, each Ecological System is directly linked to NVC by a list of core associations that occur within it. Because the structure of the NVC is hierarchical, each association occurs in only one alliance. An association may occur in more than one Ecological System, however, and is limited only by the range of ecological settings in which that association occurs. Ecological Systems are similar in scale to the map classes used for the GRSA map legend; they are a broader scale concept that embodies the concepts of several highly specific associations that might be found in a particular setting. Ecological Systems are also similar in scale to the NVCS Version 2 Group Level. See Appendix B for a cross-walk of GRSA map classes to the NVCS Version 2 Groups.

Biological Diversity

During the completion of this project, field crews also collected information that was used to create element occurrences according to Natural Heritage Methodology as detailed in Appendix C. These data are provided to Park staff as a separate product, and not included in detail here, but are summarized in the Discussion section.

Table 1. The 1997 U.S. National Vegetation Classification physiognomic-floristic hierarchy for terrestrial vegetation (FGDC 1997;Grossman et al. 1998) with a supplemental Alliance Group level.

Level	Primary Basis for Classification	Example
Class	Growth form and structure of vegetation	Shrubland
Subclass	Growth form characteristics, e.g., leaf phenology	Deciduous Shrubland
Group	Leaf types, corresponding to climate	Cold-deciduous Shrubland
Formation	Additional physiognomic and environmental factors	Temperate Cold-deciduous Shrubland
Alliance Group	*Regional floristically and environmentally related Alliances*	*Rocky Mountain Montane Deciduous Scrub*
Alliance	Dominant/diagnostic species of the uppermost or dominant stratum	Mountain Mahogany (*Cercocarpus montanus)* Shrubland Alliance
Plant Association (Plant Association)	Additional dominant/diagnostic species from any stratum	Mountain Mahogany / Mountain Muhly Shrubland (*Cercocarpus montanus /Muhlenbergia montana* Shrubland)

Table 2. National Vegetation Classification hierarchy for terrestrial vegetation following the FGDC (2008) standard.

Level	Level name	Criteria	Example
Upper levels			
L1	Formation Class	Broad combinations of general dominant growth forms that are adapted to basic temperature (energy budget), moisture, and/or substrate or aquatic conditions.	Mesomorphic Shrub and Herb Vegetation (Shrubland and Grassland)
L2	Formation Subclass	Combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate or aquatic conditions.	Temperate and Boreal Shrub and Herb Vegetation (Temperate and Boreal Shrubland & Grassland)
L3	Formation	Combinations of dominant and diagnostic growth forms that reflect global macroclimatic factors as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.	Temperate Shrub and Herb Vegetation (Temperate Shrubland & Grassland)
Mid levels			
L4	Division	Combinations of dominant and diagnostic growth forms and a broad set of diagnostic plant taxa that reflect biogeographic differences in composition and continental differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon – Stipa – Bouteloua* Grassland & Shrubland Division (North American Great Plains Grassland & Shrubland)
L5	Macrogroup	Combinations of moderate sets of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences in composition and subcontinental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii – Schizachyrium scoparium – Sorghastrum nutans* Grassland & Shrubland Macrogroup (Great Plains Tall Grassland & Shrubland)
L6	Group	Combinations of relatively narrow sets of diagnostic plant species (including dominants and co-dominants), broadly similar composition, and diagnostic growth forms that reflect biogeographic differences in composition and sub-continental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes	*Andropogon gerardii – Sporobolus heterolepis* Grassland Group (Great Plains Mesic Tallgrass Prairie)
Lower levels			
L7	Alliance	Diagnostic species, including some from the dominant growth form or layer, and moderately similar composition that reflect regional to subregional climate substrates, hydrology, moisture/nutrient factors, and disturbance regimes.	*Andropogon gerardii – (Calamagrostis canadensis – Panicum virgatum)* Herbaceous Alliance (Wet-mesic Tallgrass Prairie)
L8	Association	Diagnostic species, usually from multiple growth forms or layers, and more narrowly similar composition that reflect topo-edaphic climate, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii – Panicum virgatum – Helianthus grosseserratus* Herbaceous Vegetation (Central Wet-mesic Tallgrass Prairie)

Project Area Description

Location and Setting

The project area lies in eastern Saguache and Alamosa counties in south-central Colorado in the northeastern portion of the San Luis Valley, and extends east into the Sangre de Cristo Mountains (**Figure 1**). The nearest large town is Alamosa, approximately 56 km (35 miles) to the southwest of the park headquarters. The three small communities of Mosca, Hooper, and Moffat lie along Colorado Highway 17 near the western project boundary. Another small community, Crestone, lies in the northern portion of the project area.

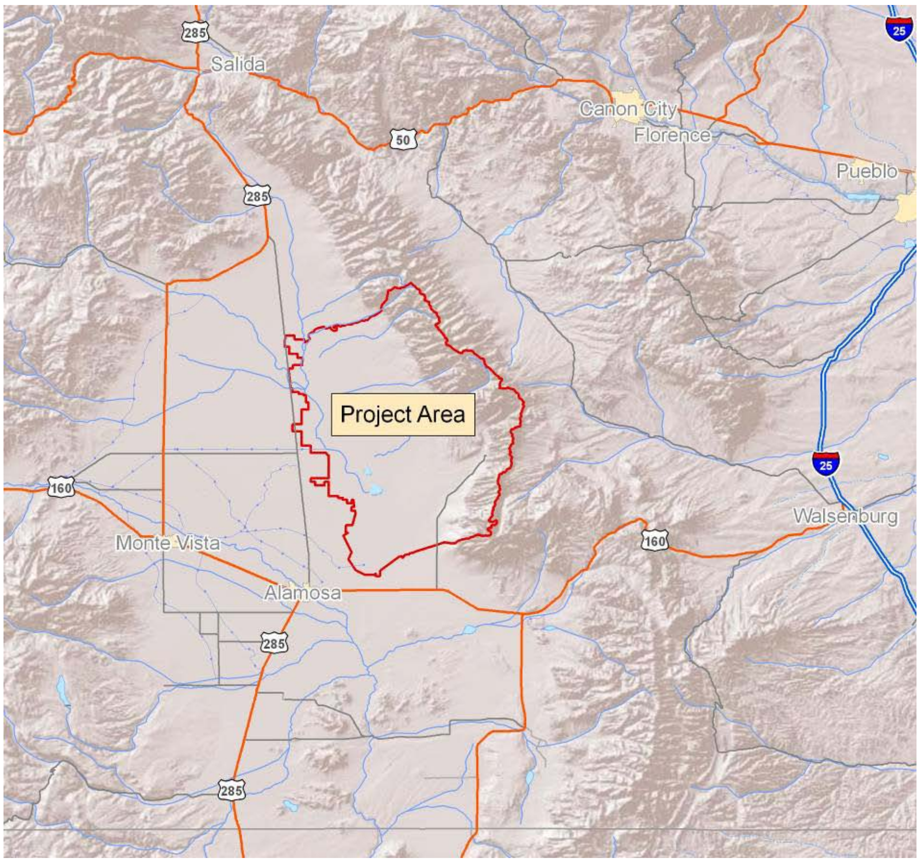

Figure 1. Location of GRSA in southern Colorado.

The project area is managed by multiple federal and state agencies as well as private landowners (**Figure 2**, **Table 3**). Management areas include the Great Sand Dunes National Park and Preserve, the Baca National Wildlife Refuge, Rio Grande National Forest, Blanca Wetlands and Zapata Falls Recreation Areas (Bureau of Land Management), San Luis Lakes State Park, State Trust Lands, and Medano-Zapata Ranch of The Nature Conservancy and other private landowners. The project area is 167,148 ha (413,031 acres), and represents the planning areas used by local agencies for conservation and fire planning. This large project area was created to facilitate multi-agency planning for natural resource management. The area encompasses an elevational gradient of approximately 2,070 m (6,800 ft.) from about 2,290 m (7,500 ft) at Blanca Wetlands to 4,360 m (14,294 ft) at Crestone Peak).

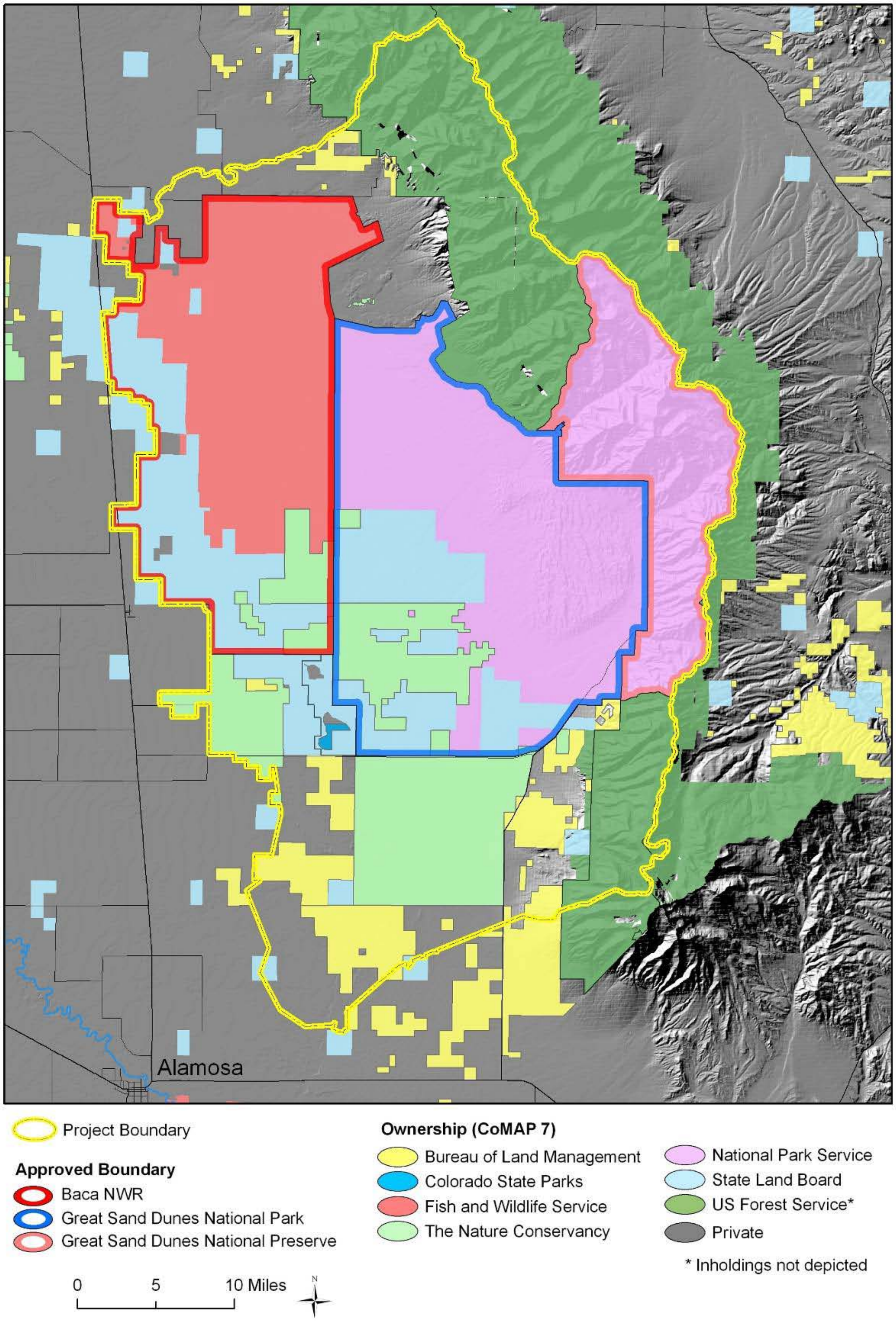

Figure 2. Map of GRSA Vegetation Mapping boundary and land ownership in the vicinity

Table 3. Land ownership in GRSA footprint.

Owner/Manager	Strata	Acres	Sq. Miles	Area%
National Park Service	NPS	149,500	233	37
US Fish and Wildlife Service	Other	92,800	145	22
US Forest Service	Other	59,150	92	14
The Nature Conservancy	Other	54,400	85	13
Private	Other	44,830	70	11
Bureau of Land Management	Other	7,430	12	2
Colorado Division of Wildlife	Other	2,960	5	1
State of Colorado	Other	2,495	4	0.50

Regionally this area is part of the southern Rocky Mountains. Biogeographically, the lower elevation/valley floor occurs within the Upper Rio Grande Basin Section of the Great Plains and Palouse Dry Steppe Province and the mountainous portion occurs in the Southern Parks and Ranges Section of the Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province (USFS Ecomap–Bailey et al. 1995, 1998). The multiple biogeographic sections from different provinces in one project area indicate a highly diverse set of plant communities and high overall biological diversity will likely be present. This expectation is further suggested by the wide array of landforms (playas, sand sheet, sabkha, dune field, alluvial fan, and mountains) across several elevation zones (valley floor, alluvial fan, montane, subalpine, and alpine). This will be discussed further in the following sections.

Physiographic Setting and Topography

Great Sand Dunes National Park and Preserve is located in southern Colorado's San Luis Valley. The San Luis Valley is defined by the San Juan Mountains on the west and the Sangre de Cristo Mountains on the east and is the first major drainage basin of the Rio Grande River (Figure 1). The southern half of the San Luis Valley extends into New Mexico and is characterized by the lava flows and isolated volcanoes of the Taos Plateau. The northern half is a broad, flat plain known as the Alamosa Basin. Separating the Taos Plateau and the Alamosa Basin are exposed remnants of the San Juan Mountains, known as the San Luis Hills. GRSA is in the east-central portion of the Alamosa Basin and extends from the drainage terminus of the valley floor to the top of the Sangre de Cristo Mountains. The San Luis Valley and surrounding mountains define GRSA's viewshed (**Figure 3**).

GRSA consists of two connected units – a Park and a Preserve. The National Park portion of GRSA is situated on the valley floor. The lowest elevation in the park is 2,993 m (7,525 ft), at the southwest corner near San Luis Lake. This corner is mostly flat playa lake deposits that can be seasonally flooded. Sandy hills are present on the northeast side of active playa. From the southwest corner there is a gentle upward slope (about 1%) toward the northeast. This area is sand dominated and very hummocky due to the presence of small relict and active dunes. The gentle slope is broken where it encounters the alluvial fans of the Sangre de Cristo Mountains, the main dunefield, or where sand ramps onto the lower slopes of the mountains. This occurs at an elevation of 2,440 to 2,560 m (8,000 to 8,400 ft).

The main dunefield is located in a bend of the Sangre de Cristo Mountains, adjacent to Medano Pass. It is roughly 13 km (8 miles) from north to south and 9.5 km (6 miles) from east to west.

The majority of the dunefield consists of large, north-south trending dune ridges separated by troughs. In some areas, the dune forms are 230 m (750 ft) tall.

The National Preserve portion of GRSA is in the Sangre de Cristo Mountains and it is characterized by deep canyons and steep slopes. Elevations range from 2,560 to 4,146 m (8,400 to 13,604 ft). There are six peaks with elevations greater then 3,960 m (13,000 ft) in the preserve, with the highest being Tijeras Peak. The northern portion of the preserve is the deep canyon of the Sand Creek drainage, which crosses the thickness of the range before turning northward to drain the backside of the range. The canyon is up to 1,266 m (4,155 ft) deep in places, and the highest reaches are bounded by cliffs formed by glaciation. The middle portion of the preserve is the Medano Creek drainage which is similar to Sand Creek but on a smaller scale. The southern portion consists of seven small drainages that simply drain the west side of the range.

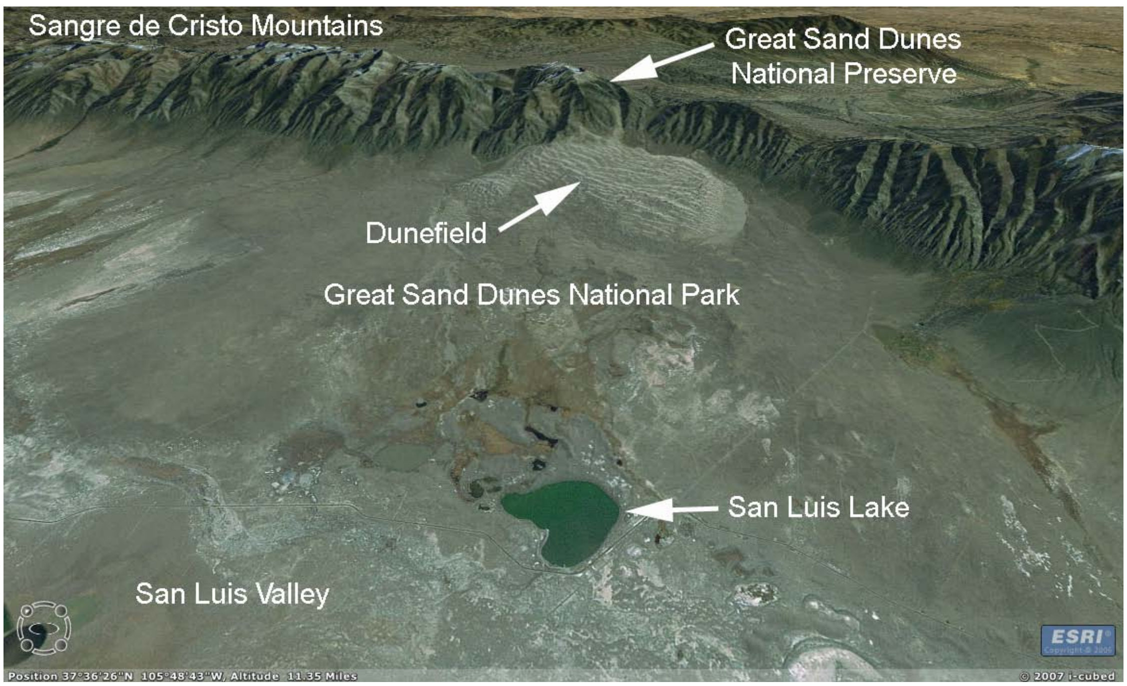

Figure 3. Viewshed of project area looking from southeast.

Climate

Great Sand Dunes National Park and Preserve's climate is a function of its location in a mountainous setting near the center of the North American Continent. Weather systems that affect the area come from a variety of directions. Those that come from the southwest originate in the Pacific off the Mexican coast. Weather from the northwest brings in moisture from the Gulf of Alaska. Weather from the east commonly originates in the Gulf of Mexico and precipitates when cold fronts from the north pass through. Since the western-sourced moisture must cross a number of mountain ranges on its way to Great Sand Dunes, it often comes in at elevations above 15,000 ft. The moisture from the Gulf of Mexico comes in at much lower elevations and must spill over the Sangre de Cristo Mountains via the local passes. Droughts can occur when high pressure systems persist over the center of the continent, prevent moisture from entering the area. Wet conditions can occur when El Niño events develop in the Pacific.

Climate data is collected at GRSA at several locations. The official data comes from a National Weather Service (NWS) weather observation station that has been located in the Park since 1950 (Figure 4). A SNOTEL station (NRCS, SNOw TELemetry) was installed on Medano Pass in 1995. A RAWS (cooperating Federal agencies, Remote Automated Weather Station) site was set up in 2004 near the park horse barn. The USGS installed a climate station near Indian Spring in 2005 (USGS, National Water Information System).

Annual temperatures are characterized by cold winters and mild summers. The coldest month is January, with an average temperature of 23 °F. The warmest is July with an average temperature of 65 °F. The coldest temperature recorded at GRSA was -25 °F in January of 1963. The hottest recorded temperature is 96 °F in June of 1982. The average yearly low temperature is -11 °F and the average yearly high temperature is 88 °F.

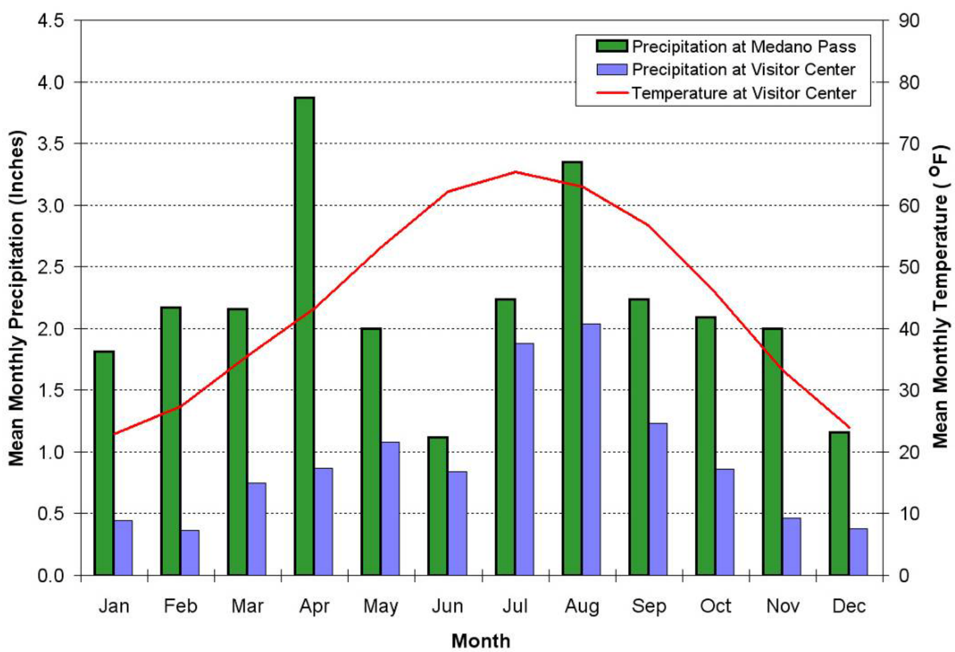

Figure 4. Climate data for NWS weather station at GRSA .

There is a strong precipitation gradient from the valley floor to the mountain tops. Average annual precipitation within the park varies from 7 to 41 inches (18-104 cm). At the NWS station, the average precipitation is 11 inches (28 cm). The record high precipitation is 20.14 inches (51.2 cm) in 1997 and the record low is 5.85 inches (14.9 cm) in 1951. July and August are characterized by monsoonal weather patterns and are usually the months with the highest precipitation. The period from November through February tends to be the driest, and most precipitation falls as snow. At the Medano Pass SNOTEL site, the average precipitation is 29 inches (74 cm). The precipitation pattern in the mountains is bimodal with a snow driven peak in April and a rain driven peak in August.

Geology

Geology and geologic processes play a major role in the distribution of vegetation at Great Sand Dunes National Park and Preserve and the larger project area. GRSA lies in a rift valley setting that is typical of the Basin and Range Province of the western United States. The National Park is primarily a “basin” location, and supports desert shrub type vegetation. The National Preserve is in a “range” location, with montane vegetation types.

Rifting began about 29 million years ago and is responsible for the current landscape of the GRSA area. Rifting is an extensional process that pulls the earth’s crust apart. In this case the forces are pulling apart in an east-west direction, resulting in structures that are oriented north-south. In the San Luis Valley, rifting has broken the crust into blocks that have rotated vertically. Blocks on the west side of the major fault have rotated downward, forming the San Luis Valley. As the blocks down-dropped, a depositional basin was created that filled with sediment carried in from the surrounding highlands, resulting in a broad flat plain. Subsidence has been greatest adjacent to GRSA, and the small streams of the area have not filled the accommodation space, resulting in a depression with internal drainage. This depression is known locally as the “Closed Basin”. The blocks on the east side of the fault have rotated upward and rise abruptly from the valley floor,forming the Sangre de Cristo Mountains. The abruptness of the uplift is due to the narrowness of the fault zone along which it occurs. The maximum relief from the valley floor to the top of the Sangre de Cristo Mountains is nearly 2,100 m (6,900 ft). These geologic processes have produced topography that affects hydrology and thus the vegetation.

The surficial geology of the basin transitions along a topographic gradient, and is dominated by eolian sand deposits. At the lowest level are sabkha deposits. These evaporite mineral-hardened deposits are at or near the bottom of the Closed Basin where surface and groundwater drain. Often they correlate with playa lakes. The primary outlet for water is evaporation, resulting in an alkaline environment dominated by salt tolerant plants. On the margin of the sabkha are finer grained lake deposits that are still somewhat alkaline, but which support Baltic Rush meadows. As the ground surface rises above the capillary fringe of the water table, the ground becomes less salty and the loose sand deposits of the sand sheet develop. Depth to groundwater determines if deep-rooted shrubs or shallow-rooted grasses and forbs develop. The growth of vegetation on the sand sheet influences the development of the dunefield. Increasing vegetation growth increases surface roughness and decreases wind energy at ground level, stabilizing the sand. The main dune field of Great Sand Dunes is situated at the mountain front where wind energy is greatest. Here, active dunes are mostly barren of vegetation except in the troughs between dunes where various grasses and forbs are adapted to the mobile sand environment.

The sabkha is where streams deposit sand. The wave action of the playa lakes concentrates the accumulated sand into beach deposits. When the lakes dry the sand is exposed to unimodal wind from the southwest and it is transported across the sand sheet. Vegetative growth controls the rate of sand movement. At the dunefield the wind regime becomes bimodal or complex, resulting in vertical dune growth in response to the change in wind patterns. At the range front, the sand is deposited onto the lower mountain slopes, forming sand ramps.

In the Sangre de Cristo mountain range the major rock type is Precambrian (>542 million years ago, mya) metamorphic rocks with igneous intrusions. The larger drainage basins incise the width of the Sangre de Cristo Mountains; and include areas with Pennsylvanian age (304 - 318 mya) and Permian age (250 - 304 mya) sedimentary rocks. Rocks of this age include the Crestone Conglomerate and clastic sediments of the Sangre de Cristo Formation and some minor amounts of marine sediments. In Figure 5, the metamorphic rocks are mapped as the brown area, the igneous areas are gold or purple colored, and the sedimentary units are blue.

Soils

Soils in the San Luis Valley are developed in fluvial and eolian sediments. The eolian sediments tend to be mobile and ephemeral, resulting in poorly developed soils. Soils in the Sangre de Cristo Mountains are derived from the weathering of bedrock. Between the valley floor and the mountain range are soils developed on alluvial fans.

Most of the valley soils within the vegetation mapping project boundary are too sandy to be considered productive farmland. Instead a few large ranching operations occupy the area. With few exceptions the sparse vegetation necessarily defines this area as marginal grazing land, except for the more lush meadows which exist alongside streams and springs. The one exception to that lies along the western margin where sandy loam soil of the Gunbarrel-Mosca-San Luis soil map units (CO401) are found. There, irrigated cropland exists.

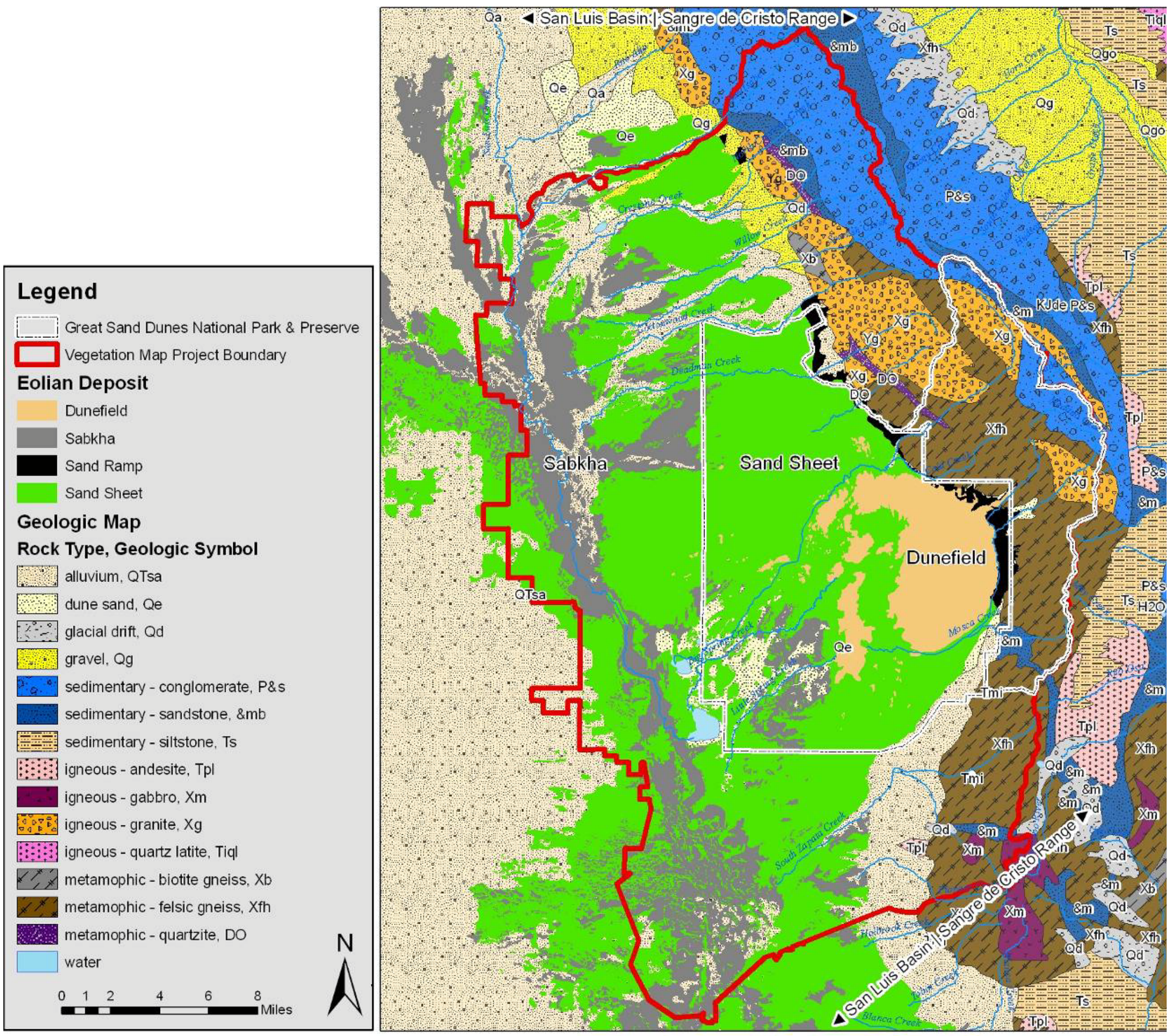

Figure 5. Geology map of GRSA.

Along most of the western portion of the mapped area are the sandy loam soils of the Hooper-San Luis- Corlett soil map units (CO404). They tend to have high alkali content and can be periodically flooded. Within the CO404 zone and alone the San Luis Creek Channel is a clay loam of the Alamosa-La Jara-Vastine soil map unit (CO409). It also has a high alkaline content. In the areas of high alkalinity are salt tolerant plants, such as salt grass and greasewood.

The eastern valley bottom within the project area is covered by loose sand. In the north there is the sand and loamy sand of the Space City-Costilla-Cotopaxi soil map units (CO403). In the south is the sand of the Cotopaxi-Dune Land-Space City soil map unit (CO402). This are is either barren of vegetation or covered by sparse grasses and shrubs that are adapted to a sandy

Where the alluvial fans are exposed (not covered by sand), the stony and cobbly loam Urracca-Commodore-Blackhall soil map unit is developed (CO405). Grasslands and pinyon-juniper forests are common here.

The soils of the Sangre de Cristo Mountains have not been surveyed or described as extensively as the soils of the San Luis Valley, but they are mapped as the Leadville-Granile-Lakehelen (CO303) and the Mirror-Teewinot-Bross (CO411) soil map units. The CO411 unit is found on the range top and CO303 covers the flanks. In general they are very rocky loam, and commonly steep. They support montane and alpine vegetation.

Hydrology and Water Resources

Hydrologic resources perform vital processes in the development of the physical system at Great Sand Dunes National Park and Preserve and the larger project area. Stream flow transports sand, supplying it to the system and modifying the margins of the dunefield. The evaporation of saline groundwater leads to the precipitation of evaporite minerals that form the sabkha. These processes also have an important effect on biological systems since the structure of plant and animal communities depends on water availability. The San Luis Valley is technically a desert, however, water is abundant.

The Closed Basin in which GRSA is situated contains a complete hydrologic cycle. Water input comes from precipitation and is greatest in the mountains. Snow accumulates, especially on the north-facing slopes, providing increased stream runoff during the late spring and summer. Within the mountainous portion of the drainage basin streams are gaining, as tributaries join and bank storage maintains base flow. As the streams exit the mountains and flow over the unconsolidated sediment of the San Luis Valley, they become losing streams and will terminate on the valley floor as they lose water to both infiltration and evapotranspiration. Only the larger streams will connect with the water bodies in the playas area and this only happens during average and above-average spring runoffs. Stream and ground water flow is toward the southwest to the bottom of the Closed Basin. There, water accumulates in lakes and ponds and exits the system by evaporation, completing the hydrologic cycle. There are accounts given by long-time residents that the Closed Basin filled in the 1920s and 1940s and overflowed to become a tributary to the Rio Grande. A filled Closed Basin would have been a lake tens of miles long, several miles across, but less then 20 ft (6 m) deep. Many of the streams within the Closed Basin are now diverted for irrigation, so the opportunity for the Basin to fill is lessened.

Lakes and ponds are found throughout the system and vary by their position in the hydrologic gradient. Tarn lakes are common near treeline elevations where glaciation produced cirques. Depression springs known as interdunal ponds are found mid-gradient on the valley floor in the sandy environment between active and relict dunes where the water intercepts the ground surface. At the terminus of the hydrologic system, where the gradient drops to zero, playa lakes are temporary features. The exception is San Luis Lake, which is recharged by the nearby Closed Basin Canal and managed by the state of Colorado as a state park. San Luis Lake is the largest lake and it generally is less than 260 ha (one square mile) in area. Most of the ponds are much smaller. Some of the interdunal ponds can be less than 0.4 ha (1 acre) in area.

Sand Creek is the largest stream in the area. Flow for this creek has been measured since 1994. Its average cumulative discharge is 11,800 acre ft and average peak discharge is 160 cubic ft per second. The minimum annual discharge was 237 acre ft during the 2002 water year. The maximum was 19,400 acre ft in the 1995 water year. Peak discharges of around 500 cfs have been estimated based on high water marks following flash flood events. The estimates are based on projections of discharge versus water depth for a rated section of the channel. Deadman Creek is the next largest stream, but has a short period of record. Medano Creek has been continuously monitored since the mid-1990s. It has an average annual discharge of 4,100 acre ft with an average peak flow of 39 cubic ft per second. Maximum annual discharge occurred in 1995 and was 10,000 acre ft. Minimum occurred in 2002 and was 408 acre ft. There are numerous other, mostly intermittent, small streams that flow into the valley.

Flora and Fauna

Vegetation Patterns

The San Luis Valley lies within the rain shadow of the San Juan Mountains to the west. Due to low precipitation, a short growing season, and high elevation, the valley is described as a high cold desert. As a closed basin, it is geographically isolated by mountain ranges on the west and east, and by hills to the north and the south. The vegetation patterns are unique within the valley compared to its surroundings. Areas of unique ecology combined with geographic isolation, are often of biological interest because they often exhibit high levels of endemism and rarity (Pague and Simonson 1994).

The valley floor includes a broad hydrologic gradient ranging from open water wetlands and saline flats and playas to xeric shrublands and active and stabilized sand dunes. The lower slopes along the base of the mountains support grasslands and shrublands and transition into woodlands of mostly pinyon pine (*Pinus edulis*) mixed with occasional Rocky Mountain juniper (*Juniperus scopulorum*). Where the dune field extends up on the slopes of the alluvial fan there are small open woodlands of ponderosa pine (*Pinus ponderosa*). Above this level, in the montane and sub-alpine zones the forests consist of a mix of white fir (*Abies concolor*), Douglas fir (*Pseudotsuga menziesii*), aspen (*Populus tremuloides*), Engelmann spruce (*Picea engelmannii*) and sub-alpine fir (*Abies lasiocarpa*). The montane valley bottoms are typically steep and narrow and tend to support a very compressed riparian zone with a diverse mix of riparian and upland species. The subalpine forests tend to transition abruptly into alpine tundra, willow shrublands, alpine fellfields, and areas of barren bedrock and scree.

Synopsis of Biological Inventories at GRSA

Although observations and checklists of vegetation and animals were informally compiled throughout GRSA's history as a national monument, formalized inventories were not produced until the 1990s.

One of the first formalized all-taxa surveys was completed by the Colorado Natural Heritage Program (CNHP) in 1997 and 1998 (Rondeau et al. 1998; Pineda et al. 1999). The CNHP documented numerous biologically significant elements within Great Sand Dunes and adjacent

San Luis Lakes. The primary goal of the CNHP projects was to identify locations having natural heritage significance, with a special emphasis on private lands.

Extensive field inventories recognized a total of 46 biologically significant elements within the Great Sand Dunes ecosystem and adjacent San Luis Lakes that are tracked by the CNHP. These include 15 plant communities, including five significant wetland communities, three plants, 16 insects, nine birds, and three mammals. Many of these elements are restricted in range, either known to be endemic to the Great Sand Dunes ecosystem, or endemic to the San Luis Valley, or have undergone a reduction in range, and are now relegated to the San Luis Valley. Considering the relatively compact size of this study area, the number of significant elements indicates that this is an area of remarkably high biological wealth.

Beginning with the National Park Service's Natural Resource Challenge in 1999, the Rocky Mountain Inventory and Monitoring Network identified inventory needs at several parks and monuments, including Great Sand Dunes National Park and Preserve. As part of the service-wide emphasis on inventory and monitoring, the National Park Service developed task agreements with various agency, institutional, and stewardship science personnel to conduct biological inventories within its National Parks. The primary objective of NPS inventories was to document the occurrence of at least 90% of vertebrates and plants expected to occur within each park. For GRSA, the inventories were components of a suite of biological inventories of vertebrates and vascular plants being conducted within the Rocky Mountain Network. The objectives of the inventories were (1) to document the occurrence of plant or vertebrate animal species; (2) to describe the distribution and, where possible, the population densities of those species; (3) to identify critical habitats for those species; (4) to identify species of special management concern, and (5) to recommend long-term monitoring programs for those species.

Because of the combination of independent insect- and benthic macroinvertebrate-related inventories, the Colorado Natural Heritage Program Inventories, and the Natural Resource Challenge inventories, GRSA now has one of the most complete floral and faunal inventories of all National Park Service units. A synopsis of both independently-undertaken inventories and those inventories completed under the guidance of the Natural Resource Challenge follows.

Vascular Plants

A checklist of vascular plants of Great Sand Dunes National Monument (Dixon 1999) was developed over a 30-year period from 1969-1999, and documented about 406 taxa occurring in the (then) Monument. This was, at the time, one of the most thorough botanical inventories in all of Colorado. Given the thoroughness of this inventory, this checklist was considered to be comprehensive for the monument.

Using this very thorough checklist as a baseline, Spackman-Panjabi, et al. (2002, 2004; CNHP) completed a two-year vascular plant inventory in 2003. At the conclusion of this project, the GRSA master list for vascular plants contained 604 taxa, and 92% were represented by voucher specimens at the GRSA Herbarium. However, the surveys suggest that there are many more vascular plant species that remained to be documented. Species lists compiled by other botanists working in the area (Dixon 2003, Hogan 2000) include hundreds of taxa that were not documented from GRSA. A reasonable estimate is that 25-50% of these species are likely to occur on GRSA, and that up to 400 additional taxa could be collected from the parklands.

This inventory also concluded that GRSA lands support the occurrence of several rare plant species. *Draba smithii* (Smith's draba) is a globally imperiled species that is only known from approximately 16 locations in Colorado, and nowhere else in the world, which points to the significance of the two locations of this species at GRSA. *Cleome multicaulis* (slender spiderflower) is also globally rare, and is known from one location in GRSA. Although the Slender spiderflower is also known from a fairly wide range continuing south into Mexico, the most vigorous populations known are found in the San Luis Valley of Colorado. *Cryptantha cinerea* var. *pustulosa* (James catseye) is another rare species that is known from GRSA. This species is also known from New Mexico, Arizona, and Utah, but its status in the other states is not known. The sterile hybrid *Hymenoxys* x*helenoides* (Intermountain bitterweed), collected in 2003, is known from a few small, widely scattered populations in Colorado, Utah, Arizona, and New Mexico. The conservation attention that this entity warrants is questionable because it is a sterile hybrid, not a true species (Anderson et al. 1995). However, the Colorado Natural Heritage Program includes *H.* x*helenoides* on a list of rare Colorado taxa, and tracks specific locations within the state.

Non-native and Invasive Plants

Wood and Rew (2004; Montana State University) surveyed approximately 6,032 acres of GRSA. The inventory did not include the northern portions of the now Park and Preserve, as these lands were not yet within the legislated boundaries at that time. The total land area occupied by weeds was calculated, including overlaps in physical space (a number of species might occupy portions of the same physical space but each area is considered a unique infestation and added separately), for a cumulative infested area of 1,227 acres. Further, the total infested area of all species was calculated, (a number of species might infest the same physical space but the area infested is counted only once). Total infested area was estimated to be 1,059 acres. Among those species specifically targeted and located by this survey include: Russian knapweed (*Acroptilon repens*), cheatgrass (*Bromus tectorum*), whitetop or hoary cress (*Cardaria draba*), Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), field bindweed (*Convolvulus arvensis*), Russian olive (*Elaeagnus angustifolia*), leafy spurge (*Euphorbia esula*), perennial pepperweed (*Lepidium latifolium*), Russian thistle (*Salsola tragus*), and hairy mullein (*Verbascum thapsus*).

Benthic Macroinvertebrates

Zuellig et al. (2005; USGS) initiated a benthic macroinvertebrate survey of the Sand Creek Basin in 2004. The primary objective of the study was to qualitatively inventory target aquatic-insect groups in perennial streams, and selected unique standing-water habitats, such as springs, and wetlands associated with the Sand Creek Basin. Efforts focused on documenting the presence of aquatic-insect species within the following taxonomic groups: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These insect orders were chosen because published species accounts, geographic distribution, and identification keys exist for many Colorado species. Given the extent of available information for these groups, there existed a potential for identifying new species and documenting range extensions of known species.

Sampling began in the spring of 2004 and continued through October 2005 with monthly or bimonthly site visits. Effort was made to sample spring, summer, winter, and fall to capture the seasonality associated with the aquatic-insect emergence of this region. All sampling required extended backcountry travel. Given these challenging logistics, several sampling methods typically used to collect aquatic insects were modified for backcountry conditions.

Nearly 4,200 specimens were examined from 71 site visits. Of the specimens examined, 70 species were identified from 47 genera and 19 families. The caddisflies were the most diverse with 31 species, followed by the stoneflies with 24 species, and the mayflies with 14 species.

Terrestrial Invertebrates

In August of 1990, a study was initiated to inventory the known insects of the (then) GRSA National Monument (Weissmann and Kondratieff 1999a) by searching museums for arthropod specimens labeled from the Great Sand Dunes. This list was further augmented by on-site collecting from August 1990 through September 1991 at the Great Sand Dunes, where various habitats within the dunes were sampled for invertebrates. In June and August of 1999, Indian Spring Natural Area was independently inventoried for arthropod fauna (Pineda 2000). Combining these inventories, over 1,000 species of arthropods are recorded. Among these findings were four endemic species of beetles (*Cicindela theatina, Amyblyderus triplehorni, A. werneri,* and *Hypocaccus* n.sp.), of which descriptions for two of these species (*A. triplehorni* and *A. werneri*) were published in 1999 (Weissmann and Kondratieff 1999b), two undescribed beetle species (Coleoptera: Histeridae), one undescribed robber fly (Diptera: Asilidae, *Proctacanthus* n.sp.), and a number of rare species which were not previously documented or were unexpected records. Among all of the endemic species known at Great Sand Dunes, *Cicindela theatina* is perhaps the most well studied, its natural history published in 2003 (Pineda and Kondratieff 2003).

Fish

Bramblett (Bramblett and Zale, 2002; Montana State University) conducted a survey of the fish populations in Upper, Middle and Lower Sand Creek during the summer of 2002. Within this basin, the sampling located populations of cutthroat subspecies (*Oncorhynchus clarki* subspecies), and brook trout (*Salvelinus fontinalis*). The Rio Grande cutthroat trout is the subspecies of cutthroat trout native to the Rio Grande Basin (Behnke 1992); however, the pre-Columbian distribution of Rio Grande cutthroat trout in the Sand Creek basin is unknown. In any event, it is apparent that brook trout were stocked into lower Sand Creek at some point, and stocking of cutthroat trout by the Colorado Division of Wildlife (CDOW) in Upper, Lower, and Little Sand Creek lakes has resulted in their occurrence in waters below these lakes. The occurrence of cutthroat trout both above and below natural barriers, together with a sharply demarcated upper end of brook trout distribution, is consistent with a “brook trout from below, cutthroat trout from the lakes” hypothesis. Because both Pikes Peak (an *O. clarki stomias – O. clarki bouvieri* hybrid) and Rio Grande strains of cutthroat trout were stocked in the lakes, the cutthroat that now occur in Sand Creek are likely to contain genes from the two strains, as well as possibly genes of the original resident cutthroat trout in Sand Creek, if any were present before stocking. As a result, the current fish assemblages in the Sand Creek basin are the result of fish stocking superimposed on whatever native fish populations may have occurred prior to stocking.

Bramblett and Zale (2002) also put together put together a synopsis of the fish species occurring in Medano Creek, based on unpublished file data from CDOW. In 1985, the brook trout population in the Medano Creek basin was chemically reclaimed, and Rio Grande cutthroat trout were introduced in 1987. Subsequent fish surveys in 1989, 1997, and 1998 found no brook trout and indicated that the cutthroat trout population was increasing. The Hudson Branch of Medano Creek was surveyed in 1999, and Rio Grande cutthroat trout of several year classes were captured. In Little Medano Creek, five small Rio Grande cutthroat trout were captured in a 1990 survey, indicating successful reproduction. Thus, the Rio Grande cutthroat trout population in Medano Creek basin is considered by CDOW to be secure and expanding.

In 1996 and 1997, 200 Rio Grande suckers were transplanted into Medano Creek from Rio Tusas, New Mexico. Subsequent surveys were conducted in 1998, 1999, and 2000. Eleven mature Rio Grande suckers were captured in the1998 CDOW fish survey. No reproduction was documented, despite the presence of sexually mature suckers and optimal water temperatures (10˚ C to 15˚ C). Low numbers of Rio Grande suckers were captured in surveys in 1999. Reproduction was documented in 2000, when 34 suckers less than 76 mm were captured. However, adult suckers remained rare.

Herpetiles
Muths and Street (2002; USGS) completed herpetile inventories in 2001, and identified nine species occupying the habitats inside the park boundaries. Most of these inventories were confined to the boundaries that existed in 2001; areas north and east of the national monument and national preserve boundaries were not inventoried at that time. Those amphibians identified were: the tiger salamander (*Ambystoma tigrinum*), Plains spadefoot toad (*Spea bombifrons*), Woodhouse's toad (*Bufo woodhousii*), and the Great Plains toad (*Bufo cognatus*). The reptiles found included the short-horned lizard (*Phrynosoma hernandesi*), eastern fence lizard (*Sceloporus undulates*), variable skink (*Eumeces gaigeae*), bull snake (*Pituophis catenifer*), and Garter snake (*Thamnophis elegans*). Other species not found in this survey but reported by others (Hammerson, 1999) include the chorus frog (*Pseudacris triseriafa*), milk snake (*Lampropeltis triangulum*) and western rattlesnake (*Crotalus viridis*).

Birds
Giroir (2005; Rocky Mountain Bird Observatory) completed avian inventories for GRSA in 2004. To implement the inventory, a series of habitat-stratified point count transects was implemented using distance-sampling methodology in each of the major habitat types of GRSA (alpine tundra, aspen, piñon-juniper, ponderosa pine, riparian, sand dunes, semidesert shrubland, spruce-fir, and wetland). Wintering, migratory, and nocturnal bird species were also surveyed by conducting point counts along drivable roads in GRSA. During the point count transects, field biologists detected a total (in all habitats combined) of 3107 individual birds of 110 species. Among those species most commonly surveyed were violet-green swallow (*Tachycineta thalassina*), horned lark (*Eremophila alpestris*), vesper sparrow (*Pooecetes gramineus*), warbling vireo (*Vireo gilvus*), and mourning dove (*Zenaida macroura*). Field biologists detected 31 individual raptors of seven species: northern harrier (*Circus cyaneus*), sharp-shinned hawk (*Accipiter striatus*), Swainson's hawk (*Buteo swainsoni*), redtailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), peregrine falcon (*Falco peregrinus*), and great-horned owl (*Bubo virginianus*). Species detected in low numbers included: wild turkey (*Meleagris gallopavo*), long-billed curlew (*Numenius americanus*), juniper titmouse (*Baeolophus ridgwayi*), marsh wren (*Cistothorus palustris*), and Virginia's warbler (*Vermivora virginiae*).

The following species that were documented during the inventory are listed by the Colorado Partners in Flight (COPIF) Land Bird Conservation Plan (Beidleman 2000) as "High Priority" for conservation needs in Colorado: northern harrier, Swainson's hawk, peregrine falcon , long-billed curlew, white-throated swift (*Aeronautes saxatalis*), broad-tailed hummingbird (*Selasphorus platycercus*), red-naped sapsucker (*Sphyrapicus nuchalis*), olive-sided flycatcher (*Contopus cooperi*), Hammond's flycatcher (*Empidonax hammondii*), gray flycatcher

(*Empidonax wrightii*), Cordilleran flycatcher (*Empidonax occidentalis*), western kingbird (*Tyrannus verticalis*), loggerhead shrike (*Lanius ludovicianus*), pinyon jay (*Gymnorhinus cyanocephalus*), horned lark, violet-green swallow, juniper titmouse, western bluebird (*Sialia Mexicana*), American pipit (*Anthus rubescens*), Virginia's warbler, blackthroated gray warbler (*Dendroica nigrescens*), MacGillivray's warbler (*Oporornis tolmiei*), Wilson's warbler (*Wilsonia pusilla*), green-tailed towhee (*Pipilo chlorurus*), Brewer's sparrow (*Spizella breweri*), sage sparrow (*Amphispiza belli*), and brown-capped rosy-finch (*Leucosticte australis*).

Based on the number of "High Priority" bird species that inhabit the area the park was nominated for recognition as a National Audubon Society Important Bird Area. The Audubon Society program recognizes sites that provide essential habitat to one or more bird species during breeding season, migration, or winter. The program draws on science-based criteria to identify and conserve a network of key habitats for birds. The recognition of a site does not confer any legal or regulatory status, and is voluntary on the part of the land manager

Mammals

A two-year small mammal survey was initiated in 2003 by the USGS Arid Lands Field Station in Albuquerque, New Mexico (Valdez 2006). Surveys were carried out in lowland habitats that ranged from sand sheet grasslands, piñon-juniper forests, and riparian areas along Medano Creek, to montane conifer and aspen forests at the higher elevations, covering the entire elevation range of the Park. The 2003 efforts were concentrated on the newly acquired land of the Great Sand Dunes National Preserve, although work was also done on the original monument lands. The most frequently surveyed mammals were the deer mouse (*Peromyscus maniculatus*), the long-tailed vole (*Microtus longicaudus*), and the least chipmunk (*Tamias minimus*). Other species not trapped but observed included the coyote (*Canis latrans*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), mountain cottontail (*Sylvilagus nuttallii*), red squirrel (*Tamiasciurus hudsonicus*), and long-tailed weasel (*Mustela frenata*). Additionally, the yellow-bellied marmot (*Marmota flaviventris*), Abert's squirrel (*Sciurus aberti*), and common porcupine (*Erethizon dorsatum*) were also accounted for on this survey.

Seven species of bat were inventoried, of which the most common was the long-legged myotis (*Myotis volans*). The long-legged myotis was the second most abundant species at GRSA. Thirty-two of 52 long-legged myotis captured in 2003 were females, 16 of which were lactating or pregnant, strongly indicating the presence of a maternity roost in the area. The long-eared myotis (*M. evotis*) was the second most abundant bat species documented. Other bat species include: the big brown bat (*Eptesicus fuscus*), the western small-footed myotis (*Myotis ciliolabrum*), Townsend's big-eared bat (*Corynorhinus townsendii*), and the hoary bat (*Lasiurus cinereus*), although none showed a sign of reproductive condition.

A noteworthy record of occurrence was the capture of a juvenile snowshoe hare (*Lepus americanus*). Also noteworthy was a male ermine (*Mustela erminea*) caught near Upper Sand Creek Lake. This ermine represents a new record for GRSA and Saguache County. The ermine is the smallest member of the weasel family (Mustelidae) that is known to occur in Colorado.The mammal inventory described above was inclusive primarily of small mammal occurrences. Large mammalian fauna well known to occur at the Park and Preserve include: mountain lions, black bears, elk, mule deer, bighorn sheep, and pronghorn.

Methods

The methods to produce a vegetation map for parks the size of GRSA are described in detail in USGS - NPS Vegetation Mapping Program Documents and Standards (http://biology.usgs.gov/npsveg/standards.html) and only summarized here. The general groups of tasks include planning meetings, collecting and analyzing existing data, development of the classification, development of the sampling strategy, field work, data input and analysis, photo interpretation, cartography, map validation and accuracy assessment. These tasks necessarily interact with one another throughout the entire process.

Planning and Scoping

The initial planning and scoping meeting was held at Great Sand Dunes National Park on March 16-17, 2005. The GRSA Vegetation Classification and Mapping project team incorporated the combined expertise and oversight of several organizations. The core technical work was split among five groups: The technical mapping portion was contracted to the BOR RSGIG in Denver, CO and the Rocky Mountain Geographic Science Center of the United States Geological Survey (USGS). The Colorado Natural Heritage Program (CNHP) was contracted to collect, analyze, classify, and write-up the requisite plant association data and conduct fieldwork to support the vegetation mapping and accuracy assessment (AA). NatureServe was contracted to support the field surveys, data analysis, classification, and vegetation mapping. The NPS Rocky Mountain Network (ROMN) developed sample designs for initial plots and accuracy assessment sites.

Additional partners included several other landowners in the project boundary. The United States Fish and Wildlife Service (USFWS) collaborated closely on all steps of the project and provided a similar data set for a portion of the comprehensive project boundary. The United States Forest Service (USFS) provided key input and financial support. Several local stakeholders also played a central planning and users role, such as the Nature Conservancy, the Baca Grande Property Owners Association, Crestone/Baca Land Trust, San Luis Valley Ecosystem Council and Friends of the Dunes.

Oversight and programmatic considerations were managed by the ROMN and National Vegetation Mapping Program of the National Park Service. GRSA personnel provided key guidance on specific Park needs and facilitated several operational components of field work.

For the core partners in the project specific technical responsibilities and deliverables included the following:

BOR Responsibilities and Deliverables:

- Participate in scoping and other planning meetings;
- Work closely with USGS and other partner image interpreters to assure a common understanding of the classification of vegetation in the Park;
- Interpret imagery;
- Transfer interpreted information to a digital spatial database and produce hard copy (paper) vegetation maps;
- Create digital vegetation coverages including relevant attribute information;

- Produce geodatabase with all relevant attributes for map polygons, vegetation plots, and accuracy assessment locations;
- Create a contingency table comparing the mapped classes with the AA classes in order to determine map accuracy;
- Provide any ancillary digital files developed during the mapping process;
- Document and record digital FGDC compliant metadata files (*.html) for all created spatial data;
- Produce hard copy (paper) vegetation maps;
- Produce the final report and CD-ROM describing procedures used in preparing all products;

USGS Responsibilities and Deliverables:
- Participate in scoping and other planning meetings;
- Work closely with BOR and other partner photo interpreters to assure a common understanding of the classification of vegetation in the Park;
- Acquire, quality assure and interpret imagery;
- Transfer interpreted information to a digital spatial database;
- Create digital vegetation coverages including relevant attribute information;
- Produce geodata with all relevant attributes for map polygons;
- Provide any ancillary digital files developed during the mapping process;
- Document and record digital FGDC compliant metadata files (*.html) for all created spatial data;
- Produce the final report and CD-ROM describing procedures used in preparing all products;

CNHP Responsibilities and Deliverables:
- Participate in scoping and other planning meetings;
- Research existing vegetation data from GRSA;
- Collect 600+ Vegetation Plots;
- Work closely with BOR and USGS photo interpreters to assure a common understanding of the classification of vegetation in the Park;
- Work closely with NatureServe to assure consistency with NVC classification standards;
- Enter and analyze data from Vegetation Plots to produce a final classification for mapping;
- Enter and analyze fuel data;
- Collect, and enter data for, 1500+ Accuracy Assessment Points;
- Create a Vegetation Field Key;
- Write Local Descriptions for all Vegetation Types;
- Provide information for the Final Report;
- Deliver data in digital form from Vegetation Plots and Accuracy Assessment Points;
- Deliver classification of GRSA vegetation;
- Deliver local vegetation descriptions;
    - Review map class field key
- Deliver key to the vegetation associations of GRSA;
- Deliver relevant sections in the Final Report.

NatureServe Responsibilities and Deliverables:

- Assist in project scoping and planning activities;
- Develop a preliminary vegetation classification for the study area from secondary sources;
- Assist in training field crews in standard NPS vegetation sampling methods for classification and accuracy assessment;
- Work closely with BOR and USGS photo interpreters to assure a common understanding of the classification of vegetation in the Park;
- Work closely with CNHP to assure consistency with NVC classification standards;
- Be available for consultation in data management and vegetation classification;
- Collaborate with vegetation mappers in developing mapping classes;
- Support image-interpretation by spending time in field with image-interpreters and being available for consultation and collaboration;
- Review and finalize draft classification, local community descriptions, and field key to community types;
- Provide information and sections for the Final Report;
- Deliver classification of GRSA vegetation;
- Deliver local vegetation descriptions;
    - Reviews CNHP locals, makes standard (QC) and produces final description report.
- Deliver key to the Vegetation of GRSA;
    - Review association field key, NS writes and delivers map class key
- Provide information and relevant sections in the Final Report.

Scoping Meetings

The project participants met on several occasions over the course of the project to discuss progress and develop the scope of activities that needed to be completed over the near-term. These usually informally structured meetings were held at least once per year, often more frequently. Perhaps in contrast to other similar projects, the bulk of communication occurred in small group phone calls, e-mails and in face to face meetings that are too numerous and informal to include here. The following is a summary of several of the most pertinent meetings.

Project 'Kick-Off' and Scoping Meeting:

The project kick-off meeting was held at the Great Sand Dunes National Park and Preserve (GRSA) on February 22-23, 2005 (Figure 6). All partners attended with the goals of discussing and planning:

- The background and motivation for the USGS-NPS Vegetation Mapping Program;
- The integration of fire-fuels field and analytical components into the project;
- A preliminary vegetation association list;
- A proposed sample design (plot and accuracy assessment) that will attempt to satisfy multiple criteria (vegetation quantification; fuel models and long-term monitoring);
- Options for imagery acquisition and analysis;
- Various approaches to field logistics and the general project timeline.

The meeting was successful and accomplished all of these goals. Perhaps most importantly the consensus was to proceed with a large, ecological based footprint that included multiple key landowners and managers in the San Luis Valley of Colorado where GRSA is located (Figure 7). This was an extremely large footprint that extended well beyond the parks boundaries. This was only possible because of the existing approach to management within the valley – a collaborative and cooperative system that enables all federal, state and local stakeholders – and a plan to share both financially and through in kind services, costs to the NPS National Vegetation Mapping Program.

Figure 6. GRSA Kick Off Meeting Participants, February 22-23, 2005

Field Preparation Meetings:

Prior to beginning field work in 2005 (and 2006 and 2008) the project team met to discuss issues for the approaching field seasons. These included developing an agenda for the orientation and training of the field crews, completion and application of the sample designs, scheduling the plot work, and defining appropriate Park contacts for various issues that might arise.

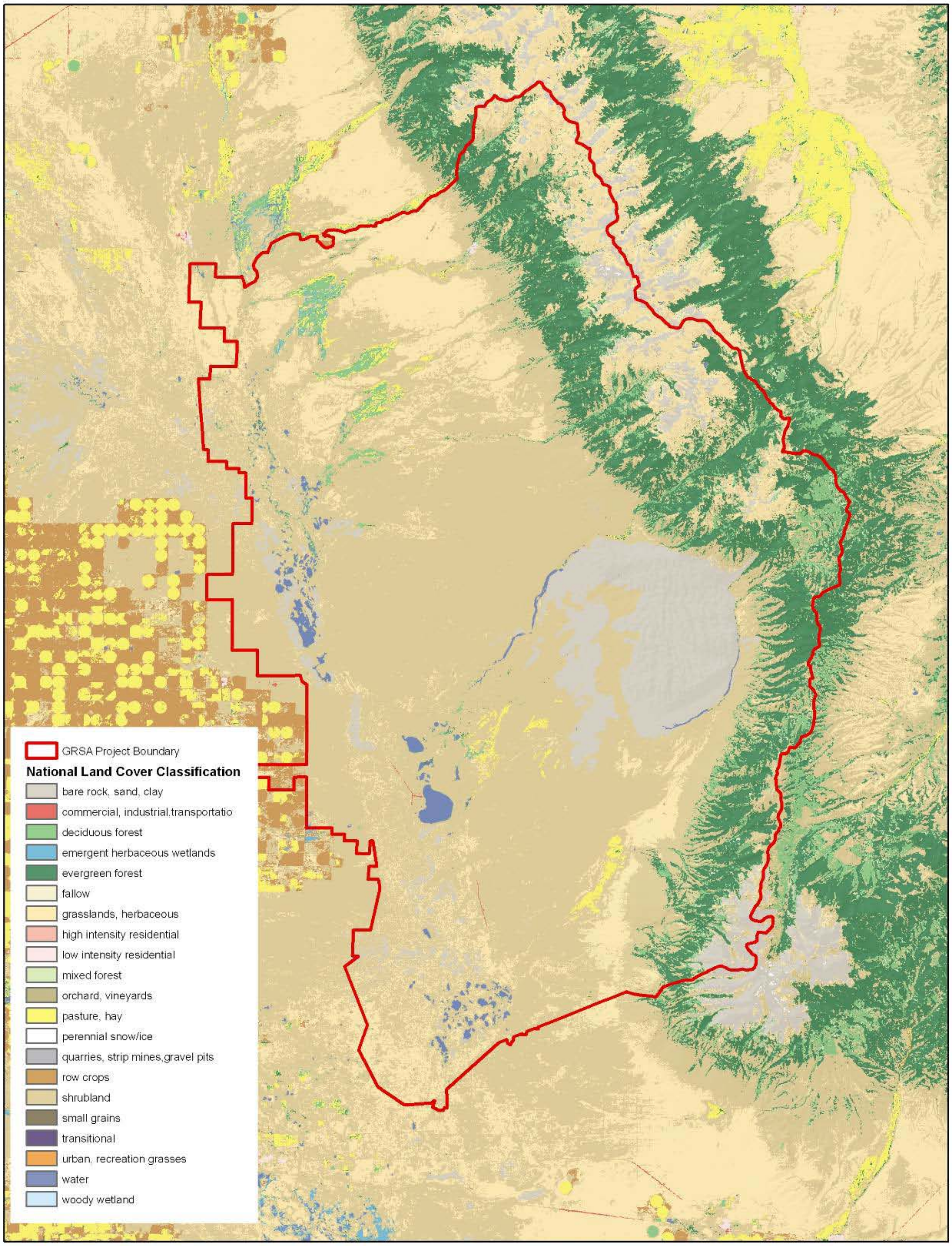

Figure 7. GRSA Vegetation Mapping boundary and major landcover types from the 2001 National Landcover Dataset.

Map Class and Interim Status Meetings:

An interim project status meeting was held in October, 2005 following the completion of the 2005 summer field season (the first of two plot field seasons). The purpose of the meeting was for the project participants to summarize their progress on the project and to plan remaining tasks to be completed prior to the start of the 2006 field season. Topics covered during the meeting included progress on defining the Map Classes, comparison of plot data collected from the field with the preliminary list of associations, progress of checking the data and entering it into the PLOTS database, and the status of the fuels and photographic data. We also discussed the ongoing mapping efforts being conducted by the USFWS and how these data would be integrated into the larger GRSA projects footprint.

A similar meeting was held in December of 2006 that presented an overview of the final plot collection season. We then discussed the planned imagery acquisition and analyses and map classes for use in these maps. CNHP and NatureServe presented a preliminary map class schema after a review of the final vegetation classification and consideration of prior work. Using a preliminary map legend in sampling design helps insure all map classes are adequately sampled. We discussed more detailed work that would be conducted by CNHP and NatureServe to either lump or split types.

Accuracy Assessment Meeting:

Following completion of the vegetation sampling in 2006 the project focused on image interpretation and mapping (no significant field work was conducted in 2007). We began planning for an accuracy assessment (AA) in early 2008. However, all planning was done via email and phone. Topics included the methodology for defining the appropriate number and distribution (spatial and thematic) of the AA plots, development of the cost surface to be used in placing the plots on the map, data to be collected at the plot locations, and logistics for completing the required number of plots in a single season.

Episodic Planning Meetings:

As noted most planning and collaboration for the project actually occurred in interactions not listed above. Several planning meetings were held prior to and during field and mapping work. These were intended to provide the forum for discussing various logistical issues and determining the scope and scale of various project aspects. Questions of whether and how to permanently mark the plots, the availability of crew housing, backcountry camping, land access, the content of the preliminary association list, the content of the map class list, image interpretation, data sharing and other questions were discussed at these planning meetings.

Preliminary Data Collection and Review of Existing Information

Vegetation Studies

Existing studies documenting the vegetation of the GRSA project area were reviewed and incorporated to inform the classification and image analysis portions of the project. These included a study of wetlands in the San Luis Lakes area (Cooper and Severn 1992), a study of the vegetation patterns of the former GRSA National Monument from 1936 to 1990 (MacArthur and Sanderson 1992), and a study of the alpine plant communities of the southern Sangre de Cristo Mountains (Baker 1983).

Cooper and Severn (1992) conducted a study of wetlands in the San Luis Valley and had one study area including 12 transects located at San Luis Lakes within the GRSA Vegetation Mapping project area. Data from this study were included with vegetation plot data and used to inform the photo interpretation. These data were not included in the classification due to differences in collection and reporting methods that precluded them from being combined. Important among these was that Cooper and Severn (1992) specifically located plots along the hydrologic gradient in an effort to describe plant community zonation in relation to the water table gradient and with respect to duration and frequency of inundation.

MacArthur and Sanderson (1992) completed a study of the vegetation patterns of the former GRSA National Monument from 1936 to 1990. That study installed 118 permanent Relevé plots and compared a time series of aerial photography to classify and assess changes in the vegetation on and surrounding the dunes fields. While generally informative, plot data from that study was not included in the classification analysis due to differences in plot size and cover classification scheme. Plot forms reproduced in the report listed only anecdotal plot locations such as for plot number B-9 which gave the plot location as “Mountains north of Little Medano Creek” and therefore were not used for image analysis.

Baker (1983) conducted a study of the alpine vegetation of the Wheeler Peak area of the southern Sangre de Cristo Mountains in New Mexico. While this study presented similar types as were located in the project area, its distant location precluded its direct use in the classification or image analysis

A preliminary classification was built by intersecting the Southwest Regional Gap Analysis Project (SWReGAP; Lowry et al. 2005) map of vegetation types with the GRSA project area boundary. This provided an initial list of US NVC Associations that could occur in the project area that was revised according to the subsequent edits made to the SWReGAP spatial data (see Classification Sample Design section for discussion). Additionally, other data indicating vegetation types known to occur in the area was reviewed and included to create a comprehensive list of potential types. The preliminary classification list included 219 types and is provided in Appendix D.

Digital Data

Digital data was acquired from a variety of sources for visualization, background information, and for assisting in the interpretation of vegetation map classes. These data fall into three broad categories: vegetation maps, landscape data, and imagery sources.

Vegetation maps include regional and local maps over a variety of scales. The small scale maps available provide a regional perspective on the landscape and these include various ecoregion maps such as the U.S. EPA Ecoregions, Bailey’s Ecoregions, Omernik’s Ecoregions, National Land Cover Data, and SWReGAP. Maps of a more local type are more useful to the interpretive effort. The Bureau of Land Management (BLM) produced a detailed map of the Blanca Wetlands in the southern portion of the mapping area. The U.S. Fish & Wildlife Service produced a National Wetlands Inventory (NWI) that was used for reference. In 2000, the Park produced a large scale vegetation and land cover product for the dunes area. A 2003 vegetation and land cover product was produced by AgroEngineering for the central portion of the current project area. The United States Forest Service (USFS) produced a digital product for the mountainous portion of the project area. This USFS product completed field inventory in 2000 but is continually updated. These previous products were all helpful as reference for the current vegetation mapping.

Landscape data includes the digital elevation model (DEM) produced by the USGS. Using the base DEM data we were able to generate aspect, hillshade, and slope rasters that were useful for both the sampling plan and for interpretation. The Park had produced a shape file of aeolian deposits that covered the project area that was particularly helpful in identifying some map classes. A soils (SSURGO - NRCS Soils) database was also available for the project area and was used for reference.

A variety of imagery types were made available for this project. The base or primary layer used for interpretation was the 2006 color National Agricultural Imagery Program (NAIP) 1 m imagery. This image was the primary source for creating the line work used in this project. In addition, we used a 2007 Quickbird multiband Image for reference and interpretation. This image covered the western portion of the project area. The USFWS contracted a private operator to fly the flatlands to the east of the Sangre de Cristo Range. These images were later mosaiced together by the USFWS and were also used for reference and interpretation. The USFWS used this product as their primary image interpretation layer for the Baca NWR portion of the project area.

Classification Phase Sample Design

The classification phase of a large vegetation mapping project like at GRSA requires a robust but efficient sample design (how and where sample locations are placed in time and space) that generates a thorough description of the range of plant communities across the landscape. The design must account for common and extensive as well as rare and unique vegetation types. Design options include a complete census or some form of a survey or sample. To census the large extent (approximately 413k acres) and often extreme topography of the area of interest at GRSA was not possible. Therefore, a survey design was developed that would result in a classification data set that was comprehensive yet realistic to implement within our budget. Moreover, the paucity of existing data on the vegetation communities at GRSA required a design that would both spread the sample out across the large landscape placing crews in a diversity of locations (yet account for accessibility), as well as opportunistically allowing samples of novel community types encountered in the field.

Previous vegetation mapping projects used a variant of “Gradsect Sampling” (GRADient-directed tranSECTs; Gillison and Brewer 1985) and a purely biophysical sample frame (defined below). In previous projects (i.e., at Rocky Mountain National Park, Salas et al. 2005) the biophysical sample frame did not perform as well as would have been liked (it was not well correlated with patterns in the vegetation of interest). While the GradSect design form has worked reasonably well in the past, we chose to use instead a Generalized Random Tessellation Stratified (GRTS) design (Stevens and Olsen 2003, 2004 see also http://www.epa.gov/nheerl/arm). We changed survey design form for several reasons. Key features of the GRTS design include: (1) spatial balance, (2) an unbiased variance estimator, (3) (optionally) a “neighborhood” variance estimator with improved precision, (4) valid addition (or replacement) of sites (Stevens 1997; Stevens and Olsen 2003, 2004; Theobald et al. 2007), and (5) (optionally) variable probability sampling across subpopulations and/or explicit stratification. An additional attribute of GRTS designs is the capacity to increase sample size given changes in design requirements (such as occurs when a site is determined to be inaccessible). Sites can be added from a list of replacements yet the overall validity of the site distribution is retained. These attributes help ensure that GRTS survey designs are representative of the target population of interest (Lohr 1999), may be efficiently implemented, and allow unbiased inference from sampled sites to un-sampled elements of the resource of interest (Hansen et al. 1983). This last attribute of GRTS is possible because the design generates known inclusion probabilities (or "sample weights") and can adjust for biases in the design and be used in design-based inference. Therefore, it is a more appropriate design for long term monitoring. The ROMN will potentially use sample locations from the GRSA vegetation mapping project as locations for future monitoring. For example, this might allow future sampling at these locations and an analysis of changes in vegetation.

All ROMN GRTS designs are created in R using the library 'spsurvey' (Kincaid 2005, ver. 2.0, available from: http://cran.r-project.org/). Copies of original files are preserved and maintained by the ROMN including the computer code containing the original settings and functions, the sample frame shapefile(s), and of course the sample points created by the design.

Design Specifications

A set of design specifications detail the basic survey design form (i.e., GRTS as described above), a description of the sample frame, and description of any strata or unequal weight categories (subpopulations) within the target population. Other design specifications include the total sample size, allocation of these samples across strata and weight categories, temporal considerations such as allocation of samples to year- or season-based panels (if any), the number and distribution of oversamples (and how these replacement sites are to be used) and the strategy for site revisits (if any). The following sections briefly describe each of these for the GRSA classification phase GRTS design.

Sample Frame

The sample frame is the data from which a design algorithm selects potential sample locations. Frames are typically GIS data layer(s) that represent the best available approximation of the resource of interest. Sample frames must contain all topology (boundaries) with associated attributes that the design will allocate samples across (such as different vegetation types within a park). For the GRSA classification sample design, ROMN developed a sample frame using the SWReGAP Ecological Systems landform (Figure 8) and landcover (Figure 9a and b) layers and a cost or accessibility surface created by the ROMN (NPS ROMN 2008). The SWReGAP Ecological Systems layer was felt to be the best available map of landcover for the GRSA project boundary.

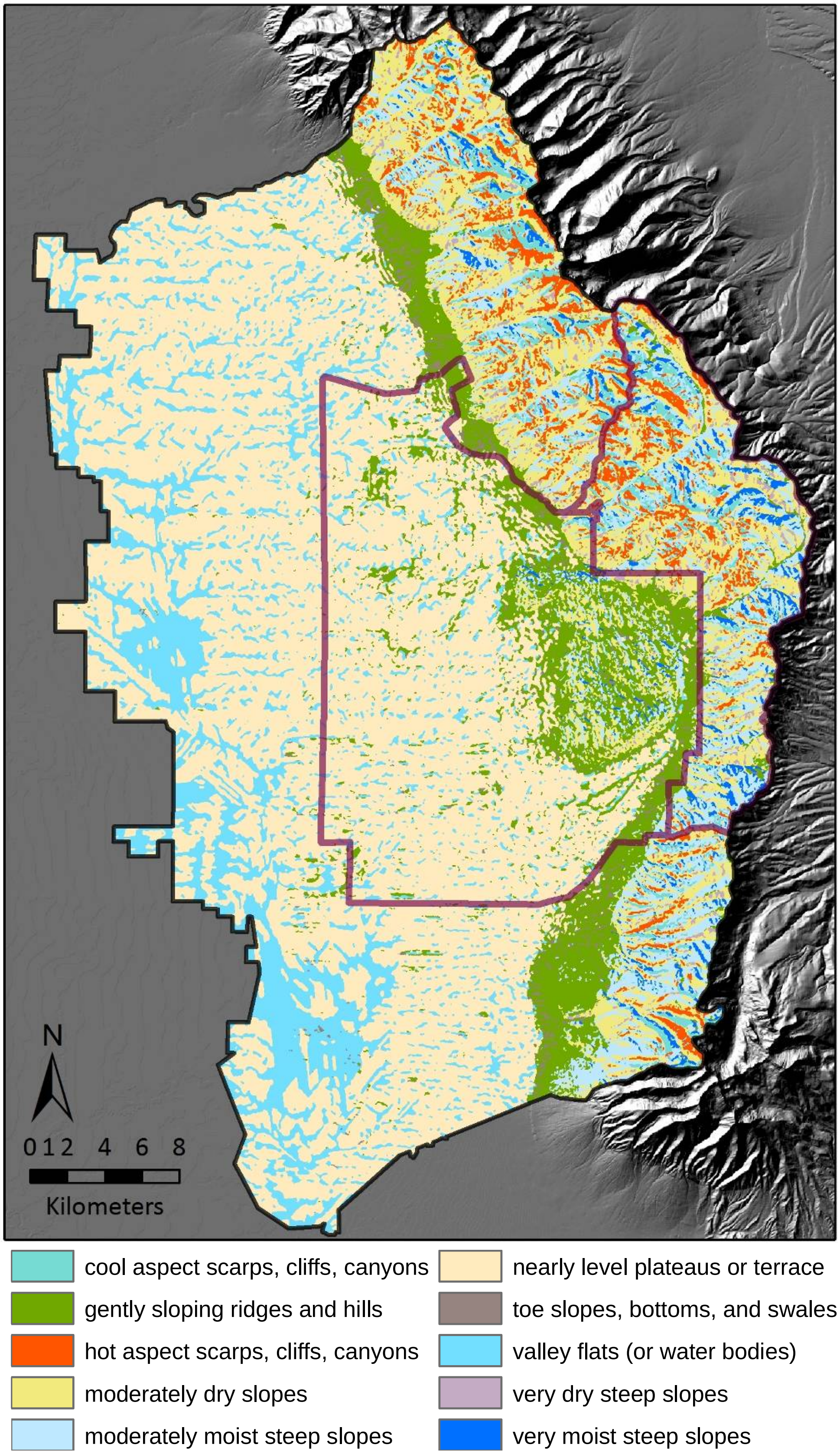

Figure 8. Southwest Regional Gap Analysis Project landform layers.

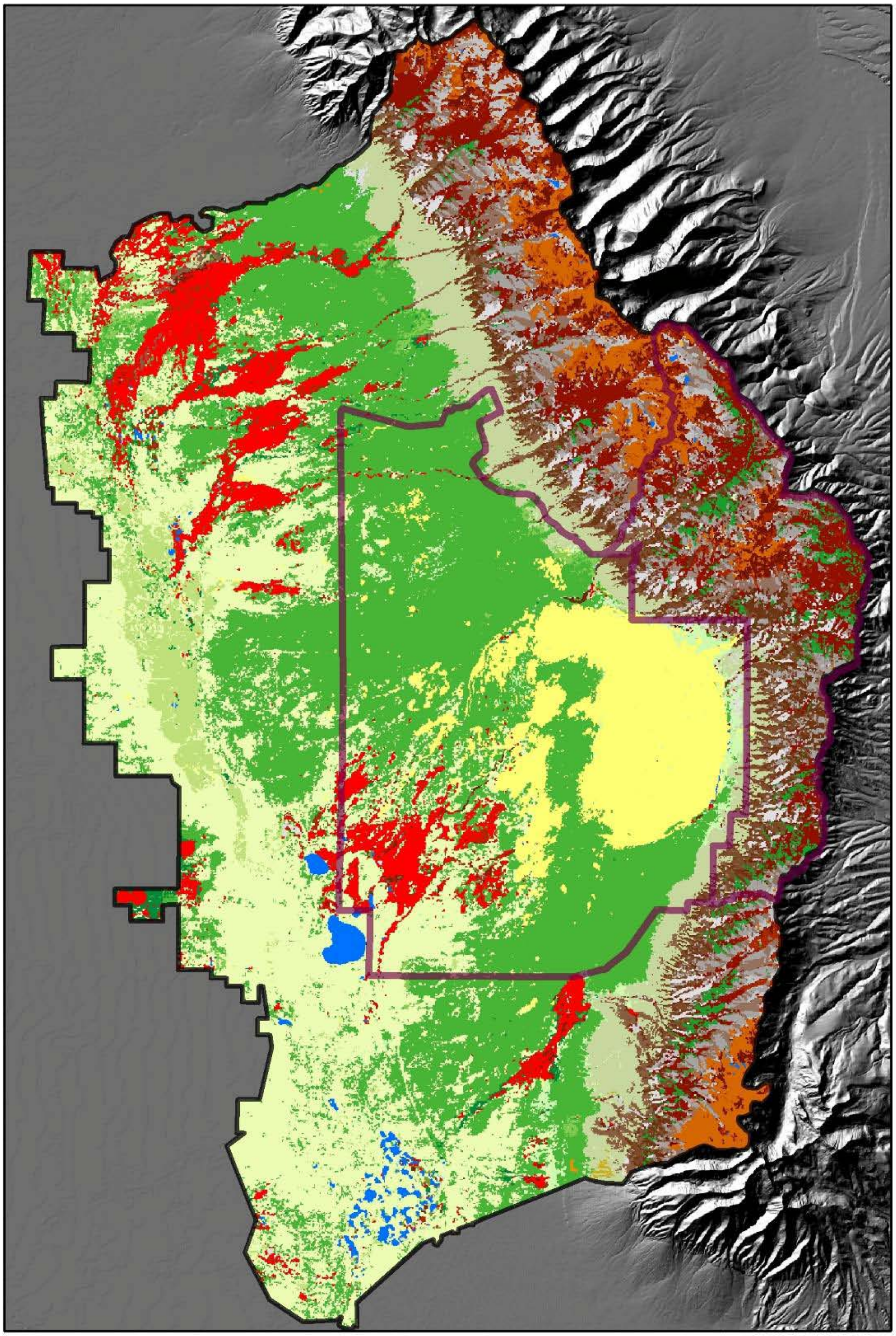

Figure 9a. Southwest Regional Gap Analysis Project Ecological Systems (landcover) and landform layers.

Note: The Ecological Systems data shown here are prior to any editing as discussed in the text (see Figure 11 for the final version)

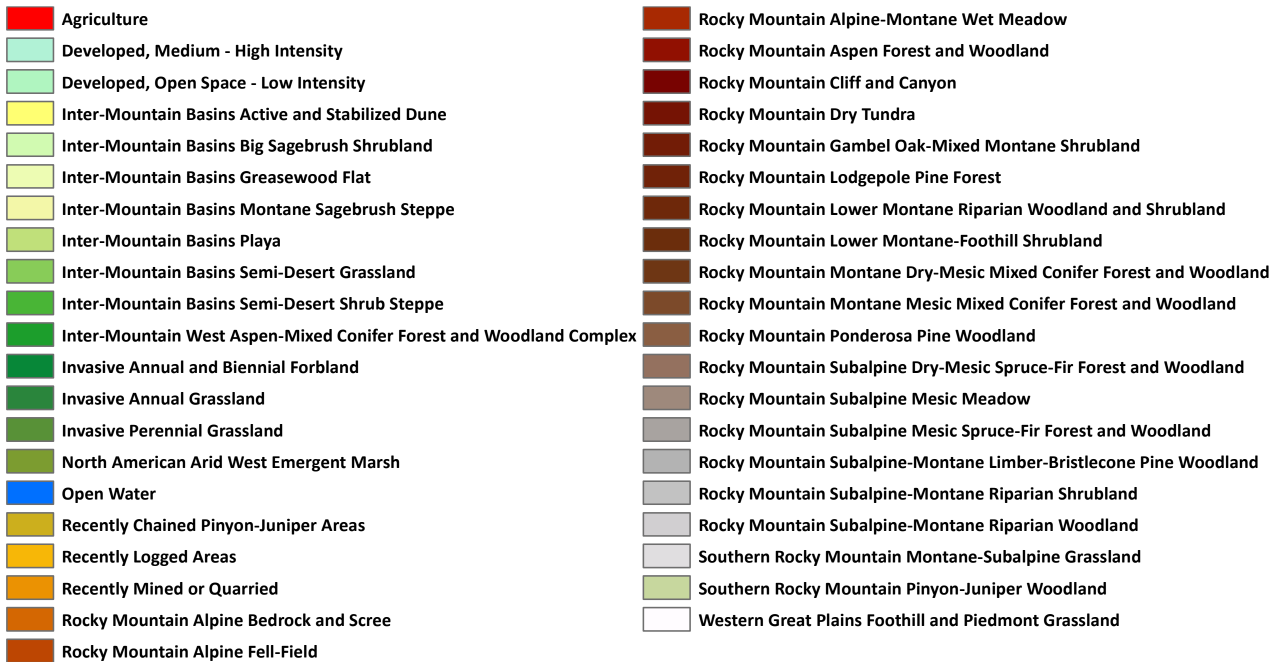

Figure 9b. Legend for Ecological Systems (landcover) map.

Southwest ReGAP Source Data and Processing

SWReGAP data were developed as part of the USGS GAP Analysis Program. The SWReGAP was the first formal GAP project designed at a regional, multi-state scale. The land cover and landform map was generated using regionally consistent geospatial data (79 Landsat ETM+ scenes from 1999 to 2004 with 237 seasonal images and DEM derivatives across Arizona, Colorado, Nevada, New Mexico and Utah), similar field data collection protocols, a standardized land cover legend, and a common modeling approach. Approximately 93,000 field samples (across all five states) were collected to train the land cover modeling effort. The classes within the SWReGAP landcover data layer were derived from a regionally consistent meso-scale legend developed by NatureServe as the Terrestrial Ecological Systems Classification framework for the conterminous United States (Comer et al. 2003). Ecological systems are defined as “groups of plant community types that tend to co-occur within landscapes with similar ecological processes, substrates and/or environmental gradients”. Although distinct from the US-NVC, the vegetation component of an ecological system is described by one or more NVC alliances or associations (though this relationship is not strictly hierarchical). While the ecological system concept emphasizes existing dominant vegetation types, it also incorporates physical components such as landform position, substrates, hydrology, and climate. The initial SWReGAP target legend developed by NatureServe and the mapping teams identified approximately 110 potentially mappable ecological systems from the 140 that occur in the five-state region. Omitted ecological systems were mostly small patch (below minimum mapping unit) or peripheral to the region and lacked adequate training sites. The Terrestrial Ecological Systems Classification focuses on natural and semi-natural ecological communities. For SWReGAP, altered and disturbed land cover and land use classes were considered separately. These classes were incorporated into the SWReGAP legend using descriptions adopted from either the National Land Cover Dataset (NLCD) 2001 legend (e.g. Agriculture, Developed-Medium-High Intensity) (Homer et al. 2004) or were given special “altered or disturbed” designation within the SWReGAP legend (e.g. recently burned, recently logged areas, invasive annual grassland, etc.).

The SWReGAP landform data layer was developed using topographic position and slope gradients as modeled in a GIS. The ten landform classes are: 1) Valley flats, 2) Gently sloping toe slopes, 3) Gently sloping ridges, fans and hills, 4) Nearly level terraces and plateaus, 5) Very moist steep slopes, 6) Moderately moist steep slopes, 7) Moderately dry steep slopes, 8) Very dry steep slopes, 9) Cool aspect scarps, cliffs and canyons, and 10) Hot aspect scarps, cliffs and canyons. The GIS model was created using ArcInfo AML and a 30 meter DEM (digital elevation model). DEM data was from the USGS National Elevation Dataset (1999). A validation of this model has not been performed.

The Colorado SWReGAP landcover and landform layers (rasters, 30m cell size) were downloaded on May 1, 2005 (http://earth.gis.usu.edu/swgap/landform.html). We then visually examined the patterns and types of landcover and landform types in the GRSA project boundary. There were 41 Ecological System and NLCD landcover types identified in the original landcover layer and all 10 landform types within the GRSA project boundary. Review of the landform layer indicated no major issues with the data in the GRSA project area. The general fit of the Ecological Systems types to aerial and satellite imagery as well as expert knowledge (GRSA park staff) of the landscape was generally good (better than any other available data at this scale). However, a few systemic and several localized problems were discovered.

The largest issue was a mistaken classification of several areas on the sand sheet and toe slope of the mountain front as Agriculture. We systematically reviewed all areas labeled as Agriculture and changed them to a more appropriate class based on the surrounding types and expert opinion. On the sand sheet this switch was usually to a denser mesic meadow type characterized by a heterogeneous mix of graminoid dominated vegetation with bare or sandy areas, and shallow open water. After reviewing the extent of this particular misclassification we decided to create a new provisional Ecological System type called Inter-Mountain Basins Mesic Meadow for sampling design. It is similar to the small patch Inter-Mountain Basins Alkaline Closed Depression (CES304.998) Ecological System but occurs as a large patch type at GRSA. It became the San Luis Valley Mesic Meadow mapping unit because of the unique local hydrologic processes and very large extent. In a few areas there was a complex mix of (usually old) row crop, pasture and other truly agricultural landcover intergrading with this new meadow type so we had to create new topology in some cases. We used as auxiliary data a National Wetlands Inventory map of the GRSA area to help guide where Agriculture should be reclassified to mesic meadow.

There were also some obviously incorrect areas that should have been an Agriculture type (such as center pivot irrigation circles) but that were not in the SWReGAP data. These were corrected using heads-up digitizing. Combined with the reclassification discussed above and this new line work, the area in Agriculture changed from 23,099 acres to 866. The total area in the new provisional Ecological System of Inter-Mountain Basins Mesic Meadow was 16,333 acres.

There were several areas classified as a forested type (such as Rocky Mountain Ponderosa Pine Woodland) that were clearly not correct (i.e., they were in a lake or in locations that would not support woody vegetation of this type, F. Bunch personal communication). These were corrected to more appropriate types using expert opinion, surrounding types and a variety of GIS blending tools (see Figure 10 for an example).

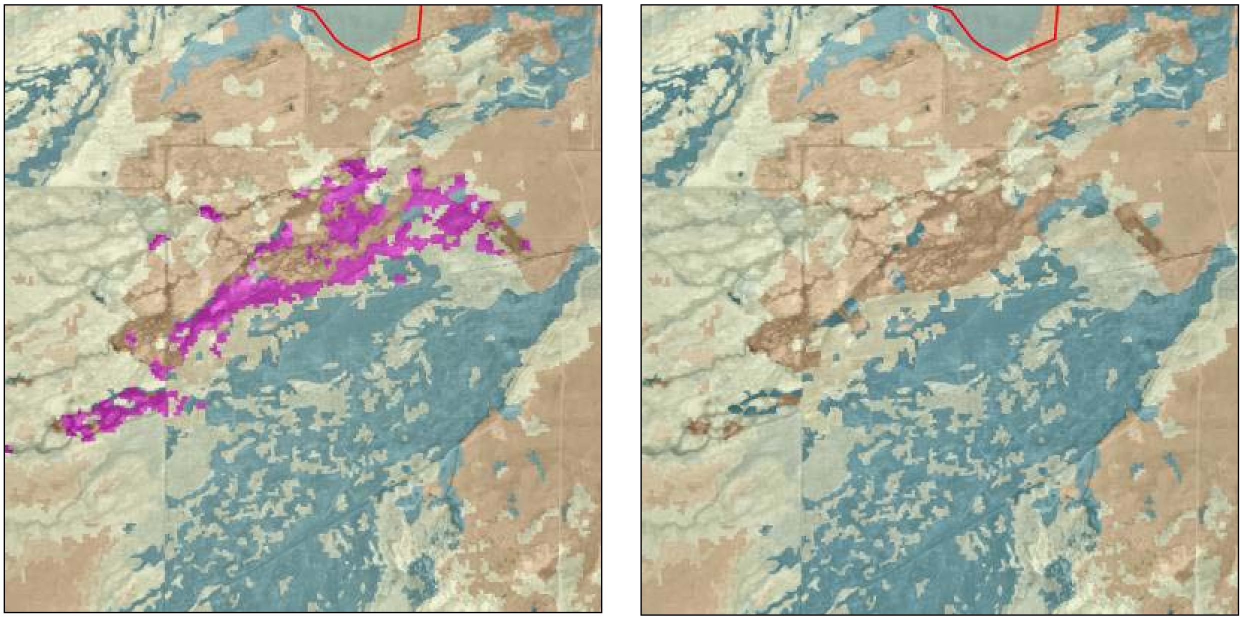

Figure 10. Example of editing applied to incorrect Rocky Mountain Ponderosa Pine Woodland types on the sand sheet of GRSA.

Note: The panel on the left shows the erroneous Ponderosa Pine Woodland as purple areas. The panel on the right shows how these were removed and blended into surrounding types.

Almost 500 acres of Rocky Mountain Gambel Oak-Mixed Montane Shrubland were found in the original data. This Ecological System does not occur in the project area, but only north of the project area on alluvial fan and mountain slopes near Villa Grove. These were corrected to more appropriate types using expert opinion, evaluation of the surrounding types and a variety of GIS blending tools.

Over 4,200 acres of an Inter-Mountain Basins Big Sagebrush Shrubland was found in the original data. This Ecological System does not occur in the project area, but is common north of the project area near Villa Grove and south of the project area on the west side of La Veta Pass. These were corrected to more appropriate types using expert opinion, surrounding types and a variety of GIS blending tools.

Finally, two large Recently Chained Pinyon-Juniper Areas were very incomplete in the original SWReGAP data. We cleaned up these polygons, adding 535 acres. The revised version is shown in Figure 11 a and b.

Note that all of these changes should be viewed as essentially hypotheses to be tested through the GRSA vegetation mapping project. However, we felt that the issues with the sample frame were potentially problematic enough to warrant these *a priori* corrections. All topology changes were done at a scale of 1:12k using heads-up digitizing in ArcMap 9.2. Background imagery used to guide changes in linework was 2001 black and white DOQs.

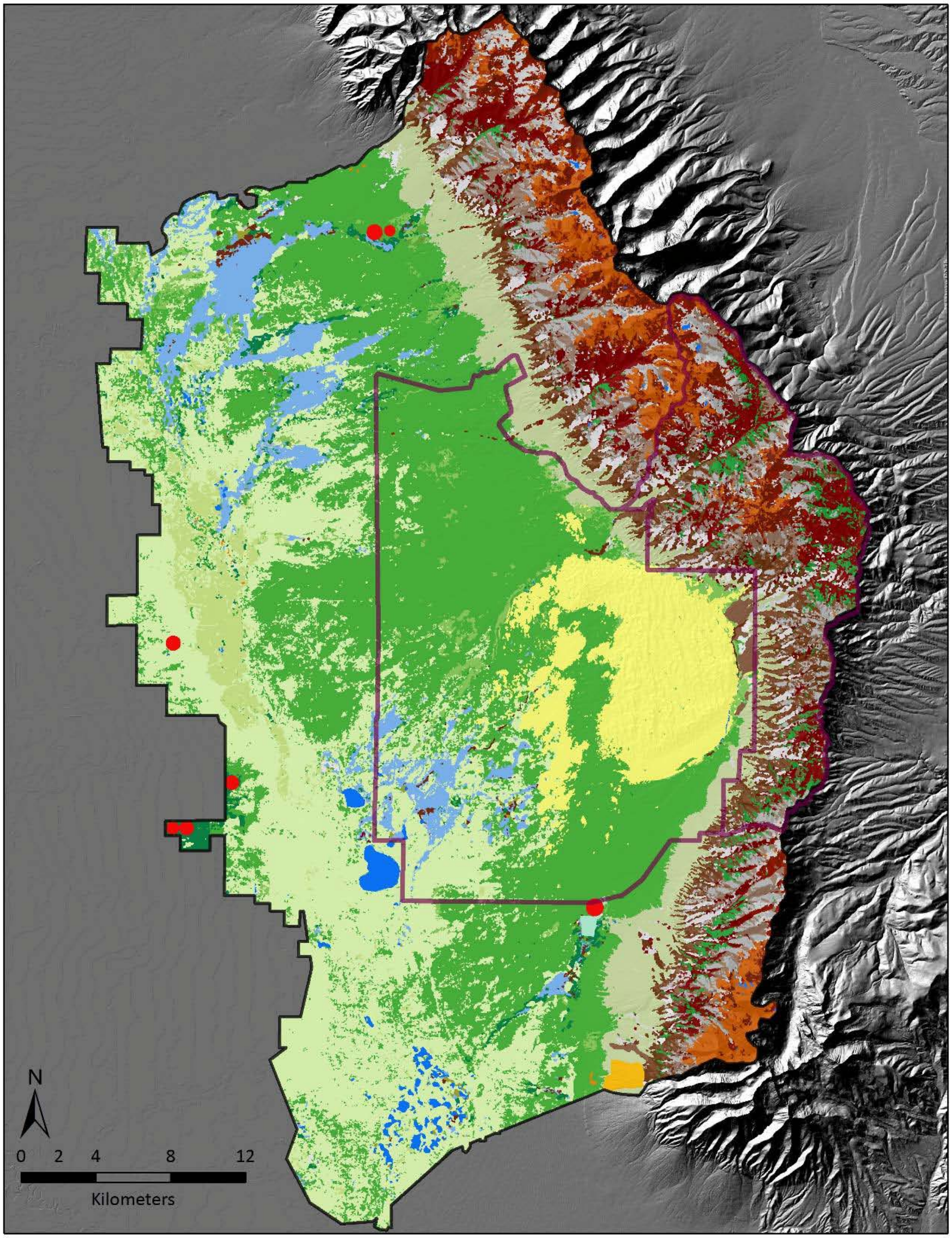

Figure 11a. Final Ecoloigical Systems as used in the classification sample frame

Note: Cost and landform classes are not shown.

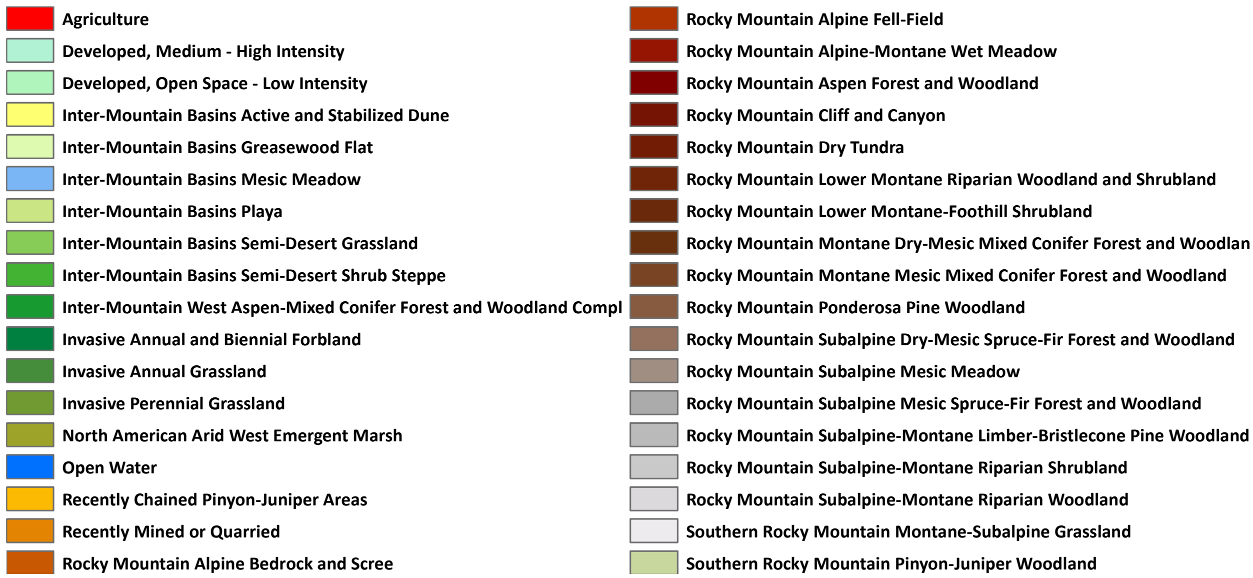

Figure 11b. Legend for final Ecological Systems map.

After processing the SWReGAP Ecological Systems data we elected to intersect (and therefore isolate) the SWReGAP landform with the most common Ecological Systems in the GRSA target area (which in total accounted for approximately 70% of the project area). This was done to further refine the sample frame. It essentially deconvolutes landform from Ecological System type, creating units explicitly characterized by habitat and a dominant landform (e.g., "Ponderosa Pine Woodland on gentle gradient dry slopes"). We did not do this to all Ecological System as we felt that for the less common types polygons were already small with a relatively homogeneous underlying landform.

The final layer (Ecological Systems and landform intersected) had 81 unique system-landform combinations, including seven that did not receive any classification plots. There were 39,194 polygons,with a mean size of 6.9 ha. Polygons ranged in size from 0.5 to 8,093 hectares.

Accessibility: Cost Surface

Sampling locations in the remote, wilderness settings of GRSA can be difficult to access. Steep, rugged terrain severely limits access to many canyon bottoms and high peaks. Expense, safety, and wilderness aesthetics issues may prohibit the use of helicopter transport and mountaineering practices, such as rock climbing, to reach isolated sites. Additionally, most of GRSA is backcountry with limited trail access. Sampling front- and backcountry equally can be cost-prohibitive. However, GRTS designs can deal with the costs of accessing remote sites by adjusting the probability of selecting sites in high-cost areas to be low (or even zero), limiting the number of sites in these kinds of areas. Restraint must be exercised, however, because greatly reducing the chances of selecting high-cost areas will inflate the variance of estimates and potentially eliminate from the classification unique vegetation types.

To incorporate cost into the design we generated a cost surface. The model used (NPS ROMN 2008) generates a raster of the estimated time required to access any point in the park based on a network (roads) of no cost locations. The central algorithm of this model predicts traveling speed from the slope of the terrain being crossed (Tobler 1993, Imhof 1950), modified by a series of auxiliary variables including landcover type (we used the SWReGAP Ecological Systems layer, modified as above, with coefficients for permeability derived from consultation with GRSA park staff). Impassable barriers (no access at all) such as streams (over a certain size), lakes and a slope threshold of 35 degrees were also included in the model. The final cost values were classified into five access classes using a natural breaks algorithm. We then intersected these cost zones with the polygons of the sample frame and used these polygons as the actual input to the sample design algorithm which, when coupled with the sample size allocation (see below) allowed cost to directly factor into site selection.

Strata and Subpopulations

Ownership boundaries (Figure 2) were used to create two explicit strata: NPS and Other (including other public, TNC and private; Figure 12). Over 60% of the project area was non-NPS ownership. The 74 Ecological System-landform types were used to create subpopulations used to allocate samples across the landscape.

Sample size

The total sample size of 600 plots was based on the project resources available for a full field season. These samples were differentially allocated across strata: 75% (450) in the NPS strata and 25% (150) for the Other strata (this reflects the reality of the NPS funding for the project). The number of sites for each of the 74 Ecological-system landform types was based on the vegetation community types expected in each Ecological System and the confidence in their classification. All Ecological System have an identified set of Associations (community types) that are expected to occur within them (Comer et al. 2003). GRSA Associations form subsets of these component Associations because of the restricted range of the project boundary. These Associations have a set of rarity codes (G1 for a globally rare community type, through G5 for a common type) and confidence values in the classification of the community (ranging from 1 to 3, with 1 equal to high confidence). Samples were allocated based on the number of G1-G3 Associations within each Ecological System, with a sample size of 4 plots given for each G1, G2 or G3 Association in a type. If the confidence for an Association was low (3), 4 plots were also allocated to the Ecological System as a whole. After all Ecological Systems had been evaluated in this process, approximately 120 plots (out of the target size of 600) remained. These plots were added to the Ecological Systems based on the professional judgment of the project ecologists and special management needs of the Park. Additional subdivisions of sample allocation for Ecological System with a landform delineation were based on the approximate relative areal distribution within the Ecological System by landform type. Details of the implementation of the classification phase sample design are provided in Appendix E.

Opportunistic Sampling

Any sampling done outside of the GRTS design site was designated as Opportunistic. Because of the coarseness of the sample frame and the objective of sampling the full diversity of plant communities in order to classify the vegetation at GRSA, Opportunistic sites were more common than design sites. The rules for locating an Opportunistic site are detailed in the Field Manual in Appendix F.

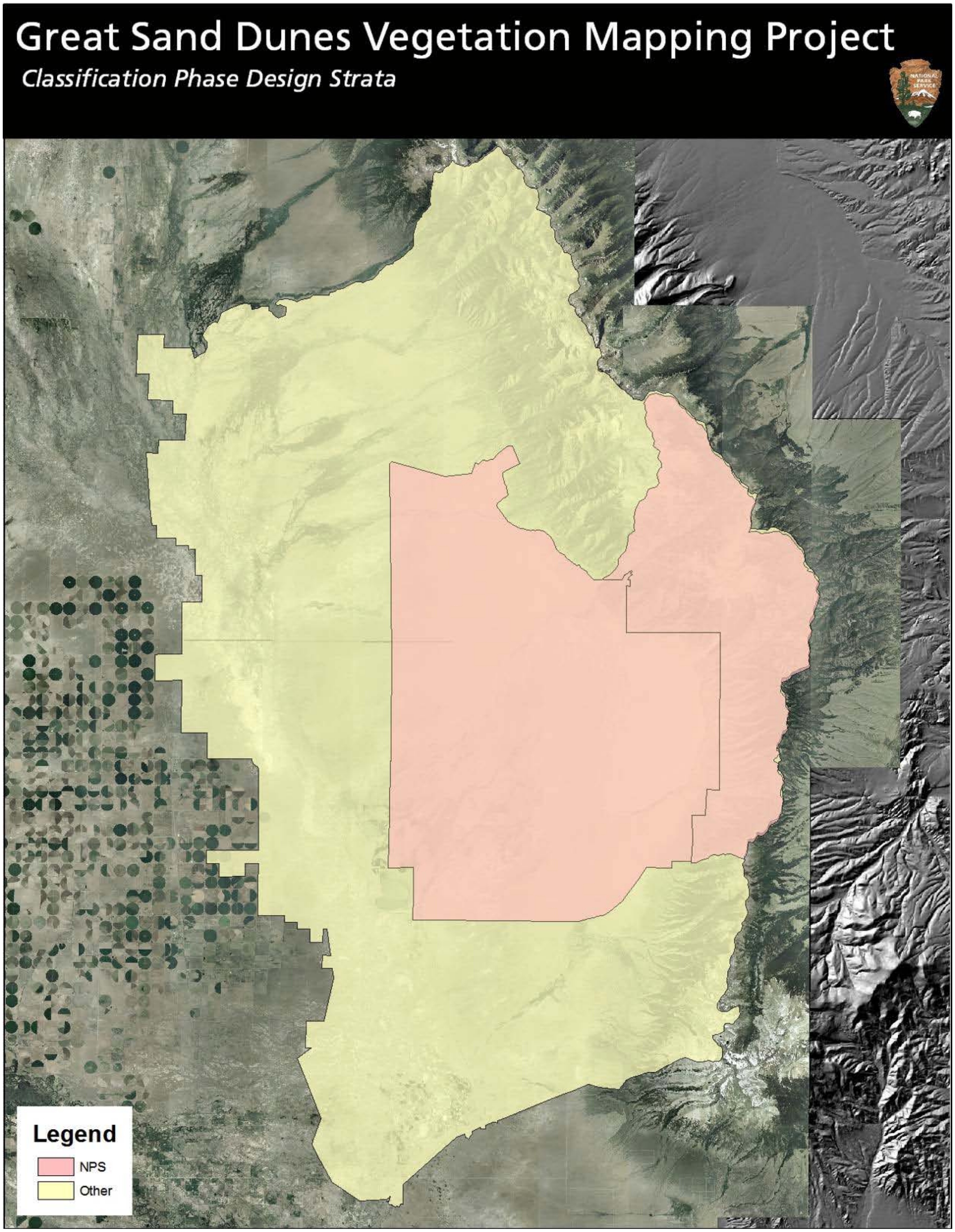

Figure 12. Classification phase strata from NPS and non NPS ownership.

Field Survey Methods

Data Collection: Vegetation Data

Four crews of two people each were hired to collect data in GRSA during the 2005 and 2006 summer field seasons. The crews were trained in the vegetation and fuels sampling methodology and provided with maps identifying possible plot collection sites. Crews were also given a list of the 219 potential vegetation types in the preliminary classification and the objective to collect a minimum of three plots in each type. Since the GRSA project area is large, diverse, and inaccessible by vehicle in many places, crews were hired both for their botanical and ecological skills, and for their ability to work effectively in remote and variable outdoor conditions, and to potentially do so from backcountry camping sites. Crews were provided with training in project methods, housing, vehicles, and all non-personal field equipment.

Field crews were provided with a field manual describing the field form and the plot sampling methodology, as well as supplemental information on backcountry safety, plant species lists, and accepted plant species codes. A copy of the field manual and examples of the field forms are provided in Appendix F. The field forms include several sections to document the plot location, the environmental attributes, the vegetation attributes, and to make comments. **Table 4** lists the specific attributes included in each section on the vegetation plot form.

Table 4. Specific attributes collected on the vegetation plot form

Section	Attributes
Location Information	Plot code, plot type, survey date, surveyors, provisional map class name, provisional association name, UTM zone and coordinates, GPS accuracy, comments, plot dimensions, Camera #, Photo #'s, representativeness of the vegetation to the provisional association, and representativeness of the plot within the stand
Environmental Attributes	Elevation, slope, aspect, topographic position, landform, surficial geology, Cowardin class, hydrology, soil texture, soil drainage, % ground cover, and environmental comments
Vegetation Attributes	Leaf phenology, leaf type, physiognomic class, height class, cover class, and dominant species by strata, vegetation comments, species list for all species in the plot indicating stratum and cover class, and any additional species from outside the plot

Note: Observation points omit the complete species list, but include all other attributes

Based on the results of the initial vegetation analysis and sampling design, proposed plot locations were evaluated for distance from access points and difficulty of travel. Plot locations in areas determined to likely be more than three or four hours from an access point were considered as backcountry, while those less than that were considered as front country. All front country sites were accessed via day hikes from the nearest road access point. Backcountry sites were accessed via foot trail on multi-night backpacking trips. Crews typically stayed in a single campsite for 1 to 3 nights, and remained in the backcountry for 3 to 7 nights. Note that these implementation plans do not change the cost attributes of the sites selected by the GRTS design;, rather, they only change how site visits are apportioned to available field effort and planning.

The following provides a general overview of the data collection process. Before leaving for the field each day, and prior to each multi-day trip, the field supervisor planned a strategy for collecting plots most efficiently. Consideration was given to proximity of selected sites to roads, trails, and to other sites, as well as topography and vegetation in the area to be surveyed, and would plan routes to collect the most plots without excessive travel time. All field equipment and personal gear needed for the duration of the planned trip was then gathered by crew members.

GPS units as well as maps and compasses were used to navigate to the selected area. Upon arrival at the selected site, the crew evaluated the area to identify a specific location to place the plot (see Appendix F for additional details about plot types used), by walking through the previously identified polygon to get a sense for the structure and composition of the vegetation. If the polygon contained a vegetation type or types for which sufficient data was lacking, a relatively homogenous and representative area was chosen in which to place a plot. If the polygon was diverse, two or more locations might be selected in order to capture that variation. If the polygon contained only types that had already been sufficiently well documented, a crew could choose to collect an Observation Point or to navigate to a different site from the design instead. An observation point is a short version of a vegetation plot which uses a dimensionless plot to document the structure, dominant species, and environmental attributes in the area. It can be collected using the same forms and instructions as for full vegetation plots, but in a fraction of the time.

During passage between polygons, crew members assessed the vegetation types encountered. If under-documented vegetation types or possible new vegetation types were found that might help complete the classification of GRSA, a vegetation plot or an observation point was opportunistically collected. Locations and characteristics of weeds or rare plants observed in the course of accessing plot locations were recorded as well.

At each sampling location, plot data were collected using the protocols of the NPS National Vegetation Mapping Program. At the plot center, a permanent plot marker was buried (a small copper tag inscribed with the project acronym, plot code, and date, attached to a galvanized nail). A Garmin GPSMap 76cx was used to record the UTM location of the marker and the approximate accuracy of the location was noted. A plot was laid out using measuring tapes, according to the size specified in the field manual for that vegetation type (most plots were 400 m^2 rhomboidal or circular). Vegetation analysis was completed by dividing the vegetation visually into strata, or height classes, and recording the percent cover by dominant species. If the site was a vegetation plot and not an observation point, a comprehensive species list for the plot was developed by recording the species name and percent cover for each plant found within the plot. Numerous other data describing the environmental characteristics of the site were collected at each plot including elevation, slope, aspect, soil texture, surficial geology, percent ground cover, and hydrology. Before leaving the plot, crews attempted to assign the vegetation to one of the preliminary vegetation types. If the plot did not fit into a vegetation type, a type was assigned based on the dominant species in the top two strata. Four pictures were taken from the plot center on the cardinal directions at each plot. In 2005 the cameras used were Nikon CoolPix 5400, In 2006 and 2008 some of the Nikons failed and were replaced with the Pentax Optio W60 camera. When the plot had been completed, crews would navigate to the next selected area and begin the process again.

Data Collection: Forest Fuels Data
Throughout both the 2005 and 2006 field seasons, forest fuels data were collected at each plot location visited. These data were collected mostly for the use of GRSA fire personnel; however, forest stand structure (tree size and density by species) is valuable data for characterizing

vegetation types. Fuels data collected included information on both live and dead/down fuels. Live fuels data included the species, DBH, DAB, height, crown ratio, and tree structure stage, as well as the cover of shrubs and herbaceous species. In particularly dense stands, crews were permitted to sub-sample a quarter of the full plot. For the dead/down fuels, crews recorded depth of litter and duff, shrub cover, herbaceous cover, cover of bare soil, and the cover of wood, litter, and duff (see field forms in Appendix F).

Data Collection: Accuracy Assessment Data

Accuracy assessment (AA) data were collected during the 2008 field season from late June to early October. Over the course of the summer, three two-person crews navigated to the randomly selected sample locations and documented the existing vegetation. Upon arriving at a sample location crews used the key to map classes and key to vegetation associations to classify the vegetation. The frame of reference for the sample location was a dimensionless plot surrounding the sample point equal in size to the 0.5 ha minimum mapping unit and contained within the polygon of interest. AA sample point data were collected using the same equipment as was used to collect vegetation plot data.

Plot Data Management and Classification Analysis

Prior to data entry, all plot forms were checked to ensure quality control (QC). Particular attention was paid to making sure that the recorded plot location was correct and that all relevant fields were filled in. Where information was missing, an effort was made to find and record that information, often from the associated fuels form, or from other data sheets produced by the same crew on that or an adjacent day. Changes to field form entries were made in red pen and marked with a date and the reviewer’s initials. All plot forms were then photocopied and the duplicate was removed and stored off-site.

Following the QC of the datasheets, the data were entered into the PLOTS 2.0 database; all digital data were subjected to a second QC to eliminate any data entry errors. During this second QC, the database was examined, sorted, and queried to find missing data, misspellings, duplicate entries, and typos. The species lists were carefully examined to make sure that only USDA-NRCS PLANTS Database names and acronyms were used, and that species names and assignments to strata were consistent and logical. Plant lists were compared to the assigned association name to assure correlation.

In the PLOTS database, the “plot type” field designates if the record is for a vegetation plot (plot type=1) or an observation point (plot type=2). Each plot or point was labeled with the preliminary classification name the crews assigned in the field at the time the data was collected.

Management of plot photos was facilitated using the GPS Photo-Link software from Geo-Spatial Experts, Inc. Using that program, GPS coordinates of the photo location were embedded in the EXIF data for each photo, and a banner was attached to the bottom edge of the photo with information regarding the project name, plot number, UTM coordinates, date, and time for the plot. The software also produced a thumbnail of the plot photo and an ESRI shape file of the plot locations.

Vegetation Classification

A classification analysis was completed to quantitatively assign plots to the association level within the context of the US NVC. Vegetation data from the full vegetation plots were used in the quantitative analysis, while observation point data were subjectively assigned to NVC associations by NatureServe and CNHP ecologists.

Species and cover data for all vegetation plots were exported from the PLOTS database in list format and the mid-points of the cover class ranges estimated in the field were used as discrete cover values for the analysis. All species records were retained and used in the analysis. The cover values for species which occurred in more than one stratum of an individual plot were combined to provide a single cover value per species per plot. The data set was then exported to PC-ORD version 5.04, a multivariate statistics software package by MJM Software (McCune and Mefford 2006).

Based on the range of ecological zones and the diversity of communities sampled, cluster analysis and indicator species analysis were used to divide the entire data set into nine subgroups for further analysis. The divisions roughly stratified the data set by elevation and the dominant species found in the plot. One subgroup contained outlier plots which generally had one or two strongly dominant species and which did not relate to other plots (e.g. cattail marsh with 80% *Typha latifolia*). The separate analysis of the subgroups helped to prevent ecologically unrelated community types from being compared. For example, subdividing the dataset prevented sparsely vegetated playas on the valley floor from being analyzed in the same group as sparse alpine scree slopes.

Hierarchical agglomerative cluster analysis was used to explore each of the subgroups. This analysis used a flexible beta linkage method and a Sorenson distance measure (McCune and Grace 2002). Beta values of the recommended -0.25 and an experimental -0.5 were compared for clarity of grouping, and in most cases beta = -0.5 provided the structure with the least amount of chaining. Indicator Species Analysis was used to guide the decision of where to prune the dendrogram. The number of groups was based on the level with the most significant species ($p^*<0.05$) and the lowest average p^* value (Dufrêne and Legendre 1997). Where necessary to reach the association level, further division of the subgroups was based on comparison queries in MS Access and MS Excel, and reviewing species composition, environmental data, and plot notes. In this way, remaining plots were assigned to existing NVC associations or were given provisional names. Classification of observation point data to NVC types was based on this approach. Provisional associations, or "Park Specials", were created to represent new associations for which we had sufficient data. Statistical methods were employed as much as possible to identify groupings, but some of the final designations were based on a review of existing community concepts and knowledge of the local ecology.

Image Processing & Analysis

The imagery used for the mapping included a variety of sources, resolutions and spectral bands. The following summarizes those image types:

- Scanned and mosaiced 2006 1:12,000-scale infrared aerial imagery for the areas west of the Sangre de Cristo Mountain range
- 2006 NAIP imagery for the entire project area

- 2006 and 2007 Quickbird imagery for the western portion and the western mountainous portion respectively of the project area

The image processing was conducted separately for the Baca National Wildlife Refuge and the remainder of the mapping area. The Baca National Wildlife Refuge used the 2006 1:12,000 scale infrared imagery and was processed using Erdas Imagine 8.7 software (see Appendix A for more details). The remainder of the project area used a combination of NAIP and Quickbird imagery (see Appendix G for more details).

Image Processing – Baca NWR

The imagery was collected using a Digital Sensor System (DSS) mounted in a Cessna 182 aircraft. The Applanix DSS is a direct geo-referencing system based on a medium-format, airborne digital camera. The collection effort was followed by color-balancing, orthorectification, and mosaicing into one image file. The final image was subsequently segmented to generate polygons. Much of the polygon labeling was done using traditional photointerpretation rather than machine logic.

Image Processing – Remaining Areas:

Imagery collected was a primary step in the interpretation sequence and the results were primarily used for the creation of digital lines to be attributed later, and to extract tree density values. We used three different image datasets to create these data themes. These include the NAIP and Quickbird imagery described above. Image processing began initially using both Erdas Imagine and Definiens eCognition. Image processing efforts with eCogntion were abandoned early on due to time and familiarity considerations.

Map Classes

The mapping legend was created and refined iteratively throughout much of the project using expertise from ecologists and vegetation mappers. The map classes are derived from the National Vegetation Classification (NVC). Limitations of the imagery and vegetation mapping methods preclude delineation of most associations, with the majority of the map classes occurring at the alliance level or groups of alliances in the case of diverse riparian and alpine type map classes. The objective for the broader map classes was that they be ecologically based groups related to vegetation associations that co-occurred on the landscape.

Development of map classes was based on current knowledge of the park vegetation and past experience as to what types could be successfully mapped. Creation of preliminary map classes began the spring of 2005 before field sampling with a refined list of 30 Ecological Systems and 6 land use/cover types for the park and their component alliances (103) and associations (219) that potentially occurred within the park creating a hierarchical framework. Incorporating preliminary map units in sampling design help insure adequate sampling of all map classes.

After the 2005 field season, the hierarchical map class framework was refined with additional Ecological Systems, subsystems (modified by physiognomy), and component associations. This helped clarify relationships between map classes and associations. At this time map class descriptions were developed to document and communicate concepts between ecologists and vegetation mappers, and to field crew members who were recording draft map classes on field forms.

During the winter of 2006 and 2007, the mapping legend was further refined by deleting Blue Spruce Alliance map class and changing the map class names to represent a specific NVC association, alliance or group of alliances that defined each mapping unit. During the summer of 2008, field crews conducted an accuracy assessment of the vegetation map. Based on the results of the assessment, minor changes (collapsing of similar map classes) were made to improve accuracy. Table 5 presents the final list of map classes with a summary of component associations. A map class key is included in Appendix H. A cross-walk of GRSA map classes to the new NVC, version 2 Group Level is provided in Appendix B.

Finally, slope (degrees), aspect and elevation were calculated for each polygon using zonal statistics and the DEM, and derived slope and aspect rasters. Acres and hectares were calculated using XTools Pro for ArcGis Desktop (www.xtoolspro.com).

Table 5. Final map unit descriptions for GRSA.

MC#	MAP CLASS	SUMMARY DESCRIPTION
2	Aspen Forest Alliances	Aspen (*Populus tremuloides*) dominated forests and woodlands with 75% relative cover or more of tree canopy composed of deciduous species. Conifers contribute less than 25% relative cover in the tree canopy. If *Populus angustifolia* (narrowleaf cottonwood) trees are present, then *Populus tremuloides* is strongly dominant. Elevation ranges from 2,507-3,555 m on a variety of substrates, but sites tend to be relatively mesic. This map unit includes both riparian and upland aspen stands as it was not practical to separate them. It does not include aspen-dominated avalanche chutes, but *Populus tremuloides* Forest stands may occur on the sand ramp.
3	Aspen - Limber Pine Forest Alliance	Mixed aspen-conifer forest or woodland found in the montane - subalpine zone. Aspen (*Populus tremuloides*) and conifers codominate with neither having more than 75% relative cover in the tree canopy. Limber pine (*Pinus flexilis*) is the dominant conifer. Other trees may include scattered bristlecone pine (*Pinus aristata*), ponderosa pine (*P. ponderosa*), and Douglas-fir (*Pseudotsuga menziesii*), but neither codominates. White fir (*Abies concolor*) is absent. Aspen and mixed aspen conifer types may be associated with disturbance such as fire.
5	Barren Sand Dune	Barren or near barren portions of active sand dunes and sandsheet blowouts (<5% total plant cover) which is below PI detection level. May include scattered individuals of early seral species such as blowout grass (*Redfieldia flexuosa*) and lemon scurf-pea (*Psoralidium lanceolatum*), and sometimes Indian ricegrass (*Achnatherum hymenoides*). Separating signature from Herbaceous Stabilized Dune will be challenging as it does not take much herbaceous vegetation cover (5-10%) to stabilize sand. Describe in notes if there is evidence of site being recently buried by sand (deposition) or blown out (sand removal such as buried shrubs), especially if near edge of dune field. Imagery that map is based on is several years old and dunes move and barren sand revegetates after wet periods.
7	Cattail Herbaceous Alliances	Herbaceous wetlands dominated typically by dense cattails (either *Typha latifolia* or *Typha domingensis*). May occur as smaller patches within larger emergent wetlands.
8	Chained Pinyon-Juniper Areas	Pinyon-juniper woodlands that were largely chained in 1970s to reduce tree cover and promote herbaceous growth (forage for wildlife and livestock). Vegetation often has scattered shrubby pinyon (*Pinus edulis*) trees with shrubs and grasses. Areas are restricted to Pinyon - Juniper Zone in extreme southeastern portion of project area outside park. Unnatural boundary lines are visible on imagery and should make this range improvement practice evident. Vegetation may have come back as seral pinyon – juniper woodland or savanna, shrublands, steppe or grassland communities. This map class may be confused with ongoing roto-chopping of pinyon - juniper woodlands (using a hydroaxe) by the BLM and CDOW, which is a selective tree thinning treatment. These sites have large amounts of wood chips on soil surface and are generally not found in drainages (upland trees only). They would be classified as a different Pinyon-Juniper map class depending on understory.

Table 5. Final map unit descriptions for GRSA.

MC#	MAP CLASS	SUMMARY DESCRIPTION
9	Coyote Willow Temporarily Flooded Shrubland Alliances	Riparian shrubland dominated or codominated by coyote willow (*Salix exigua*). Other willows such as strapleaf willow (*Salix ligulifolia*) or shining willow (*Salix lucida* ssp. *caudata*) may codominate. Gray alder (*Alnus incana*) and water birch (*Betula occidentalis*) may be present, but are not dominant. Scattered trees (<10% cover) may be present especially narrowleaf cottonwood (*Populus angustifolia*). Understory is variable and ranges from barren to abundant forbs and graminoids species such as *Carex utriculata, Eleocharis acicularis, Juncus balticus,* and *Muhlenbergia asperfolia*.
11	White Fir - Douglas-fir Forest and Woodland Alliances	Upland and lowland montane mixed conifer forest or woodland typically codominated by Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*). However, either species may be absent or dominant in tree canopy and understory. White fir is more common on relatively mesic mid to low slopes whereas Douglas-fir tends to dominate relatively drier/cooler higher elevation sites. Stands dominated by blue spruce (*Picea pungens*) are included in this map class, but are uncommon and restricted to riparian zones. Other tree species may be present to codominant, but not dominant in the tree canopy such as bristlecone pine (*Pinus aristata*), pinyon (*P. edulis*), limber pine (*P. flexilis*), ponderosa pine (*P. ponderosa*), aspen (*Populus tremuloides*), Rocky Mountain juniper (*Juniperus scopulorum*), and at higher elevations, Engelmann spruce (*Picea engelmannii*). Understory is variable. Aspen – Douglas-fir (White fir) Upland Forest Alliances and White Fir - Mixed Deciduous Lowland Forest Alliances map classes are similar but are codominated by deciduous species in the tree canopy.
12	Fourwing Saltbush Shrubland Alliance	Shrublands with an open to moderately dense canopy dominated by four-wing saltbush (*Atriplex canescens*). Rabbitbrush (*Ericameria* and *Chrysothamnus* spp.) may be present to codominant. Greasewood (*Sarcobatus vermiculatus*) is not codominant, but scattered greasewood may be present. This map class is found along drainages on the alluvial fan and is relatively uncommon at the park.
13	Greasewood Sand Deposit Shrubland and Steppe Alliances	Open to moderately dense greasewood (*Sarcobatus vermiculatus*) dominated shrubland or steppe on dunes and sandsheet. Scattered rabbitbrush (*Ericameria nauseosa* or *Chrysothamnus greenei*) are often be present and may codominant. The typically sparse herbaceous layer has *Achnatherum hymenoides, Chenopodium* spp. and *Kochia americana* present. This association typically occurs in areas with deep sand and a relatively shallow water table. Substrate is typically alkaline. Surface sand is loose and not cemented with carbonates (sabkha). This includes transition areas with greasewood flat shrublands, where occasional deflation areas expose the hard sabkha (carbonate-cemented sand) or clay layer, but shallow sand lens (shallow coppice dunes/sand sheet) cover more than half the ground surface. Indian ricegrass (*Achnatherum hymenoides*) appears to be a good indicator of this greasewood stabilized sandsheet type.
14	Alluvial Flat Herbaceous Alliances	These grasslands form relatively distinct, small patches within greasewood flat shrubland. Stands are typically dominated by saltgrass (*Distichlis spicata*) or alkali sacaton *(Sporobolus airoides*). Larger patches may transition into the more mesic and sometimes similar San Luis Valley Mesic Meadow (lush saltgrass meadows with mesic species not typical of drier alluvial flat type). Substrates are saline, alkaline, fine textured (clayey or silty soils or more commonly sabkha (carbonate-cemented sand). Although these grasslands are generally dry, they may flood seasonally or intermittently and be adjacent to and include small patches (below MMU) emergent marsh (where water table is near surface most of the year).
15	Greasewood Flat Shrubland and Steppe Alliances	Open to moderately dense greasewood (*Sarcobatus vermiculatus*) dominated shrublands or steppe on alluvial flats on the valley floor. Substrates are fine textured (clayey or silty), or more commonly sabkha (carbonate-cemented sand). Scattered rubber rabbitbrush (*Ericameria nauseosa*) is often present and may be dominant locally with or without greasewood. Seepweed (*Suaeda* spp.) may be present and also dominate locally. The sparse to moderate herbaceous layer often has *Chenopodium* spp., *Distichlis spicata*, *Juncus balticus, Leymus triticoides, Muhlenbergia asperfolia, Pascopyrum smithii,* and *Spartina gracilis*. This association typically occurs in areas with a relatively shallow water table and may be seasonally flooded. Substrate is saline and alkaline. This includes transition areas with greasewood sand deposit shrubland, where occasional shallow sand lens (shallow coppice dunes/sand sheet) occur on alluvial flat (sabkha) as long as they cover

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MC#	MAP CLASS	SUMMARY DESCRIPTION
		less than half the ground surface.
17	Herbaceous Stabilized Dune and Sandsheet Alliances	Vegetated dunes and sandsheets characterized by herbaceous layer typically dominated by scurfpea (*Psoralidium lanceolatum*) and/or blowout grass (*Redfieldia flexuosa*) [early seral stage] and Indian ricegrass (*Achnatherum hymenoides*), needle-and-thread (*Hesperostipa comata*) or sand muhley (*Muhlenbergia pungens*) [late seral]. This type often occurs as patches (vegetated blowouts) within a shrubland or steppe. Total vegetation ranges from sparse to moderate (5-45%). This occurs in areas with deeper, loose sand that is not cemented by carbonates (sabkha). In transition zones occasional deflation areas may expose the hard sabkha layer, but shallow sand lens (shallow coppice dunes/sand sheet) cover more than half the ground surface
18	Montane-Foothill Dry-Mesic Shrubland Alliances	These shrublands are found on montane, colluvial slopes and extend down on to the alluvial fan. Sites are between 2643 m and 3143 m elevation and often occur on exposed, rocky substrates. On drier sites found on warm south and west aspects, stands have an open shrub canopy dominated or codominated by hillside oceanspray (*Holodiscus dumosus*), green rabbitbrush (*Chrysothamnus viscidiflorus*), Parry's rabbitbrush (*Ericameria parryi*) or skunkbush sumac (*Rhus trilobata*). Shrubs are denser on relatively mesic lower slopes. On more mesic sites, hillside oceanspray (*Holodiscus dumosa*), chokecherry (*Prunus virginiana*), golden currant (*Ribes aureum*), trumpet gooseberry (*R. leptanthum*), Woods' rose (*Rosa woodsii*), and mountain snowberry (*Symphoricarpos oreophilus*) are common and may dominate. Mountain mahogany (*Cercocarpus montanus*) may be present, but does not dominate. The sparse to dense herbaceous layer is dominated by perennial graminoids such as blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), sand dropseed (*Sporobolus cryptandrus*) at lower elevations and mountain mahogany (*Muhlenbergia montana*) and Arizona fescue (*Festuca arizonica*) at higher elevations. Scattered trees limber pine (*Pinus flexilis*) and Douglas-fir (*Pseudotsuga menziesii*) and inclusions of grassland patches may be present.
20	Interdunal Swale Wetland Alliances	Wetland vegetation that occurs in distinctive interdunal swales (deflation areas between active dunes). These groundwater-fed wetlands have shallow water tables and are not visibly connected to other surface water (at least 200 meters away from intermittent or perennial stream channels). Sites often hold open water during part of the year. Vegetation often occurs in zonal rings reflecting the soil moisture gradient from wet in the center to mesic grasslands in outer rings. Dominant species include mesic and wetland obligate graminoids such as *Calamagrostis stricta, Carex pellita, Carex utriculata, Distichlis spicata, Juncus balticus, Muhlenbergia asperifolia, Pascopyrum smithii, Schoenoplectus acutus, Schoenoplectus americanus, Schoenoplectus nevadensis*, and/or *Schoenoplectus pungens*. Occasionally stands of coyote willow (*Salix exigua*) may form in these wetlands and persist during sand burial as sand dunes encroach making them less distinctive.
21	San Luis Valley Mesic Meadow Alliances	Relatively lush grasslands occurring on the valley floor that may seasonally flood. Substrates include sandsheet, sabkha, and alluvial flats. Many stands are associated with springs and are naturally subirrigated. Many of these naturally subirragated sites have been expanded by historic and ongoing irrigation, although vegetation is largely dominated by native species forming a moderately dense to dense herbaceous layer. Mesic graminoids typically dominate the herbaceous layer. Lush saltgrass (*Distichlis spicata*) may dominate sites with mesic indicator species especially on drier portions of the meadow or often the mesic indicator species codominate or dominate the vegetation. Graminoids include *Carex pellita, C.praegracilis, Hordeum jubatum, Juncus balticus, Leymus triticoides, Muhlenbergia asperifolia, M. wrightii, Pascopyrum smithii, Poa fendleriana, Puccinellia nuttalliana, Sporobolus airoides,* and forbs *Argentina anserina, Cleome multicaulis, Iris missouriensis, and Potentilla hippiana*. Scattered rabbitbrush or other shrubs may be present. Wetland species such as *Carex nebrascensis, Eleocharis palustris, Schoenoplectus americanus, S. nevadensis*, and/or *S. pungens* may be present, but only dominate as emergent wetland inclusions occurring below MMU. The more mesic stands are very similar to Emergent Marsh map class and separation in these cases is more a matter of scale with respect to MMU. Some of the mesic meadow is being used as pasture by bison, elk and, to a lesser extent, cattle.

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MC#	MAP CLASS	SUMMARY DESCRIPTION
22	Playa Alliances	Herbaceous vegetation, typically saltgrass (*Distichlis spicata*) occurring within a distinct playa. May include rings of mesic and sometimes wetland species in lowest elevation portion. These sites are seasonally or intermittently flooded with white or gray salt crust depositing in the center (lowest elevation portion) when dry. If site is not associated with a distinct playa, then map as herbaceous inclusion within greasewood flat, alluvial flat herbaceous or SLV mesic meadow map units. This map unit includes the barren portions within distinct playas.
23	Wash	Stream channels and washes that are not characterized by riparian trees or shrubs, but rather upland vegetation such as scattered rabbitbrush (Ericameria nauseosa). May occur on alluvial fan or sandsheet, but typically occurs below MMU, except for the broad channels of Medano and Sand creeks on the sandsheet.
24	Montane-Lower Subalpine Wetland Alliances	These middle elevation herbaceous communities are dominated by obligate and facultative wetland herbaceous species that are found on wetter sites with very low-velocity surface and subsurface flows. Stands range from lower montane into lower subalpine (2,600-3,300 m elevation) zones. Sites are typically found on flat to gently sloping basins, but may also occur with slopes up to 15% (below seeps). This type occurs as a large beaked sedge (*Carex utriculata*) dominated wet meadow at Willow Creek Park and possibly elsewhere. Smaller stands are more common as narrow strips bordering ponds, lakes, and streams, and on toeslopes below seeps where it is generally below MMU in size. Soils of this system may be mineral or organic with a shallow water table. This map class may occur as a mosaic of several plant associations, often dominated by graminoids, including *Calamagrostis canadensis, Caltha leptosepala, Cardamine cordifolia, Carex utriculata, C. vernacula, Deschampsia caespitosa, Eleocharis quinqueflora*, and *Senecio triangularis*. Shrubby cinquefoil (*Dasiphora floribunda*) shrubs and scattered willows may be present in some stands. Similar to Alpine – Upper Subalpine Herbaceous Wetland Alliances, but lacks presence of alpine species.
25	Mountain Mahogany Shrubland Alliance	Foothill shrublands that extend up to montane on south and west aspects. Stands occur on rocky colluvial slopes and ridges. Substrates are rocky and often include bedrock outcrops. Vegetation is characterized by an open to moderately dense short shrub layer dominated by mountain mahogany (*Cercocarpus montanus*). Scattered pinyon (*Pinus edulis*) and limber pine (*Pinus flexilis*) trees may be present. Other common shrubs and dwarf shrub include *Artemisia frigida, Holodiscus dumosa, Ribes cereum, Rosa woodsii*, and *Symphoricarpos oreophila*. The sparse to moderately dense herbaceous layer is often dominated by *Muhlenbergia montana*. Other common species include *Carex rossii, Heliomeris multiflora,* and *Heterotheca villosa*. Sometimes this shrubland intergrades with *Muhlenbergia montana* grasslands.
26	Narrowleaf Cottonwood Sand Dune Woodland Association	This plant association consists of stands of narrowleaf cottonwood (*Populus angustifolia*) on sandsheet and dunes. Associated with Sand Creek and other streams out on the sandsheet. Sandsheet stream channels are not very stable and move away from cottonwood stands as sand deposits in trees forming coppice dunes. The narrowleaf cottonwood occurs on ridges of these sand dunes and the age of tree stand increases with distance from the active stream channel. Stands consist of mature and young cottonwoods with a generally sparse understory composed of largely of sandsheet species and may include *Ericameria nauseosa, Senecio spartioides, Rhus trilobata, Achnatherum hymenoides, Psoralidium lanceolatum, Pascopyrum smithii*, and *Redfieldia flexuosa*. Substrate is deep sand and aeolian processes characterize sites.
27	Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance	This alliance consists of stands of narrowleaf cottonwood (*Populus angustifolia*) along stream terraces in the lower montane zone (generally <3,000 m) and alluvial fan portions of the project area and may extend into the sandsheet on the sand ramp and valley floor where stream channel generally rocky and stable. Alluvial processes characterize site. There is typically an understory of shrubs and herbaceous plants. Other trees present may include aspen (*Populus tremuloides*) and scattered white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menzesii*), ponderosa pine (*Pinus ponderosa*) or Rocky Mountain juniper (*Juniperus scopulorum*). Diverse shrubs may be present to dominant in the understory and include *Acer glabrum, Alnus incana, Betula occidentalis, Ericameria nauseosa, Jamesia*

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MC#	MAP CLASS	SUMMARY DESCRIPTION
		americana, Ribes aureum, Ribes idaeus, R. leptanthum, Rosa woodsii, Salix drummondiana, and *S. exigua*. The herbaceous layer is sparse to moderately dense depending on shrub cover and dominated by mesic forbs and grasses such as *Maianthemum stellata, Juncus balticus* and *Pascopyrum smithii*. Substrates derived from alluvium sometimes with colluvial rocks and exposed bedrock.
28	Emergent Marsh Alliances	Wetland vegetation that occurs on the valley floor and is typically associated with springs, stream terraces and pond shores. If found in interdunal swales, then a stream channel is nearby (<200 m) and likely connecting hydrologically to surface flows. Stands are permanently to seasonally flooded. These wetlands have shallow water tables and may hold open water during all or part or the year. Substrates vary from coarse to finer textured alluvial deposits or organic muck. Vegetation is dominated by wetland sedge (*Carex*), spicksedge (*Eleocharis*) and rush (*Juncus*) species such as *Carex nebrascensis, C. pellita, C. simulata, C. utriculata, Eleocharis acicularis, E. palustris, Juncus balticus, Schoenoplectus acutus, S. americanus*, or *S. maritimus*. Other mesic and wetland species include *Callitriche palustris, Hippuris* spp., *Iris missouriensis, Lemna minor, Mentha arvensis, Myriophyllum sibiricum, Polygonum amphibium, Potamogeton foliosus, Ranunculus aquatilis, Sparganium eurycarpum,* and *Triglochin maritima*. May occur as small patch inclusions (below MMU) in other mesic map classes. Stands dominated by *Typha* spp. are mapped in Cattail Herbaceous Alliances map class.
30	Piedmont Semi-Desert Grassland Alliances	Dry grasslands occurring on rocky alluvial fans above the sandsheet on the valley floor and in openings within pinyon - juniper woodlands. Characteristic species include blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), etc. Scattered rabbitbrush (*Ericameria* spp.) and prickly-pear cacti (*Opuntia* spp.) are often present. Not found above pinyon-juniper woodland (higher elevaton grasslands included in Montane Grassland map class). Mountain muhly (*Muhlenbergia montana*) and fescues (*Festuca* spp.) are generally absent or have low cover. The lower alluvial fan becomes sandy as it transitions to the deep sands of the sandsheet. Does not include grasslands on sand ramp where sandsheet extends up on to the alluvial fan and is dominated by aeolian processes (dunes, blowouts).
31	Pinyon Pine / Rockland Woodland Association	This pinyon - juniper woodland is known from colluvial slopes and ridges between 2765 m and 2884 m in elevation. The canopy is composed of pinyon (*Pinus edulis*) which forms an open to moderately dense canopy with 10-50% cover. Rocky Mountain juniper (*Juniperus scopulorum*) may be present, but is often absent. The understory is generally sparse, with neither shrub nor herbaceous cover exceeding 10% cover to for a layer. Bedrock outcrops are typically present with 20-40% ground cover. Combined with large rocks and gravel, they make up at least 50% of the ground cover. Bare soil can also be prevalent, leaving litter to cover between 10-25% of the ground surface. Slopes range from 40 degrees on steep colluvial slopes to 12 degrees on rocky ridgetops. Substrates tend to be loose and actively eroding. Soils are rapidly to well-drained loamy sand.
32	Pinyon Pine Woodland with Herbaceous or Sparse Understory	This is open pinyon – juniper woodland is found on mid to low slopes of the alluvial fan between 2,471 m and 2,727 m in elevation and on colluvial slopes. The canopy is composed of pinyon (*Pinus edulis*) and Rocky Mountain juniper (*Juniperus scopulorum*) with 20-30% cover with occasional ponderosa pine (*Pinus ponderosa*). Shrubs are absent or sparse and do not form an understory layer. If present the herbaceous layer is composed of a sparse to dense (2-75% cover) herbaceous layer dominated by grasses and forbs such as *Muhlenbergia montana, Bouteloua gracilis, Carex rossii, Heliomeris multiflora, Hesperostipa comata, Poa fendleriana* and *Heterotheca villosa*. Sparse understory stands have high ground cover of large or small rocks or bare soil (60-95%) with litter up to 40% cover, often concentrated as needlefall beneath the trees. Rocks can be of uniform size and form a pavement of cobble, indicating flowing water, or of mixed sizes indicating mass wasting.
33	Ponderosa Pine - Aspen Forest Alliance	Moderately dense to dense mixed woodlands codominated by ponderosa pine (*Pinus ponderosa*) and aspen (*Populus tremuloides*) with over 30% relative cover of both conifers and deciduous trees. Narrowleaf cottonwood (*Popululs angustifolia*) may also codominate in lowland sites. Other conifer tree species such as limber pine (*Pinus flexilis*) and Douglas-fir (*Pseudotsuga menziesii*) may be present to codominate as long as ponderosa pine is dominant. If white fir (*Abies concolor*) is present then map as Aspen - Douglas Fir (White Fir)

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MC#	MAP CLASS	SUMMARY DESCRIPTION
		Upland Forest Alliances. Known stands are mostly from near Mosca Pass.
34	Ponderosa Pine Sand Ramp Woodland	Open canopied tree layer of scattered or clumped ponderosa pine (*Pinus ponderosa*) (5-25% cover) that occurs on the sand sheet and the sand ramp extending up to near the Point of No Return. Substrates are deep sand with aeolian processes characterizing the site. Scattered to moderately dense shrubs may occur between tree canopies. Shrubs are typically rubber rabbitbrush (*Ericameria nauseosa*) with scattered gray horsebrush (*Tetradymia canescens*), snakeweed (*Gutierrizia sarothrae*), mountain mahogany (*Cercocarpus montanus*) or winterfat (*Krascheninnikovia lanata*). Common herbaceous species are needle-and-thread (*Hesperostipa comata*) and Indian ricegrass (*Achnatherum hymenoides*).
35	Alpine Bedrock and Scree	Barren and sparsely vegetated alpine bedrock, talus, scree slopes or boulder fields. Elevation ranges from 3,434-3,888 m. Alpine plants may be present in cracks and in protected microsites and are often diverse. Species include *Aquilegia caerulea, Artemisia arctica, Cirsium scopulorum, Festuca brachyphylla, Geum rossii, Minuartia obtusiloba, Polemonium viscosum, Saxifraga bronchialis, Senecio atratus, Silene acaulis, Trisetum spicatum* and many other alpine cushion and turf plants. (To separate from montane-subalpine Cliff, Canyon and Massive Bedrock map class sites, determine if polygon is mostly alpine to upper subalpine or mostly lower subalpine to montane, or look for a natural break between the subalpine to alpine zone.)
36	Alpine Fell-Field Alliances	Wind blasted alpine vegetation that occurs on upper slopes, saddles, and ridges ranging from 3,476-4,076 m in elevation. Gravel and bare ground typically have moderate to high cover. Vegetation is characterized by sparse to moderate cover of herbaceous species dominated by cushion plants. Common species are *Androsace chamaejasme, Arenaria fendleri, Artemisia scopulorum, Carex elynoides, C. rupestris* var. *drummondiana, Erigeron pinnatisectus, E. simplex, Festuca brachyphylla, Geum rossii, Luzula spicata, Minuartia obtusiloba, Oreoxis alpina, Paronychia pulvinata, Phlox condensata, Potentilla pulcherrima, Saxifraga rhomboidea, Selaginella densa, Silene acaulis, Tetraneuris acaulis, Tonestus pygmaeus, Trifolium dasyphyllum* and *Trisetum spicatum.*
37	Cliff, Canyon and Massive Bedrock	Sparse vegetation and barren rock outcrops that occur on steep colluvial slopes and cliff faces that occur in foothill, montane, and subalpine zones. Stands frequently are southerly and westerly aspects. Characterized by low cover of scattered shrubs and/or trees on rock and scree slopes. This is distinct from the alpine scree and talus because of its lower elevation and potential for trees. In the alpine, talus has no trees, whereas in the montane zone the talus is often sparsley treed. Common species include pinyon (*Pinus edulis*), limber pine (*Pinus flexilis*), Douglas-fir (*Pseudotsuga menziesii*) on north slopes and higher elevations), mountain mahogany (*Cercocarpus montanus*) and hillside oceanspray (*Holodiscus dumosa*). Similar to Pinyon-Juniper Woodland with Shrub Understory and Pinyon Pine Rockland Woodland, but this type is distinguished by presence of steep talus, cliff faces, and sparse tree and shrub cover (<5% cover). (To separate this class from alpine bedrock and scree map class sites, determine if polygon is mostly alpine to upper subalpine or mostly lower subalpine to montane, or look for a natural break between the subalpine to alpine zone).
38	Alpine Turf Alliances	This alpine turf vegetation is found on gentle to moderate slopes, flat ridges, valleys, and basins where the soil has become stabilized by vegetation. Sites are windswept and snow pack is thin and melts relatively early in spring. The vegetation is characterized by a dense cover of low-growing, perennial graminoids and forbs. Rhizomatous, sod-forming graminoids especially as *Carex elynoides* or *C. rupestris, C. siccata, Kobresia myosuroides* often dominate or codominate with prostrate and mat-forming forbs with thick rootstocks or taproots like *Geum rossii, Phlox pulvinata, Silene acaulis, Trifolium dasyphyllum* or prostrate dwarf shrubs *Artemisia arctica, Dryas octopetala, Salix nivalis, Vaccinium caespitosum*, and *V. scoparium*. Other common species include *Calamagrostis purpurascens, Danthonia intermedia, Dasiphora floribunda, Deschampsia caespitosa, Festuca brachyphylla, Minuartia obtusiloba, Poa glauca* ssp. *rupicola, Saxifraga* spp., *Selaginella densa, Sibbaldia procumbens, Solidago* spp., and *Trisetum spicatum*. Although alpine dry turf generally forms the matrix vegetation of the alpine zone, it typically intermingles with alpine bedrock and scree, ice field, fell-field, and alpine wetlands.

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41	Subalpine Spruce-Fir Forest and Woodland Alliances	The matrix forests of the subalpine slopes with elevations ranging from 2,946 m to 3,617 m on both mesic and dry sites. These spruce-fir forests typically have more Engelmann spruce (*Picea engelmannii*) than subalpine fir (*Abies lasiocarpa*), frequently with spruce strongly dominating the tree canopy. Douglas-fir (*Pseudotsuga menziesii*) may persist in canopy in lower elevation stands, but does not regenerate. Scattered bristlecone pine (*Pinus aristata*) may be present, but do not codominate. The understory is variable and may be sparse or moderately dense with *Festuca thurberi, Juniperus communis, Mertensia ciliata, Vaccinium myrtillus* or moss present to abundant.
42	Subalpine-Montane Limber-Bristlecone Pine Woodland Alliances	This map class occurs on relatively small, harsh sites often with rocky substrates and exposed to desiccating winds (ridgelines). Higher-elevation occurrences are found well into the subalpine-alpine transition on wind-blasted, mostly west-facing slopes and exposed ridges. This map class includes both limber pine (*Pinus flexilis*) and/or bristlecone pine (*Pinus aristata*) dominated woodlands at elevations ranging from 2,700-3,600 m elevation. Bristlecone pine stands typically occur on dry, rocky ridges and upper slopes in the subalpine zone up to treeline and may transition into krummholz. Limber pine stands occur in subalpine and extend down into the montane zone. Tree canopies are typically open and patchy, and dominated by *Pinus flexilis* or *Pinus aristata*. Other trees are frequently present and occasionally codominant such as *Picea engelmannii* in subalpine and *Abies concolor, Pinus ponderosa,* and *Pseudotsuga menziesii,* in lower elevation stands and ecotones between the ridges and matrix subalpine or montane forests. *Pinus flexilis* growing in mixed conifer montane stands is generally classified to *Abies concolor* or *Pseudotsuga menziesii* forest or woodland alliances.
43	Subalpine Riparian Forest Alliances	This forest map class is confined to riparian environments occurring on floodplains or stream terraces in the subalpine zone extending into the upper montane zone where cold air drainage extends range of subalpine species (3,600-2,900 m elevation). These seasonally flooded conifer forests and woodlands have Engelmann spruce (*Picea engelmannii*) and/or subalpine fir (*Abies lasiocarpa*) codominant to dominant in the canopy. Scattered aspen (*Populus tremuloides*) are common with mesic understory species. Douglas-fir (*Pseudotsuga menziesii*), blue spruce (*Picea pungens*) or white fir (*Abies concolor*) are typically absent but may be occasionally present in lower elevation transitional stands. Stand often occur in very narrow in V-shaped valleys and canyons and may be difficult to map (below MMU).
44	Subalpine-Alpine Riparian Shrubland Alliances	These alpine and upper subalpine riparian shrublands occur in broad, subirrigated, snowmelt-fed alpine basins extending up surrounding lower slopes, and as narrow bands of dense shrubs lining lakeshores and stream banks and terraces. Elevation range between 3300-3770 m. Occurrences can also be found in fens, around seeps, and springs on hillslopes. Vegetation is characterized by short shrubs. *Salix planifolia* is the dominant shrub species with *Salix brachycarpa* present in drier microsites. The herbaceous layer is composed of mesic and wetland species such as *Calamagrostis canadensis, Caltha leptosepala* var*. leptosepala, Carex albonigra, C. aquatilis, C. scopulorum, Deschampsia caespitosa, Mertensia ciliata, Pedicularis groenlandica, Polygonum bistortoides, Rhodiola rhodantha* and *Senecio triangularis.* Stands are often adjacent to herbaceous wetlands.
45	Sandsheet Rabbitbrush Shrubland and Steppe Alliances	Open to moderately dense shrub steppe or shrublands dominated by rabbitbrush (*Ericameria nauseosa*) occurring widely on the stabilized sandsheet and sand ramp near Point of No Return. *Krascheninnikovia lanata* and *Sarcobatus vermiculatus* may be present with low cover. Substrate is deep, loose sand. Herbaceous species include *Achnatherum hymenoides, Hesperostipa comata, Muhlenbergia pungens* or *Sporobolus airoides*.
46	Montane-Subalpine Grassland Alliances	These mountain grasslands occur from lower montane to upper subalpine zones between 2776 m and 3662 m in elevation on gentle to steep colluvial slopes, ridgetops, and less commonly in valley bottoms and along upper stream terraces. Highest elevation sites are restricted to warm southerly aspects. Montane stands are typically dominated by *Festuca arizonica, Muhlenbergia montana and Bouteloua gracilis,* whereas *Festuca thurberi* or *Danthonia parryi* dominate subalpine stands. May include forb dominated upland meadows. These small and large-patch grasslands are intermixed with matrix stands of spruce-fir, montane mixed conifier forests, and aspen forests.

Table 5. Final map unit descriptions for GRSA.

MC#	MAP CLASS	SUMMARY DESCRIPTION
48	Ponderosa Pine Woodland with Shrub Understory	This is an open to moderately dense ponderosa pine woodland that occurs on moderately steep colluvial slopes and alluvial fans in lower montane zone. Substrates are variable. Vegetation is characterized by an open to moderately dense tree canopy dominated by ponderosa pine (*Pinus ponderosa*) with scattered Rocky Mountain juniper (*Juniperus scopulorum*) and occasional pinyon (*Pinus edulis*). The understory is characterized by open to moderate shrub layer dominated by *Ribes cereum.* Other common shrubs and dwarf shrub include *Artemisia dracunculus, A. frigida, Holodiscus dumosa, Rosa woodsii*, and *Symphoricarpos oreophila*. Scattered herbaceous species include *Carex rossii, Heliomeris multiflora,* and *Heterotheca villosa.*
49	Ponderosa Pine Woodland with Herbaceous Understory	This open ponderosa pine woodland occurs on gentle to steep colluvial slopes in montane zone. Vegetation is characterized by an open tree canopy dominated by *Pinus ponderosa*. Scattered Douglas-fir (*Pseudotsuga menziesii*) may be present. The understory is composed of an open to dense (10-75% cover) herbaceous layer dominated by grasses such as mountain muhly (*Muhlenbergia montana*) and Arizona fescue (*Festuca arizonica*). Other common herbaceous species include *Bouteloua gracilis, Carex rossii, Heliomeris multiflora, Hesperostipa comata, Poa fendleriana* and *Heterotheca villosa*. Known stands are from near Mosca Pass and tend to be small with larger stands up Medano and Sand creek drainages.
50	Subalpine Fir (Engelmann Spruce) - Aspen Forest Alliance	This subalpine forest is characterized by a mixed tree canopy of aspen and Engelmann spruce and/or subalpine fir. Aspen (*Populus tremuloides*) and conifers codominate with neither having more than 75% relative cover in tree canopy. Engelmann spruce (*Picea engelmannii*) and/or subalpine fir (*Abies lasiocarpa*) generally dominate conifer layer, although Douglas-fir (*Pseudosuga menziesii*) may be present. Stands occur on both upland and bottomland sites and are often riparian or disturbed upland sites. Sites are gentle to steep colluvial slopes, benches and stream terraces in subalpine zone. Aspen Forest Alliance is similar but has less than 25% relative cover of conifers in tree canopy.
51	Subalpine Fir - Engelmann Spruce - Bristlecone Pine - Limber Pine Krummholz Shrubland Alliance	Krummholz occurs near upper tree line and is composed of dwarfed, shrubby conifers. Elevations range from 3527-3750 m on harsh, windswept sites. Sites are nearly level to steeply sloping. Soils are shallow, rocky, gravelly or sandy loams. Rock outcrop is common. Stands are a mosaic of dense patches of dwarfed evergreen conifer trees (usually less than 2 m tall) and alpine turf, wet meadow and fellfields. The woody canopy is dominated by stunted subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*) and/or bristlecone pine (*Pinus aristata*). Other woody species include shrubs and dwarf-shrubs, such as *Ribes montigenum, Salix brachycarpa, S. glauca, S. planifolia, Vaccinium membranaceum,* and *V. scoparium*, that may be present to codominant. Stands strongly dominated by alpine willows (*Salix brachycarpa, S. glauca,* or *S. planifolia*) should be mapped as Alpine Willow (Spruce) map class.
53	White Fir - Mixed Deciduous Lowland Forest Alliances	Mixed deciduous-conifer forest or woodland found in lowland sites in montane zone and often occurs as riparian vegetation. The tree canopy is composed of a mixture of conifers such as white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menziesii*), and blue spruce (*Picea pungens*) and deciduous trees such as narrowleaf cottonwood (*Populus angustifolia*) at lower elevations, and aspen (*Populus tremuloides*). Deciduous and conifer trees codominate with neither having more than 75% relative cover in tree canopy. Stands occur on gentle to moderately steep low to mid slopes, benches and stream terraces between 2632 to 3103 m elevation. The shrub layer is often composed of *Acer glabrum* or *Physocarpus monogynus*. This mixed deciduous/white fir type is common in montane riparian areas, stream channels and floodplains up to lower slopes in mountain valleys. It is similar to narrowleaf cottonwood or aspen forest alliances which can have up to 25% relative cover of conifers in tree canopy.

Table 5. Final map unit descriptions for GRSA.

MC#	MAP CLASS	SUMMARY DESCRIPTION
55	Winterfat Dwarf-shrubland Alliance	Dwarf-shrubland occurring as small patches within alluvial fan shrublands steppe and grasslands. Stands are dominated by winterfat (*Krascheninnikovia lanata*) with scattered fringed sagebrush (*Artemisia frigida*), rabbitbrush species (*Chrysothamnus viscidiflorus, Ericameria greenii, E. nauseosa*), and prickly pear (*Opuntia polyacantha*). Sparse to moderately dense herbaceous layer is dominated by needle-and-thread (*Hesperostipa comata*), hairy golden aster (*Heterotheca villosa*), and sand dropseed (*Sporobolus cryptandrus*). Other herbaceous species present include *Achnatherum hymenoides, Artemisia dracunculus, Bouteloua gracilis, Chenopodium* spp*., Cryptantha fendleri, Eriogonum cernuum, Erysimum capitatum, Lappula occidentalis,* and *Machaeranthera tanacetifolia*. Typically occurs as patches within the alluvial fan rabbitbrush map class. Distinctive patches of winterfat are found on alluvial fan near park entrance that is very light in color (white or blue gray).
56	Avalanche Chute Shrubland	This map class is restricted to avalanche chutes and includes relatively mesic runout zone. Sampled from 2924-3448 m elevation on rocky and typically steep sites. Vegetation is characterized by stunted and snow damaged trees, and various shrubs, but is variable and may include patches of herbaceous vegetation. Rock cover is often high. Vegetation structure is maintained by periodic avalanches. Species of trees vary with elevation and include dwarfed conifers such as *Picea engelmannii, Abies lasiocarpa, Pinus aristata, Pseudotsuga menziesii, Abies concolor*, and frequently young *Populus tremuloides*. Common shrubs are *Acer glabrum, Holodiscus dumosus, Jamesia americana, Physocarpus monogynus, Ribes montigenum, R. leptanthum, Rosa woodsii, Rubus idaeus, Salix scouleriana and Sambucus racemosa*. Common herbaceous species may include *Achillea millefolium, Carex foenea, Erigeron eximius, Fragaria virginiana, Oreochrysum parryi, Saxifraga bronchialis, Seneco atriatus* and *Trisetum spicatum*.
57	Alpine Willow (Spruce) Shrubland Alliances	Isolated patches of alpine willows (*Salix planifolia* and *S. brachycarpa*) found in mesic upland sites such as seep areas below snow fields, alpine slopes and occasionally ridges (3355-3700 m elevation). Sites are often below areas of snow accumulation. Occurs in uppermost portions of watersheds and is not associated with distinct riparian zones like the Subalpine-Alpine Riparian Shrubland Alliances map class. *Salix planifolia* generally is more common in wetter portions of the stand.
59	Invasive Forbland	Sparse to dense herbaceous vegetation dominated by introduced annual and perennial forbs (including *Centaurea* sp*., Cirsium arvense, Dactylis glomerata, Euphorbia esula, Halogeton glomeratus, Kochia scoparium, Lepidium latifolium, L. perfoliatum, Melilotus* spp*., Salsola tragus*, etc. Mostly used to characterize the former golf course that is in the process of being restored to native vegetation, but includes locallly disturbed areas that meet the MMU requirement. This map class may be broaden to include areas dominated by invasive grasslands such as *Agropyron cristatum, Agrostis stolonifera, Bromus inermis, B. tectorum, Poa pratensis, Phleum pratense, Thinopyrum intermedium* and other introduced forage species.
60	Pinyon-Juniper Woodland with Shrub Understory	This is pinyon-juniper woodland that occurs on colluvial slopes ridges and alluvial fans. Substrates are variable, but generally dry and rocky. Vegetation is characterized by an open to moderately dense tree canopy dominated by pinyon (*Pinus edulis*) with scattered Rocky Mountain juniper (*Juniperus scopulorum*) and occasional ponderosa pine (*Pinus ponderosa*). Understory is characterized by shrubs and is composed of an open to dense (5-75% cover) shrub layer often dominated by mountain mahogany (*Cercocarpus montanus*). Other shrubs include *Rhus trilobata* or *Ribes* spp.

Table 5. Final map unit descriptions for GRSA.

MC#	MAP CLASS	SUMMARY DESCRIPTION
61	Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances	Rabbitbrush dominated shrublands restricted to alluvial fans. Excludes deep sand areas on the alluvial fan near Point of No Return Parking Area. Soils are coarse textured gravelly or cobbly loams or sandy loams. Vegetation is characterized by an open to dense short shrub layer dominated by rubber rabbitbrush (*Ericameria nauseousa*). Other shrubs may be present such as green rabbitbrush (*Ericameria greenii*), snakeweed (*Gutierrizia sarothrae*), gray horsebrush (*Tetradymia canescens*), or winterfat (*Krascheninnikovia lanata*). The herbaceous layer is sparse to moderately dense and is dominated by dry grasses such as *Bouteloua gracilis, Hesperostipa comata,* etc. This is a large patch type that occurs below the pinyon-juniper woodlands on broad alluvial fans. It also occurs as small linear patches along drainage bottoms, between the riparian vegetation and upland pinyon-juniper woodland.
63	Aspen - Douglas Fir (White Fir) Upland Forest Alliances	Mixed aspen-conifer forest or woodland found in upland sites in montane zone. Aspen (*Populus tremuloides*) and conifers codominate with neither having more than 75% relative cover in tree canopy. Generally Douglas-fir (*Pseudotsuga menziesii*) codominates with aspen (*Populus tremuloides*), however white fir (*Abies concolor*) may be present and occasionally codominate. The understory is variable. Sites are not riparian. It is similar to aspen forest which can have up to 25% relative cover of conifers in tree canopy.
64	Alpine - Upper Subalpine Herbaceous Wetland Alliances	Alpine wetlands typically found in topographically low areas, but also occur on moderately steep slopes below snow fields and seeps (usually between 3440-3935 m elevation). Landforms are variable and include minor drainage channels, valley/cirque floors, stream terraces, benches, swales and colluvial slopes. Slopes are typically gentle, but range from 0-33%. Soils are relatively deep organic muck, but include sandy-clay loams. The vegetation is characterized by a typically dense herbaceous layer dominated or codominated by alpine or subalpine wetland species. Common species include *Caltha leptosepala, Cardamine cordifolia, Carex microptera, Carex scopulorum, Deschampsia caespitosa, Geum rossii, Mertensia ciliata, Polygonum bistortoides, Senecio triangularis, and Sibbaldia procumbens* sometimes with scattered *Salix planifolia*.
65	Montane Riparian Shrubland Alliances	These montane to lower subalpine riparian shrublands occur as narrow bands of shrubs lining streambanks and alluvial terraces in narrow mountain valley bottoms. It is found at montane and lower subalpine elevations between 2550-3300 m and often occurs as a mosaic of multiple communities that are shrub- and herb-dominated. The dominant shrubs reflect the large elevation gradient with gray alder (*Alnus incana)* and water birch (*Betula occidentalis),* chokecherry *(Prunus virginiana),* Bebb willow *(Salix bebbiana)*, Drummond's willow (*S. drummondiana),* park willow *(S. monticola)* at lower elevations and tall planeleaf willow *(S. planifolia)* at higher elevations. Common graminoids include *Calamagrostis canadensis* and *Carex utriculata*. Stands may be surrounded by trees such as aspen (*Populus tremuloides),* narrowleaf cottonwood (*P. angustifolia),* and various conifers.
66	Urban Semi-industrial	Quarries
67	Farmlands	Cropland, irrigation circles
68	Urban Residential	Farmhouses, residential developments, temples
69	Roads	Maintained roads
70	Water	Includes all open water such as reservoirs or wetland ponds
71	Other	Typically disturbed areas such as the former golf course being restored to native vegetation.
101	Snow	Permanent and semi-permanent snow landcover

Polygon Attribution

Image interpretation was done by delineating directly on printouts with the NAIP image as background and line work plotted on top. Polygons were attributed and linework was adjusted as much as feasibly possible. The information from the paper printouts was then manually transferred to the digital database. All the printouts were compiled into map books which accompanied us during field trips. Field annotations and interpretations were also manually transferred to the digital database.

Instrumental to the image interpretive effort was the use of the GPS located vegetation plots collected by the field crew. These plots gave us a good idea of what the signatures of the individual map classes should look like. In addition to the tablular data associated with each vegetation plot were the four photographs collected at each plot. These photographs helped not only in identifying the immediate area but also provided us with a “look” at the areas surrounding the vegetation plot which might be a different map class.

The Baca NWR portion of the project was attributed differently and we direct the reader to Appendix A for further details. The line work between the two datasets was similar when originally joined however there were several areas that needed to be matched or adjusted to avoid a glaring demarcation in the final vegetation map between the two efforts. BOR and USFWS worked together to create a smooth transition between the two datasets.

Map Verification

As the ortho-photo interpretation and digital transfer for sections of the Park were completed, draft 1:12,000-scale hard copy vegetation maps were printed for review. In all cases, these draft maps were checked against the interpreted photographs to ensure that the polygons were labeled properly and to locate any extra or missing lines. We also compared the map labels to the plot data if they fell in the same location. Copies of the revised draft map were then sent into the field on several occasions with the photo interpreters for ground-truthing. During the ground-truthing process, we verified image signatures using landmarks and GPS waypoints. The map and map classes were then modified to correct any mistakes.

Accuracy Assessment Phase Sample Design

Sample Design

Our aim in mapping the vegetation of GRSA was to provide accurate descriptions and locations of vegetation types as described by the National Vegetation Classification System (NVCS). A margin of error is inherent to interpreting vegetation using aerial photographs and the primary objective of an Accuracy Assessment (AA) is to develop numeric estimates of this error or how precise each map class is in regards to its true value. Accuracy can also be explained as a measure of the absence of errors—the more frequent the errors, the less the degree of accuracy.

For the GRSA vegetation mapping project, the AA involves an analysis of data sets measuring the probability of map accuracy (or, the absence of error) using a field based classification acquired at randomly selected sites for each map class (a thematic accuracy assessment). Positional accuracy is not considered. Given that polygon boundaries are only occasionally “hard” and subject to interpretation it makes little sense to spend the effort to quantify a subjective boundary.

According to the NPS Vegetation Mapping Program’s Accuracy Assessment Procedures document (TNC et al. 1994), AA of spatial data has two primary objectives:

1. To allow the users of the data to assess the data's suitability for a particular application.

2. To allow the producers of the data to learn more about the data's errors and improve the mapping process.

These two views of an AA are known as "users accuracy," which is the probability that the map actually represents what was found on the ground (also referred to as errors of commission), and "producers accuracy" which is the probability that an AA point has been mapped correctly (also referred to as errors of omission). Both users and producers accuracy are obtained from the same set of data using different analyses.

The objectives of collecting samples for accuracy assessment are somewhat different than those for classification. Here, the sampling is aimed at drawing inferences about the nature and magnitude of discrepancies between the true properties of a point or area and its representation on the map. Specifically, the purpose of collecting samples to assess the accuracy of the GRSA vegetation map are:

1. To obtain a measure of the probability with which a particular location has been assigned its correct vegetation class (thematic accuracy).

2. To determine how well a particular location is positioned compared to its true position in the field (positional accuracy).

With these types of objectives, the randomness of the sample sites should be emphasized, and the number of samples sites will be heavily influenced by statistical constraints. In other words, the objectives require a sufficient number of samples to permit statistical inferences to be drawn about the data as a whole. The GRSA AA sample design generally follows the NBS/NPS Vegetation Mapping Program Accuracy Assessment Procedures manual. However, as with the classification phase, the GRSA AA design employed a different sample design algorithm (GRTS) than used in other Vegetation Mapping projects largely for many of the same reasons as in the classification phase. Perhaps the most and novel implications of using a GRTS AA design is the capacity for design-based inference of map class extent and precision across the entire project extent.

Design Specifications

The core design specifications for the AA design include the basic survey design form (i.e., GRTS as described above under the classification phase sample design), the sample frame, strata or unequal weight categories (subpopulations) within the frame, sample size and allocation of samples across strata or weight categories, and the number and distribution of oversamples (and how these replacement sites are to be used).

Sample Frame

The sample frame is the data from which the GRTS design algorithm selects potential sample locations. The core of the sample frame for the GRSA AA design is the final draft map created by the GRSA vegetation mapping project (Figure 13). Note that the GRSA AA design does not include the Baca NWR. To implement the AA design using this sample frame we had to modify the map by dissolving polygons based on several attributes, creating internal buffers for each polygon and integrating a cost surface. These modifications are summarized in the following sections.

Dissolving by density class

The draft GRSA map (Figure 13) included 19,572 polygons. Each polygon has an attribute describing the density of vegetative cover. While this is a core piece of data in the map, it is not useful for AA purposes; no objective included assessing the accuracy of this attribute. We therefore dissolved all contiguous polygons of the same map class but with different density classes. This generated a version of the map with 6,821 polygons.

Internal polygon buffering

GRSA AA objectives do not include assessing positional accuracy or the actual placement of the lines in the map. Given that vegetation boundaries are only occasionally "hard" and subject to interpretation it makes little sense to spend the effort to quantify a subjective boundary. We therefore created internal buffers for each polygon in the sample frame to help place the observation area the crews assessed entirely within the target polygon.

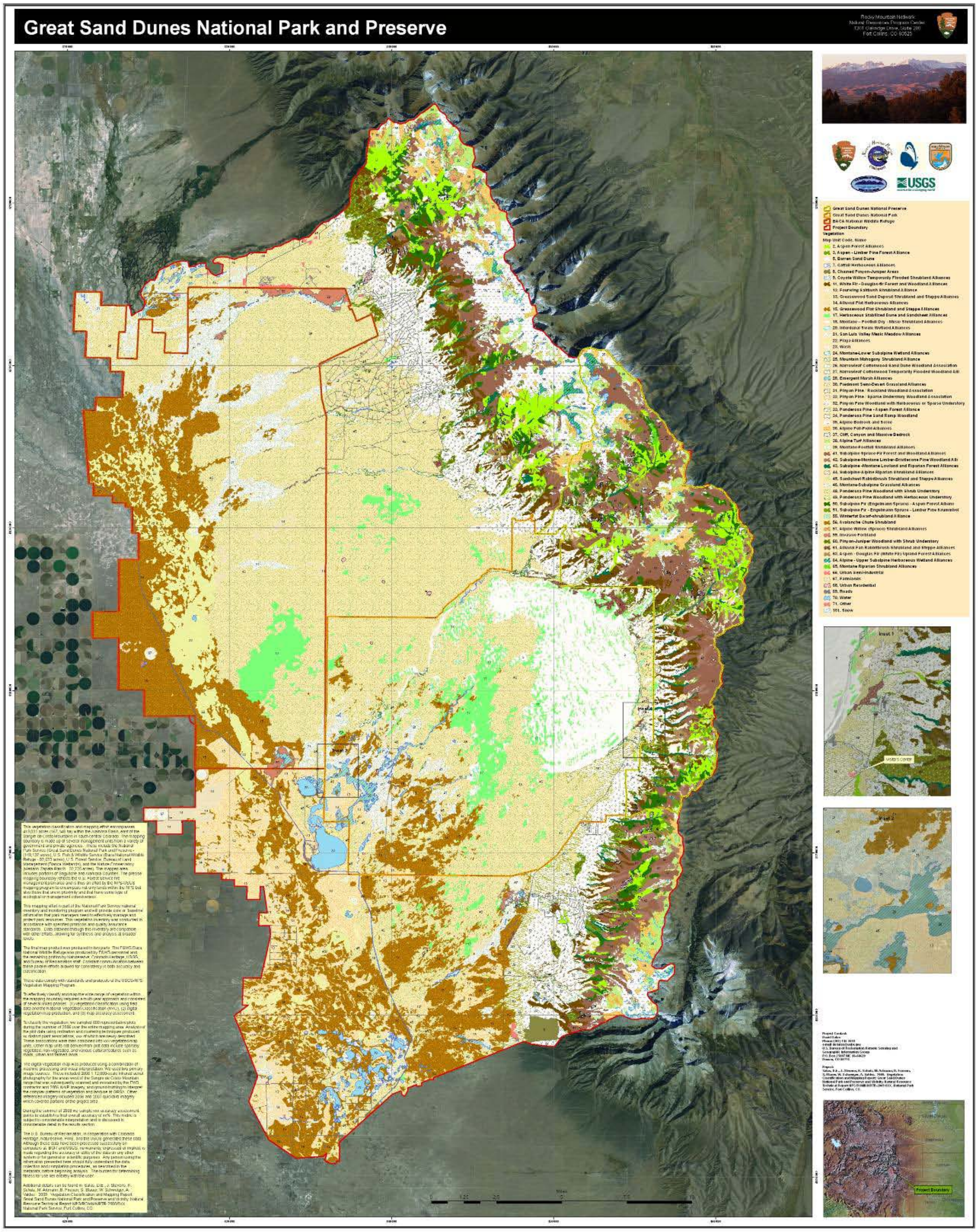

Figure 13. Basis for the AA design sample frame, the final draft GRSA Vegetation Map.

Note: The map also shows the Baca NWR which was not included in the GRSA AA design. A full-size plot of this map is provided to the park, and a high-resolution image is available from the USGS-NPS Vegetation Characterization Program website.

Cost Surface

Just as with the classification phase design a cost surface was needed to deal with the remote wilderness setting of much of GRSA. The cost surface used in the classification design was adequate and served to control for accessibility in that design. However, we wanted to improve the model for the AA design given the much larger sample size and the stricter requirements for sampling the chosen location imposed by AA analysis (e.g., no Opportunistic sites allowed).

We used the same basic model (NPS ROMN 2008; but improved somewhat in the intervening three years) to generate a raster of the estimated time required to access any point in the park. As with the classification phase design, the central algorithm of this model predicts traveling speed from the slope of the terrain being crossed (Tobler 1993, Imhof 1950) and creates a raster of travel time to all points in the vegetation map boundary.

For the AA design the cost model incorporated a series of auxiliary variables to adjust the travel times (like the classification phase version). Landcover type was built into the model (we used the SWREGAP Ecological Systems layer as modified for the classification design, with coefficients that modified off trail travel derived from consolation with GRSA park staff). We also incorporated impassable barriers (no access at all) such as streams (over a certain size) and lakes. We modified the degree of impassability on streams by applying a finer resolution Strahler order class to each stream segment. We improved the roads and trails layers used in the model by updating the data and using more road type classes from that used in the classification phase cost surface. The speed coefficients that set the rate of travel (and thus cost) on each road type were improved based on our experience from the classification phase. We modified the ‘point of no return’ slope threshold of 35 degrees to 40 degrees. This change was based on an analysis of slopes for a small support area around each of the 1,163 sites that were visited (and the 13 that were deemed inaccessible) during 2005/2006 in the classification phase. Figure 14 shows the relationship between this slope and the cost to access each of these sites. There is a ceiling in slope around 40 degrees - most sites were below this slope – suggesting we could increase the point of no return a bit for the AA design and hopefully capture more of the target area without undue crew suffering. We also added a set of seven ‘cost free’ start locations to the model (in addition to all gravel and paved roads). These back country locations were developed based on experience from the classification phase. The backcountry spots were base camp locations where crews would stage out of for sample hitches and thus opened up significant area in the backcountry. Finally, again based on our experiences in the classification phase, we added a maximum one-way day trip time cap of 14400 seconds (4 hours). Any point beyond this in the cost surface was deemed out of bounds.

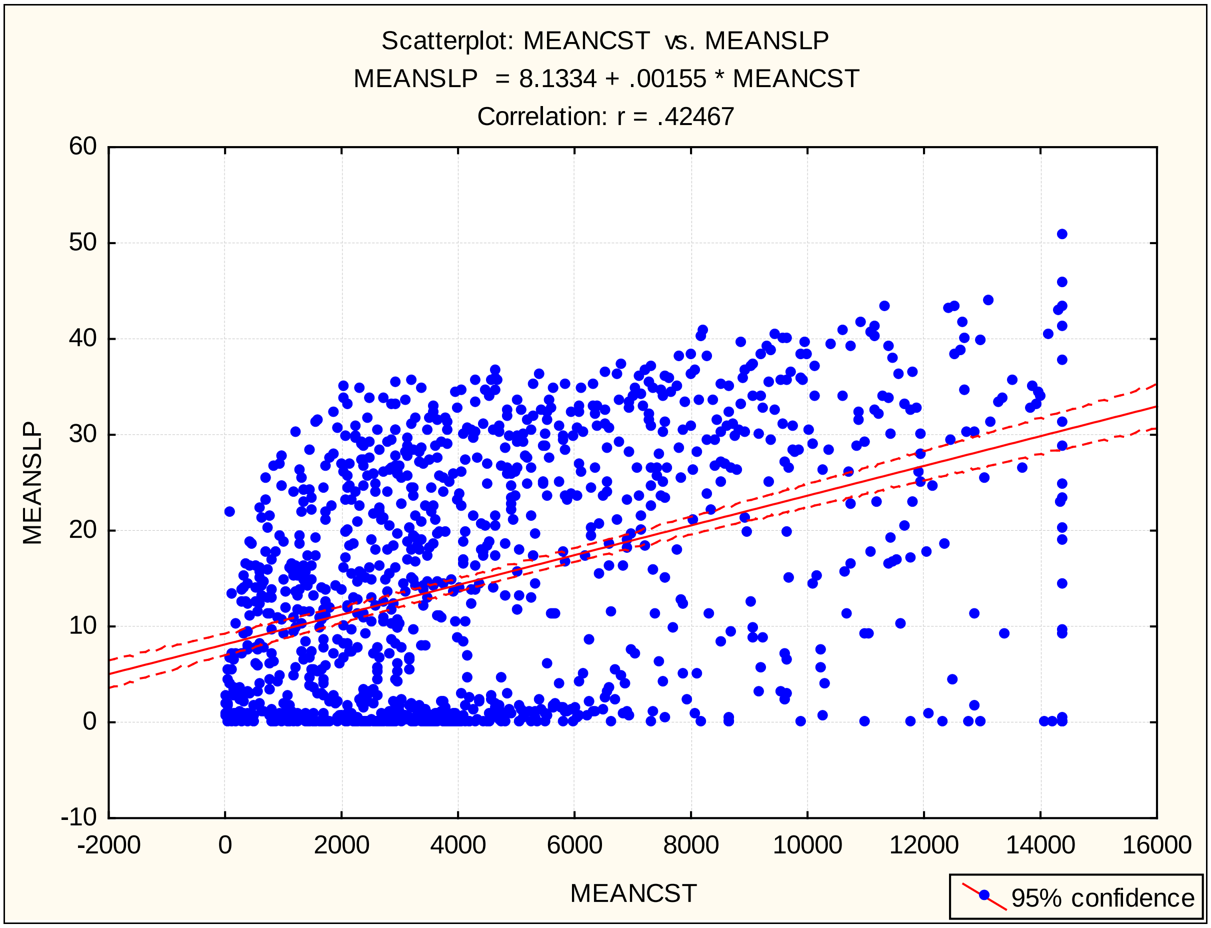

Figure 14. 2005/06 plot mean slope in a small support area around each sites vs. the cost to access each site

The final cost surface is shown in Figure 15. The GRTS design required ordinal classes of cost. We chose 10 classes (vs. the five used in the classification phase – again, we wanted more resolution for the AA design). The choice of 10 as the number of classes was arbitrary, but seems to give both a reasonable partitioning of the distribution yet not too many individual classes. We explored three methods for classifying the distribution of cost values for each of these plots into the 10 classes: percentile, equal interval and a Jenks natural breaks algorithm. The evaluation of the results from these three methods is largely qualitative. The 'best' method will place more area in easier classes, yet not have dramatically different areas across all classes. The Natural Breaks (Jenks and Caspall 1971) approach placed 70% of the target area in easier access classes (as per Vegetation mapping program guidance), yet did not create a long tailed distribution of higher cost classes (that would could negatively impact design based variance estimates) so was determined to give the most appropriate solution.

We intersected cost zones with the dissolved and internally buffered polygons of the sample frame and used these polygons as the actual input to the sample design algorithm which, when coupled with the sample size allocation (see below) allowed cost to directly factor into site selection.

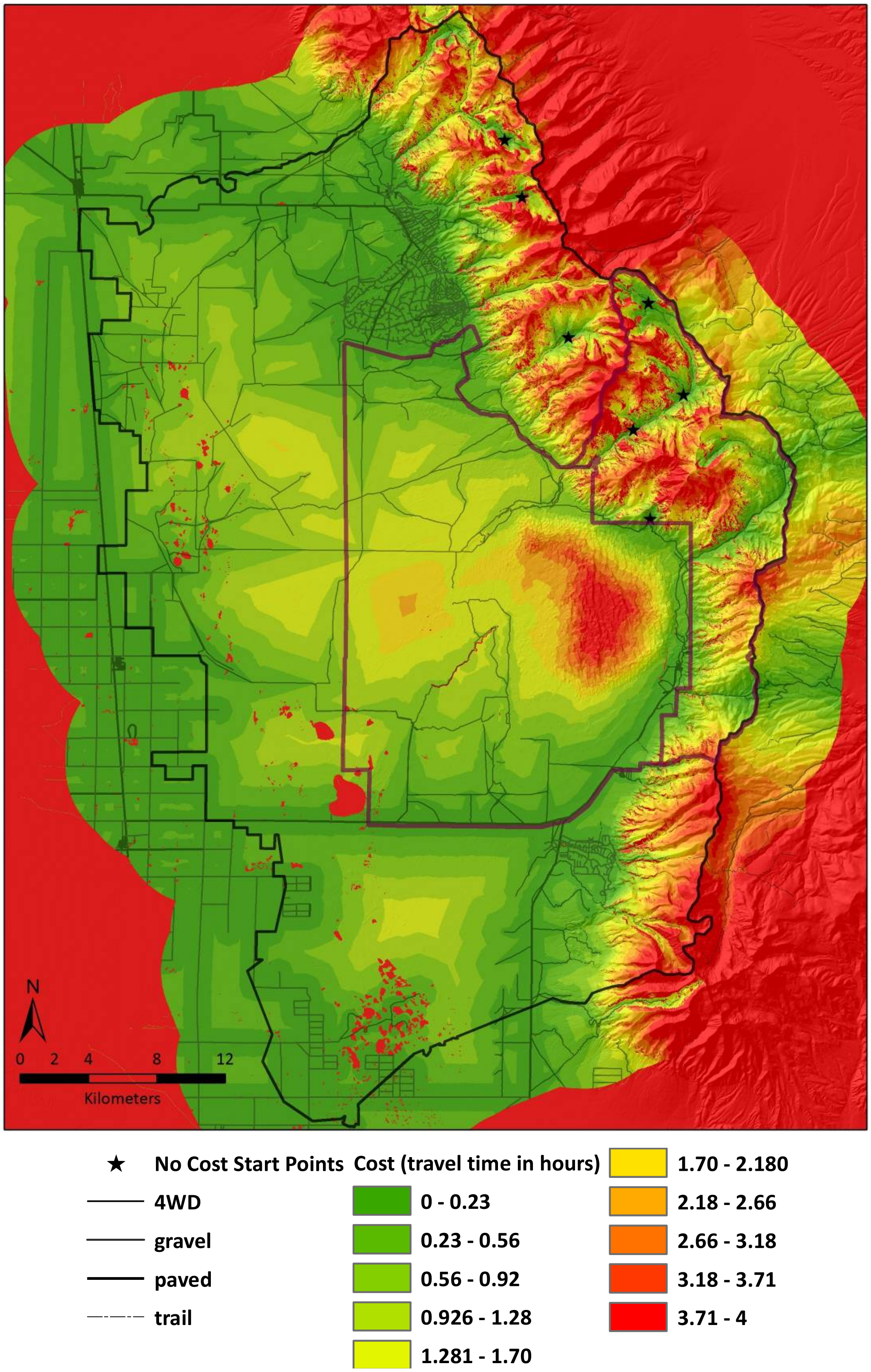

Figure 15. Final AA cost surface.

Note: The cost free start locations, roads and trails in the target area are also shown. The color ramp corresponds to the 10 classes derived from a natural breaks classification of the cost value for each cell (travel time in hours).

Strata and subpopulations

There are no explicit strata in the GRSA AA design. However, the AA results followed by the USFWS on the Baca are included in this GRSA report and therefore this area of the project is a *de facto* or *post hoc* stratum.

Subpopulations in the design are defined by the combined Map Class cost classes. There are 51 vegetated types or Map Classes. All non-vegetation Map Class types are excluded from the AA. This includes 7 classes (Other, Farmlands, Urban Residential, Urban Semi-industrial, Invasive Forbland, Water, and Roads) with a total of 2,259 hectares (1.7% of total area). These areas were assumed to have a very high accuracy, as there is little, if any, ambiguity in their interpretation. The result of this is that the reported overall accuracies are most probably lower than the actual overall map accuracy. There are up to 10 cost classes possible for each Map Class type but because many combinations are not realized there are ‘only’ 400 unique combinations of Map and Cost Class in the map.

Table 6 gives a summary of each Map Class type in the design with several statistics and attributes including the sample size as selected by the GRTS design for each class.

Sample size

Operational and budget constraints dictate a total AA sample size of approximately 1,500 plots. These 1,500 sample events are allocated to each Map Class type as detailed in Table 6. Vegetation mapping program guidance states that there should be 1 AA point for every 1.67 hectares of Map Class area (with this area measured prior to any buffering but after dissolves for any internal attributes like density) with a minimum of 5 and a maximum of 30 points per map class.

Sample size per cost class

The default base N (most are 30) were allocated to cost classes within a Map Class in an iterative fashion in an attempt to 1) keep most samples in easier classes, 2) distribute samples to classes that account for at least 70% of a Map Classes total area and 3) reduce the variability in sample weights across cost classes. Given the number of Map Class – cost classes these details are not shown in **Table 6**.

Oversample

A very large oversample (30x base for a total sample size in the design over 45,000) was allocated in the design. The oversample sites follow the same rules as the base samples.

Buffering among AA points

One shortcoming of the GRTS design in its application to a vegetation map AA is it does not allow an *a priori* separation distance among points in the design. This is not allowed by GRTS as in most design contexts this would be an artificial removal of sampleable area that could bias a design in unknowable ways.

However, for the GRSA AA design we determine that sampled AA sites should avoid overlapping MMU Observation Areas as much as possible (some overlap is acceptable). This was accomplished by generating distances among all points in the design and then only moving forward as candidate points those that have a lower numeric design rank (the order of GRTS design points as created by the design is key) and are separated by a minimum distance. For the larger buffer or 0.5 ha MMU Observation Area types this distance is conceptually 100 meters but a 10% overlap is allowed so it is set at 90 meters. For the small buffer or 0.1 ha MMU Observation Area types this distance is conceptually 58 meters but a 10% overlap is allowed so it is set at 52 meters.

In some cases (very small polygon and rare types, see **Table 6**), it was not possible to have sufficient sample sizes within a type with these separation distances. To achieve some independence when MMU Observation Area overlap crews (1) alternated sequential calls among visits to the points and (2) conduct AA assessment blind to other crew conducting AA (this way, theoretically, the second person could even stand in the same spot (100% overlap) and make an independent call uninfluenced by what the first person came up with). If crews were working alone (or in pairs for safety, but only one person is "qualified" to be making the calls), overlapping sites were assigned to different crews (again, with blind answers between teams). Appendix E provides additional detail on the implementation of the AA design.

Data Collection – AA Points

Field maps were produced that showed the sample point and polygon boundary. The addition of the polygon boundary to the field map aided in navigation to the point and provided the field crews with some contextual information. Field crews navigated to each point using the field maps produced for this effort in addition to a GPS with a known target location.

In June of 2008, the CNHP Accuracy Assessment field crews were given printouts of the imagery and topographic maps overlaid with the map class polygons. These maps contained 1,537 randomly selected locations to be used as AA Points. The field crews were instructed to navigate to these points and complete an AA datasheet. Given the time frame of the project, and the rugged nature of the Park, it was assumed that not all of the generated points would be accessible. A set of oversample AA Points was included on the maps as replacements for those base points which might be discovered to be inaccessible or otherwise unusable. Between June and October 2008, the Field Crews collected 1,537 AA Points (Figure 16). Crews sampled 1,154 AA points from the base list and 383 points from the oversample list.

Table 6. Frequency and extent summary of relevant AA design aspects.

VEG CODE	Map Class	Frequency	Sum_Ha	Avg_Ha	Std_Ha	Min_Ha	Max_Ha	Avg_Cost5 hours	Avg_P to A	MMUObs Ha	SepDist	All55mBuff %Area Allowed	All27mBuff %Area Allowed	Included in AA?	Sum_ha / 1.67 N criteria	Final N	
2	Aspen Forest Alliances	285	3997.1200	14.0250	56.6038	0.5110	576.5666	1.6097	0.0552	0.5	90	92.21	98.89	1	2393.49	30	
3	Aspen - Limber Pine Forest Alliance	46	266.3345	5.7899	6.6123	0.5103	30.4621	1.9594	0.0457	0.5	90	83.24	99.25	1	159.48	30	
5	Barren Sand Dune	235	7038.0435	29.9491	398.2128	0.5132	6107.4913	1.4101	0.0440	0.5	90	96.31	99.78	1	4214.40	30	
7	Cattail Herbaceous Alliances	62	152.6571	2.4622	5.5222	0.2022	38.5157	1.5323	0.1011	0.5	52	68.39	85.02	1	91.41	30	
8	Chained Pinyon-Juniper Areas	1	280.1201	280.1201		280.1201	280.1201	0.5409	0.0035	0.5	90	100.00	100.00	1	167.74	10	
9	Coyote Willow Temporarily Flooded Shrubland Alliances	5	7.5825	1.5165	0.8655	0.4340	2.3145	1.4398	0.0557	0.1	52	30.02	94.28	1	4.54	5	overlap
11	White Fir - Douglas-fir Forest and Woodland Alliances	403	4575.0908	11.3526	23.2999	0.5028	199.6393	1.5651	0.0518	0.5	90	91.08	98.66	1	2739.58	30	
12	Fourwing Saltbush Shrubland Alliance	3	2.3837	0.7946	0.2828	0.5992	1.1188	0.3155	0.0772	0.1	52	0.00	100.00	1	1.43	5	overlap
13	Greasewood Sand Deposit Shrubland and Steppe Alliances	536	8185.7410	15.2719	76.2808	0.2790	1158.4707	0.4557	0.0519	0.5	90	92.91	98.84	1	4901.64	30	
14	Alluvial Flat Herbaceous Alliances	433	2837.9741	6.5542	27.9868	0.2454	467.1746	0.5821	0.0541	0.5	90	81.70	97.79	1	1699.39	30	
15	Greasewood Flat Shrubland and Steppe Alliances	864	13548.9196	15.6816	118.0913	0.2283	2409.1892	0.5254	0.0557	0.5	90	93.38	98.85	1	8113.13	30	
17	Herbaceous Stabilized Dune and Sandsheet Alliances	847	4018.1270	4.7440	51.2888	0.2041	1467.3927	1.6630	0.0637	0.5	90	78.57	94.61	1	2406.06	30	
18	Hillside Oceanspray Shrubland Alliance	14	71.9404	5.1386	3.9580	0.5205	12.1853	1.2904	0.0406	0.5	52	91.02	100.00	1	43.08	30	
20	Interdunal Swale Wetland Alliances	16	19.9904	1.2494	0.8065	0.5056	3.0200	1.2933	0.0585	0.1	52	0.00	86.43	1	11.97	12	
21	San Luis Valley Mesic Meadow Alliances	307	3247.4109	10.5779	44.5339	0.2339	606.8449	0.8735	0.0559	0.5	90	90.72	98.22	1	1944.56	30	
22	Playa Alliances	238	1086.4395	4.5649	9.7851	0.3254	86.6495	0.7839	0.0549	0.5	90	73.06	96.14	1	650.56	30	
23	Wash	83	370.1200	4.4593	20.5461	0.5002	188.1239	0.2963	0.0881	0.1	52	53.98	82.80	1	221.63	30	
24	Montane-Lower Subalpine Wetland Alliances	25	92.9272	3.7171	7.9013	0.2708	35.7752	1.8948	0.0745	0.1	52	68.18	88.84	1	55.65	30	
25	Mountain Mahogany Shrubland Alliance	59	279.2625	4.7333	7.9981	0.2599	48.8481	1.9343	0.0613	0.5	90	81.54	96.57	1	167.22	30	
26	Narrowleaf Cottonwood Sand Dune Woodland Association	38	70.0254	1.8428	2.2070	0.5228	8.7026	1.0446	0.0627	0.1	52	36.10	91.19	1	41.93	30	
27	Narrowleaf Cottonwood Temporarily Flooded Woodland Alli	161	1088.5272	6.7610	13.2715	0.5032	127.3351	0.4588	0.0548	0.1	52	75.67	96.60	1	651.81	30	
28	Emergent Marsh Alliances	144	742.4657	5.1560	18.9317	0.2150	201.0110	1.0651	0.0670	0.5	90	77.34	95.05	1	444.59	30	
30	Piedmont Semi-Desert Grassland Alliances	179	2410.3899	13.4659	52.8293	0.5088	499.6399	0.1696	0.0480	0.5	90	94.16	99.07	1	1443.35	30	
31	Pinyon Pine / Rockland Woodland Association	74	528.7032	7.1446	15.4645	0.5279	97.1188	1.8475	0.0576	0.5	90	85.80	97.97	1	316.59	30	
32	Pinyon Pine / Sparse Understory Woodland Association	25	288.1132	11.5245	20.5395	0.5377	85.8001	0.2224	0.0590	0.5	90	92.99	97.68	1	172.52	30	
33	Ponderosa Pine - Aspen Forest Alliance	15	67.7608	4.5174	5.3496	0.5513	17.5758	0.4202	0.0520	0.5	52	79.75	97.36	1	40.58	30	
34	Ponderosa Pine Sand Ramp Woodland	24	250.2952	10.4290	18.5416	0.5500	87.3641	0.6249	0.0411	0.5	90	90.63	99.48	1	149.88	30	
35	Alpine Bedrock and Scree	274	3026.4616	11.0455	44.8072	0.5010	477.9328	2.8028	0.0513	0.5	90	90.72	98.53	1	1812.25	30	
36	Alpine Fell-Field Alliances	136	1757.9877	12.9264	26.0345	0.5054	158.1526	3.1039	0.0436	0.5	90	92.89	99.08	1	1052.69	30	
37	Cliff, Canyon and Massive Bedrock	556	2730.1509	4.9103	19.1847	0.5016	348.3430	2.9662	0.0612	0.5	90	76.20	95.41	1	1634.82	30	
38	Alpine Turf Alliances	277	2898.7231	10.4647	29.8638	0.5164	405.0513	2.8652	0.0511	0.5	90	89.49	98.60	1	1735.76	30	
39	Montane-Foothill Shrubland Alliances	211	1229.5604	5.8273	9.1724	0.5025	51.3064	1.5108	0.0531	0.5	90	84.16	97.41	1	736.26	30	
41	Subalpine Spruce-Fir Forest and Woodland Alliances	310	7208.7663	23.2541	70.0247	0.5005	661.8572	2.3225	0.0436	0.5	90	96.60	99.48	1	4316.63	30	
42	Subalpine-Montane Limber-Bristlecone Pine Woodland Alli	294	2259.1600	7.6842	13.5295	0.5029	131.7565	2.1413	0.0495	0.5	90	87.71	98.66	1	1352.79	30	
43	Subalpine Riparian Forest Alliances	42	265.2590	6.3157	7.6627	0.5553	33.7928	1.1972	0.0583	0.1	52	47.26	94.76	1	158.84	30	
44	Subalpine-Alpine Riparian Shrubland Alliances	54	208.6956	3.8647	4.7630	0.3062	22.6718	2.0103	0.0604	0.1	52	57.99	93.91	1	124.97	30	
45	Sandsheet Rabbitbrush Shrubland and Steppe Alliances	505	32732.1498	64.8161	614.1305	0.5008	11159.5185	0.5077	0.0454	0.5	90	98.70	99.82	1	19600.09	30	
46	Montane-Subalpine Grassland Alliances	453	1315.4887	2.9039	4.7191	0.5017	48.3954	1.4395	0.0636	0.5	90	60.82	92.15	1	787.72	30	
47	Pinyon-Juniper Woodland with Herbaceous Understory	324	9114.5308	28.1313	103.8214	0.5132	1229.8889	0.5154	0.0404	0.5	90	97.26	99.69	1	5457.80	30	
48	Ponderosa Pine Woodland with Shrub Understory	49	296.1574	6.0440	14.1005	0.6140	88.6864	0.8155	0.0475	0.5	90	76.54	98.02	1	177.34	30	
49	Ponderosa Pine Woodland with Herbaceous Understory	28	70.5965	2.5213	2.6403	0.5003	10.5434	1.0563	0.0590	0.1	52	56.21	89.18	1	42.27	30	
50	Subalpine Fir (Engelmann Spruce) - Aspen Forest Allianc	202	2316.6513	11.4686	20.4507	0.5122	154.6929	1.9179	0.0470	0.5	90	92.82	98.89	1	1387.22	30	
51	Subalpine Fir - Engelmann Spruce - Limber Pine Krummhol	73	361.1042	4.9466	7.6294	0.5211	40.3324	2.7389	0.0488	0.5	90	80.22	97.45	1	216.23	30	
53	White Fir - Mixed Deciduous Lowland Forest Alliances	44	249.0367	5.6599	5.5440	0.6347	23.2425	0.8964	0.0512	0.1	52	35.87	97.85	1	149.12	30	
55	Winterfat Dwarf-shrubland Alliance	9	24.0741	2.6749	2.7230	0.2288	8.4285	0.2133	0.0500	0.5	52	77.99	97.59	1	14.42	14	
56	Avalanche Chute Shrubland	84	221.3181	2.6347	2.1955	0.5022	12.4564	2.4463	0.0753	0.1	52	19.95	79.57	1	132.53	30	
57	Alpine Willow (Spruce) Shrubland Alliances	77	325.5598	4.2280	8.2234	0.2226	44.7946	1.9978	0.0637	0.5	90	78.15	93.26	1	194.95	30	
59	Invasive Forbland	33	92.8601	2.8139	4.7321	0.5093	27.7371	0.3276	0.0682	0.1	52	34.97	85.69	1	55.60	30	
60	Pinyon-Juniper Woodland with Shrub Understory	139	1763.3780	12.6862	28.5678	0.5134	273.9578	1.2171	0.0471	0.5	90	92.99	99.26	1	1055.91	30	
61	Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances	46	331.3276	7.2028	17.1632	0.5257	111.0883	0.5415	0.0513	0.5	90	84.55	97.86	1	198.40	30	
63	Aspen - Douglas Fir (White Fir) Upland Forest Alliances	98	900.4632	9.1884	13.7729	0.5222	85.5680	1.6254	0.0459	0.5	90	89.24	98.95	1	539.20	30	
64	Alpine - Upper Subalpine Herbaceous Wetland Alliances	82	387.1629	4.7215	10.5184	0.5135	62.1059	1.9666	0.0575	0.5	90	75.86	96.74	1	231.83	30	
65	Montane Riparian Shrubland Alliances	5	53.7671	10.7534	15.6804	0.5702	37.9582	0.9401	0.0690	0.1	52	89.05	97.70	1	32.20	12	
66	Urban Semi-industrial	37	56.3040	1.5217	1.5174	0.5036	8.6310	0.0847	0.0537	0.1	52	50.02	90.04	0	33.71	0	
67	Farmlands	5	200.9381	40.1876	38.5995	2.6630	90.8766	0.1022	0.0163	0.5	90	100.00	100.00	0	120.32	0	
68	Urban Residential	46	70.2355	1.5269	0.9519	0.5109	5.0903	0.2833	0.0469	0.1	52	25.39	97.47	0	42.06	0	
69	Roads	18	471.9153	26.2175	54.2258	0.2583	174.7904	0.1795	0.2457	0.1	52	0.00	87.67	0	282.58	0	
70	Water	110	1097.8172	9.9802	46.1418	0.2239	474.7971	2.3798	0.0611	0.5	90	90.99	95.58	0	657.38	0	
71	Other	7	76.5305	10.9329	14.3187	1.0263	38.0101	0.2732	0.0298	0.5	90	97.13	100.00	0	45.83	0	
101	Snow	156	193.3375	1.2393	2.0428	0.2082	16.6447	2.9948	0.0751	0.1	52	33.98	72.39	0	115.77	0	
Grand Total		**9906**	**129831.9344**	**13.1064**		**0.2022**	**11159.5185**					**91.51**	**98.55**			**1468**	
Means												**72.68**	**95.47**				

Notes:
Summary stats are for non-buffered polygons

Type required small buffer based on area
Type given small buffer based on ecology
Type required reduced separation distance
Type requires independent sampling via crews

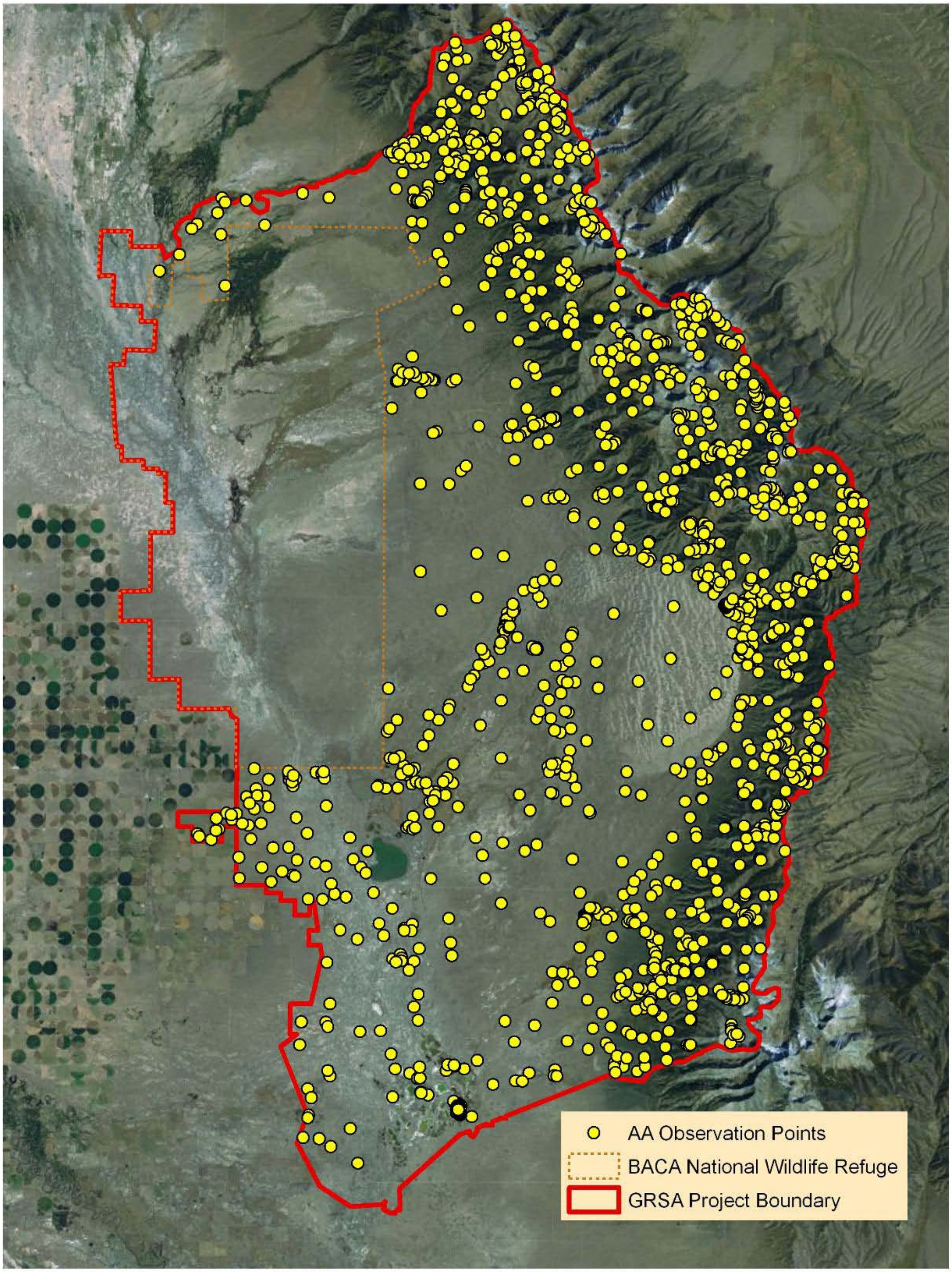

Figure 16. Locations of AA points at GRSA.

At the end of the field season, all AA point paperwork was subjected to the same quality control (QC) procedures as the vegetation plot data. All AA point data were then entered into the PLOTS database. Following the data entry, the AA data in the database was subjected to another round of QC to catch data entry errors. A map class column is included with the database. Those points which did not fit well into an existing NVC Association were keyed to map class by hand. Subsequent to the compilation of the data was a final review of the AA observation point map class designation to insure that the field crew map unit designation was correct.

AA Metrics

Once all the AA data had been entered and compiled the accuracy analysis portion of the project was started. This involved a number of steps including an initial binary accuracy assessment, calculation of confidence intervals, a fuzzy evaluation of the AA data, and hypotheses testing.

Binary accuracy assessment

All AA plots and their respective map class (reference layer) were compared to the digital vegetation polygon data (predictive layer). This provides an initial overall accuracy assessment and omission and commission errors (User's and producer's accuracy respectively). (Unless otherwise noted all subsequent formulas are described from ESRI and TNC 1994)

User's accuracy is calculated as:

$$\frac{n_{ii}}{n_{i+}}$$

where *i* is the land cover type, n_{ii} is the number of matches between map and reference data and n_{i+} is the total number of samples of *i* in the map. This formula is the number of "correct" observations divided by the sum of the column.

Producer's accuracy was calculated as:

$$\frac{n_{ii}}{n_{+i}}$$

where n_{+i} = total number of sample of *i* in the reference data. This formula is the number of "correct" observations divided by the sum of the row.

Overall accuracy for the map was calculated as:

$$\frac{\sum_{i=1}^{k} n_{ii}}{n}$$

where *k* is the number of land cover types and n is the total number of reference points. This formula is simply the sum of the diagonal entries divided by the total number of AA points.

Confidence Interval: The 90% confidence interval for a binomial distribution is obtained from the following equation:

$$\hat{p} \pm \left\{ z_{\alpha} \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} + \frac{1}{(2n)} \right\}$$

where $z_{\alpha} = 1.645$ (this comes from a table of the z-distribution at the significance level for a two-sided limit with a 90% confidence interval), $\hat{p}$ is the sample accuracy (0 to 1.0) and n is the number of sites sampled. The term $1/(2n)$ is the correction for continuity. The correction should be applied to account for the fact the binomial distribution describes discrete populations.

A kappa statistic is calculated for overall accuracy for each fuzzy level evaluated as follows:

Kappa can be used as a measure of agreement between model predictions and reality (Congalton1991) or to determine if the values contained in an error matrix represent a result significantly better than random (Jensen 1996). Kappa is computed as

$$k = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum(x_{i+} \times x_{+i})}$$

where N is the total number of sites in the matrix, r is the number of rows in the matrix, x_{ii} is the number in row i and column i, $x+i$ is the total for row i, and x_{i+} is the total for column i (Jensen1996). Existing Arcview scripts made this onerous process easy and repeatable (kappa_stats.avx by Jenness and Wynne (2004) or kappa.avx developed by the RS/GIS Laboratories at Utah State University (2003) and available at http://www.gis.usu.edu/~chrisg/avext/.

Fuzzy Accuracy Assessment

The need for an alternative to the standard binary approach of accuracy assessment was recognized some time ago. Gopal and Woodcock (1994) described the first fuzzy accuracy assessment approach that is commonly used today. This type of analysis allows for degrees of membership to a particular class. That is, we are allowed to recognize that a particular class may be considered wrong using a strict binary approach but with the fuzzy analysis that class may be mostly correct. This does provide a much better representation of the continuity present in the real world and still allows us to map using discrete classes.

The standard approach to assigning fuzzy membership to a class is to review each of the AA plots and assign a fuzzy level to that plot. Fuzzy level designations are shown in **Table 7**. The result of this fuzzy designation then allowed us to evaluate each fuzzy level using the standard binary approach. That is, we developed a contingency table for fuzzy levels 5, 4 and 3. Because we are only interested in the fuzzy levels that allow for varying degrees of membership and still be considered correct we ignored fuzzy levels 2 and 1. During the evaluation process CNHP and BOR debated the merits of each plot and fuzzy membership. Consensus was reached on each designation before moving on to the next AA plot.

All plots that received a “correct” designation during the initial binary assessment received a fuzzy membership 5. All other plots were then selected for other fuzzy membership designations.

To evaluate fuzzy levels 4 and 3 using a contingency table we recalculated the reference layer (AA Plot) to be equal to the predicted layer (digital polygon map) depending upon the fuzzy level. To do this we created three columns in the AA table. These are columns "fuzz5", "fuzz4" and "fuzz3." Evaluation of fuzzy level 5 is identical to the initial binary accuracy assessment as described above. The designation of values in the fuzz4 and fuzz3 columns is as follows. If a plot received a field designation with an alternate map class possibility then it received a fuzzy designation of 4. All levels at and below 4 were calculated to equal the polygon code. This column was then used as the "reference" layer in the contingency table. These would show up as "correct" in the contingency table for fuzzy level 4. However, at fuzz5 this would still show up as wrong which is what we would expect for the very stringent class membership at fuzzy level 5. When we calculate the contingency table for fuzzy level 3 this AA plot would show up as correct because it received a fuzzy code of 4 and therefore it follows logically that it must also be correct at fuzzy level 3. Adjacent to the fuzz5, fuzz4 and fuzz3 columns is the "vegcode" which is the code for the predicted value (polygon layer). The contingency tables are discussed in the "Results" section of this report.

Table 7. Fuzzy set accuracy ranks (Gopal and Woodcock, 1994).

Fuzzy Class	Description
1	Absolutely Wrong: This answer is absolutely unacceptable. Very Wrong
2	Understandable but Wrong: Not a good answer. There is something about the site that makes the answer understandable but there is clearly a better answer. This answer would pose a problem for the users of the map
3	Reasonable or Acceptable Answer: Maybe not the best possible answer but it is acceptable; this answer does not pose a problem to the user if it is seen on the map. Correct
4	Good Answer: Would be happy to find this answer given on the map. Very Right
5	Absolutely Right: No doubt about the match. Perfect

Hypothesis Testing: The purpose of the hypothesis test for this accuracy assessment is to determine weather or not the accuracy estimate exceeds 80% (program standard). For the purposes of this accuracy assessment we use the following hypotheses:

"The hypothesis that 80% accuracy has been met will be accepted unless the sample map accuracy is low enough so that the conclusion that rejection is appropriate can be drawn with some predetermined degree of certainty."

In order to accept or reject this hypothesis we use the confidence interval. There is an extremely close relationship between confidence intervals and hypothesis testing. When a 90% confidence interval is constructed, all values in the interval are considered plausible values for the parameter being estimated. Values outside the interval are rejected as implausible. If the value of the parameter specified by the null hypothesis is contained in the 90% interval then the null hypothesis cannot be rejected at the .01 level. If the value specified by the null hypothesis is not in the interval then the null hypothesis can be rejected at the .01 level.

Results

Field Data Collection

Vegetation and forest fuel plot data, and observation point data were collected at GRSA from June through early October of 2005 and 2006. Crews collected a total of 811 data records, including 603 vegetation plots (374 in 2005 and 229 in 2006) and 208 observation points (91 in 2005 and 117 in 2006). During the summer of 2008, a total of 1,537 accuracy assessment points were collected. The majority of the data records collected (~75%) were located within the boundary of GRSA, while the remaining data records (~25%) were located within the greater project area boundary on lands surrounding the Park and Preserve. Figure 17. shows the location of the 811 data records (vegetation plots and observation points) collected in the GRSA project area.

Vegetation Classification

The classification analysis used 600 vegetation plots. In these plots, there were 11,837 records of plants identified to genus or species, averaging roughly 20 species per plot. Overall, crews identified 698 species and subspecies, representing 298 genera and 76 families. Approximately 89% of the records were identified to species and 11% were identified to genus. Crews provisionally assigned the vegetation plots into 314 associations.

The initial cluster analysis and indicator species analysis produced 245 groups. The query evaluation and review by project ecologists resulted in lumping some of these for a final classification of 198 types classified to the equivalent of the association level (Table 8). Those included 176 types classified to the NVC association and 22 types not listed in the NVC but classified as Park Specials or Provisional. Additionally, seven data plots were classified to the six NVC alliances.

After all plots had been classified to NVC vegetation types, local descriptions were written for each type, and a dichotomous key to the vegetation types was developed. Local descriptions are provided in Appendix I and a key to vegetation types is provided in Appendix H. The local descriptions are based on the plot data from the GRSA project area only and describe the structure, composition, and environmental characteristics for the type as it occurs there. Because the descriptions are based only on the GRSA field data, their completeness and accuracy is a function of the number of plots and observation points collected for each particular type. Additional plots in any given type can further inform the classification of the type and its description.

The field key combines the characteristics indicated by the plot data with the essence of the NVC concept for each of the associations. It provides the user with a series of dichotomous choices that concludes in identification of the association. The field key was used during the 2008 accuracy assessment to determine the vegetation type at each of the AA Points. Based on the results of its use during AA, minor edits were made to the key to ensure completeness, to clarify the text, and simplify its use.

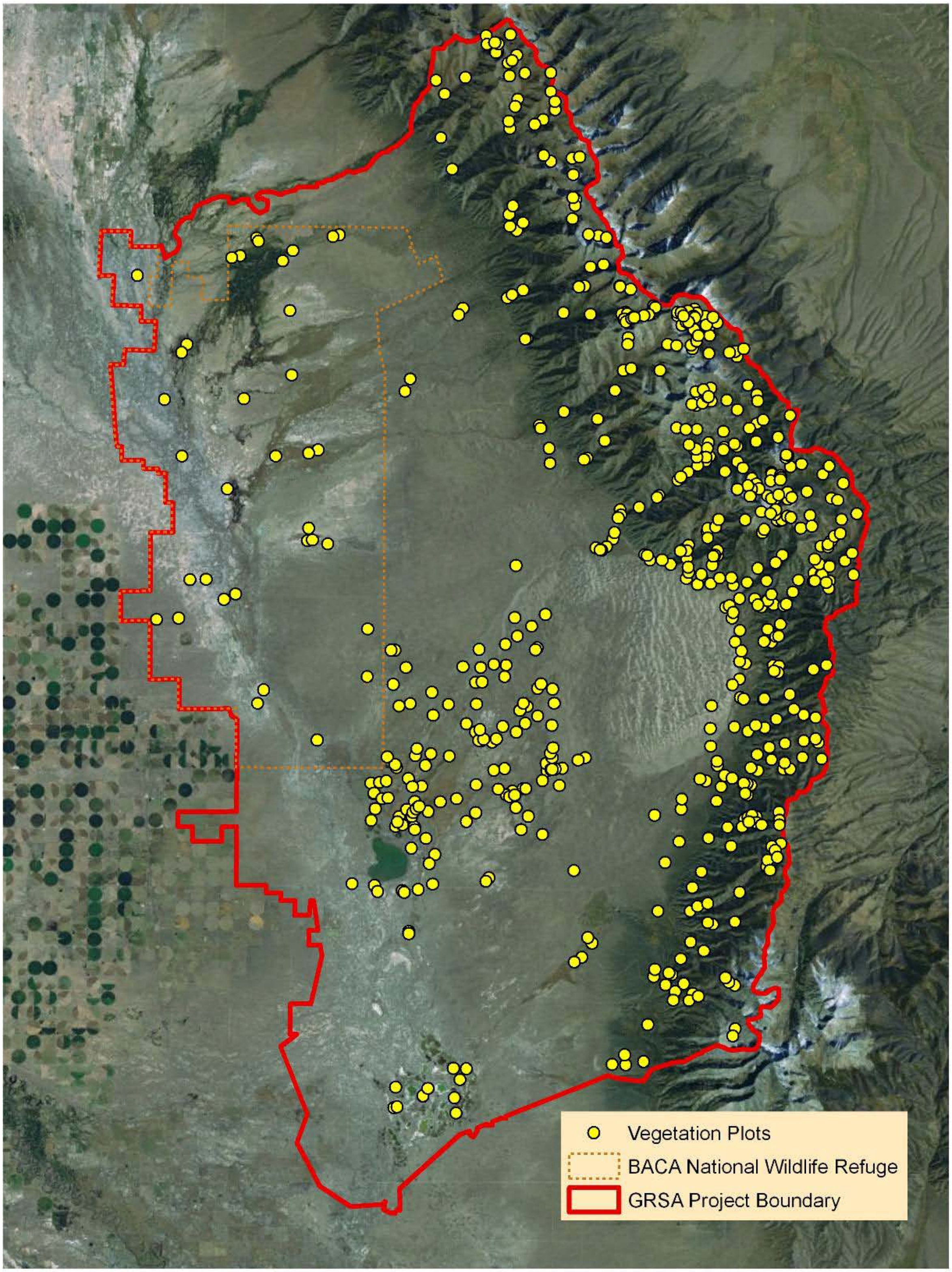

Figure 17. Location of vegetation plots collected at GRSA.

Vegetation Alliances and Associations

The vegetation classification work resulted in a total of 176 NVC associations representing 90 alliances. Within the NVC types there were 64 Forest and Woodland types, 35 Shrubland types, 72 Shrub Herbaceous (steppe) and Herbaceous Vegetation types and 5 Sparsely Vegetated types. An additional 22 types were not part of the NVC (1 Provisional association and 21 Park Specials). This final vegetation classification for GRSA is shown in Table 8 below.

Potential New Vegetation Types

In large project areas such as GRSA, it is expected that field crews will locate and sample vegetation types that were not previously described in the National Vegetation Classification (NVC). In the vegetation classification 11% of the vegetation types did not match current concepts of NVC associations. In addition to three new vegetation types with enough data to create new NVC associations, *Pinus aristata* Krummholz Shrubland (CEGL005415), *Pinus flexilis / Festuca arizonica - Muhlenbergia montana* Woodland (CEGL005416), and *Suaeda calceoliformis* Herbaceous Vegetation (CEGL005417), 21 Park Special vegetation types were developed (**Table 8**). A Park Special is a local vegetation type that differ significantly from existing NVC association concepts, but lacks enough data to develop into a new NVC association. Some of these Park Special communities may become NVC associations at a later date, after additional data is collected and classified. However, some of these Park Special vegetation types will likely be subsumed into existing NVC associations. This will happen when funding for an in depth review of community concepts of related NVC associations occurs during the global description writing process.

There were no changes to the GRSA classification resulting from Accuracy Assessment (AA) field work because of the AA methodology change not to collect vegetation data from AA points.

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
Forest and Woodland			
Abies concolor - (Pseudotsuga menziesii) / Jamesia americana - Holodiscus dumosus Scree Woodland	CEGL000890	Abies concolor Woodland Alliance	A.553
Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest	CEGL000255	Abies concolor Forest Alliance	A.152
Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest	CEGL000240	Abies concolor Forest Alliance	A.152
Abies concolor / Betula occidentalis Woodland	Park Special	NA	NA
Abies concolor / Festuca arizonica Woodland	CEGL000887	Abies concolor Woodland Alliance	A.553
Abies concolor / Symphoricarpos oreophilus Forest	CEGL000263	Abies concolor Forest Alliance	A.152
Abies lasiocarpa - Picea engelmannii / Juniperus communis Woodland	CEGL000919	Abies lasiocarpa Woodland Alliance	A.559
Abies lasiocarpa - Picea engelmannii / Mertensia ciliata Forest	CEGL002663	Abies lasiocarpa Temporarily Flooded Forest Alliance	A.177
Abies lasiocarpa - Picea engelmannii / Moss Forest	CEGL000321	Abies lasiocarpa - Picea engelmannii Forest Alliance	A.168
Abies lasiocarpa - Picea engelmannii / Salix drummondiana Forest	CEGL000327	Abies lasiocarpa Seasonally Flooded Forest Alliance	A.190
Abies lasiocarpa - Picea engelmannii / Sparse Understory Forest	Park Special	NA	NA
Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus Forest	CEGL000343	Abies lasiocarpa - Picea engelmannii Forest Alliance	A.168
Abies lasiocarpa / Erigeron eximius Forest	CEGL000310	Abies lasiocarpa - Picea engelmannii Forest Alliance	A.168
Picea engelmannii / Ribes montigenum Forest	CEGL000374	Picea engelmannii Forest Alliance	A.164
Picea engelmannii / Vaccinium myrtillus Forest	CEGL000379	Picea engelmannii Forest Alliance	A.164
Pinus aristata - (Picea engelmannii) / Juniperus communis Woodland	Park Special	NA	NA
Pinus aristata / Festuca arizonica Woodland	CEGL000759	Pinus aristata Woodland Alliance	A.537
Pinus aristata / Festuca thurberi Woodland	CEGL000760	Pinus aristata Woodland Alliance	A.537
Pinus aristata / Ribes montigenum Woodland	CEGL000761	Pinus aristata Woodland Alliance	A.537
Pinus aristata / Vaccinium myrtillus Woodland	CEGL002895	Pinus aristata Woodland Alliance	A.537
Pinus edulis - (Juniperus monosperma) / Bouteloua gracilis Woodland	CEGL002151	Pinus edulis - (Juniperus spp.) Woodland Alliance	A.516
Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland	Park Special	NA	NA
Pinus edulis - Juniperus spp. / Cercocarpus montanus - Mixed Shrubs Woodland	CEGL000780	Pinus edulis - (Juniperus spp.) Woodland Alliance	A.516

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
Pinus edulis / Rockland Woodland	CEGL000794	Pinus edulis - (Juniperus spp.) Woodland Alliance	A.516
Pinus edulis / Sparse Understory Forest	CEGL000795	Pinus edulis Forest Alliance	A.135
Pinus flexilis / Festuca arizonica - Muhlenbergia montana Woodland	CEGL005416	Pinus flexilis Woodland Alliance	A.540
Pinus flexilis / Juniperus communis Woodland	CEGL000807	Pinus flexilis Woodland Alliance	A.540
Pinus ponderosa / (Ericameria nauseosa) / Achnatherum hymenoides Sand Deposit Woodland	CEGL001490	Pinus ponderosa Woodland Alliance	A.530
Pinus ponderosa / Festuca arizonica Woodland	CEGL000856	Pinus ponderosa Woodland Alliance	A.530
Pinus ponderosa / Juniperus scopulorum Woodland	CEGL000861	Pinus ponderosa Woodland Alliance	A.530
Pinus ponderosa / Muhlenbergia montana Woodland	CEGL000862	Pinus ponderosa Woodland Alliance	A.530
Populus angustifolia - Abies concolor / Betula occidentalis Woodland	Park Special	NA	NA
Populus angustifolia - Juniperus scopulorum Woodland	CEGL002640	Populus angustifolia Temporarily Flooded Woodland Alliance	A.641
Populus angustifolia / Alnus incana Woodland	CEGL002642	Populus angustifolia Temporarily Flooded Woodland Alliance	A.641
Populus angustifolia / Betula occidentalis Woodland	CEGL000648	Populus angustifolia Temporarily Flooded Woodland Alliance	A.641
Populus angustifolia / Rhus trilobata Woodland	CEGL000652	Populus angustifolia Temporarily Flooded Woodland Alliance	A.641
Populus angustifolia / Ribes aureum Woodland	Park Special	NA	NA
Populus angustifolia / Salix (monticola, drummondiana, lucida) Woodland	CEGL002645	Populus angustifolia Temporarily Flooded Woodland Alliance	A.641
Populus angustifolia / Salix drummondiana - Acer glabrum Woodland	CEGL002646	Populus angustifolia Temporarily Flooded Woodland Alliance	A.641
Populus angustifolia / Salix exigua Woodland	CEGL000654	Populus angustifolia Temporarily Flooded Woodland Alliance	A.641
Populus angustifolia Sand Dune Forest	CEGL002643	Populus angustifolia Temporarily Flooded Forest Alliance	A.310
Populus tremuloides - Abies concolor / Acer glabrum Forest	Park Special	NA	NA
Populus tremuloides - Abies concolor / Physocarpus monogynus Forest	Park Special	NA	NA
Populus tremuloides - Abies lasiocarpa / Juniperus communis Forest	CEGL000527	Abies lasiocarpa - Populus tremuloides Forest Alliance	A.422

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
Populus tremuloides - Abies lasiocarpa / Shepherdia canadensis Forest	CEGL000529	Abies lasiocarpa - Populus tremuloides Forest Alliance	A.422
Populus tremuloides - Pinus flexilis Forest	CEGL000540	Pinus flexilis - Populus tremuloides Forest Alliance	A.425
Populus tremuloides - Pinus ponderosa Rocky Mountain Forest	CEGL000541	Pinus ponderosa - Populus tremuloides Forest Alliance	A.399
Populus tremuloides - Pseudotsuga menziesii / Juniperus communis Forest	CEGL000545	Populus tremuloides - Pseudotsuga menziesii Forest Alliance	A.426
Populus tremuloides / Acer glabrum Forest	CEGL000563	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Alnus incana Forest	CEGL001150	Populus tremuloides Temporarily Flooded Forest Alliance	A.300
Populus tremuloides / Bromus ciliatus - (Thermopsis spp.) Forest	Park Special	NA	NA
Populus tremuloides / Calamagrostis canadensis Forest	CEGL000574	Populus tremuloides Seasonally Flooded Forest Alliance	A.340
Populus tremuloides / Carex siccata Forest	CEGL000578	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Cornus sericea Forest	CEGL000582	Populus tremuloides Temporarily Flooded Forest Alliance	A.300
Populus tremuloides / Festuca thurberi Forest	CEGL000585	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Hesperostipa comata Forest	CEGL000608	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Juniperus communis Forest	CEGL000587	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Physocarpus monogynus Forest	CEGL005932	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Ribes montigenum Forest	CEGL000600	Populus tremuloides Temporarily Flooded Forest Alliance	A.300
Populus tremuloides / Rosa woodsii Forest	CEGL003149	Populus tremuloides Temporarily Flooded Forest Alliance	A.300
Populus tremuloides / Salix drummondiana Forest	CEGL002902	Populus tremuloides Temporarily Flooded Forest Alliance	A.300
Populus tremuloides / Salix scouleriana Forest	CEGL000604	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Sambucus racemosa Forest	CEGL000605	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Shepherdia canadensis Forest	CEGL000606	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Symphoricarpos oreophilus Forest	CEGL000610	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Thalictrum fendleri Forest	CEGL000619	Populus tremuloides Forest Alliance	A.274
Populus tremuloides / Vaccinium myrtillus Forest	CEGL000620	Populus tremuloides Forest Alliance	A.274
Populus tremuloides Scree Woodland	Park Special	NA	NA
Pseudotsuga menziesii / Bromus ciliatus Forest	CEGL000428	Pseudotsuga menziesii Forest Alliance	A.157
Pseudotsuga menziesii / Cercocarpus montanus Woodland	CEGL000898	Pseudotsuga menziesii Woodland Alliance	A.552

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
Pseudotsuga menziesii / Festuca arizonica Forest	CEGL000433	Pseudotsuga menziesii Forest Alliance	A.157
Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland	CEGL000902	Pseudotsuga menziesii Woodland Alliance	A.552
Pseudotsuga menziesii / Jamesia americana Forest	CEGL000438	Pseudotsuga menziesii Forest Alliance	A.157
Pseudotsuga menziesii / Juniperus communis Forest	CEGL000439	Pseudotsuga menziesii Forest Alliance	A.157
Pseudotsuga menziesii / Symphoricarpos oreophilus Forest	CEGL000462	Pseudotsuga menziesii Forest Alliance	A.157
Shrubland			
Abies concolor - Pseudotsuga menziesii / Jamesia americana Avalanche Chute Shrubland	Park Special	NA	NA
Abies lasiocarpa - Picea engelmannii / Salix (brachycarpa, glauca) Krummholz Shrubland	CEGL000986	Abies lasiocarpa - Picea engelmannii - Pinus (aristata, flexilis) Krummholz Shrubland Alliance	A.811
Abies lasiocarpa - Picea engelmannii Krummholz Shrubland	CEGL000985	Abies lasiocarpa - Picea engelmannii - Pinus (aristata, flexilis) Krummholz Shrubland Alliance	A.811
Alnus incana - Betula occidentalis Shrubland	CEGL001142	Alnus incana Temporarily Flooded Shrubland Alliance	A.950
Alnus incana - Salix drummondiana Shrubland	CEGL002652	Alnus incana Temporarily Flooded Shrubland Alliance	A.950
Atriplex canescens / Achnatherum hymenoides Shrubland	CEGL001289	Atriplex canescens Shrubland Alliance	A.869
Cercocarpus montanus / Muhlenbergia montana Shrubland	CEGL002914	Cercocarpus montanus Shrubland Alliance	A.896
Dasiphora floribunda / Festuca thurberi Subalpine Shrubland	Park Special	NA	NA
Dasiphora fruticosa ssp. floribunda Subalpine Shrubland	CEGL003499	Dasiphora fruticosa ssp. floribunda Temporarily Flooded Shrubland Alliance	A.958
Ericameria nauseosa / Sporobolus airoides Shrubland	CEGL002918	Ericameria nauseosa Shrubland Alliance	A.835
Ericameria nauseosa Sand Deposit Sparse Shrubland	CEGL002980	Ericameria nauseosa Shrubland Alliance	A.835
Ericameria parryi / Achnatherum hymenoides Shrubland	CEGL003751	Ericameria parryi Shrubland Alliance	A.818
Krascheninnikovia lanata / Achnatherum hymenoides Dwarf-shrubland	CEGL001323	Krascheninnikovia lanata Dwarf-shrubland Alliance	A.1104
Paronychia pulvinata - Silene acaulis Dwarf-shrubland	CEGL001976	Paronychia pulvinata Dwarf-shrubland Alliance	A.1085
Pinus aristata Krummholz Shrubland	CEGL005415	Abies lasiocarpa - Picea engelmannii - Pinus (aristata, flexilis) Krummholz Shrubland Alliance	A.811
Prunus virginiana - (Prunus americana) Shrubland	CEGL001108	Prunus virginiana Shrubland Alliance	A.919

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
Rhus trilobata Dune Shrubland	Park Special	NA	NA
Salix brachycarpa / Mesic Forbs Shrubland	CEGL001135	Salix brachycarpa Seasonally Flooded Shrubland Alliance	A.998
Salix drummondiana / Mesic Forbs Shrubland	CEGL001192	Salix drummondiana Temporarily Flooded Shrubland Alliance	A.973
Salix exigua - Salix ligulifolia Shrubland	CEGL002655	Salix (exigua, interior) Temporarily Flooded Shrubland Alliance	A.947
Salix exigua - Salix lucida ssp. caudata Shrubland	CEGL001204	Salix (exigua, interior) Temporarily Flooded Shrubland Alliance	A.947
Salix exigua Dune Shrubland	Park Special	NA	NA
Salix exigua Temporarily Flooded Shrubland	CEGL001197	Salix (exigua, interior) Temporarily Flooded Shrubland Alliance	A.947
Salix monticola / Mesic Forbs Shrubland	CEGL002658	Salix monticola Temporarily Flooded Shrubland Alliance	A.981
Salix nivalis / Geum rossii Dwarf-shrubland	CEGL005936	Salix (reticulata, nivalis) Dwarf-shrubland Alliance	A.1119
Salix planifolia / Calamagrostis canadensis Shrubland	CEGL001225	Salix planifolia Temporarily Flooded Shrubland Alliance	A.982
Salix planifolia / Carex aquatilis Shrubland	CEGL001227	Salix planifolia Seasonally Flooded Shrubland Alliance	A.1008
Salix planifolia / Carex scopulorum Shrubland	CEGL001229	Salix planifolia Seasonally Flooded Shrubland Alliance	A.1008
Salix planifolia / Carex utriculata Shrubland	CEGL005937	Salix planifolia Seasonally Flooded Shrubland Alliance	A.1008
Salix planifolia / Deschampsia caespitosa Shrubland	CEGL001230	Salix planifolia Temporarily Flooded Shrubland Alliance	A.982
Salix planifolia / Mesic Forbs Shrubland	CEGL002893	Salix planifolia Seasonally Flooded Shrubland Alliance	A.1008
Sarcobatus vermiculatus / Distichlis spicata Shrubland	CEGL001363	Sarcobatus vermiculatus Intermittently Flooded Shrubland Alliance	A.1046
Sarcobatus vermiculatus / Ericameria nauseosa Shrubland	CEGL001362	Sarcobatus vermiculatus Intermittently Flooded Shrubland Alliance	A.1046
Sarcobatus vermiculatus / Leymus triticoides Shrubland	Park Special	NA	NA
Sarcobatus vermiculatus / Sporobolus airoides Shrubland	CEGL001368	Sarcobatus vermiculatus Intermittently Flooded Shrubland Alliance	A.1046
Sarcobatus vermiculatus Disturbed Shrubland	CEGL001357	Sarcobatus vermiculatus Intermittently Flooded Shrubland Alliance	A.1046
Sarcobatus vermiculatus Dune Shrubland	CEGL001364	Sarcobatus vermiculatus Shrubland Alliance	A.1041

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
Suaeda moquinii Shrubland	CEGL001991	Suaeda moquinii Intermittently Flooded Shrubland Alliance	A.941
Symphoricarpos oreophilus Shrubland	CEGL002951	Symphoricarpos oreophilus Shrubland Alliance	A.2530
Vaccinium (caespitosum, scoparium) Dwarf-shrubland	CEGL001140	Vaccinium (caespitosum, myrtillus, scoparium) Dwarf-shrubland Alliance	A.1114
Herbaceous Vegetation			
Achnatherum hymenoides - Psoralidium lanceolatum Herbaceous Vegetation	CEGL001650	Achnatherum hymenoides Herbaceous Alliance	A.1262
Bouteloua gracilis Herbaceous Vegetation	CEGL001760	Bouteloua gracilis Herbaceous Alliance	A.1282
Cardamine cordifolia - Caltha leptosepala Herbaceous Vegetation	CEGL001958	Cardamine cordifolia Saturated Herbaceous Alliance	A.1699
Cardamine cordifolia - Mertensia ciliata - Senecio triangularis Herbaceous Vegetation	CEGL002662	Cardamine cordifolia Saturated Herbaceous Alliance	A.1699
Carex aquatilis - Pedicularis groenlandica Herbaceous Vegetation	CEGL001804	Carex aquatilis Seasonally Flooded Herbaceous Alliance	A.1404
Carex aquatilis Herbaceous Vegetation	CEGL001802	Carex aquatilis Seasonally Flooded Herbaceous Alliance	A.1404
Carex elynoides - Geum rossii Herbaceous Vegetation	CEGL001853	Carex elynoides Herbaceous Alliance	A.1303
Carex elynoides Herbaceous Vegetation	CEGL001852	Carex elynoides Herbaceous Alliance	A.1303
Carex nebrascensis Herbaceous Vegetation	CEGL001813	Carex nebrascensis Seasonally Flooded Herbaceous Alliance	A.1417
Carex pellita Herbaceous Vegetation	CEGL001809	Carex pellita Seasonally Flooded Herbaceous Alliance	A.1414
Carex praegracilis Herbaceous Vegetation	CEGL002660	Carex praegracilis Seasonally Flooded Herbaceous Alliance	A.1419
Carex rupestris - Geum rossii Herbaceous Vegetation	CEGL001861	Carex rupestris Herbaceous Alliance	A.1307
Carex scopulorum - Caltha leptosepala Herbaceous Vegetation	CEGL001823	Carex scopulorum Seasonally Flooded Herbaceous Alliance	A.1420
Carex scopulorum Herbaceous Vegetation	CEGL001822	Carex scopulorum Seasonally Flooded Herbaceous Alliance	A.1420
Carex siccata - Geum rossii Herbaceous Vegetation	CEGL001808	Carex siccata Herbaceous Alliance	A.1298
Carex simulata Herbaceous Vegetation	CEGL001825	Carex simulata Saturated Herbaceous Alliance	A.1469
Carex utriculata Herbaceous Vegetation	CEGL001562	Carex (rostrata, utriculata) Seasonally Flooded	A.1403

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
		Herbaceous Alliance	
Carex utriculata Perched Wetland Herbaceous Vegetation	CEGL002922	Carex (rostrata, utriculata) Seasonally Flooded Herbaceous Alliance	A.1403
Cirsium scopulorum - Polemonium viscosum Herbaceous Vegetation	CEGL001959	Cirsium scopulorum Herbaceous Alliance	A.1608
Danthonia parryi Herbaceous Vegetation	CEGL001795	Danthonia parryi Herbaceous Alliance	A.1316
Deschampsia caespitosa - Caltha leptosepala Herbaceous Vegetation	CEGL001882	Deschampsia caespitosa Saturated Herbaceous Alliance	A.1456
Deschampsia caespitosa - Carex microptera Herbaceous Vegetation	CEGL001883	Deschampsia caespitosa Seasonally Flooded Herbaceous Alliance	A.1408
Deschampsia caespitosa - Geum rossii Herbaceous Vegetation	CEGL001884	Deschampsia caespitosa Temporarily Flooded Herbaceous Alliance	A.1355
Deschampsia caespitosa Herbaceous Vegetation	CEGL001599	Deschampsia caespitosa Seasonally Flooded Herbaceous Alliance	A.1408
Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation	CEGL001773	Distichlis spicata Intermittently Flooded Herbaceous Alliance	A.1332
Distichlis spicata Herbaceous Vegetation	CEGL001770	Distichlis spicata Intermittently Flooded Herbaceous Alliance	A.1332
Dryas octopetala - Carex rupestris Dwarf-shrub Herbaceous Vegetation	CEGL001892	Dryas octopetala Dwarf-shrub Herbaceous Alliance	A.1577
Dryas octopetala - Carex spp. Dwarf-shrub Herbaceous Vegetation	CEGL001893	Dryas octopetala Dwarf-shrub Herbaceous Alliance	A.1577
Eleocharis acicularis Herbaceous Vegetation	CEGL001832	Eleocharis acicularis Seasonally Flooded Herbaceous Alliance	A.1421
Eleocharis palustris Herbaceous Vegetation	CEGL001833	Eleocharis (palustris, macrostachya) Seasonally Flooded Herbaceous Alliance	A.1422
Ericameria nauseosa / Bouteloua gracilis Shrub Herbaceous Vegetation	CEGL003495	Ericameria nauseosa Shrub Short Herbaceous Alliance	A.1546
Ericameria nauseosa / Muhlenbergia pungens - Achnatherum hymenoides Shrub Herbaceous Vegetation	CEGL002921	Ericameria nauseosa Shrub Short Herbaceous Alliance	A.1546
Festuca arizonica - Muhlenbergia montana Herbaceous Vegetation	CEGL001606	Festuca arizonica Herbaceous Alliance	A.1245
Festuca brachyphylla - Trisetum spicatum Herbaceous Vegetation	CEGL001896	Festuca brachyphylla Herbaceous Alliance	A.1321
Festuca brachyphylla Herbaceous Vegetation	CEGL001797	Festuca brachyphylla Herbaceous Alliance	A.1321
Festuca thurberi Subalpine Grassland Herbaceous Vegetation	CEGL001631	Festuca thurberi Herbaceous Alliance	A.1256

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
Geum rossii - Polygonum bistortoides Herbaceous Vegetation	CEGL001967	Geum rossii Herbaceous Alliance	A.1645
Geum rossii - Sibbaldia procumbens Herbaceous Vegetation	CEGL001969	Geum rossii Herbaceous Alliance	A.1645
Geum rossii Herbaceous Vegetation	CEGL001964	Geum rossii Herbaceous Alliance	A.1645
Glyceria grandis - Schoenoplectus acutus Herbaceous Vegetation [ParkSpecial]	Park Special	NA	NA
Halogeton glomeratus Semi-Natural Herbaceous Vegetation	Park Special	NA	NA
Hesperostipa comata - Achnatherum hymenoides Herbaceous Vegetation	CEGL001703	Hesperostipa comata Bunch Herbaceous Alliance	A.1270
Hippuris vulgaris Herbaceous Vegetation	CEGL003315	Hippuris spp. Permanently Flooded Herbaceous Alliance	A.3540
Hordeum jubatum Herbaceous Vegetation	CEGL001798	Hordeum jubatum Temporarily Flooded Herbaceous Alliance	A.1358
Juncus balticus - Pascopyrum smithii Herbaceous Vegetation	Park Special	NA	NA
Juncus balticus (Iris missouriensis) Mixed Herbaceous Vegetation	Park Special	NA	NA
Juncus balticus Herbaceous Vegetation	CEGL001838	Juncus balticus Seasonally Flooded Herbaceous Alliance	A.1374
Kobresia myosuroides - Geum rossii Herbaceous Vegetation	CEGL001908	Kobresia myosuroides Herbaceous Alliance	A.1326
Minuartia obtusiloba Herbaceous Vegetation	CEGL001919	Minuartia obtusiloba Herbaceous Alliance	A.1630
Muhlenbergia asperifolia Herbaceous Vegetation	CEGL001779	Muhlenbergia asperifolia Intermittently Flooded Herbaceous Alliance	A.1334
Muhlenbergia montana Herbaceous Vegetation	CEGL001646	Muhlenbergia montana Herbaceous Alliance	A.1260
Muhlenbergia pungens Herbaceous Vegetation	CEGL002363	Muhlenbergia pungens Herbaceous Alliance	A.2652
Myriophyllum sibiricum Herbaceous Vegetation	CEGL002000	Myriophyllum sibiricum Permanently Flooded Herbaceous Alliance	A.1761
Pascopyrum smithii Herbaceous Vegetation	CEGL001577	Pascopyrum smithii Herbaceous Alliance	A.1232
Phragmites australis Western North America Temperate Semi-natural Herbaceous Vegetation	CEGL001475	Phragmites australis Semipermanently Flooded Herbaceous Alliance	A.1431
Polygonum amphibium Permanently Flooded Herbaceous Vegetation [Placeholder]	CEGL002002	Polygonum spp. (section Persicaria) Seasonally Flooded Herbaceous Alliance	A.1881
Potamogeton foliosus Herbaceous Vegetation	CEGL002742	Potamogeton foliosus Permanently Flooded Herbaceous Alliance	A.2518
Puccinellia nuttalliana Herbaceous Vegetation	CEGL001799	Puccinellia nuttalliana Intermittently Flooded Herbaceous	A.1335

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
		Alliance	
Ranunculus aquatilis - Callitriche palustris Herbaceous Vegetation	CEGL001984	Ranunculus aquatilis Semipermanently Flooded Herbaceous Alliance	A.1679
Redfieldia flexuosa - (Psoralidium lanceolatum) Herbaceous Vegetation	CEGL002917	Redfieldia flexuosa Herbaceous Alliance	A.2505
Rhus trilobata Rocky Mountain Shrub Herbaceous Vegetation	CEGL002910	Rhus trilobata Shrub Herbaceous Alliance	A.1537
Rorippa palustris Herbaceous Vegetation	Park Special	NA	NA
Salicornia rubra Herbaceous Vegetation	CEGL001999	Salicornia rubra Seasonally Flooded Herbaceous Alliance	A.1818
Salsola spp. Herbaceous Vegetation [Provisional]	CEGL004004	NA	NA
Schoenoplectus acutus Herbaceous Vegetation	CEGL001840	Schoenoplectus acutus - (Schoenoplectus tabernaemontani) Semipermanently Flooded Herbaceous Alliance	A.1443
Schoenoplectus americanus - Carex spp. Herbaceous Vegetation	CEGL004144	Schoenoplectus americanus Semipermanently Flooded Herbaceous Alliance	A.1432
Schoenoplectus americanus - Eleocharis palustris Herbaceous Vegetation	CEGL001585	Schoenoplectus americanus Semipermanently Flooded Herbaceous Alliance	A.1432
Schoenoplectus americanus Western Herbaceous Vegetation	CEGL001841	Schoenoplectus americanus Semipermanently Flooded Herbaceous Alliance	A.1432
Schoenoplectus maritimus Herbaceous Vegetation	CEGL001843	Schoenoplectus maritimus Semipermanently Flooded Herbaceous Alliance	A.1444
Sibbaldia procumbens - Polygonum bistortoides Herbaceous Vegetation	CEGL001933	Sibbaldia procumbens Herbaceous Alliance	A.1635
Sparganium eurycarpum Herbaceous Vegetation	CEGL003323	Sparganium eurycarpum Permanently Flooded Herbaceous Alliance	A.2598
Spartina gracilis Herbaceous Vegetation	CEGL001588	Spartina gracilis Seasonally Flooded Herbaceous Alliance	A.1407
Sporobolus airoides - Distichlis spicata Herbaceous Vegetation	CEGL001687	Sporobolus airoides Intermittently Flooded Herbaceous Alliance	A.1331
Sporobolus airoides Monotype Herbaceous Vegetation	CEGL001688	Sporobolus airoides Herbaceous Alliance	A.1267
Suaeda calceoliformis Herbaceous Vegetation	CEGL005417	Suaeda calceoliformis Intermittently Flooded Herbaceous Alliance	A.2689
Trifolium nanum Herbaceous Vegetation	CEGL005939	Trifolium (dasyphyllum, nanum) Herbaceous Alliance	A.1637
Typha (latifolia, angustifolia) Western Herbaceous Vegetation	CEGL002010	Typha (angustifolia, latifolia) - (Schoenoplectus spp.)	A.1436

Table 8. Classified Plant Associations and Alliances for GRSA, arranged by physiognomic group.

GLOBAL_NAME	ELCODE	ALLIANCE_NAME	A_KEY
		Semipermanently Flooded Herbaceous Alliance	
Typha domingensis Western Herbaceous Vegetation	CEGL001845	Typha domingensis Seasonally Flooded Temperate Herbaceous Alliance	A.1392
Sparse Vegetation			
Aquilegia caerulea - Cirsium scopulorum Scree Sparse Vegetation	CEGL001938	Aquilegia (caerulea, flavescens) Sparsely Vegetated Alliance	A.1603
Holodiscus dumosus Rock Outcrop Sparse Vegetation	CEGL002801	Rock Outcrop Sparsely Vegetated Alliance	A.1838
Sarcobatus vermiculatus / Juncus balticus Sparse Vegetation	CEGL002919	Sarcobatus vermiculatus Intermittently Flooded Sparsely Vegetated Alliance	A.1877
Saxifraga bronchialis Scree Slope Sparse Vegetation	CEGL005902	Saxifraga bronchialis Sparsely Vegetated Alliance	A.2635
Senecio atratus - Cirsium scopulorum Herbaceous Rockland	Park Special	NA	NA

Note: CEGL codes are assigned by NatureServe to track NVC associations within their databases. Park Specials are not part of the NVC and therefore do not have a CEGL code.

Photographic Database

The photographic dataset collected in documenting the vegetation plots in 2005 and 2006, and the AA points in 2008 includes approximately 8,000 digital photographs. The photos collected at the vegetation plot sites typically include four photos per plot (one taken on each cardinal direction) and totals approximately 3,200 frames. The photos taken in 2008 in conjunction with the AA point sampling typically include 4 photos taken on the cardinal directions and total 5,000 frames.

All photos were post processed using GeoSpatialExpert Inc.'s GPS Photo-Link software to create a spatial reference to the photo location and to attach a banner of pertinent information to the front of the photo. The Photo-Link software was also used to produce an ESRI shapefile of the sample locations with thumbnail photos and hotlinks to all of the post processed photos. Figure 18 shows a representative example of the post processed photos. The dataset of digital photos has been provided for integration into a database and map that will allow users to easily query and display the photos.

Figure 18. Example of post-processed project photo.

Vegetation Map

A total of 167,148 ha (413,031 acres) were classified and mapped. This effort was created by combining two separate but coordinated mapping teams. The USFWS created the vegetation map for the Baca NWR which represents 37,446 ha (92,530 ac) of the entire project area. The remaining 129,702 ha (320,501 ac) was mapped by an alliance of the Colorado Natural Heritage Program, NatureServe, USGS, and BOR.

The mapped area includes native and non-native vegetation associations, alliances, natural and man-made features, and unvegetated or sparsely vegetated map classes. Fifty-eight map classes were used to describe the landscape. Of all the map classes, the most frequently occurring within the entire mapping area was Greasewood Flat Shrubland and Steppe Alliances (map class15) with 1,576 polygons ranging in size from 0.1 acres to 10,455 acres. The most abundant map class was Sandsheet Rabbitbrush Shrubland and Steppe Alliances (map class 45), covering 120,469 acres or about 29% of the project area. Spatial statistics for each of the map classes are listed in **Table 9**. There were a total of 14,139 polygons with a size range from less than 0.1 acres to 51,482 acres with the mean polygon size of 32.6 acres.

In addition to the vegetation codes that describe each polygon, there is a physiognomic code that allows one to simplify the entire map down to herbaceous, herbaceous wetland, shrub, tree, treed wetland, and bare ground. Additional codes include mean polygon values for vegetation density, elevation, and slope. Values for acres and hectares are also included.

Physiognomic codes for each map class are self evident. Mean values for vegetation density, elevation, and slope were determined using the “Zonal Statistics” tool in the “Spatial Analyst” extension in ArcMap. Vegetation densities were determined using two different methods. Areas in the eastern portion of the project area in the mountains were analyzed using Model Maker (Erdas Imagine software) using slope, aspect, and spectral thresholds from PCA band 1. The processes are described in greater detail in Appendix G. The flatlands received a density classification using a “tasseled cap” analysis of Landsat Thematic Mapper imagery as a proxy for a vegetation density value. The mean values for each polygon were determined using the same “Zonal Statistics” tool described above for other polygon values. These densities are “binned” into four classes; 0-9 percent, 10-24 percent, 25-60 percent, and 61-100 percent) as specified by the Northern Colorado Plateau Network (NCPN).

Table 9. Spatial statistics for map units.

Map Unit No.	Map Unit Name	Frequency	Acres				Hectares			
			Min	Max	Mean	Sum	Min	Max	Mean	Sum
2	Aspen Forest Alliances	503	1.2	675.9	19.6	9877.1	0.5	273.5	7.9	3997.1
3	Aspen - Limber Pine Forest Alliance	49	1.3	75.3	13.4	658.1	0.5	30.5	5.4	266.3
5	Barren Sand Dune	235	1.3	15091.9	74.0	17390.8	0.5	6107.5	29.9	7037.8
7	Cattail Herbaceous Alliances	62	0.5	95.2	6.1	377.2	0.2	38.5	2.5	152.7
8	Chained Pinyon-Juniper Areas	1	692.2	692.2	692.2	692.2	280.1	280.1	280.1	280.1
9	Coyote Willow Temporarily Flooded Shrubland Alliances	30	0.3	25.0	3.1	94.1	0.1	10.1	1.3	38.1
11	White Fir - Douglas-fir Forest and Woodland Alliances	528	1.2	493.3	21.4	11305.3	0.5	199.6	8.7	4575.1
12	Fourwing Saltbush Shrubland Alliance	3	1.5	2.8	2.0	5.9	0.6	1.1	0.8	2.4
13	Greasewood Sand Deposit Shrubland and Steppe Alliances	877	0.7	2485.0	24.2	21184.9	0.3	1005.7	9.8	8573.2
14	Alluvial Flat Herbaceous Alliances	1001	0.0	569.6	10.3	10322.4	0.0	230.5	4.2	4177.3
15	Greasewood Flat Shrubland and Steppe Alliances	1576	0.1	10455.1	38.0	59922.1	0.0	4231.0	15.4	24249.6
17	Herbaceous Stabilized Dune and Sandsheet Alliances	927	0.0	2845.4	14.1	13046.6	0.0	1151.5	5.7	5279.8
18	Montane – Foothill Dry - Mesic Shrubland Alliances	238	1.2	116.0	13.5	3216.1	0.5	47.0	5.5	1301.5
20	Interdunal Swale Wetland Alliances	21	0.0	18.6	3.8	80.0	0.0	7.5	1.5	32.4
21	San Luis Valley Mesic Meadow Alliances	523	0.0	5207.9	34.6	18077.5	0.0	2107.5	14.0	7315.7
22	Playa Alliances	510	0.0	4107.4	20.0	10187.1	0.0	1662.2	8.1	4122.6
23	Wash	86	1.2	464.9	10.8	928.0	0.5	188.1	4.4	375.5
24	Montane-Lower Subalpine Wetland Alliances	26	0.7	52.2	5.4	141.2	0.3	21.1	2.2	57.2
25	Mountain Mahogany Shrubland Alliance	61	0.6	120.7	11.3	690.1	0.3	48.8	4.6	279.3
26	Narrowleaf Cottonwood Sand Dune Woodland Association	64	0.0	34.3	3.7	238.0	0.0	13.9	1.5	96.3
27	Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance	197	1.2	157.6	14.1	2773.3	0.5	63.8	5.7	1122.3
28	Emergent Marsh Alliances	151	0.5	496.7	12.8	1939.7	0.2	201.0	5.2	785.0
30	Piedmont Semi-Desert Grassland Alliances	200	1.3	1174.2	29.8	5956.2	0.5	475.2	12.1	2410.4
31	Pinyon Pine / Rockland Woodland Association	90	1.3	240.0	14.5	1306.5	0.5	97.1	5.9	528.7
32	Pinyon Pine Woodland with Herbaceous or Sparse Understory	870	1.3	2823.1	26.7	23234.4	0.5	1142.4	10.8	9402.6
33	Ponderosa Pine - Aspen Forest Alliance	15	1.4	43.4	11.2	167.4	0.6	17.6	4.5	67.8
34	Ponderosa Pine Sand Ramp Woodland	28	1.4	215.9	22.1	618.5	0.6	87.4	8.9	250.3
35	Alpine Bedrock and Scree	469	1.2	1181.0	26.9	12598.6	0.5	477.9	10.9	5098.5
36	Alpine Fell-Field Alliances	144	1.2	390.8	30.2	4344.1	0.5	158.2	12.2	1758.0
37	Cliff, Canyon and Massive Bedrock	361	1.2	49.5	4.8	1714.7	0.5	20.0	1.9	693.9
38	Alpine Turf Alliances	308	1.3	402.2	23.3	7162.9	0.5	162.8	9.4	2898.7

Table 9. Spatial statistics for map units.

Map Unit No.	Map Unit Name	Frequency	Acres Min	Acres Max	Acres Mean	Acres Sum	Hectares Min	Hectares Max	Hectares Mean	Hectares Sum
41	Subalpine Spruce-Fir Forest and Woodland Alliances	503	1.2	1187.1	35.4	17813.2	0.5	480.4	14.3	7208.8
42	Subalpine-Montane Limber-Bristlecone Pine Woodland Alliances	431	1.2	235.8	13.0	5582.5	0.5	95.4	5.2	2259.2
43	Subalpine -Montane Lowland and Riparian Forest Alliances	90	1.4	73.9	13.2	1187.3	0.6	29.9	5.3	480.5
44	Subalpine-Alpine Riparian Shrubland Alliances	55	0.8	56.0	9.4	515.7	0.3	22.7	3.8	208.7
45	Sandsheet Rabbitbrush Shrubland and Steppe Alliances	911	0.0	51482.8	132.2	120468.8	0.0	20834.3	53.5	48752.0
46	Montane-Subalpine Grassland Alliances	463	1.2	119.6	7.0	3250.6	0.5	48.4	2.8	1315.5
48	Ponderosa Pine Woodland with Shrub Understory	56	1.5	214.0	13.1	731.8	0.6	86.6	5.3	296.2
49	Ponderosa Pine Woodland with Herbaceous Understory	29	1.2	26.1	6.0	174.4	0.5	10.5	2.4	70.6
50	Subalpine Fir (Engelmann Spruce) - Aspen Forest Alliances	250	1.3	373.6	22.9	5724.6	0.5	151.2	9.3	2316.7
51	Subalpine Fir - Engelmann Spruce – Bristlecone Pine - Limber Pine Krummholz	95	1.3	99.7	9.4	892.3	0.5	40.3	3.8	361.1
53	White Fir - Mixed Deciduous Lowland Forest Alliances	46	1.6	55.4	13.4	615.4	0.6	22.4	5.4	249.0
55	Winterfat Dwarf-shrubland Alliance	11	0.6	20.8	5.4	59.5	0.2	8.4	2.2	24.1
56	Avalanche Chute Shrubland	84	1.2	30.8	6.5	546.9	0.5	12.5	2.6	221.3
57	Alpine Willow (Spruce) Shrubland Alliances	79	0.5	109.9	10.2	804.5	0.2	44.5	4.1	325.6
59	Invasive Forbland	61	0.0	404.0	22.0	1343.0	0.0	163.5	8.9	543.5
60	Pinyon-Juniper Woodland with Shrub Understory	220	1.2	554.8	19.8	4357.4	0.5	224.5	8.0	1763.4
61	Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances	49	1.3	270.1	16.7	818.7	0.5	109.3	6.8	331.3
63	Aspen - Douglas Fir (White Fir) Upland Forest Alliances	106	1.3	211.4	21.0	2225.1	0.5	85.6	8.5	900.5
64	Alpine - Upper Subalpine Herbaceous Wetland Alliances	83	1.3	153.5	11.5	956.7	0.5	62.1	4.7	387.2
65	Montane Riparian Shrubland Alliances	8	1.4	84.6	16.6	132.9	0.6	34.3	6.7	53.8
66	Urban Semi-industrial	37	1.2	21.3	3.8	139.1	0.5	8.6	1.5	56.3
67	Farmlands	6	6.6	224.6	102.4	614.5	2.7	90.9	41.4	248.7
68	Urban Residential	46	1.3	12.6	3.8	173.6	0.5	5.1	1.5	70.2
69	Roads	17	0.6	431.9	68.6	1166.3	0.3	174.8	27.8	472.0
70	Water	132	0.1	1173.2	21.1	2778.7	0.0	474.8	8.5	1124.5
71	Other	7	2.5	93.9	27.0	189.1	1.0	38.0	10.9	76.5
101	Snow	156	0.5	41.1	3.1	477.7	0.2	16.6	1.2	193.3

Accuracy Assessment

We performed a fuzzy accuracy assessment on the digital thematic map for GRSA. A fuzzy class was only analyzed using a contingency table for the top three fuzzy classes that are considered "correct". The overall map accuracies for each of the fuzzy classes are outlined in **Table 10** and include a 90% confidence interval and Kappa statistic. The contingency tables are too large to include in the body of this report but are attached in a sleeve at the end of the report and are included as a Microsoft Excel data file in the accompanying DVD. Each map class is analyzed in terms of its individual accuracy for omission and commission (producer's error and user's error respectively) for three levels of fuzzy accuracy and includes a 90% confidence interval. A summary table of all map class accuracies for both omission and commission for all fuzzy levels is shown in **Table 10** . Mean errors of omission and commission for each fuzzy level are shown in the last row of tables 11, 12, and 13 and separately in table 14. Individual map class metrics are discussed below.

Table 10. Overall map accuracies.

Overall Accuracy		Confidence Int. (90 %)	Kappa
Fuzzy 5	56.7%	2.1%	54.9%
Fuzzy 4	66.9%	2.0%	66.1%
Fuzzy 3	72.4%	1.9%	72.0%

Contingency tables contain a large quantity of information and are read as follows. The rows represent the predicted value for each of the polygons (the map) and the columns represent the reference or "accuracy assessment point." All correct map values will be summed in the principal diagonal. The sum of the principal diagonal divided by the total number of sample points provides the overall map accuracy. Each map class has its own map accuracy; that is, there are two types of map accuracies to be evaluated. These are errors of omission and commission. These terms are also known as "Producers Accuracy" and "Users Accuracy" respectively. The individual map accuracies metrics also include the total number of samples (n) and a confidence interval with a 90% two-sided limit.

The summary table allows one to see the salient portions of each contingency table. Tables 11, 12, and 13 show the data metrics for each map class, a mean value for each type of error, and a mean value for the confidence interval for each type of error. As expected, the overall accuracy of the map and individual accuracies increase as requirements are relaxed.

Map Class adjustments

A review of the initial accuracy assessment showed that only three map classes failed to meet the mapping standards at fuzzy level 3 using the criteria of reaching program standards if the accuracy falls within the 90% confidence interval. In addition, other map classes may meet standards from a strict perspective but may make sense to combine. The map classes with low accuracy figures include Cliff, Canyon, and Massive Bedrock, Montane – Foothill Shrubland Alliances, and Ponderosa Pine Woodland with Shrub Understory.

The Cliff, Canyon and Massive Bedrock type was sampled with only five points, making it difficult to judge from a statistical perspective. The Ponderosa Pine Woodland with Shrub Understory suffers from a sampling artifact. This type has a very low commission error (high error) of only 12.9%. If we use the digital point AA data to see where the error occurred we see that in one erroneously labeled polygon we have 21 sample points out of a 31 total points. The polygon label should have been Ponderosa Pine Sand Ramp Woodland. The Montane – Foothill Shrubland Alliances are confused with Hillside Oceanspray Shrubland Alliance and the Mountain Mahogany Shrubland Alliance. These three were considered for collapsing into one map class. However, because the Mountain Mahogany Shrubland Alliance is an important indicator of the winter range for deer this map class was maintained separate and the lower accuracies for both error types accepted. The other map classes considered for collapsing were map classes 32 and 47, Pinyon Pine / Sparse Understory Woodland Association and Pinyon Pine Woodland with Herbaceous Understory. These two types are confused with one another and may be reasonably combined. When we started the mapping effort we knew we where going to have trouble with the Subalpine Riparian Forest Alliances as these are often very narrow and intermingle with White Fir – Mixed Deciduous Lowland Forest Alliances. Although the White Fir – Mixed Deciduous Lowland Forest Alliances could stand alone as this accuracy is reasonable, the riparian type suffers greatly by confusion with the lowland type. The Park thought that the Subalpine Riparian Forest Alliances map class was important enough to keep so that map class was maintained as such with no adjustments.

Map Adjustments

After discussions with the Park it was agreed that the following map classes would be collapsed into one another:

The Montane – Foothill Shrubland Alliances and Hillside Oceanspray Shrubland Alliance – map classes 18 and 39 to form Montane – Foothill Dry - Mesic Shrubland Alliances.

Pinyon Pine / Sparse Understory Woodland Association and Pinyon Pine Woodland with Herbaceous Understory – map classes 32 and 47 to form Pinyon Pine Woodland with Herbaceous or Sparse Understory.

Table 11. Summary statistics for errors of omission and commission at fuzzy level 5.

		Producers Error (Omission error)			Users Error (commission error)		
Map Class	Map Class Name	n	% Accurate	confidence interval	n	% Accurate	confidence interval
2	Aspen Forest Alliances	41	63.4%	13.6%	32	81.3%	12.9%
3	Aspen - Limber Pine Forest Alliance	25	56.0%	18.3%	32	43.8%	16.0%
5	Barren Sand Dune	30	96.7%	7.1%	31	93.5%	8.9%
7	Cattail Herbaceous Alliances	12	100.0%	4.2%	27	44.4%	17.6%
8	Chained Pinyon-Juniper Areas	11	100.0%	4.5%	11	100.0%	4.5%
9	Coyote Willow Temporarily Flooded Shrubland Alliances	6	100.0%	8.3%	7	85.7%	28.9%
11	White Fir - Douglas-fir Forest and Woodland Alliances	86	18.6%	7.5%	34	47.1%	15.6%
12	Fourwing Saltbush Shrubland Alliance	1	0.0%	50.0%	5	0.0%	10.0%
13	Greasewood Sand Deposit Shrubland and Steppe Alliances	31	80.6%	13.3%	30	83.3%	12.9%
14	Alluvial Flat Herbaceous Alliances	24	87.5%	13.2%	32	65.6%	15.4%
15	Greasewood Flat Shrubland and Steppe Alliances	49	49.0%	12.8%	33	72.7%	14.3%
17	Herbaceous Stabilized Dune and Sandsheet Alliances	44	63.6%	13.1%	31	90.3%	10.3%
18	Montane – Foothill Dry - Mesic Shrubland Alliances	31	58.1%	16.2%	60	30.0%	10.6%
20	Interdunal Swale Wetland Alliances	11	100.0%	4.5%	13	84.6%	20.3%
21	San Luis Valley Mesic Meadow Alliances	35	71.4%	14.0%	30	83.3%	12.9%
22	Playa Alliances	26	84.6%	13.6%	27	81.5%	14.1%
23	Wash	27	100.0%	1.9%	31	87.1%	11.5%
24	Montane-Lower Subalpine Wetland Alliances	4	75.0%	48.1%	17	17.6%	18.2%
25	Mountain Mahogany Shrubland Alliance	31	48.4%	16.4%	32	46.9%	16.1%
26	Narrowleaf Cottonwood Sand Dune Woodland Association	33	90.9%	9.7%	31	96.8%	6.8%
27	Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance	29	93.1%	9.5%	42	64.3%	13.4%
28	Emergent Marsh Alliances	26	84.6%	13.6%	26	84.6%	13.6%
30	Piedmont Semi-Desert Grassland Alliances	13	100.0%	3.8%	31	41.9%	16.2%
31	Pinyon Pine / Rockland Woodland Association	10	80.0%	25.8%	31	25.8%	14.5%
32	Pinyon Pine Woodland with Herbaceous or Sparse Understory	87	64.4%	9.0%	64	87.5%	7.6%
33	Ponderosa Pine - Aspen Forest Alliance	14	71.4%	23.4%	31	32.3%	15.4%
34	Ponderosa Pine Sand Ramp Woodland	54	55.6%	12.0%	31	96.8%	6.8%
35	Alpine Bedrock and Scree	66	83.3%	8.3%	68	80.9%	8.6%
36	Alpine Fell-Field Alliances	10	70.0%	28.8%	31	22.6%	14.0%

Table 11. Summary statistics for errors of omission and commission at fuzzy level 5.

		Producers Error (Omission error)			Users Error (commission error)		
Map Class	**Map Class Name**	**n**	**% Accurate**	**confidence interval**	**n**	**% Accurate**	**confidence interval**
37	Cliff, Canyon and Massive Bedrock	15	20.0%	20.3%	5	60.0%	46.0%
38	Alpine Turf Alliances	79	34.2%	9.4%	35	77.1%	13.1%
41	Subalpine Spruce-Fir Forest and Woodland Alliances	71	26.8%	9.3%	30	63.3%	16.1%
42	Subalpine-Montane Limber-Bristlecone Pine Woodland Alliance	41	31.7%	13.2%	31	41.9%	16.2%
43	Subalpine Riparian Forest Alliances	4	0.0%	12.5%	20	0.0%	2.5%
44	Subalpine-Alpine Riparian Shrubland Alliances	16	81.3%	19.2%	33	39.4%	15.5%
45	Sandsheet Rabbitbrush Shrubland and Steppe Alliances	73	41.1%	10.2%	31	96.8%	6.8%
46	Montane-Subalpine Grassland Alliances	37	64.9%	14.3%	30	80.0%	13.7%
48	Ponderosa Pine Woodland with Shrub Understory	18	22.2%	18.9%	31	12.9%	11.5%
49	Ponderosa Pine Woodland with Herbaceous Understory	6	50.0%	41.9%	32	9.4%	10.0%
50	Subalpine Fir (Engelmann Spruce) - Aspen Forest Alliance	27	51.9%	17.7%	34	41.2%	15.4%
51	Subalpine Fir - Engelmann Spruce – Bristlecone Pine - Limber Pine Krummholz	23	65.2%	18.5%	30	50.0%	16.7%
53	White Fir – Mixed Deciduous Lowland Forest Alliances	23	0.0%	2.2%	32	0.0%	1.6%
55	Winterfat Dwarf-shrubland Alliance	13	84.6%	20.3%	11	100.0%	4.5%
56	Avalanche Chute Shrubland	15	80.0%	20.3%	32	37.5%	15.6%
57	Alpine Willow (Spruce) Shrubland Alliances	52	46.2%	12.3%	32	75.0%	14.2%
59	Invasive Forbland	35	71.4%	14.0%	32	78.1%	13.6%
60	Pinyon-Juniper Woodland with Shrub Understory	58	19.0%	9.3%	32	34.4%	15.4%
61	Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances	17	17.6%	18.2%	31	9.7%	10.3%
63	Aspen - Douglas Fir (White Fir) Upland Forest Alliances	24	29.2%	17.3%	31	22.6%	14.0%
64	Alpine - Upper Subalpine Herbaceous Wetland Alliances	8	62.5%	34.4%	34	14.7%	11.5%
65	Montane Riparian Shrubland Alliances	2	0.0%	25.0%	14	0.0%	3.6%
	Mean Accuracy		**59.7%**	**15.7%**		**55.2%**	**13.2%**

Table 12. Summary statistics for errors of omission and commission at fuzzy level 4.

		Producers Error (Omission error)			Users Error (commission error)		
Map Unit	**Map Unit Name**	**n**	**% accurate**	**confidence interval**	**n**	**% accurate**	**confidence interval**
2	Aspen Forest Alliances	39	76.9%	12.4%	32	93.8%	8.6%
3	Aspen - Limber Pine Forest Alliance	28	67.9%	16.3%	32	59.4%	15.8%
5	Barren Sand Dune	29	100.0%	1.7%	31	93.5%	8.9%
7	Cattail Herbaceous Alliances	17	100.0%	2.9%	29	58.6%	16.8%
8	Chained Pinyon-Juniper Areas	11	100.0%	4.5%	11	100.0%	4.5%
9	Coyote Willow Temporarily Flooded Shrubland Alliances	6	100.0%	8.3%	7	85.7%	28.9%
11	White Fir - Douglas-fir Forest and Woodland Alliances	78	26.9%	8.9%	34	61.8%	15.2%
12	Fourwing Saltbush Shrubland Alliance	0	n/a	n/a	5	0.0%	10.0%
13	Greasewood Sand Deposit Shrubland and Steppe Alliances	28	92.9%	9.8%	30	86.7%	11.9%
14	Alluvial Flat Herbaceous Alliances	27	92.6%	10.1%	32	78.1%	13.6%
15	Greasewood Flat Shrubland and Steppe Alliances	50	56.0%	12.5%	33	84.8%	11.8%
17	Herbaceous Stabilized Dune and Sandsheet Alliances	42	69.0%	12.9%	31	93.5%	8.9%
18	Montane – Foothill Dry - Mesic Shrubland Alliances	38	76.3%	12.7%	60	48.3%	11.4%
20	Interdunal Swale Wetland Alliances	11	100.0%	4.5%	13	84.6%	20.3%
21	San Luis Valley Mesic Meadow Alliances	29	89.7%	11.0%	30	86.7%	11.9%
22	Playa Alliances	30	80.0%	13.7%	27	88.9%	11.8%
23	Wash	29	100.0%	1.7%	31	93.5%	8.9%
24	Montane-Lower Subalpine Wetland Alliances	5	80.0%	39.4%	17	23.5%	19.9%
25	Mountain Mahogany Shrubland Alliance	34	64.7%	15.0%	32	68.8%	15.0%
26	Narrowleaf Cottonwood Sand Dune Woodland Association	30	100.0%	1.7%	31	96.8%	6.8%
27	Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance	33	93.9%	8.3%	43	72.1%	12.4%
28	Emergent Marsh Alliances	34	91.2%	9.5%	32	96.9%	6.6%
30	Piedmont Semi-Desert Grassland Alliances	28	96.4%	7.6%	31	87.1%	11.5%
31	Pinyon Pine / Rockland Woodland Association	11	90.9%	18.8%	31	32.3%	15.4%
32	Pinyon Pine Woodland with Herbaceous or Sparse Understory	90	67.8%	8.7%	64	95.3%	5.1%
33	Ponderosa Pine - Aspen Forest Alliance	16	81.3%	19.2%	31	41.9%	16.2%
34	Ponderosa Pine Sand Ramp Woodland	52	57.7%	12.2%	31	96.8%	6.8%
35	Alpine Bedrock and Scree	59	84.7%	8.5%	68	73.5%	9.5%
36	Alpine Fell-Field Alliances	15	60.0%	24.1%	31	29.0%	15.0%

Table 12. Summary statistics for errors of omission and commission at fuzzy level 4.

		Producers Error (Omission error)			Users Error (commission error)		
Map Unit	**Map Unit Name**	**n**	**% accurate**	**confidence interval**	**n**	**% accurate**	**confidence interval**
37	Cliff, Canyon and Massive Bedrock	12	25.0%	24.7%	5	60.0%	46.0%
38	Alpine Turf Alliances	78	37.2%	9.6%	35	82.9%	11.9%
41	Subalpine Spruce-Fir Forest and Woodland Alliances	65	32.3%	10.3%	30	70.0%	15.4%
42	Subalpine-Montane Limber-Bristlecone Pine Woodland Alliance	36	44.4%	15.0%	31	51.6%	16.4%
43	Subalpine Riparian Forest Alliances	10	60.0%	30.5%	20	30.0%	19.4%
44	Subalpine-Alpine Riparian Shrubland Alliances	18	88.9%	15.0%	33	48.5%	15.8%
45	Sandsheet Rabbitbrush Shrubland and Steppe Alliances	47	63.8%	12.6%	31	96.8%	6.8%
46	Montane-Subalpine Grassland Alliances	37	67.6%	14.0%	30	83.3%	12.9%
48	Ponderosa Pine Woodland with Shrub Understory	10	40.0%	30.5%	31	12.9%	11.5%
49	Ponderosa Pine Woodland with Herbaceous Understory	17	58.8%	22.6%	32	31.3%	15.0%
50	Subalpine Fir (Engelmann Spruce) - Aspen Forest Alliance	28	60.7%	17.0%	34	50.0%	15.6%
51	Subalpine Fir - Engelmann Spruce – Bristlecone Pine - Limber Pine Krummholz	25	68.0%	17.3%	30	56.7%	16.5%
53	White Fir – Mixed Deciduous Lowland Forest Alliances	27	0.0%	1.9%	32	0.0%	1.6%
55	Winterfat Dwarf-shrubland Alliance	12	91.7%	17.3%	11	100.0%	4.5%
56	Avalanche Chute Shrubland	18	88.9%	15.0%	32	50.0%	16.1%
57	Alpine Willow (Spruce) Shrubland Alliances	51	52.9%	12.5%	32	84.4%	12.1%
59	Invasive Forbland	33	78.8%	13.2%	33	78.8%	13.2%
60	Pinyon-Juniper Woodland with Shrub Understory	51	45.1%	12.4%	32	71.9%	14.6%
61	Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances	26	96.2%	8.1%	31	80.6%	13.3%
63	Aspen - Douglas Fir (White Fir) Upland Forest Alliances	25	48.0%	18.4%	31	38.7%	16.0%
64	Alpine - Upper Subalpine Herbaceous Wetland Alliances	8	75.0%	31.4%	34	17.6%	12.2%
65	Montane Riparian Shrubland Alliances	1	0.0%	50.0%	14	0.0%	3.6%
	Mean Accuracy		**70.4%**	**14.3%**		**64.9%**	**13.1%**

Table 13. Summary statistics for errors of omission and commission at fuzzy level 3.

		Producers Error (Omission error)			Users Error (commission error)		
Map Unit Name	**Map Unit**	**n**	**% accurate**	**confidence interval**	**n**	**% accurate**	**confidence interval**
2	Aspen Forest Alliances	38	81.6%	11.7%	31	100.0%	1.6%
3	Aspen - Limber Pine Forest Alliance	32	81.3%	12.9%	32	81.3%	12.9%
5	Barren Sand Dune	29	100.0%	1.7%	31	93.5%	8.9%
7	Cattail Herbaceous Alliances	17	100.0%	2.9%	29	58.6%	16.8%
8	Chained Pinyon-Juniper Areas	11	100.0%	4.5%	11	100.0%	4.5%
9	Coyote Willow Temporarily Flooded Shrubland Alliances	6	100.0%	8.3%	7	85.7%	28.9%
11	White Fir - Douglas-fir Forest and Woodland Alliances	70	37.1%	10.2%	34	76.5%	13.4%
12	Fourwing Saltbush Shrubland Alliance	0	n/a	n/a	5	0.0%	10.0%
13	Greasewood Sand Deposit Shrubland and Steppe Alliances	28	92.9%	9.8%	30	86.7%	11.9%
14	Alluvial Flat Herbaceous Alliances	28	89.3%	11.4%	32	78.1%	13.6%
15	Greasewood Flat Shrubland and Steppe Alliances	48	58.3%	12.7%	33	84.8%	11.8%
17	Herbaceous Stabilized Dune and Sandsheet Alliances	39	74.4%	12.8%	31	93.5%	8.9%
18	Montane – Foothill Dry - Mesic Shrubland Alliances	40	77.5%	12.1%	59	52.5%	11.5%
20	Interdunal Swale Wetland Alliances	11	100.0%	4.5%	13	84.6%	20.3%
21	San Luis Valley Mesic Meadow Alliances	29	89.7%	11.0%	30	86.7%	11.9%
22	Playa Alliances	32	81.3%	12.9%	27	96.3%	7.8%
23	Wash	28	100.0%	1.8%	30	93.3%	9.2%
24	Montane-Lower Subalpine Wetland Alliances	4	100.0%	12.5%	17	23.5%	19.9%
25	Mountain Mahogany Shrubland Alliance	33	66.7%	15.0%	32	68.8%	15.0%
26	Narrowleaf Cottonwood Sand Dune Woodland Association	31	100.0%	1.6%	31	100.0%	1.6%
27	Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance	35	94.3%	7.9%	43	76.7%	11.8%
28	Emergent Marsh Alliances	34	91.2%	9.5%	32	96.9%	6.6%
30	Piedmont Semi-Desert Grassland Alliances	29	96.6%	7.3%	31	90.3%	10.3%
31	Pinyon Pine / Rockland Woodland Association	10	100.0%	5.0%	31	32.3%	15.4%
32	Pinyon Pine Woodland with Herbaceous or Sparse Understory	81	75.3%	8.5%	64	95.3%	5.1%
33	Ponderosa Pine - Aspen Forest Alliance	21	95.2%	10.0%	31	64.5%	15.7%
34	Ponderosa Pine Sand Ramp Woodland	52	57.7%	12.2%	31	96.8%	6.8%
35	Alpine Bedrock and Scree	58	86.2%	8.3%	68	73.5%	9.5%
36	Alpine Fell-Field Alliances	17	70.6%	21.1%	31	38.7%	16.0%
37	Cliff, Canyon and Massive Bedrock	9	33.3%	31.4%	5	60.0%	46.0%

Table 13. Summary statistics for errors of omission and commission at fuzzy level 3.

		Producers Error (Omission error)			Users Error (commission error)		
Map Unit Name	**Map Unit**	**n**	**% accurate**	**confidence interval**	**n**	**% accurate**	**confidence interval**
38	Alpine Turf Alliances	78	41.0%	9.8%	35	91.4%	9.2%
41	Subalpine Spruce-Fir Forest and Woodland Alliances	56	41.1%	11.7%	30	76.7%	14.4%
42	Subalpine-Montane Limber-Bristlecone Pine Woodland Alliance	38	55.3%	14.6%	31	67.7%	15.4%
43	Subalpine Riparian Forest Alliances	10	60.0%	30.5%	20	30.0%	19.4%
44	Subalpine-Alpine Riparian Shrubland Alliances	20	90.0%	13.5%	33	54.5%	15.8%
45	Sandsheet Rabbitbrush Shrubland and Steppe Alliances	41	73.2%	12.6%	31	96.8%	6.8%
46	Montane-Subalpine Grassland Alliances	33	75.8%	13.8%	30	83.3%	12.9%
48	Ponderosa Pine Woodland with Shrub Understory	9	44.4%	32.8%	31	12.9%	11.5%
49	Ponderosa Pine Woodland with Herbaceous Understory	26	80.8%	14.6%	32	65.6%	15.4%
50	Subalpine Fir (Engelmann Spruce) - Aspen Forest Alliance	34	73.5%	13.9%	34	73.5%	13.9%
51	Subalpine Fir - Engelmann Spruce – Bristlecone Pine - Limber Pine Krummholz	23	73.9%	17.2%	30	56.7%	16.5%
53	White Fir – Mixed Deciduous Lowland Forest Alliances	25	0.0%	2.0%	32	0.0%	1.6%
55	Winterfat Dwarf-shrubland Alliance	12	91.7%	17.3%	11	100.0%	4.5%
56	Avalanche Chute Shrubland	20	90.0%	13.5%	32	56.3%	16.0%
57	Alpine Willow (Spruce) Shrubland Alliances	40	52.5%	14.2%	24	87.5%	13.2%
59	Invasive Forbland	33	78.8%	13.2%	33	78.8%	13.2%
60	Pinyon-Juniper Woodland with Shrub Understory	55	56.4%	11.9%	32	96.9%	6.6%
61	Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances	32	96.9%	6.6%	31	100.0%	1.6%
63	Aspen - Douglas Fir (White Fir) Upland Forest Alliances	26	61.5%	17.6%	31	51.6%	16.4%
64	Alpine - Upper Subalpine Herbaceous Wetland Alliances	8	75.0%	31.4%	33	18.2%	12.6%
65	Montane Riparian Shrubland Alliances	3	100.0%	16.7%	14	21.4%	21.6%
	Mean Accuracy		**76.8%**	**12.4%**		**70.4%**	**12.6%**

Table 14 . Mean errors for Omission and Commission

	Omission	**Commission**
Fuzzy 5	61.80%	55.70%
Fuzzy 4	72.40%	68.20%
Fuzzy 3	79.30%	74.00%

Discussion

NVC Classification

The vegetation of the GRSA project area is very diverse with nearly 200 vegetation associations described. Vegetation types range from semi-desert shrublands, mesic grasslands and emergent wetlands on the valley floor, to foothill woodlands and shrublands, montane and subalpine forests and grasslands, and alpine turf, wetland and sparsely vegetated communities in the steep, rugged mountains that tower over a mile above the San Luis Valley. Existing NVC associations accounted for 87% of the 198 vegetation types classified from data from the 603 plots and 208 observation points collected during 2005 and 2006 field sampling. The NVC vegetation associations had been previously described from other vegetation classification work regionally and locally in the case of the dune types. In addition there were three new NVC vegetation associations developed from the current GRSA vegetation classification effort bringing the total NVC types to 176 or nearly 90% of classification. Over 11% of the vegetation classification was classified as Park Specials, which are local vegetation types that are distinct enough to describe, but lacked enough data to confidently develop into new NVC associations. There was also one provisional type sampled, *Salsola* spp. Herbaceous Vegetation [Provisional]. Some plots and observation points were unclassifiable at the association level because they were thought to be atypical or ecotonal.

A significant number of undescribed vegetation types (3 new NVC and 21 Park Special vegetation types) were found at GRSA. This is because of the limited vegetation sampling in the Sangre de Cristo Range in particular and the project area in general prior to this comprehensive vegetation classification and mapping effort. Several new types were dominated by southern Rocky Mountain species such as bristlecone pine (*Pinus aristata*) and white fir (*Abies concolor*) trees or understory species such as Thurber's fescue (*Festuca thurberi*) and Arizona fescue (*Festuca arizonica*). There are also two new types that are restricted to dune and sandsheet habitats (*Rhus trilobata* Dune Shrubland [ParkSpecial] and *Salix exigua* Dune Shrubland [ParkSpecial]). In addition, the very steep west side of the Sangre de Cristo Range, which constitutes the eastern boundary of the project area, rises over a mile in elevation in a just a few miles horizontally. This extreme elevation gain creates relatively narrow bands between elevation zones and narrow mountain valleys. Riparian areas tend to be narrow and heterogeneous because they lack the broad floodplains that occur in other mountainous areas. There are several new mixed conifer-deciduous forest types and riparian woodlands described which may be a result of mixing of upland trees in riparian habitats. Finally, some introduced species dominated types were described. These non-native (semi-natural) types are important to document for management, but are rarely classified.

There are a relatively high number of Park Specials within the new types. Some of these Park Special communities may become NVC associations at a later date after additional data is collected and classification work is completed. Other Park Special vegetation types may be subsumed into existing NVC associations. This will happen when funding is available for an in-depth review of concepts of related NVC association during the global description writing/review process or when adjustments in NVC global concepts are made as needed.

Global Rarity

National Parks such as GRSA play an important role in the global effort to conserve biological diversity. As an area where management strives to maintain the natural landscape and preserve natural ecological processes, GRSA preserves examples of rare communities and species that outside of Park boundaries are threatened by a wide range of human pressures that diminish biological diversity.

In several ways, the vegetation mapping program contributes to the ability of the Parks to manage their landscapes for conservation of biological diversity. The classification completed for the mapping projects identifies Park vegetation to the association level of the NVC. Associations tracked by the Natural Heritage Programs are listed in the classification for the park. Map classes on the completed vegetation map likely to contain the highest priority of these elements can either be specifically surveyed to verify the presence of a rare community type, or these areas can be managed with consideration of the rare type in mind.

NatureServe and its network of state natural heritage programs, including CNHP, indicate the rarity and degree of imperilment of plant communities and species by assigning state and global conservation status ranks to each (Appendix C). The rank scale ranges from 1 to 5; a rank of 1 indicates critical imperilment due to rarity, endemism, and/or threats, while a rank of 5 indicates little or no risk of extirpation of the plant community or species. The plot and AA data collected for the vegetation mapping project specifically identified some occurrences of tracked elements within the Park. Plots that are classified to a tracked element have been converted to an element occurrence using a generalized method to assign an element occurrence rank. These interpreted occurrences include both species identified on the plot species lists as well as community elements identified when the plot was classified to a specific plant association. Several globally rare communities and species were located within the GRSA project area. These include 18 different G1-G2G3 communities and four G2-G2G3 plant species. The rarest community elements identified from the plot data were several G1 and G2 Ranked associations. In total, 10 G1G2-G2G3 community element occurrences were identified from the plot data.

The rarest vascular plant species identified from the plot data were the G2 ranked *Draba smithii* and *D. grayana*. Other important vascular plant elements identified in the plot data included *Cleome multicaulis* and *Castilleja puberula* (G2G3). In total, 22 G2-G2G3 vascular plant element occurrences were identified from the plot data.

Table 15 lists the G1-G2G3 ranked plant and community elements identified from the plot data.

Non-native species

A nominal amount of non-native species data were collected and provided to the park separately. The majority of the locations of non-native species were located on the valley floor and adjacent to roads and other developed areas. As described in the Methods section, these data were collected opportunistically as they were encountered in the course of collecting the plot data. A total of 30 weed locations were documented in the project area, representing 5 different species (*Acroptilon repens, Cardaria draba, Cirsium arvense, Lepidium latifolium, Tamarix ramosissima*). There were 12 species on the target list used by the crews.

Table 15. Natural Heritage Elements Identified from Plot Data

ElCode	NVC Association Name	G Rank
CEGL001490	*Pinus ponderosa / Ericameria nauseosa / Achnatherum hymenoides* Sand Deposit Woodland	G1
CEGL002643	*Populus angustifolia* Sand Dune Forest	G1
CEGL002917	*Redfieldia flexuosa* - (*Psoralidium lanceolatum*) Herbaceous Vegetation	G1
CEGL000563	*Populus tremuloides / Acer glabrum* Forest	G1G2
CEGL000255	*Abies concolor* - (*Picea pungens*) - *Populus angustifolia / Acer glabrum* Forest	G2
CEGL000600	*Populus tremuloides / Ribes montigenum* Forest	G2
CEGL001204	*Salix exigua - Salix lucida* ssp. *caudata* Shrubland	G2
CEGL002910	*Rhus trilobata* Rocky Mountain Shrub Herbaceous Vegetation	G2
CEGL001703	*Hesperostipa comata - Achnatherum hymenoides* Herbaceous Vegetation	G2?
CEGL002646	*Populus angustifolia / Salix drummondiana - Acer glabrum* Woodland	G2?
CEGL000540	*Populus tremuloides - Pinus flexilis* Forest	G2G3
CEGL000605	*Populus tremuloides / Sambucus racemosa* Forest	G2G3
CEGL001142	*Alnus incana - Betula occidentalis* Shrubland	G2G3
CEGL001230	*Salix planifolia / Deschampsia caespitosa* Shrubland	G2G3
CEGL001883	*Deschampsia caespitosa - Carex microptera* Herbaceous Vegetation	G2G3
CEGL001999	*Salicornia rubra* Herbaceous Vegetation	G2G3
CEGL002640	*Populus angustifolia - Juniperus scopulorum* Woodland	G2G3
CEGL002655	*Salix exigua - Salix ligulifolia* Shrubland	G2G3

Image-interpretation

The image interpretation and analysis used for this project was more varied than most vegetation mapping projects completed in the past. This was due to the inclusion of a large number of cooperators, each of which has their own expertise and mapping approaches. Line work was developed independently between the USFWS and the rest of the cooperators and both efforts were seamlessly integrated into one product. Both efforts attempted some form of machine logic yet reverted to photointerpretation as the only approach to polygon labeling. Both efforts attempted to map fine levels of detail but eventually had to lump a number of types in order to achieve an acceptable level of accuracy. Both efforts relied heavily on point locations acquired either for vegetation classification or image interpretation. Both teams also spent considerable man hours in the field to familiarize the image interpreters with ground conditions. Although the mapping approaches were slightly different, similar difficulties were encountered in both the use of eCognition and the interpretation of certain classes. For the areas outside of the Baca NWR there were some challenges due to the lack of high resolution infrared imagery. Quickbird imagery did have the infrared band but the resolution was limiting the ability to discern some shrubs. This was ameliorated somewhat in the lowlands area using the USFWS acquired imagery. The linework developed from the Quickbird imagery often needed to be redrawn creating unanticipated extra hours. This was due to the initial image processing with only the NAIP imagery that did not have an infrared band. It was only late in the process that the Quickbird imagery with infrared was included in the analysis but too late to create new linework.

Map Classes

The development of map classes used for this project was an iterative process. After the initial vegetation classification was developed the team put together a number of map classes that seemed reasonable. The decisions were guided by experience gleaned from previous projects, the knowledge of the terrain, and the imagery being made available. As the image interpretation progressed, there were adjustments to the map classes which included adding or removing, renaming, or re-describing classes. After the accuracy assessment phase of this project a re-examination of map classes was necessary given the low accuracy of a few types. Those types needed to be subsumed into similar types and the map classes then needed to be re-named and re-described.

The map classes reflect the both the hierarchy of the NVCS and the fledging efforts to add a new descriptive layer in the NVCS, i.e., the floristically descriptive groups and macrogroups between the Alliance and Formation levels. This level of description is proving to be a more realistic mapping target than either Alliance or Association while at the same time providing considerably more detail than that at the Formation level. The new groups or macrogroups will be made up of existing or new alliances. The vegetated map classes described in this report are groups of alliances that maintain ecological integrity. For a comparison of the how the GRSA Map classes approximate the scale of many new NVCS, version 2 Group Level and NatureServe Ecological Systems, see Appendix B.

Map Accuracy

The use of “fuzzy” techniques to describe the accuracy of thematic maps is a useful if somewhat ambiguous tool. One is forced to interpret the thematic accuracy of a product from multiple perspectives and under a number of caveats. There is no “one” figure to use as an estimate for either overall or individual map class accuracies. It is now standard to couch the results in statistical parlance of confidence intervals and sample sizes. Its use in many thematic products today originates from the recognition that the binary approach of either “right” or “wrong” belies the true nature of most map classes and even the view from the person or persons providing the “reference” data.

The great utility of a fuzzy approach is the acknowledgement of degrees of correctness. Only occasionally do map classes have discrete boundaries; more often grading into one another over distances ranging from a few to hundreds of meters. The necessity of drawing discrete lines representing non-discrete entities requires other than a binary approach.

To evaluate overall and individual map accuracies we used a system for analyzing the data referred to as “Fuzzy Analysis” which allows for varying degrees of accuracy for each map class described in the Methods section of this report. This type of analysis allows for degrees of membership to a particular class. That is, we are allowed to recognize that a particular class may be considered wrong using a strict binary approach but with the fuzzy analysis that class may be mostly correct. This does provide a much better representation of the continuity present in the real world and still allows us to map using discrete classes. In addition, the Vegetation Mapping Program (VMP) recognizes that the 80% level of accuracy may be difficult to achieve. Indeed, the Program Accuracy Assessment Procedures states that “Given that vegetation mapping is necessarily interpretive, it is recommended that relaxed requirements be used in terms of acceptable levels of error as well as confidence levels in the estimate. Otherwise, regardless how carefully the mapping process is carried out, it is unlikely that accuracy requirements will be met".

Map classes are considered adequately mapped if they are above 60% accurate for associations, 70% for alliances and 80% for groups of alliances. In addition, the map classes are considered correct if they fall within the confidence interval. This last point becomes interesting and subject to criticism because a small sample size will necessarily mean a very large confidence interval. Another item to be considered is that often a map class may not meet standards for errors of omission and be well within standards for errors of commission and vice-versa. It is these accuracies, sample sizes, confidence intervals and type of errors that must be subjectively reviewed to see if there is any usefulness to the Park to maintain low accuracy map classes. Where high errors are noted in the table it is often useful to refer to the contingency table to see where the confusion occurs. Confusion errors noted in the contingency tables may make sense and others may be nonsensical. Errors that make sense are those that confuse a mixed conifer type with another conifer type. These errors are typically interpretation errors. Other nonsensical errors such as woodland being confused with a bare ground are typically data transfer error from interpreted photograph or image to digital database. In addition, line work may not have been precise enough and several distinctly different types may have been included within one polygon. Another issue that can only be seen using the contingency table and the digital data is the sampling artifact of many sampling points ending up in one erroneously labeled polygon. An example (Ponderosa Pine Woodland with Shrub Understory) was discussed in the Results section above.

In order to "reach or negotiate" an adequate accuracy level for either map class accuracy or overall accuracy it is often necessary to collapse low accuracy map classes to like types. Often the error found will be with very similar classes which is what one hopes to find. The contingency tables are very helpful in this regard. Difficult to discern types that share errors of omission and commission are usually the likely candidates for collapsing together into one map class. Initial map accuracies for this project were low in some classes and this affected overall map accuracy.

In deciding whether or not a map class meets accuracy standards we also take into consideration the confidence interval for either errors of omission or commission. Indeed, the NBS/NPS Vegetation Mapping Program – Accuracy Assessment Procedures – Final Draft (ESRI and TNC 1994) recognizes the inherent difficulties in assigning accuracies and describes the following program requirements:

- For the NBS/NPS Vegetation Mapping Program, a per-class accuracy statement is required, and ideally each class will meet or exceed 80% accuracy. This accuracy must apply uniformly over the entire project area, and it must be applicable to the minimum level of classification detail represented in the vegetation data (Story 1994).

- As discussed in Section 4.1.1, meeting or exceeding 80% accuracy on a per-class basis will be difficult, because the sample sizes used on a per-class basis will be too low to permit the derivation of a point accuracy estimate with a narrow confidence interval, even for abundant classes. This means that in order to pass a one-tailed hypothesis test, point accuracy estimates must be much higher than the required accuracy. Given the recommendation to decrease sample sizes to as low as 5, the rarest classes would never meet accuracy requirements, because they are expected to have confidence intervals with widths of 30% and more.

- As an alternative, it is recommended that accuracy requirements be defined as being met if the appropriate hypothesis test indicates that estimated accuracy can be considered to be equal to required accuracy. This less stringent requirement is more reasonable, given that sample sizes on a per-class basis are unlikely to increase to much beyond 30 sample points, even for the most abundant classes.

- Although per-class sample size is small, overall sample size should be sufficiently large in most cases to permit accuracy requirements to be more stringent. Therefore, it is recommended that the requirement for 80% or greater accuracy be maintained for the overall classification accuracy.

- A 90% confidence level is recommended for both per-class and overall accuracy.

The contingency tables are too large to be included as part of this report, however, they are included with the deliverables as a separate Excel file for further perusal. A large format plotter is necessary to adequately print and view these files.

For some time now the fuzzy accuracy assessment approach to assessing the quality of the vegetation mapping products has been used within the VMP. The range of values for a number of different parks is remarkably similar. **Table 16** shows the overall map accuracy for nine national parks.

Table 16. Mean fuzzy accuracy values for several national parks.

National Park Unit	Fuzzy 5	Fuzzy 4	Fuzzy 3
Rocky Mountain National Park [1]	50.3%	74.7%	86.7%
Walnut Canyon National Monument [2]	50.0%	69.2%	96.9%
Sunset Crater Volcano National Monument [3]	53.9%	70.3%	86.8%
Wupatki National Monument [4]	59.1%	69.7%	92.2%
Lake Meredith National Recreation Area [5]	60.4%	67.7 %	80.9 %
Grand Teton National Park [6]	65.5%	72.8%	82.4%
Chaco Culture National Historic Park [7]	57.9%	75.7%	79.9%
Bent's Old Fort [8]	47.0%	87.0%	93.0%
This Report	56.9%	67.9%	73.7%
Mean	**55.7%**	**72.8%**	**85.8%**

[1] Salas et al. 2005, [2] Hansen et al. 2004a, [3] Hansen et al. 2004b, [4] Hansen et al. 2004c, [5] Fenton et al. 2007, [6] Cogan et al. 2005, [7] Salas et al. 2007, [8] Stevens et al. 2007.

Recommendations and Usage

The following recommendations for improving the general process of developing a Vegetation Map and updating and using the products from this specific project are provided to facilitate application of the map products and ensure the Park and its partners obtain the greatest possible benefit from the effort. The map products we discuss here include the spatial GIS files as well as the tabular PLOTS database, photograph collections, and the classification including the field keys and the type descriptions.

Improving and Learning

The GRSA vegetation classification and mapping effort was a large and ambitious project, involving multiple federal and other partners. It required the concerted effort of a diverse group of dedicated scientists and resource managers. In any project of this magnitude there are bound to be many lessons learned, both ‘bad’ and ‘good’, that should be documented and applied to future efforts. We summarize the most important examples of these lessons here.

Project Boundary and Stakeholder Involvement

One unique, beneficial and yet challenging aspect of the GRSA project was the project boundary. The boundary we used was an obvious management-driven extension of the park environs. Because the GRSA boundary and most other administrative boundaries nested within the project do not reflect any real ecological processes, they will not always provide the greatest benefit to resource management. In the San Luis Valley the somewhat rare situation exists where land management agencies have over the years developed a collaborative and mutually beneficial approach for managing resources that transcend individual boundaries. This has included development of a spatial unit on the valley floor and into the Sangre de Cristo Mountains designed to capture most relevant processes. We simply adopted this boundary for our project. The collaborative approach to land management in the Valley is largely possible because most of the residents of the Valley are engaged and supportive of these activities. Perhaps the best example of this is the expansion of GRSA into a full National Park in 2000 through addition of the formerly USFS Preserve in the Sangre de Cristo Mountains and the expansion of the sand sheet portion of the park by integration of State Land Board lands and other parcels. Congress and the Bush administration required this to be a locally driven action.

While ideally all NPS Vegetation Mapping Projects would apply a similar approach to defining project boundaries, the associated financial and project management costs will almost always be prohibitive. For the GRSA project we received real in-kind dollars and, more importantly, significant in-kind support that made this approach more feasible. Therefore, we recommend that future projects only pursue similar boundaries where the ownership and management dynamics are similar to those in the San Luis Valley.

The team we created from the core stakeholders in this effort worked well together. The best example of this is the cohesion between the USFWS Baca National Wildlife Refuge and the NPS set of products (see Appendix A for additional lessons learned on the refuge mapping activities). The USFWS, through Mike Artmann, was involved in every stage of the GRSA project. We also had a productive relationship with the USFS. The data layers shared between the NPS and the Forest Service will lead to improved management in Sangre de Cristos, especially when the crosswalk between our map classes and the USFS Region 2 Vegetation System is complete.

Sample Design

Our use of a GRTS design for selecting classification and accuracy assessment points represents a significant improvement over previous methods. Key features of the GRTS design include: (1)

spatial balance, (2) an unbiased variance estimator, (3) (optionally) a "neighborhood" variance estimator with improved precision, (4) valid addition (or replacement) of sites, and (5) (optionally) variable probability sampling across subpopulations and/or explicit stratification. We feel the GRSA project directly benefited from the spatial balance in the design and from our ability to add or replace sites from an oversample that maintained the validity of the design. The design also allowed a valid partitioning of points across NPS and non-NPS boundaries in the project, something that would have been more difficult with other methods. Our sample frame for the classification GRTS design was derived from data that represented actual vegetation types on the ground in greater detail than a purely topographic or coarse land cover frame, which likely improved the representation of vegetation types in the classification data. For both the classification and AA design we also used a realistic cost surface that improved the field operations, and this additional subdivision was readily and validly incorporated into the GRTS design.

The application of GRTS to future projects will require a principal investigator who is familiar with the design approach. Although on the surface GRTS appears more complex than similar methods, recently available tools have greatly contributed to the ease of implementation.

GRTS does require more maintenance and careful attention in the application of a design in the field when compared to a more typical Biophysical Unit based sampling design. These requirements can be addressed via training and by having a well organized field crew chief. More field time is required to travel to a preselected point, in comparison to methods where a target type can be sampled in the most accessible place. Allowing crews to create opportunistic, off-design sample sites was intendec to mitigate this requirement to some extent. GRTS also requires a specific approach to selecting replacement points which may require returning to an area previously sampled, and resulting in a potential reduction in sampling efficiency. Careful trip planning can address this potential redundancy. Finally, the design was useful in getting crews out to sites that represented a greater diversity of habitats than might otherwise have been sampled, especially early in the field season.

We have yet to apply any design-based analyses of the classification or AA data developed from the GRTS design. We plan on developing journal or additional gray literature documents that present inferences of map type extent and accuracy from these designs. This is a very attractive application and test of the theory behind the GRTS design since we will be able to compare the design-based estimates to the purely model-based values presented in this report and the 'truth' in the contiguous map-based data.

Vegetation Classification

The robustness of the vegetation classification is largely dependent on the thoroughness of classification plot sampling. At GRSA no new associations were added based on AA sampling, which is a good indication that sampling of vegetation types was comprehensive. Collection of field data for two consecutive seasons is helpful at larger parks such as GRSA because a preliminary analysis of the first year's data can be used to target missing and undersampled vegetation types and achieve better geographical distribution of sampling points.

The vegetation of the GRSA project area was as diverse as expected, with nearly 200 vegetation associations described. In order to limit project expenses, the total number of classification plot samples was restricted to about 600 with about 200 observation points. Due to the length of preliminary lists of potential associations, we emphasized sampling three to five plots of new vegetation associations and rare types (G1-G3) associations over sampling more widespread (G4-G5) NVC associations. That is, we did not want to over-sample common, well documented associations at the expense of the poorly known associations. In general, this strategy worked well for documenting vegetation diversity at the park, however, crews may have looked too hard for new types, leading them to sample some atypical stands and ecotones that were not classifiable.

As a cost-saving measure, only vegetation classification and local descriptions writing were funded. As a result, the local classification is cross-walked to existing NVC vegetation associations, but the incorporation of the new GRSA field data into the NVC or additional classification review that normally occurs during the writing and revision of the global descriptions was not funded. This may have resulted in a larger than normal number of Park Specials (local types) that will need additional review in the future.

Field Operations

Vegetation classification and mapping is only as good as the field data on which it is based. Therefore, fully supported, well trained, and motivated field crews are critical to the success of these projects. At GRSA, the park staff was aware and fully supportive of this project from the superintendent on down, which is highly motivating to field crews. The park staff was generous with their time and expertise. They helped to train field crews each season and supported crews with housing, office work space, and fostered a sense of community that was greatly appreciated. This type of positive environment encourages field crew members to return for multiple seasons, which helps in the transfer of knowledge and experience and the continuity of methodology between seasons.

CNHP developed the following recommendations to ensure that field crews collect the best data possible. These recommendations are based on experience in management of field crews for boththe ROMO and GRSA vegetation classification and mapping projects:

- Start hiring early. By the end of March most good field botanists have already accepted a position. Advertising for the positions beganin early December, and hiring was essentially complete by the end of February. Make sure your crew members are committed for the entire field season.

- Hire crew members for both botanical and outdoor skills. At GRSA crews had to live and work in the back country for long stretches. If crews lack back-country skills, they are likely to have problems collecting good data.

- Hire an even number of people and have them work in crews of two. A crew of two is typically more efficient than two solo crew members. A two-member crew is also better from a safety standpoint.

- Retain crew members for multiple seasons if possible. This reduces training time and adds consistency to the methodology used during the entire project.

- Support crews with adequate housing, equipment, and supplies. Many crew members arrive from other areas of the country and are without a stable living situation. It may cause proplems for crew morale if they have nowhere to call home between field sessions. Housing should be available to them for the duration of the summer.

- Provide vehicles for field work. Often, the personal vehicles owned by seasonal crew members own are older and less reliable than what is available to government agencies or permanent staff members. Very few permanent staff members would consider using their personal vehicle on a daily basis for field work.

- Provide crews with the tools and supplies needed to complete the required work. Measuring tapes, plot markers, GPS units, cameras, dissecting scopes, field guides, and all incidental supplies (batteries, pens, forms, files, folders) are all necessary and reasonable project costs, and should have been accounted for in the proposal cost estimate.

- Provide crews *per diem* for all field days worked.

- Provide crews with adequate training and orientation, including administrative logistics. Spend the first week or two with them in the field to ensure that all the field methods are understood and being followed.

- Meet regularly with crews to make sure that they are adequately supplied and are following the methodology. Encourage the crews to document anything they encounter or are unsure of by taking extensive notes. These notes are invaluable in the "off-season" for additional interpretation or clarification of field observations.

Mapping

The selection of aerial imagery at the beginning of the project created a number of restrictions that were felt as the line work and image interpretation progressed. Due to funding restrictions only the 3-band color NAIP imagery was used for most of the project area. Although the NAIP imagery was adequate for most purposes, it did not provide the crucial infrared band that would have helped for both the initial line generation and the image interpreation. For example, the infrared band would have helped tremendously in the separation of pure conifer stands from those of mixed conifer and deciduous types. Because the separation of these broad categories was poor, additional editing was required during image interpretation. The infrared band would also have helped in the separation of the Alpine Fell-Field Alliances, Alpine Bedrock and Scree, and Alpine Turf Alliances. Visual interpretation using the NAIP imagery for these high elevation map classes was complicated by the washed-out imagery, shadow, and poor discrimination between types. We did acquire infrared Quickbird imagery later in the project during the image interpretation phase which helped for visual interpretation in these areas, however, the added spectral resolution also generated much more line editing than was originally planned. The

USFWS acquired CIR imagery for the western portion of the project. This imagery was very helpful for the image interpretation for lower elevation map classes.

Map classes were well developed and reasonable at the start of project and most were maintained throughout the interpretation process. Those map classes that were changed or modified were often at the alliance and association level.

Accuracy Assessment

The accuracy assessment sample design will need some adjustments for future work. For those map classes with low frequency, an inordinate number of points often landed in one polygon. This leads to extreme loading of the results to the classification of just one polygon. The map class may be erroneously rated as high inaccuracy if the one polygon happens to be labeled wrong. This anomaly will have to be addressed in future work.

AA field crews sometimes made their calls on areas that were below the minimum mapping unit. Crew training should include admonishments against this practice. Many AA points were reclassified using ancillary information such as AA photographs and nearby vegetation plots. This project used a fuzzy assessment to work through ambiguities in both the accuracy assessment process and mapping / interpretation. Future projects will not use a fuzzy approach.

The GRSA map legend has some broadly defined map classes that include multiple alliances and associations. Having AA field crews key vegetation using both association and map class keys helps clarify which associations occurs within each map classes. It also provides additional information when evaluating an incorrect AA call.

Updating

The products from a Vegetation Mapping effort are intended to be applied to a variety of uses - these projects are very much about creating useful tools and data for the management of resources. However, some of this application may require the Vegetation Mapping data to be updated (or at least the limits from a static data product must be acknowledged in any application). The following brief summaries present select examples of how users might update the data.

PLOTS database

The PLOTS database contains all of the observation point, vegetation plot, fuels plot, and AA point data collected during the project. The database is structured to allow sample locations to be resampled and the data entered using the same plot code with a new date. Together these constitute an “event” and allow the database to track the vegetation sampled at the same location repeatedly through time. This will be valuable for various long-term monitoring efforts such as planned by the Rocky Mountain Network (see below).

As part of the vegetation sampling, field crews collected data on forest fuels at each plot location and entered the data into the PLOTS database. This data can be valuable for evaluating and monitoring fuel loads, modeling fire effects, and modeling potential fire behavior.

Grow the Map Forward

By necessity, the products resulting from the GRSA vegetation inventory are a static representation of a dynamic system. The imagery data that produced the map and the field data used to create other products are based on samples of conditions that existed over the span of only one to two years. Even in the absence of any large scale disturbance event, the map products will gradually become less accurate and useful as succession, erosion, sedimentation, and other natural processes change the composition and distribution of vegetation across the Park. In the event of any large scale disturbances, the map will immediately become inaccurate for some or all areas of the park. In order to maintain the usefulness of the map products, it is desirable to monitor changing vegetation conditions, and update the map over time. Taking the perspective that the map products are an integral part of the park infrastructure to be used and maintained will allow the Park to capitalize on the investment the NPS has made in creating the map and allow the map to function more dynamically than would otherwise be possible. In response to changes that occur in the vegetation, or any differences that are observed between the map and the landscape, it is important to transfer those changes to the map products using the same mapping and classification standards with which the map was created. This will allow the map to be the best possible representation of the real world conditions that exist now and through the future. A record of the changes made to the map should be maintained in a log that documents what the change was, the justification for making it, and the party making the change.

Imagery products are produced on a fairly regular basis that might be used in this effort. These include Landsat satellite imagery as well as the more inexpensive NAIP ortho-imagery as developed on a recurring basis for the project extent. A focused ground-based sampling effort may be the best means to understand the diverse changes due to disturbances and other, more subtle, changes. Funding opportunities should be pursued to focus ground sampling in disturbance-affected areas, to build a stronger knowledge base of post-disturbance vegetation response specific to GRSA and its diverse habitats. These efforts could be prioritized to areas in the park or the project that have known and obvious disturbance such as fires or landslides.

To formalize the update process, the following steps could be followed by NPS or other partners:

- Develop a protocol for updating data that includes update cycle.
- Integrate this process with monitoring efforts, especially to detect more subtle change.
- Adhere to Vegetation Mapping Program standards.
- Define exhaustively the range of disturbance conditions to consider (fire, forest pathogens, avalanche, flooding).
- Integrate process with Fire Management, especially for post-burn monitoring and the Fire Atlas application.
    - Develop attributes to classify high burn severity polygons.

Applications

The following brief summaries present select topical examples of the application of GRSA Vegetation Mapping. This is not an exhaustive list of possible applications of the data; it is likely that many more uses will develop over time.

Vegetation Keys and Descriptions

Several of the associations and map classes are similar enough in composition and naming that it is common to use the wrong name for an association or map class. The key and document providing descriptions of the associations and map classes are indispensible to ensure that the correct association or map class for the type is being used. When selecting an association or map class from the key or a list, the descriptions enable the user to identify specific attributes that define a type and be certain the selected type is correct for the application. It is important that users recognize and implement the key at an appropriate scale. Vegetation varies spatially in an almost fractal nature, and if users attempt to apply the keys to small patches or inclusions within larger units they will rapidly become frustrated. The keys should be used only for patches of more-or-less consistent vegetation that are at least 0.5 ha in size. Moreover, users must take into account the user's accuracy values. The keys will not always be correct (i.e., new types may be found, even if users are viewing the correct patch size, or the sample location may represent a new extreme in the definition of the map classes). The accuracy should be comparable to the values we reported above. If users are attempting to key a type with lower accuracy, this should be integrated into their expectations.

Plot Photos

The collection of plot photos that were taken at each plot location can be a valuable resource for many purposes beyond the vegetation map. Although the plot photos were collected to document the vegetation at the plot location, many of them provide a georeferenced view of the surrounding landscape and can be used to evaluate various aspects of the landscape in the vicinity of the plot locations. For example, when hot-linked to a GIS layer they can provide an instant on-the-ground view at over 2000 sites.

Wetland and Alpine Monitoring

The Rocky Mountain Network (ROMN) is conducting long term monitoring of two key communities at GRSA: wetlands and upland alpine habitats. Data from the Vegetation Mapping project are central in the development of both of these protocols. We used the Vegetation Map as the starting point for the wetland GRTS survey design. Wetlands are notoriously difficult to map and the Vegetation Map was by far the best data layer for the design. We created a sample frame from eight wetland map class types cross-walked to Ecological Systems and National Wetland Inventory map types, intersected with a cost surface. Sites within these patches will be sampled following the ROMN wetland protocol (Schweiger et al. 2010). Where possible, we co-located wetland sites with classification and AA sites from the Vegetation Mapping project.

The ROMN monitoring efforts for alpine vegetation focus on sentinel sites hand-picked from alpine areas at GRSA. Should time and budgets allow, we hope to increase our ability to make park-wide inferences by adding a GRTS survey design component to our monitoring approach and vegetation maps will provide a critical component of this survey approach. As an example, an initial survey design was created for GRSA using the vegetation classifications derived from the vegetation map along with elevation to stratify sampling across the major classes of alpine vegetation (Figure 19).

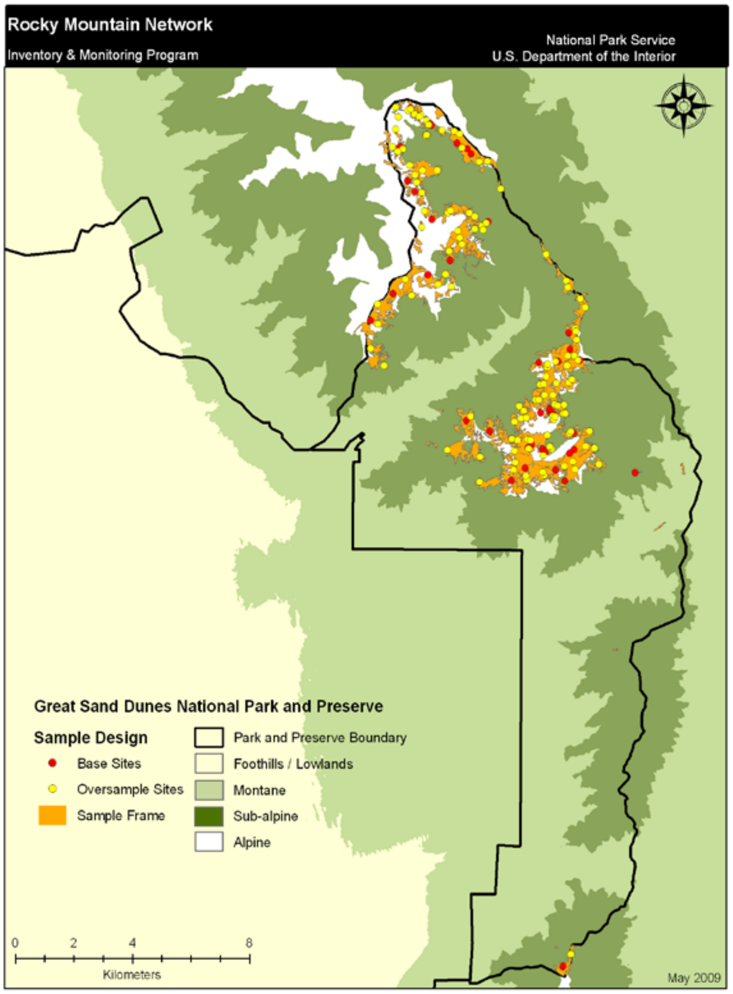

Figure 19. Example of Vegetation Map products applied to a possible survey design for long term monitoring alpine sites at GRSA.

Effects of Climate Change

A key use of the Vegetation Mapping project data will be documenting and monitoring for ecological responses to climate change. Vegetation, both at the species and community level, has been well documented to show a marked response to shifting climate regimes. Perhaps the best known example is the migration of treeline upwards as climate warms or becomes more variable. Quantifying such change using Vegetation Mapping project data will not require a 'redo' of the map in the future. Rather we can simply find key elements of the vegetation in the park and devise a sampling scheme to update just these parts of the map.

Elk Modeling

The Vegetation Map was used by USGS to create an elk and bison carrying capacity model (Wockner et al 2010). Vegetation map classes were condensed down to 13 main types relevant to elk and bison habitat use. Forage (production) values were assigned to types across the GRSA landscape based on empirical data, literature, and regression analyses. Estimated consumption by domestic and other ungulates were subtracted from these patch specific values, generating a residual amount available for elk and bison. Using average consumption values for both bison and elk, a carrying capacity for elk was derived (i.e, how many could survive on the landscape without degrading it) and provided to GRSA and other partners for critical elk management. The most important part of the model was the accurate map provided by the Vegetation Mapping project.

Pika Niche Models and Monitoring

Climate change will alter the distribution of many species, and resource managers need information on the expected rate and magnitude of these changes. Projections based on sentinel species can begin to fill this need. An appropriately conspicuous sentinel species at GRSA is the American pika (*Ochotona princeps*), which faces increasing risk of local extinction due to climate change in the western United States. Although there are major gaps in our understanding of pika distribution, dynamics, and climate sensitivity throughout this region, such gaps can be bridged relatively easily for this species. The ROMN and several partners are developing a research and monitoring protocol for pika that will rely on Vegetation Mapping project data for GRTS design sample frames and pika niche modeling.

Fire

Forest fuels data were collected at each full plot location visited. This fuels data could be used by GRSA personnel to model fire behavior in the park.

Natural Resource Condition Assessment

A natural resource condition assessment (NRCA) is a NPS program designed to generate a spatially explicit multi-disciplinary synthesis of existing scientific data and knowledge, from multiple sources, to help answer the question: what are current conditions for important park natural resources? NRCAs strive to provide a mix of new insights and useful scientific documentation about current resource conditions and some of the factors influencing those conditions (i.e., threats and stressors). A successful NRCA has practical value to park managers for their ongoing efforts to:

- Develop near-term strategies and priorities—given limited park staff and funding, what are some park areas and resources deserving their greatest attention right now;
- Engage in watershed or landscape scale resource partnerships and education efforts;

- Conduct formal planning to describe and quantify desired conditions for their most important resources, and to develop comprehensive strategies for how to best protect/restore those same resources; and

- Report to “resource condition status” performance/accountability measures as instructed by the Department of Interior and the Office of Management and Budget

A NRCA for GRSA is currently underway. It is being conducted by a diverse group of partners (many of whom were involved in the Vegetation Mapping Project) including NPS, NatureServe, and CNHP. Although in early 2010 the project was just beginning, it is clear that the vegetation map and classification of vegetation types within the park will be a core data set for this important effort. For example, the NRCA project for Rocky Mountain National Park (Theobald et al 2009) used the park vegetation map as a core element in seven out of eight indicator classes, including the extent and connectivity of riparian/wetland areas, the extent of exotic terrestrial plants, the extent of fish distributions, the extent of suitable beaver habitat, the connectivity of natural landscapes, and the extent and pattern of major ecological systems. The condition of alpine lakes was the only indicator that did not rely extensively upon the vegetation map. We anticipate that the GRSA vegetation map will play a similar role in the GRSA NRCA.

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Appendix A: Baca National Wildlife Refuge Vegetation Mapping Effort

In Collaboration with the Great Sand Dunes Vegetation Mapping Project

Introduction to USFWS methodology

The Baca National Wildlife Refuge was established in 2003 and is located on the western edge of the Great Sand Dunes National Park. Given the relative paucity of information for the newly established refuge and relatively similar vegetation types, the Service was very interested in working with the National Park Service to map vegetation in this area of the San Luis Valley. Early in the project formation, the Service decided, with the group's concurrence, to take the lead in mapping vegetation within the refuge boundary using the classification developed by the group. The goal of the Service mapping effort was to map vegetation communities to the Alliance level of the National Vegetation Classification System (NVCS) at an 80% accuracy level.

The Service utilized a combination of remote sensing techniques coupled with extensive field data collection and intensive manual photo-interpretation methods to map the vegetation types on the refuge. The Service used eCognition 4.0 software to segment base imagery into image objects which delineated vegetation communities on the ground. Base imagery used by the Service was 0.3 meter color-infrared aerial imagery, re-sampled to 2 meters, collected in June 2006. Field data was collected using Trimble GPS units loaded with ArcPad software in August 2006. Seven field biologists canvassed the refuge over 5 days and collected field data on approximately 2,400 target polygons.

The Service considered using semi-automated classification techniques to label polygons, however in the end, reverted to a more traditional manual photo-interpretation process. Accuracy assessment results, based on >680 polygons, were lower than expected at the Alliance level. To increase accuracy and ensure a seamless product between the two mapping efforts, map classes were rolled up to that of the larger mapping effort. By doing so, accuracy results were significantly improved. A complete summary of the Service's mapping process and a discussion of lessons learned can be found in Appendix A.1.

Introduction to Baca NWR

Authorized in 2000 and established in 2003, the Baca National Wildlife Refuge is one of the largest and most recent additions to the National Wildlife Refuge System. The refuge, located in Saguache and Alamosa counties in the San Luis Valley of south-central Colorado (Figure A1), is approximately 92,500 acres and is managed by the U.S. Fish and Wildlife Service (USFWS or Service). Congress authorized acquisition of land within the refuge with passage of Public Law 106-530, also known as the "Great Sand Dunes National Park and Preserve Act of 2000." This legislation, which received widespread support, focused not only on protecting the region's hydrology, which the incredibly unique sand dunes ecosystem depends upon, but also at protecting the exceptional ecological, cultural, and wildlife resources of the area.

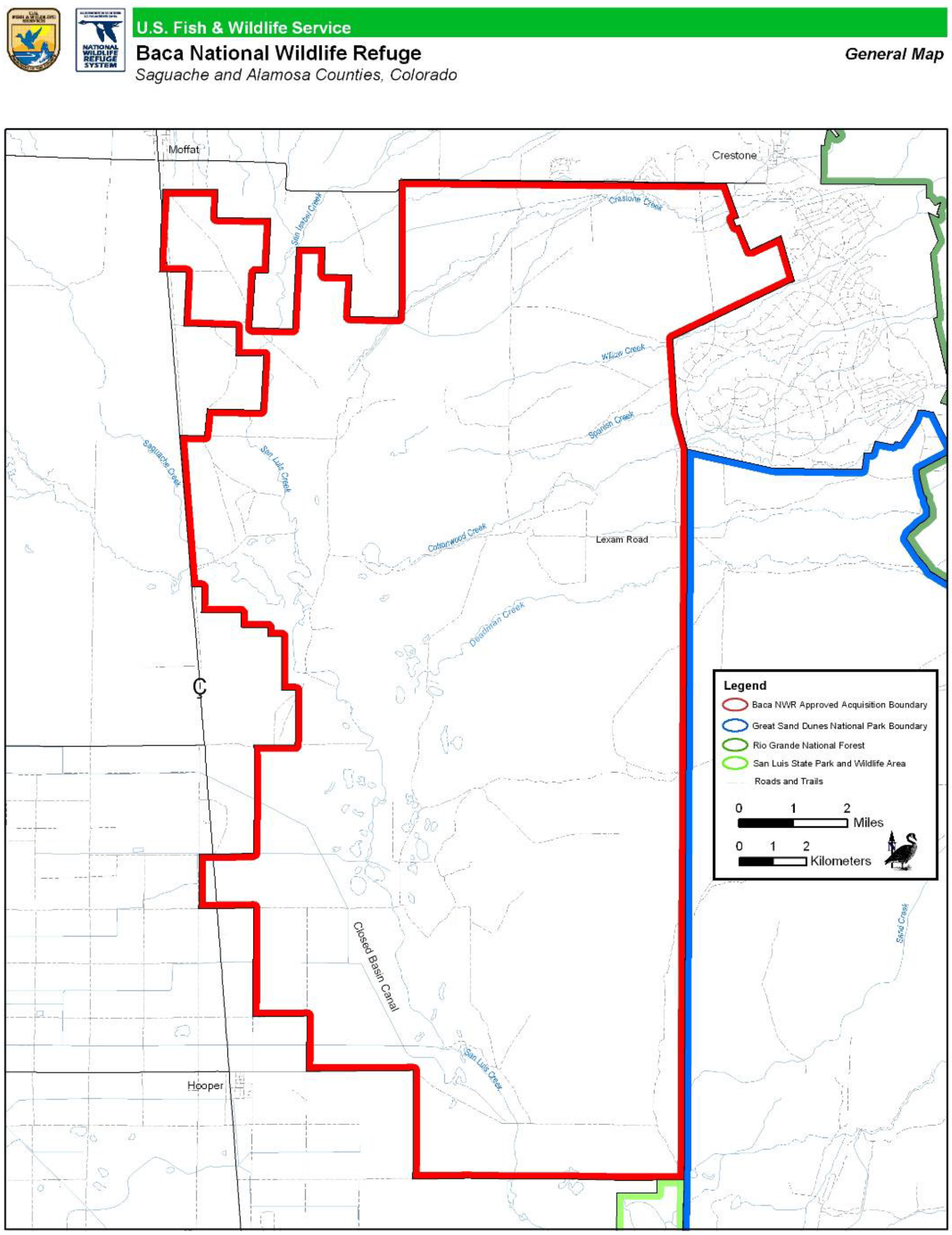


Figure A1. Location of Baca National Wildlife Refuge in southern Colorado.

Situated in the San Luis Valley, a high mountain desert surrounded by two 14,000 foot mountain ranges, the refuge contains a highly diverse suite of habitats including desert shrublands, grasslands, wet meadows, playa wetlands, and riparian areas. Fed largely by melting mountain snow, numerous streams crisscross the refuge providing an abundance of life in an otherwise arid landscape. The refuge is home to a multitude of wildlife and plant species, some of which only occur in the San Luis Valley. Adding to the uniqueness and importance of the refuge is its juxaposition to other conservation lands in the area.

The refuge abuts lands owned or managed by other conservation entities including The Nature Conservancy (TNC), the National Park Service (NPS), the U.S. Forest Service (USFS), Colorado State Land Board (SLB), and Colorado State Parks. This complex of lands, totaling more than 500,000 acres, contains one of the largest and most diverse assemblages of wetland habitats remaining in Colorado. In addition to the incredible plant and animal resources contained on the refuge, the area is also tremendously rich in cultural resource sites, some of which date to over 12,000 years ago. Many of these sites have been added to the National Register of Historic Places.

Agency Coordination on Vegetation Mapping

Given the expansive area managed by conservation interests in this area of the San Luis Valley, there was a desire early in the planning process among the key stakeholders to cooperate wherever and whenever possible. Credit should be given to all involved in pre-planning because a primary goal at the onset was to pursue a collaborative approach to mapping on a larger landscape scale, rather than each entity working in piecemeal fashion. Primary partners in this effort included National Park Service (Billy Schweiger, Rocky Mountain Inventory & Monitoring Network), Colorado Natural Heritage Program (CNHP, Joe Stevens), U.S. Fish and Wildlife Service (Mike Artmann, Region 6 regional office), NatureServe (Keith Schultz, senior ecologist), USGS Rocky Mountain Mapping Center (Beverly Friesen), BOR (Dan Cogan, later David Salas) and The Nature Conservancy (Paul Robertson at Medano-Zapata Ranch). Coordination with Rio Grande National Forest personnel also occurred by NPS project planners later in the process.

Numerous meetings were held to discuss how a joint-project could work, what and how resources could be shared, and applicable time lines for completing the project, among other topics. These meetings began in the winter of 2004, and continued throughout 2005. The project boundary was defined to include the GRSA Park and Preserve, the Baca NWR, the Medano-Zapata Ranch (TNC), and portions of USFS (Rio Grande NF), BLM, State, and other private lands totaling about 413,000 acres (Figure A2).

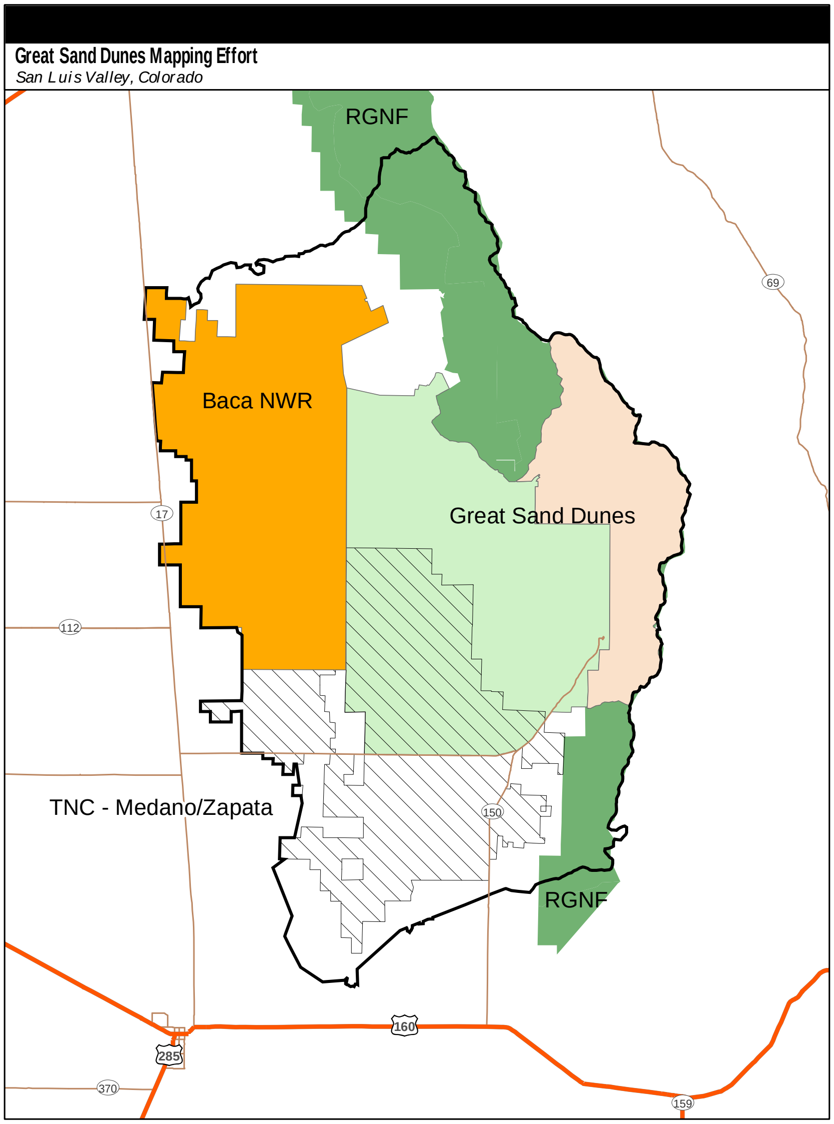


Figure A2. Project area, Baca NWR.

The Service decided in late 2005, in consultation with the group, that it possessed the necessary expertise to map the vegetation communities within the refuge boundary. This decision was based primarily on work already completed at Alamosa and Monte Vista national wildlife refuges in 2004. The work conducted in 2004, and the current effort, was accomplished with significant assistance and guidance from Patrick Donnelly, remote sensing scientist, in the Service' Albuquerque Regional Office.

The group agreed the Service would take the lead on the refuge portion of the project area (about 20% of the area). The Park Service through contracts with USGS, BOR, and CNHP, would take the lead mapping the remainder of the project area. Several reasons factored into the Service decision:

- The Service was compelled to complete the refuge portion of the project as soon as possible, given the need for information at the newly established refuge;
- The Service believed a finer level of mapping (to the Alliance level of National Vegetation Classification System) could be accomplished than proposed by the group;
- The Service believed that mapping techniques being developed and tested at two other refuges in the valley allowed for a rapid approach (eCognition, mobile GIS, ArcGIS) and, as a result, an expedited completion date;
- And finally the Service realized and desired that the mapping efforts between the Service and the partners would be joined at completion into a seamless data set for the whole area.

The classification schema or map classes were developed by the Colorado Natural Heritage Program (CNHP) and NatureServe. The final classification was comprised of 61 map classes. The classification included map classes with an individual alliance (i.e., Blue Spruce Woodland Alliance), groups of alliances (i.e., San Luis Valley Mesic Meadows Alliances), and land use map classes (i.e., open water or farmland). The Service utilized the overall classification scheme, focusing on individual alliances, to classify vegetation on the refuge. The Service offered comments during the classification development.

The Service, in early 2006, coordinated with the NPS to develop an interagency agreement to contract the collection of high-resolution color-infrared (CIR) imagery. This imagery, as described in detail below, was used by the Service as base imagery to map the vegetation, and was one of several data sets used by the partners to map the remainder of the project area. Under the agreement, the Service managed the contract of the flight, and the processing and distribution of the imagery while the NPS provided the funding for the flight. The interagency agreement was signed in April 2006; the flight occurred in June 2006.

Image Acquisition and Processing

As mentioned above, the agreement with NPS was signed April 2006 to fund the acquisition of high-resolution color-infrared imagery over the majority (82%) of the project area (Figure A3). The NPS contributed about $21,300 for this effort. The Service managed the contract, hired the contractor, and processed and distributed the imagery to the partners.

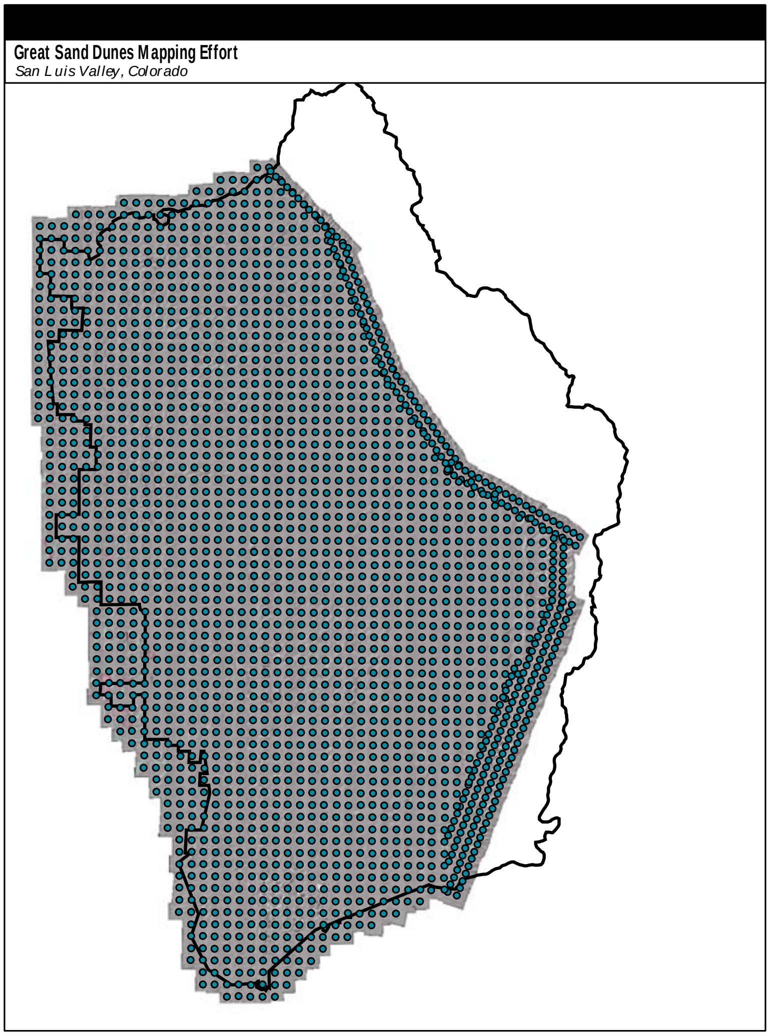


Figure A3. Extent of color-infrared (CIR) imagery collected in June 2006, approximately 82% of study area (dots represent photo centers)"..

Details of CIR imagery

Cornerstone Mapping Inc. (Lincoln NE) collected color-infrared imagery over the study area (below 10,000 ft above mean sea level) from June 10-13, 2006 using a Digital Sensor System (DSS) mounted in a Cessna 182 aircraft. The Applanix DSS is a direct geo-referencing system based on a medium-format, airborne digital camera. Coupled with the DSS were a Track-Air Flight Management System and Applanix POS-401 Inertia Measurement Unit (IMU). The contractor also installed a temporary GPS base station with a Trimble 5700 GPS unit at the Alamosa airport (approximately 20 miles from study area) to enhance the accuracy of the airborne GPS and IMU parameters. The contractor used Applanix POSPac Air post-processing software to process the raw images and to generate the exterior orientation parameters for each image. Imagery was collected between 10am and 2pm to minimize shadowing effects.

Over 384,000 acres (or 82% of project area) were captured during the CIR flights. (Note: the 10,000 foot elevation limit was related to the Cessna 182 aircraft and the 14,000 foot peaks on the east side of the project area in the Sangre de Cristo mountain range. The contractor was not able to fly at a height required to capture useable imagery over the mountains.) The mean upper elevation of imagery captured was 9,932 ft. The Service received the 2,237 raw TIFF files from the contractor on June 25th. Each file was about 50 MB in size. The ground-sample distance was approximately 0.33 m for the valley floor and slightly greater for the foothill areas captured below 10,000 feet.

Color-Balancing

We used ImageEqualizer (IE) within ERDAS Imagine 8.7 software to apply color corrections to each image. All images were loaded into IE by flight date (i.e., day 162). Statistics were calculated for each image and the "recommended" color-balance solution was recorded. We reviewed the color-balance solution parameters for all 4 of the flight dates. We then selected Red, Green, and Blue (RGB) values and standard deviation (brightness) values that best fit all flight dates. We then reran all of the images again through IE by flight date, this time applying the common RGB and standard deviation values. For this project we used the following values: Red--113; Green--108; Blue--103 and STD--12; 18; 14 respectively). The Max Gray shift was set to 40. All other default settings were used.

Ortho-Rectification

After manually checking the unrectified color-balanced images in ArcMap, we used ERDAS LPS 8.7 to generate the orthophotos. We set up 4 block files, one for each flight date. Using the exterior orientation (EO) parameters generated from the integrated GPS/IMU digital camera system, the interior orientation parameters from the camera itself, and a 30m digital elevation model (obtained from National Elevation Dataset website: http://seamless.usgs.gov), we began the orthorectification process for each image. The naming convention was standard -- "orthotifffilename".img. We set the EO parameters to "fixed" and ran the model without adding any ground control points. We used the nearest neighbor setting for the resampling method. All other defaults were used. Images were checked after the process was complete using the swipe tool in ERDAS and/or ArcGIS to test for visual accuracy. Use used both the 2005 NAIP imagery and the USGS DOQ photos as a reference for comparing photos. Linear features such as roads aligned nearly perfect.

Mosaic Process

After the orthophotos were generated for each flight date, all images were brought into ArcGIS and further checked for accuracy. We then used the Mosaic Tool in ERDAS Imagine 8.7 to build the mosiacs, again by flight date. We had issues with the workstation running out of memory when we tried to mosaic >500 images. Thus we built numerous smaller mosaics between 200-400 images and "mosaicked the mosaics" to achieve the final mosaic for the study area. We loaded images using the "load entire image" setting. For all of the individual mosaics we generated Weighted Cutlines using the default parameters. We used a feather by distance with the distance set to 1 m (approximately 3 pixels). No further color-balancing was needed or applied. Each mosaic was visually checked for data gaps and accuracy. Several small data gaps did occur on several occasions. To correct this situation, we brought in the mosaic and the corresponding orthophoto and ran the mosaic again. Some seamlines were visible, but we viewed this as an acceptable product for polygon generation.

To generate the final product, we created a shapefile for each mosaic which we converted to an area of interest (AOI) file for use in ERDAS. We brought the mosaics in using the associated AOI file. This helped visualize the final product and helped to ensure no data gaps would be present. We generated weighted cutlines with the default settings and applied the 1m feather by distance setting.

Image Segmentation and Polygon Generation

We clipped and resampled the imagery (from 0.33 to 2 m) to the refuge boundary to reduce the file size for processing in eCognition 4.0. eCognition, a commercial software developed by Definiens Inc., uses a segmentation algorithm that creates image objects based on 4 criteria: scale, color, smoothness, and compactness. The scale parameter determines the maximum allowed heterogeneity within an object. Varying the scale parameter affects the relative size of the image objects, generally in a linear fashion (e.g., larger the scale factor, larger the mean object size). The color, smoothness, and compactness optimize the homogeneity of an object. The color parameter determines the overall contribution of the spectral information in the segmentation process.

On several small subsets (700-1,000 acres) of imagery containing representative vegetative communities (playas, shrubs, grasslands), we experimented with various values for these parameters to generate appropriately sized and meaningful polygons, as judged from visual inspections. Scale values generally ranged from 40 to 200. After much trial and error, a scale factor of 40 and a color parameter of 0.15 appeared to capture meaningful image objects, although this resulted in over 60,000 polygons within the refuge. The number of polygons was not a concern at the time because the intent was to use semi-automated signature generation procedures within ERDAS to label polygons. (However, as discussed in the Photo-Interpretation and Labeling section below, this plan was altered later in the process).

In areas where cut lines were more obvious due to less than ideal color balancing, we expected eCognition would split polygons partially based on the cut lines, given the slight differences in color. This in fact did occur. Given the tradeoffs and time constraints between re-color balancing and re-mosaicking the imagery, and the minor eCognition line issues, we chose to accept that eCognition created “inaccurate” polygon breaks in small portions of the imagery. We decided it would be more expedient to fix the labeling issues during the photo-interpretation stage of the project. After the image objects were created and visually reviewed, we exported the data in shapefile format and then imported the shapefile into a file geodatabase for use in ArcGIS and field data collection.

Sampling Scheme/Field Data Collection

Sampling Scheme

Early discussions with the refuge manager about diversity of communities on the refuge, the wet meadows were more diverse than the upland shrub and grassland communities. Cursory review of aerial photos appeared to support this assertion. In addition, wetland communities were deemed a higher management priority. To reflect this higher diversity and importance, our intent was to design a sample scheme that selected a higher number of training polygons within wet meadows as compared to upland areas. Areas of monotypic greasewood (with very low diversity), especially west of the Closed Basin Canal, were sampled at an even lower rate.

In designing our sampling methodology, we used a stratified random selection process using coarse strata including playas, wet meadows, and uplands. These strata were delineated on 2004 CIR aerial photographs using heads-up digitizing. We reviewed the expected map classes (in terms of NVC alliances) for the refuge, based on the map classification provided by NatureServe and CNHP. We grouped map classes into one of these three general strata. We multiplied the number of map classes by 65 to arrive at the number of training polygons per strata. This process resulted in approximately 1,800 polygons in wet meadows, 1,000 polygons in playa region, and 400 polygons in uplands. Polygons were randomly selected using Hawths Tools extension within ArcGIS (Figure A4).

Field Data Collection

Eight biologists from two Service regions (Regions 6 and 2) met at the refuge in early August 2006 to conduct the field sampling portion of this effort. Organizers arrived on August 4th to set up base camp, computers, organize field maps, charge and test GPS units, and arrange other logistics. Field biologists, coming from as far as eastern Kansas and southern South Dakota, arrived on Sunday August 6th. Several weeks prior to arriving at the refuge, each biologist received training materials that included expected vegetation classes and the draft classification scheme, plant and community descriptions and photos, and refuge base maps for orientation purposes. General questions were addressed via conference calls prior to arriving in August.

On-site training occurred on the afternoon of August 6th, and the morning of August 7th. Field data collection began late in the day on August 7th. ArcPad training on the basics of filling in digital field forms was provided to those individuals less familiar with these techniques. In addition to the ArcPad training, we spent about a half day in the field as a group to calibrate how individuals recorded and described vegetation communities. This was an attempt to minimize bias among participants in the classification of communities.

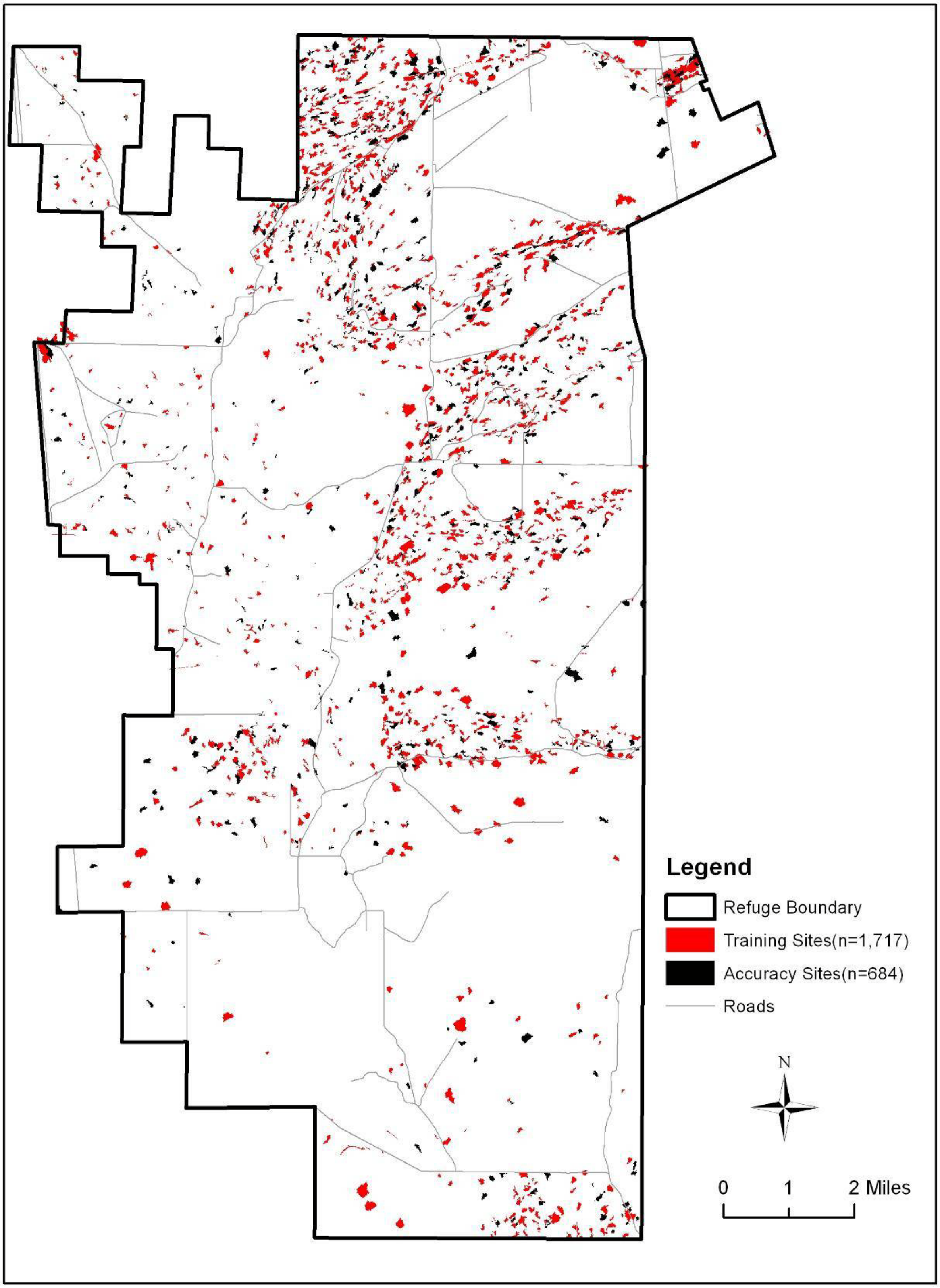


Figure A4. Map showing the distribution of training and accuracy assessment sites collected during field data collection.

All data was collected using Trimble GeoTX GPS receivers loaded with ArcPad 6.03 and digital field forms. The digital field forms included information such as:

- observer name
- date
- expected vegetation communities,
- other associated vegetation (5 fields in database),
- percent cover,
- comment field

Digital field forms were linked to look-up tables (domains within the geodatabase) which provided convenient drop-down menus for the fields mentioned above, except for the comments field. The digital forms and drop down menus were intended to increase consistency, reduce the likelihood of data errors, and increase efficiency in the field. Table A1 lists the full list of vegetation communities/alliances/land use classes loaded into the digital field forms. It was our expectation that not all of these classes occurred on the refuge, however, we wanted to be prepared. The "slv" codes were "refuge specials" created to more adequately capture the vegetation on the ground when an appropriate NVCS alliance was not available. Many of these codes, such as "slv23 *Lepiduim latifolia – Juncus balticus* community", were based on information collected at Monte Vista and Alamosa refuges during 2004.

Table A1. Pre-loaded codes used to record vegetation types during field data collection.

Domain code	**Description**
slv-30	*Agrostis gigantea* Intermittently Flooded Herbaceous Alliance
A.2565	*Artemisia frigida* Dwarf-shrubland Alliance
VII.	Bare ground / sparse vegetation
A.1571	*Bouteloua gracilis* Dwarf-Shrub Herbaceous Alliance
A.1282	*Bouteloua gracilis* Herbaceous Alliance
A.3561	*Bromus inermis* Semi-natural Herbaceous Alliance
A.2594	*Calamagrostis stricta* Temporarily Flooded Herbaceous Alliance
A.1417	*Carex nebrascensis* Seasonally Flooded Herbaceous Alliance
slv-15	*Chenopodium* spp.
slv-14	*Cirsium arvense*
A.1341	*Distichlis spicata* - (*Hordeum jubatum*) Temporarily Flooded Herbaceous Alliance
A.1332	*Distichlis spicata* Intermittently Flooded Herbaceous Alliance
slv-19	*Elaeagnus angustifolia* woodland
A.1422	*Eleocharis palustris* Seasonally Flooded Herbaceous Alliance
slv-25	*Eleocharis* spp. - *Carex* spp. Herbaceous Vegetation
A.835	*Ericameria nauseosa* Shrubland Alliance
A.1270	*Hesperostipa comata* Bunch Herbaceous Alliance
A.1358	*Hordeum jubatum* Temporarily Flooded Herbaceous Alliance
VII.C.4.N.b.	intermittently flooded mud flats (e.g. playa lakes)
A.1374	*Juncus balticus* Seasonally Flooded Herbaceous Alliance
slv-23	*Lepidium latifolium - Juncus balticus* Herbaceous Vegetation
A.1204	*Leymus cinereus* Herbaceous Alliance

Domain code	Description
slv-7	*Medicago* spp.
A.1334	*Muhlenbergia asperifolia* Intermittently Flooded Herbaceous Alliance
VII.C.3.C.b.	Non-agriculture disturbed areas
slv-13	*Oryzopsis hymenoides*
A.1232	*Pascopyrum smithii* Herbaceous Alliance
VII.A.2.N.a.	Pavement with sparse vascular vegetation
A.1381	*Phalaris arundinacea* Seasonally Flooded Herbaceous Alliance
A.641	*Populus angustifolia* Temporarily Flooded Woodland Alliance
A.947	*Salix* (*exigua, interior*) Temporarily Flooded Shrubland Alliance
A.645	*Salix amygdaloides* Temporarily Flooded Woodland Alliance
V.II.C.4.N.a	Sand flats
A.1046	*Sarcobatus vermiculatus* Intermittently Flooded Shrubland Alliance
A.1041	*Sarcobatus vermiculatus* Shrubland Alliance
A.1443	*Schoenoplectus acutus* Semipermanently Flooded Herb. Alliance
A.1432	*Schoenoplectus americanus* Semipermanently Flooded Herbaceous Alliance
A.1433	*Schoenoplectus pungens* Semipermanently Flooded Herbaceous Alliance
A.1267	*Sporobolus airoides* Herbaceous Alliance
water	Water

In addition to collecting dominant species information for each training polygon (i.e., NVCS alliance), we also had the ability to collect up to 5 additional “associated vegetation” or sub-dominant species information with values representing relative abundance (Table A2). The additional species information assisted in sorting out mixed or confusing signatures during the labeling process. We also collected information on invasive species on the refuge. If an invasive species occurred within a target polygon, it was recorded with a relatively abundance value.

Table A2. Codes used during data collection to represent percent cover of dominant plant communities.

Percent Cover	Description
<1%	Scarce
1-10%	Poorly Represented
10-25%	Well Represented
25-60%	Abundant
>60%	Luxuriant

Lodging accommodations were provided at the refuge headquarters on the north end of the refuge near Crestone. Daily work areas (generally 2-4 square miles) were selected for each biologist in the morning. Each biologist had a working hard copy map, hand-held radio, Trimble unit, and digital camera for use in the field. Only those polygons covering the intended work area, and a small buffer, were extracted from the database using the ArcPad Check-Out functionality. The primary reason for doing this was to limit the amount of data stored on each Trimble unit and to reduce the likelihood of duplicating effort.

Additional features such as roads, streams, stream crossings, access points, and refuge boundary information were also loaded on the Trimble units. At the end of each day, data was ‘checked-in” to the master geodatabase and reviewed by the data collector for errors. All GIS work was done using ArcGIS version 9.0. and ArcPad 6.03.

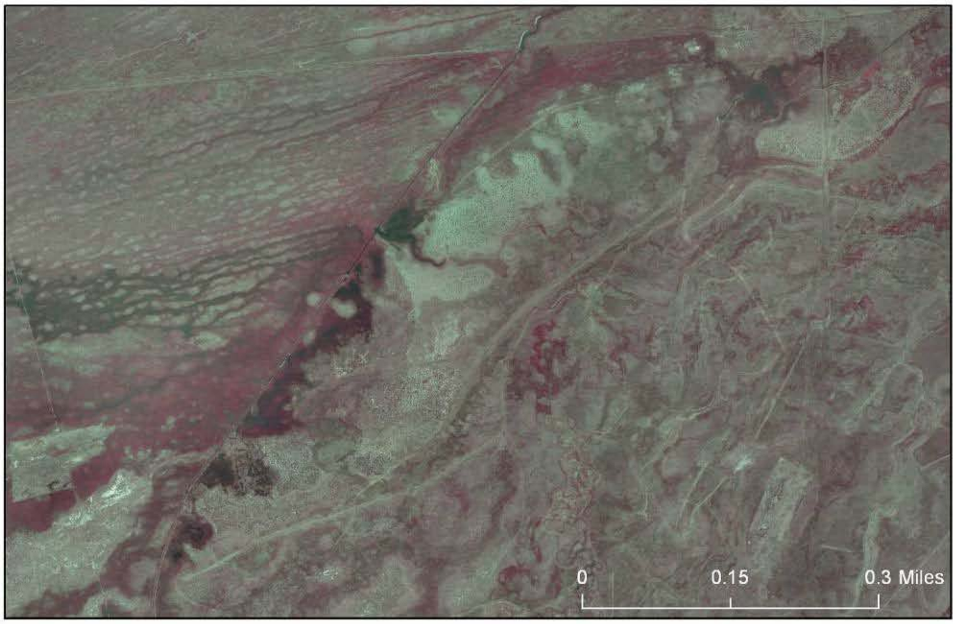
Field Data Collection Results

We collected field data on approximately 2,400 polygons over 4 full days logging about 280 man-hours in the field. Twenty-three (23) work blocks were established dividing the refuge in manageable areas for data collection. Each work area was approximately 2-4 square miles, depending on the number of target polygons. We successfully gathered data on about 75% of the polygons originally targeted for data capture. Data collection was aided through the use of all-terrain vehicles (ATVs) which allowed access to much of the refuge. Data collection concluded about noon on Friday and was followed by a debriefing meeting and wrap-up session.

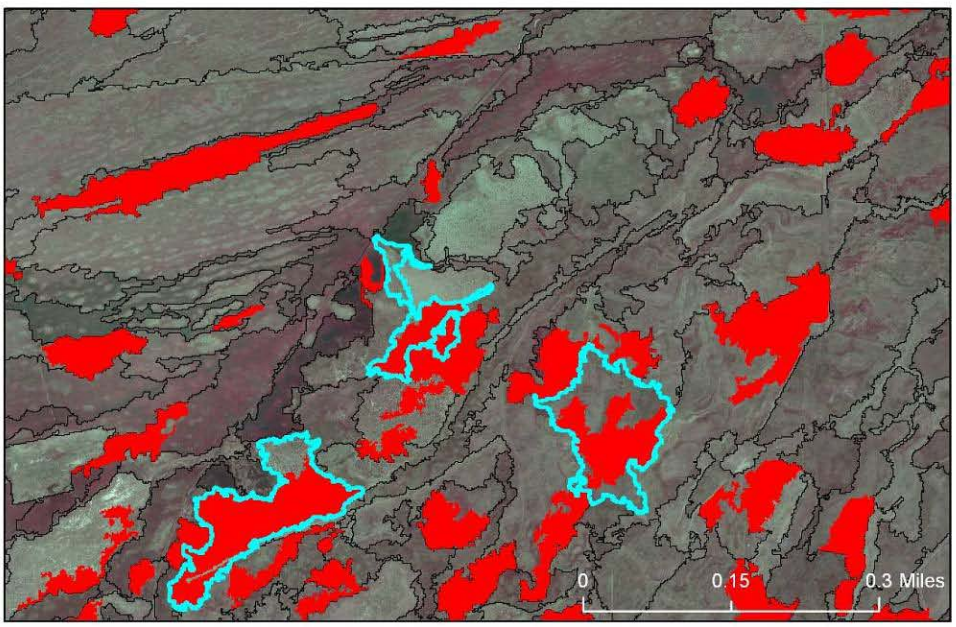
Photo Interpretation and Polygon Labeling

As mentioned earlier, our intent was to use the large number of training polygons collected in the field to generate signature sets in ERDAS representing unique vegetation communities. This method proved a challenge early on for a variety of technical reasons, most notably a lack of in-depth knowledge by the Service lead in working with these advanced methods. Some issues with eCognition polygon generation and color-balancing also was a factor, but to a lesser degree. After discussions with other Service team members, the decision was made to abandon the more automated approach and instead revert to a traditional manual photo-interpretation (PI) process. Although potentially more time consuming and subjective, this decision represented a process that could be carried out to completion in a timely manner and fully utilize the >1,700 training polygons.

Once the decision was made to manually photo-interpret the refuge, the number of polygons generated during the initial segmentation (>61,000 at scale parameter of 40) proved overwhelming. As mentioned earlier, a number of trial and error iterations were made at various scale parameters during the initial segmentation process. We reviewed all of the iterations again, and decided that the segmentation produced at a scale factor of 70, which reduced the number of polygons to about 16,000, would provide an acceptable solution. Therefore, we finalized our decision to move forward mapping the refuge using the segmentation generated at scale parameter set to 70 and color parameter set to 0.15 (same for both). Figure A5 illustrates the difference between the scale parameters used in the segmentation.



Example of CIR imagery collected in early June 2006 of a wet meadow region on the refuge.



Same area with eCognition generated polygons using scale factor of 70, and Shape factor of 0.15.; the red areas are training polygons generated at a scale of 40.

Figure A5. Example of eCognition-generated polygons at scale factor 40 and 70.

We used the training polygons captured in the field in August, to manually photo-interpret the refuge using the CIR photos collected in June. The process, although somewhat cumbersome, did provide an end point for completion of the labeling process. This process took about 4 months, working on and off, to complete. Polygons set aside for accuracy assessment (n = 684) were excluded and not used in the labeling process. No additional follow-up field visits were conducted.

The photo-interpretation work was completed in late 2007. The goal of the Service mapping effort was to map (at 80% accuracy) to the level of a single NVCS alliance, (i.e., *Juncus balticus* Seasonally Flooded Herbaceous Alliance). Attempts were made to assess the accuracy of the map product soon after the photo-interpretation phase was completed. The results of the initial accuracy assessment were lower than expected in several major classes, in particular, distinguishing between the herbaceous classes such as *Distichilis spicata* (saltgrass), *Juncus balticus* (Baltic rush), and *Sporobolus airoides* (alkali sacaton) which comprise a large component of the wet meadow and playa-type habitats on the refuge. It was also apparent that teasing out small differences within the herbaceous communities in the wet meadows proved very challenging given the manual PI methods.

Given that our initial results were disappointing and suggested that our goal of mapping to the alliance level of NVCS was not attainable at the >80% accuracy level, we took a step back and assessed our options for moving forward. With the overall intent of the larger landscape effort (to have a seamless product), we decided the most straightforward way to move ahead was to use the coarser map classes, where applicable, and crosswalk our mapping classes, particularly “refuge specials”, to match the larger effort (see Appendix A). This decision would serve two primary end points; 1) a seamless data set, and 2) increased accuracy for our mapping effort (by combining classes).

Accuracy Assessment

As mentioned in the above section, our attempt to map at the single alliance level with acceptable accuracy was not successful. Therefore, we grouped map classes following the map classification scheme for the larger effort. In the end, a total of 15 map classes were used to classify the vegetation communities and/or land use on the refuge. These classes and their respective accuracies are listed below in Table A3**.** Many distinct and rare map classes such as riparian willow communities and cottonwood woodlands were mapped and assessed based on direct-recognition methods, (e.g., the photo-interpretation process) thus accuracy is 100%. They were easily delineated in the imagery, and eCognition did well to extract these classes. In contrast, many of the mislabeled polygons in the upland shrub communities were due to missing the dominant shrub, i.e., labeling greasewood in the rabbitbrush map class and visa-versa. In the wet meadows map class, the most commonly mislabeled polygons were that of the surrounding shrubs, typically greasewood.

Table A3. Accuracy Assessment Matrix.

Map Class	Accuracy	Comments
San Luis Valley Mesic Meadow Alliances	92%	Those polygons incorrectly mapped were labeled primarily as a shrub community
Playa Alliances	100%	All of the accuracy polygons were captured within this map class.
Greasewood Flats Shrubland and Steppe Alliances	90%	Those polygons incorrectly mapped fell primarily within the San Luis Valley Mesic Meadow Class
Greasewood Sand Deposit Shrubland and Steppe Alliances	87%	Those polygons incorrectly mapped fell primarily within the San Luis Valley Mesic Meadow Class

Map Class	Accuracy	Comments
Sandsheet Rabbitbrush Shrubland and Steppe Alliances	73%	Some confusion with Greasewood occurred. If greasewood is included, accuracy rises to 89%.
Alluvial Flat Herbaceous Alliances	77%	Those polygons incorrectly mapped were labeled primarily as a shrub community
Coyote Willow Temporarily Flooded Shrubland Alliances	100%	Visually checked 100% of polygons in map
Herbaceous Stabilized Dunes and Sandsheet Alliances	90%	This map class represented that portion of the refuge dominated by Indian Ricegrass and other herbaceous species on the sandsheet.
Narrowleaf Cottonwood Temporarily Flooded Woodland Alliances	100%	Visually checked 100% of polygons in map
Emergent Marsh Alliances	100%	Visually checked 100% of polygons in map
Land Use Map Classes		
Invasive Forbland	68%	
Urban Residential	100%	Visually checked 100% of polygons in map
Farmland	100%	Visually checked 100% of polygons in map
Water	100%	Represented open water in canal and in wetlands/lakes. Visually checked 100% of polygons in map
Wash	100%	Represented bare sand in old creek channels. Visually checked 100% of polygons in map.

Conclusion and Discussion

The final product of this mapping effort for the refuge is shown in Figure A6. As reflected in Table 4, the majority (>90%) of vegetation fell within 5 major map classes (see the main report for a full description of the map classes). The top three map classes were shrub communities dominated by either rubber rabbitbrush or black greasewood communities. Together these three classes comprised over 70% of the refuge. In some locations, the species were co-dominant, especially in transition areas between changes in substrate material (i.e., sand sheet and sabkha regions). We used substrate information provided by the National Park Service to delineate the two greasewood map classes. Greasewood shrublands occurring on the sand sheet were placed in the “Greasewood Sand Deposit” map class, while greasewood occurring on the sabkha was placed in the “Greasewood Flats” map class.

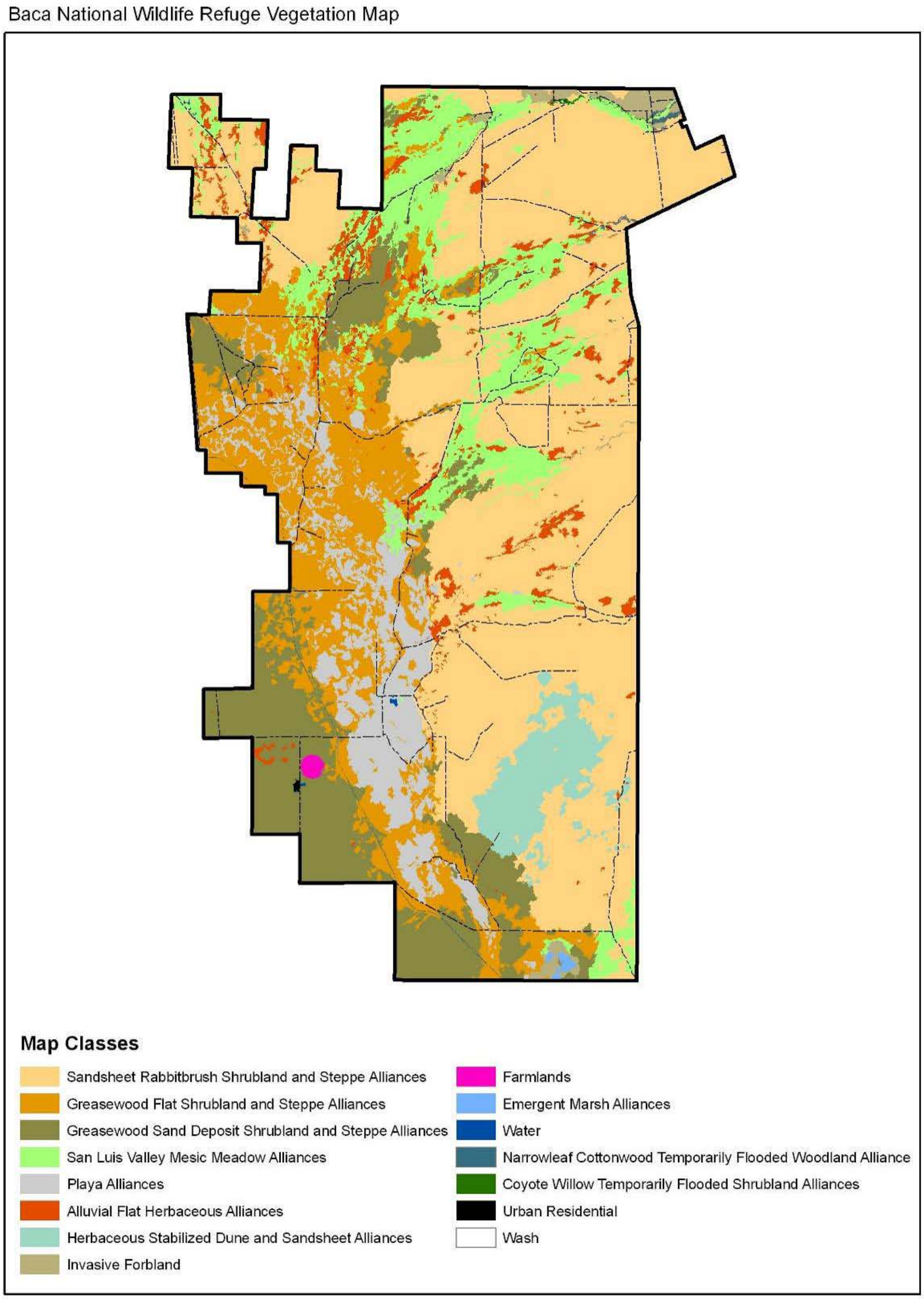


Figure A6. Final Vegetation Map, Baca National Wildlife Refuge.

Table A4. Acreage Summary of Map Classes, Baca National Wildlife Refuge.

Final Map Class	Acres	%
Sandsheet Rabbitbrush Shrubland and Steppe Alliances	39,671.55	42.9%
Greasewood Flat Shrubland and Steppe Alliances	15,412.13	16.7%
Greasewood Sand Deposit Shrubland and Steppe Alliances	12,249.38	13.2%
San Luis Valley Mesic Meadow Alliances	10,087.73	10.9%
Playa Alliances	7,338.07	7.9%
Alluvial Flat Herbaceous Alliances	3,177.41	3.4%
Herbaceous Stabilized Dune and Sandsheet Alliances	3,159.39	3.4%
Invasive Forbland	1,009.65	1.1%
Farmlands	118.01	0.1%
Emergent Marsh Alliances	93.83	0.1%
Water	69.73	0.1%
Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance	60.19	0.1%
Coyote Willow Temporarily Flooded Shrubland Alliances	54.32	0.1%
Urban Residential	17.40	0.0%
Wash	13.39	0.0%
	92,532.18	100.0%

There was considerable variation in the height and structure of the shrub communities throughout the refuge. Greasewood occurring west of the Closed Basin Canal were predominantly shorter (< 2 feet) and not nearly as robust as those growing farther east on the sand sheet. Many areas appeared decant and in poor condition. In contrast, we observed greasewood >5 feet tall with broad basal cover on the sand sheet. Variation in height and structure for rabbitbrush appeared to be less noticeable, and typically in the range of 3-4 feet tall. There was some confusion delineating mixed shrub communities as reflected in the accuracy table.

Within both shrub communities, particularly on the sand sheet and surrounding the playa wetlands, we did observe a considerable amount of slender spiderflower, *Cleome multicaulis*. This plant is considered rare and known to only one area outside of the San Luis Valley. While we made notes of its occurrence, we did not quantify an estimate on the number of plants or acres containing the plant.

The San Luis Valley Mesic Meadows class was the next largest map class composing about 11% of the refuge. These meadows are vast when standing within them. They contain a mixture of herbaceous grasses and forbs including *Carex* and *Poa* species, Baltic rush, western wheatgrass, saltgrass, and alkali sacaton, the latter two occurring in drier areas. Micro-topography seemed to play a role in the distribution of plant species within the meadows. Alkali sacaton and alkali muhly (*Muhlenbergia asperifolia*) tended to be on raised “hummocks” with a slightly higher elevation (<1 foot), thus were slightly drier than the surrounding area. The meadows are fed by snowmelt in the Sangre de Cristo mountain range, and aided by a simple irrigation distribution system, which has been in place for over 100 years.

We observed little in terms of invasive plants (i.e., *Lepidium* sp.) in the large wet meadows. We did observe and map the extent of giant redtop along several of the streams coming into the meadows. Although present, the redtop did not appear to be spreading into the meadows, but rather appeared confined to the benches adjacent to the stream.

Intermixed with the meadows and shrub communities are playa wetland basins. The map class "playa alliances" captures this area well. These basins are characterized by a large amount of bare soil, with scattered saltgrass, western wheatgrass, alkali sacaton, and greasewood around the fringes. The amount of saltgrass varied from a minor component to extensive stands with complete coverage. A majority of the playa basins are located on the southern third of the refuge in the area locally known as the "sump". The sump is the lowest portion of the Closed Basin. Significantly more invasive species, particularly whitetop and Russian knapweed, occurred in the playa areas.

The remaining map classes composed a small percentage of the refuge, however, a couple of notes are warranted. Much of the 1,010 acres in the invasive forbland class was composed of old agricultural fields around the headquarters on the north end of the refuge. This was mapped in the field as "non-agricultural disturbed areas", and rolled into the invasive class. The other area of significant invasive plants occurred in the large wetland complex on the southern boundary. Canada thistle was the primary invasive species occurring throughout the bulrush/cattail fringe within the wetland.

The coyote willow communities occurred primarily along Crestone Creek and the side laterals. These were easily distinguished from the surrounding herbaceous meadows. Similarly, the narrow-leaf cottonwood communities near headquarters along Crestone Creek were easily classified.

Lessons Learned

This was a large and complex mapping effort. Significant coordination and cooperation between many partners resulted in information and resource sharing, and ultimately, we believe, a better product in the end. Below are a few of the many lessons learned during this project.

- Early and often communication between partners was essential in keeping all parties engaged and up to speed. We credit Billy Schweiger, National Park Service, for taking the overall project lead.
- Sharing of information and resources through interagency agreements was beneficial, and led to data being available to all involved which improved the final product.
- Use of technology in the form of digital maps and field forms, GIS databases, and GPS units greatly enhanced the efficiency of Service personnel in collecting field data.
- Having a "SWAT" team approach by bringing in field biologists for an extended, intensive field session provided the necessary resources to collect the amount of field data required to successfully map the refuge. It also provided valuable real-world training for those biologists in the use of technology to map vegetation.
- This project could have been completed sooner had we devoted more time up front to follow-up visits to the refuge during the photo-interpretation phase.
- The segmentation process using eCognition was beneficial and saved considerable time in the end. It provided a repeatable process to delineating polygons.

- Good logistical support and accurate base maps saved time in the field and enhanced safety for data collectors. Being prepared from all types of conditions in the field increased efficiency and reduced downtime.
- Use of ATV's greatly increased the efficiency of data gathering.
- Good communication with the refuge manager about refuge management needs and how the intended product will be used is critical to achieving success.
- Finally, while we only suffered one data loss on the Trimble units, it signified the importance of backing up data, early and often while in the field.

Acknowledgments

This project could not have been conducted without the support and assistance from many individuals, both within the Service and among cooperating agencies, in particular, the National Park Service. We especially want to thank Patrick Donnelly, Remote Sensing Scientist, for his technical support and guidance throughout this project. If not for the effort from these field biologists: Andy Bishop (Rainwater Basin) Mel Nenneman (Valentine NWR), Tim Menard (Flint Hills NWR), Shilo Comeau (Lacreek NWR), Dave Lindsey and Kari McGuire (Albuquerque Regional Office), the field collection portion of this work would not have yielded as much information as it did. We also would like to thank Greg Langer for use of his field truck, Dave Carter for use of radios, and Ron Garcia, Refuge Manager, for his assistance throughout this project.

Crosswalk Between Initial USFWS Classes and Final Map Classes

Below is a discussion between our initial mapping classes and the final map classes. This crosswalk can be referred to when looking at the original field data and comparing with the final data sets. The final shared data set will only have the final map classes.

***Agrostis gigantea* (code SLV 30; Redtop):** This map class occurred in linear patches on benches within the active streams channels flowing into the refuge, namely Willow, Cottonwood, and Deadman Creeks. Outside the active channel, shrubs such as rabbitbrush and greasewood were the dominant vegetation. These long linear units total only 50 acres. Given this grass species is considered invasive, it was cross-walked to the "Invasive Forbland" map class.

Bare Soil/Sparse Vegetation (code VII): This class captured those areas of bare soil outside of the playa region. Sandy blowouts, roads, and larger areas amidst the more widely distributed greasewood, largely characterize this map class. The majority of polygons were cross-walked to the "Alluvial Flat Herbaceous Alliances" class. If polygons were in close proximity to the area dominated by Indian ricegrass, those were cross-walked to the "Herbaceous Stabilized Dune and Sandsheet Alliances" map class.

***Distichilis spicata* Intermittently Flooded Herbaceous Alliance (code A.1332; saltgrass):** Similar to the *Sporobolus airoides* map class, we were not able to successfully delineate this class through the photo-interpretation process; accuracy was low. This class was cross-walked to the "Alluvial Flat Herbaceous Alliances" map class.

***Distichilis spicata* (*Horduem jubatum*) Intermittantly Flooded Herbaceous Alliance (code A.1341):** Same as above for *Distichilis spicata* Intermittently Flooded Herbaceous Alliance.

***Ericameria nauseosa* Shrubland Alliance (code A.835; rubber rabbitbrush):** This class represents the largest area on the refuge and cross-walked to the "Sandsheet Rabbitbrush Shrubland and Steppe Alliances." Some of the areas mapped in this class fall outside of the sandsheet area, especially in the extreme northwest portion of the refuge.

Intermittently Flooded Mud Flats (code VII.C.4.N.b; playa lakes): This map class captured the playa areas on the refuge. This class was cross-walked to the "Playa Alliances" map class.

***Juncus balticus* Seasonally Flooded Herbaceous Alliance (code A.1374; Baltic rush):** While *Juncus* comprises a large portion of the wet meadow communities on the refuge, other species such as *Poa* ssp., *Eleocharis* ssp., *Distichilis spicata, Sporobolus airoides*, and *Iris* ssp. occur throughout. This map class was cross-walked to the "San Luis Valley Mesic Meadow Alliances" map class.

***Medicago* spp. (code SLB-7; alfalfa):** This represented one pivot-irrigation circle on the refuge, located near the residence/business. The class was cross-walked to the "Farmland" map class. This pivot-circle was about 118 acres. No other alfalfa was observed on the refuge.

Non-Agriculture, Disturbed Areas: This map class was a "catch-all" class to describe areas with invasive grasses and forbs, common in old agriculture field settings (i.e., near refuge headquarters). A large area within a wetland complex on the southern refuge boundary was mapped to this class as well due to large infestation of Canada thistle and other weedy species. This class was cross-walked to the "Invasive Forbland" class.

Oryzopsis hymenoides **(code SLV-13; Indian ricegrass):** This map class represented nearly monotypic stands of Indian ricegrass in the southeastern portion of the refuge. Although not an alliance under NVC, it was deemed important by refuge management to delineate its extent as best as possible. The substrate was largely sandy soils. This map class was cross-walked to the "Herbaceous Stabilized Dune and Sandsheet Alliances" map class.

Pascopyrum smithii **Herbaceous Alliance (code A.1232; western wheatgrass):** Given the general location of this limited map class, which was typically near the periphery of the meadows, we combined this map class with the meadows. Thus this class was cross-walked to the "San Luis Valley Mesic Meadow Alliances"

Populus angustifolia **Temporarily Flooded Woodland Alliance (code A.641; narrowleaf cottonwood):** This map class is the same. On the refuge, this map classes was largely restricted to the cottonwoods along North and South Crestone Creek. Smaller stands occur slightly north of Cottonwood Creek. This map class represents about 60 acres.

Salix (exigua, interior) **Temporarily Flooded Shrubland Alliance (code A.947; Coyote willow):** This map class was the same. On the refuge, this class was restricted to the willows along Crestone Creek, and the lateral ditches. This map class represents approximately 55 acres.

Sand Flats: This map class captured sandy, non-vegetated areas along ephemeral streams mostly on the eastern side of the refuge. This class was cross-walked to the "Wash" map class. This map class composed 13 acres on the refuge.

Sarcobatus vermiculatu**s Shrubland Alliance (code A.1041; Black greasewood):** This map class captured the greasewood not associated with the playa region, primarily to the west of the Closed Basin Canal. This map class was cross-walked to one of two map classes based on location in relation to the dominant substrates (sandsheet or sabkha). Greasewood polygons falling within the "sandsheet" were placed into the "Greasewood Sand Deposit Shrubland and Steppe Alliances." Those falling within the "sabkha" were placed in the Greasewood Flat Shrubland and Steppe Alliances map class. Greasewood polygons not falling within either the sandsheet or the sabkha were mapped based on additional photo-interpretation and/or proximity to surrounding polygons.

Sarcobatus vermiculatus **Intermittently flooded Shrubland Alliance (code A.1046; Black greasewood):** This map class captured greasewood occurring near or in the playa region associated with more regularly flooded soils. Same process as above was used to cross-walk this class to the larger effort.

Sporobolus airoides **Herbaceous Alliance (code A.1267; Alkali sacaton):** Although we were hopeful to be able to extract stands of this alliance, we were not able do so with acceptable accuracy. Confusion between saltgrass and bare soil was common. This map class was cross-walked to the "Alluvial Flat Herbaceous Alliances" map class.

Residential: This map class applied to the one farmstead/business (Hot Springs) within the refuge boundary. This map class was cross-walked to the "Urban Residential" class. This area represents about 17 acres on the refuge.

Water: Map classes same between classifications. This represents open water on the refuge, primarily the Closed Basin Canal, and stream channels where polygons were large enough to be delineated by eCognition. This was cross-walked to the "Water" class.

Appendix B:
National Vegatation Classification, Version 2 Hierarchy with GRSA Map Classes Crosswalked to Group Level

(NVC, Version 2 Group level is under development - February 2010 version)

*Map classes that occur in multiple NVCS, Version 2 Groups. The GRSA MU are largely based on NVC Version 1 alliances. Some of these alliance and component associations and will be split into appropriate Groups in the NVC Version 2 in the future.

Class	Subclass	Formation	Division	MG Key	Macrogroup	Group	GRSA MU #	GRSA Map Unit Name
1 Forest & Woodland (Mesomorphic Tree Vegetation)								
	1.C Temperate Forest							
		1.C.2 Cool Temperate Forest						
			1.C.2.b Western North American Cool Temperate Forest					
				MG020	Rocky Mountain Subalpine & High Montane Conifer Forest			
						Rocky Mountain Subalpine Mesic-Wet Spruce - Fir Forest & Woodland Group		
							41	Subalpine Spruce-Fir Forest and Woodland Alliances*
							56	Avalanche Chute Shrubland
						Rocky Mountain Subalpine Dry-Mesic Spruce - Fir Forest & Woodland Group		
							41	Subalpine Spruce-Fir Forest and Woodland Alliances*
							50	Subalpine Fir (Engelmann Spruce) - Aspen Forest Alliance
							51	Subalpine Fir - Engelmann Spruce - Bristlecone Pine - Limber Pine Krummholz Shrubland Alliance
						Southern Rocky Mountain Subalpine-Montane Bristlecone Pine Woodland Group		
							42	Subalpine-Montane Limber-Bristlecone Pine Woodland Alliances
							3	Aspen - Limber Pine Forest Alliance
						Rocky Mountain Subalpine & Montane Aspen Forest & Woodland Group		
							2	Aspen Forest Alliances*
				MG022	Southern Rocky Mountain Lower Montane Forest			
						Southern Rocky Mountain Douglas-fir - White Fir - Blue Spruce Mesic Forest Group		
							11	White Fir - Douglas-fir Forest and Woodland Alliances*
							53	White Fir - Mixed Deciduous Lowland Forest Alliances*
						Southern Rocky Mountain White Fir - Douglas-fir Dry Forest Group		
							11	White Fir - Douglas-fir Forest and Woodland Alliances*
							63	Aspen - Douglas Fir (White Fir) Upland Forest Alliances
						Southern Rocky Mountain Ponderosa Pine Forest & Woodland Group		
							49	Ponderosa Pine Woodland with Herbaceous Understory
							48	Ponderosa Pine Woodland with Shrub Understory
							33	Ponderosa Pine - Aspen Forest Alliance
							34	Ponderosa Pine Sand Ramp Woodland

Class	Subclass	Formation	Division	MG Key	Macrogroup	Group	GRSA MU #	GRSA Map Unit Name
			1.C.2.c Western North American Scrub Woodland & Shrubland					
				MG027	Rocky Mountain Two-needle Pinyon - Juniper Woodland			
						Southern Rocky Mountain Pinyon - Juniper Woodland Group		
							60	Pinyon-Juniper Woodland with Shrub Understory
							31	Pinyon Pine / Rockland Woodland Association
							32	Pinyon Pine Woodland with Herbaceous or Sparse Understory
						Rocky Mountain Two-needle Pinyon - Juniper Ruderal Woodland Group		
							8	Chained Pinyon-Juniper Areas
		1.C.3 Temperate Flooded & Swamp Forest						
			1.C.3.c Western North American Flooded & Swamp Forest					
				MG034	Rocky Mountain and Great Basin Flooded & Swamp Forest			
						Rocky Mountain and Great Basin Lower Montane and Foothill Riparian Woodland Group		
							26	Narrowleaf Cottonwood Sand Dune Woodland Association
							27	Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance
							53	White Fir - Mixed Deciduous Lowland Forest Alliances*
						Rocky Mountain and Great Basin Subalpine-Montane Riparian Forest Group		
							2	Aspen Forest Alliances*
							43	Subalpine Riparian Forest Alliances
							11	White Fir - Douglas-fir Forest and Woodland Alliances*
							53	White Fir - Mixed Deciduous Lowland Forest Alliances*
2 Shrubland & Grassland (Mesomorphic Shrub & Herb Vegetation)								
	2.C Temperate & Boreal Shrubland & Grassland							
		2.C.1 Temperate Grassland, Meadow & Shrubland						
			2.C.1.a Vancouverian & Rocky Mountain Grassland & Shrubland					
				MG049	Southern Rocky Mountain Montane Shrubland			
						Southern Rocky Mountain Cercocarpus-Mixed [Dry] Foothill Shrubland Group		
							25	Mountain Mahogany Shrubland Alliance
						Southern Rocky Mountain Gambel Oak-Mixed [Mesic] Montane Shrubland Group		
							18	Montane-Foothill Dry-Mesic Shrubland Alliances
				MG167	Rocky Mountain-Vancouverian Montane Dry Grassland			
						Southern Rocky Mountain Montane-Subalpine Grassland Group		
							46	Montane-Subalpine Grassland Alliances
		2.C.5 Temperate & Boreal Freshwater Wet Meadow & Marsh						
			2.C.5.b Western North American Freshwater Marsh					
				MG073	Western North American Freshwater Marsh			
						Western Temperate Interior Freshwater Emergent Marsh Group		
							7	Cattail Herbaceous Alliances
							28	Emergent Marsh Alliances
							20	Interdunal Swale Wetland Alliances

Class	Subclass	Formation	Division	MG Key	Macrogroup	Group	GRSA MU #	GRSA Map Unit Name
				MG075	Western North American Wet Meadow & Shrub Carr			
						Rocky Mountain and Great Basin Subalpine-Montane Riparian/Seep Low Shrubland Group		
							57	Alpine Willow (Spruce) Shrubland Alliances
							65	Montane Riparian Shrubland Alliances*
						Rocky Mountain and Great Basin Lower Montane-Foothill Riparian/Seep Low Shrubland Group		
							9	Coyote Willow Temporarily Flooded Shrubland Alliances
							65	Montane Riparian Shrubland Alliances*
						Rocky Mountain and Great Basin Lower Montane-Foothill Riparian/Seep Non-Willow Tall		
						Shrubland Group		
							65	Montane Riparian Shrubland Alliances*
						Vancouverian & Rocky Mountian Subalpine-Montane Wet Meadow Group		
							64	Alpine - Upper Subalpine Herbaceous Wetland Alliances
							24	Montane-Lower Subalpine Wetland Alliances
		2.C.6 Salt Marsh						
			2.C.6.d Western North American Interior Alkaline-Saline Wetland					
				MG082	Cool Semi-Desert Alkali-Saline Wetland			
						Inter-Mountain Basins Alkaline-Saline Shrubland Group		
							15	Greasewood Flat Shrubland and Steppe Alliances
						Inter-Mountain Basins Alkaline-Saline Herbaceous Flat Group		
							21	San Luis Valley Mesic Meadow Alliances
							22	Playa Alliances
3 Semi-Desert (Xeromorphic Scrub & Herb Vegetation)								
	3.B Cool Semi-Desert Scrub & Grassland							
		3.B.1 Cool Semi-Desert Scrub & Grassland						
			3.B.1.a Western North American Cool Semi-Desert Scrub & Grassland					
				MG093	Cool Semi-Desert Saltbrush Scrub			
						Shadscale-Saltbush Cool Semi-Desert Scrub Group		
							12	Fourwing Saltbush Shrubland Alliance
				MG095	Cool Semi-Desert Xero-Riparian			
						Cool Semi-Desert Xero-Riparian Wash		
							23	Wash

Class	Subclass	Formation	Division	MG Key	Macrogroup	Group	GRSA MU #	GRSA Map Unit Name
				MG171	Intermountain Dry Shrubland & Grassland			
						Intermountain Basins Semi-Desert Shrub-Steppe Shrubland Group		
							61	Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances
							45	Sandsheet Rabbitbrush Shrubland and Steppe Alliances
							13	Greasewood Sand Deposit Shrubland and Steppe Alliances
							55	Winterfat Dwarf-shrubland Alliance
						Intermountain Basins Semi-Desert Grassland and Steppe Group		
							14	Alluvial Flat Herbaceous Alliances
							17	Herbaceous Stabilized Dune and Sandsheet Alliances
							30	Piedmont Semi-Desert Grassland Alliances
						Intermountain Dry Ruderal Shrubland & Grassland		
							59	Invasive Forbland
4 Polar & High Montane Vegetation (Cryomorphic Shrub & Herb Vegetation)								
	4.B Temperate & Boreal Alpine Vegetation							
		4.B.1 Alpine Scrub, Forb Meadow & Grassland						
			4.B.1.b Western North American Alpine Scrub, Forb Meadow & Grassland					
				MG099	Rocky Mountain Alpine Scrub, Forb Meadow & Grassland			
						Rocky Mountain Alpine Turf and Fell-field Group		
							36	Alpine Fell-Field Alliances
							38	Alpine Turf Alliances
6 Nonvascular & Sparse Vascular Rock Vegetation (Lithomorphic Vegetation)								
	6.B Mediterranean, Temperate & Boreal Nonvascular & Sparse Vegetation							
		6.B.2 Temperate & Boreal Cliff, Scree & Rock Vegetation						
			6.B.2.b Western North American Temperate Cliff, Scree & Rock Vegetation					
				MG113	Rocky Mountain Cliff, Scree & Rock Vegetation			
						Rocky Mountain Cliff, Scree & Rock Vegetation Group		
							37	Cliff, Canyon and Massive Bedrock
	6.D Polar & High Montane Nonvascular & Sparse Vegetation							
			6.D.2.b North American Alpine Cliff, Scree & Rock Vegetation					
				MG119	Rocky Mountain Alpine Cliff, Scree & Rock Vegetation			
						Rocky Mountain Alpine Cliff, Scree & Rock Vegetation Group		
							35	Alpine Bedrock and Scree
7 Agricultural Vegetation (Agromorphic Vegetation)								
							67	Farmlands

Appendix C: The Natural Heritage Network Ranking System and Biological Diversity

Just as ancient artifacts and historic buildings represent our cultural heritage, a diversity of plant and animal species and their habitats represent our natural heritage. Colorado's natural heritage encompasses a wide variety of ecosystems from tall grass and short grass prairie to canyon lands and sagebrush deserts, dense montane and subalpine forests, alpine cirques and rugged peaks and wide-open tundra. The species that inhabit each of these very diverse habitats are determined by water availability, temperature extremes, altitude, geologic history, and land use history and may be very common or very rare, locally and over their entire range.

Recognition and protection of species that are rare and imperiled is crucial to preserving Colorado's diverse natural heritage. The need to preserve this biological diversity and the wealth of our natural heritage has been recognized for decades in the scientific community. Recognizing that rare and imperiled species are more likely to become extinct than common ones, the Natural Heritage Methodology ranks species according to their rarity or degree of imperilment from extinction. The ranking system is scientifically based upon the number of known locations of the species as well as its biology and known threats. By ranking the relative rarity or imperilment of a species, the quality of its populations, and the importance of associated conservation sites, the methodology can facilitate the prioritization of conservation efforts so the most rare and imperiled species may be preserved first. As the scientific community realized that plant communities are equally important as individual species, this methodology has been applied to ranking and preserving rare plant communities, as well as the best examples of common communities.

The Natural Heritage Methodology is used by Natural Heritage Programs throughout North, Central, and South America, forming an international database network. The 85 Natural Heritage Network data centers are located in each of the fifty U.S. states, eleven Canadian provinces and territories, and many countries in Latin America and the Caribbean. This network enables scientists to monitor the status of species from a state, national, and global perspective. Information collected by the Natural Heritage Programs can provide a means to protect species before the need for legal endangerment status arises. It can also enable conservationists and natural resource managers to make informed, objective decisions in prioritizing and focusing conservation efforts.

What is Biological Diversity? Protecting biological diversity has become an important management issue for many natural resource professionals. Biological diversity at its most basic level includes the full range of species on Earth, from single-celled organisms such as bacteria and protists through the multi-cellular kingdoms of plants and animals. At finer levels of organization, biological diversity includes the genetic variation within species, both among geographically separated populations and among individuals within a single population. On a wider scale, diversity includes variations in the biological communities in which species live, the ecosystems in which communities exist, and the interactions between these levels. All levels are necessary for the continued survival of species and plant communities, and many are important for the well being of humans.

The biological diversity of an area can be described at four levels:

Genetic Diversity — is the genetic variation within a population and among populations of a plant or animal species. The genetic makeup of a species varies between populations within its geographic range. Loss of a population results in a loss of genetic diversity for that species and a reduction of total biological diversity for the region. Once lost, this unique genetic information cannot be reclaimed.

Species Diversity — is the total number and abundance of plant and animal species and subspecies in an area.

Community Diversity — is the variety of plant communities within an area that represent the range of species relationships and inter-dependence. These communities may be diagnostic of or even restricted to an area. The U.S. National Vegetation Classification (USNVC) is the accepted national standard for vegetation and it defines a community as an "assemblage of species that co-occur in defined areas at certain times and that have the potential to interact with one another" (Anderson et al. 1998).

Landscape Diversity — is the type, condition, pattern, and connectedness of natural communities. A landscape consisting of a mosaic of natural communities may contain one multifaceted ecosystem, such as a wetland ecosystem. A landscape also may contain several distinct ecosystems, such as a riparian corridor meandering through shortgrass prairie. Fragmentation of landscapes, loss of connections and migratory corridors, and loss of natural communities all result in a loss of biological diversity for a region.

The conservation of biological diversity should include all levels of diversity: genetic, species, community, and landscape. Each level is dependent on the other levels and inextricably linked. Humans and the effects of their activities are also closely linked to all levels of this hierarchy and are integral parts of most landscapes. A healthy natural environment and a healthy human environment go hand in hand, and recognition of the most imperiled species is a critical step in the conservation of biological diversity and maintenance of healthy natural environments.

Colorado's Natural Heritage Program

CNHP is the state's primary comprehensive biological diversity data center, gathering information and field observations to help develop statewide conservation priorities. The multi-disciplinary team of scientists, planners, and information managers at CNHP gathers comprehensive information on the rare, threatened, and endangered species and significant plant communities of Colorado. Life history, status, and locational data are incorporated into a continually updated data system. Data maintained in the CNHP's database are an integral part of ongoing research at Colorado State University and reflect the observations of many scientists, institutions and our current state of knowledge. These data are acquired from various sources, with vary levels of accuracy, and are continually being updated and revised. Sources include published and unpublished literature, museum and herbaria labels, and field surveys conducted by knowledgeable naturalists, experts, agency personnel, and our own staff of botanists, ecologists, and zoologists.

All Natural Heritage Programs house data about imperiled species and plant associations and are implementing use of the Biodiversity Tracking and Conservation System (BIOTICS) developed by NatureServe. This database includes taxonomic group, global and state rarity ranks, federal and state legal status, observation source, observation date, county, township, range, watershed, and other relevant facts and observations. BIOTICS also has a GIS mapping program component (ESRI ArcView) for digitizing and mapping occurrences of rare plants, animals, and plant communities. These rare species and plant communities are referred to as "elements of natural diversity" or simply "elements."

Concentrating on site-specific data for each element enables CNHP to evaluate the significance of each location for the conservation of biological diversity in Colorado and in the nation. By using species imperilment ranks and quality ratings for each location, priorities can be established to guide conservation action. A continually updated locational database and priority-setting system such as that maintained by CNHP provides an effective, proactive land-planning tool.

To assist in biological diversity conservation efforts, CNHP scientists strive to answer questions like the following:

- What species and ecological communities exist in the area of interest?
- Which are at greatest risk of extinction or are otherwise significant from a conservation perspective?
- What are their biological and ecological characteristics, and where are these priority species or communities found?
- What is the species' condition at these locations, and what processes or activities are sustaining or threatening them?
- Where are the most important sites to protect?
- What actions are needed for the protection of those sites and the significant elements of biological diversity they contain?
- How can we measure our progress toward conservation goals?

The Natural Heritage Ranking System

Key to the functioning of Natural Heritage Programs is the concept of setting priorities for gathering information and conducting inventories. The cornerstone of Natural Heritage inventories is the use of a ranking system to achieve the twin objectives of effectiveness and efficiency.

Ranking species and ecological communities according to their imperilment status provides guidance for where Natural Heritage Programs should focus their information-gathering activities. To determine the status of species within Colorado, CNHP gathers information on plants, animals, and plant communities. Each of these elements of natural diversity is assigned a rank that indicates its relative degree of imperilment on a five-point scale (for example, 1 = extremely rare/imperiled, 5 = abundant/secure). The primary criterion for ranking elements is the number of occurrences (in other words, the number of known distinct localities or populations). This factor is weighted more heavily than other factors because an element found in one place is more vulnerable to extinction than something found in twenty-one places. Also of importance are the size of the geographic range, the number of individuals, the trends in both population and distribution, identifiable threats, and the number of protected occurrences.

Element imperilment ranks are assigned both in terms of the element's degree of imperilment within Colorado (its State-rank or S-rank) and the element's imperilment over its entire range (its Global-rank or G-rank). Taken together, these two ranks indicate the degree of imperilment of an element. For example, the lynx, which is thought to be secure in northern North America but is known from less than five current locations in Colorado, is ranked G5 S1 (globally-secure, but critically imperiled in this state). The Rocky Mountain Columbine, which is known only in Colorado from about 30 locations, is ranked a G3 S3 (vulnerable both in the state and globally, since it only occurs in Colorado and then in small numbers). Further, a tiger beetle that is only known from one location in the world at the Great Sand Dunes National Monument is ranked G1 S1 (critically imperiled both in the state and globally, because it exists in a single location). CNHP actively collects, maps, and electronically processes specific occurrence information for animal and plant species considered extremely imperiled to vulnerable in the state (S1 - S3). Several factors, such as rarity, evolutionary distinctiveness, and endemism (specificity of habitat requirements), contribute to the conservation priority of each species. Certain species are “watchlisted,” meaning that specific occurrence data are collected and periodically analyzed to determine whether more active tracking is warranted. A complete description of each of the Natural Heritage ranks is provided in Table 1.

Table B1. Definition of Natural Heritage Imperilment Ranks

Rank	Explanation
G/S1	Critically imperiled globally/state because of rarity (5 or fewer occurrences in the world/state; or 1,000 or fewer individuals), or because some factor of its biology makes it especially vulnerable to extinction.
G/S2	Imperiled globally/state because of rarity (6 to 20 occurrences, or 1,000 to 3,000 individuals), or because other factors demonstrably make it very vulnerable to extinction throughout its range.
G/S3	Vulnerable through its range or found locally in a restricted range (21 to 100 occurrences, or 3,000 to 10,000 individuals).
G/S4	Apparently secure globally/state, though it may be quite rare in parts of its range, especially at the periphery. Usually more than 100 occurrences and 10,000 individuals.
G/S5	Demonstrably secure globally/state, though it may be quite rare in parts of its range, especially at the periphery.
G/SX	Presumed extinct globally, or extirpated within the state.
G#?	Indicates uncertainty about an assigned global rank.
G/SU	Unable to assign rank due to lack of available information.
GQ	Indicates uncertainty about taxonomic status.
G/SH	Historically known, but usually not verified for an extended period of time.
G#T#	Trinomial rank (T) is used for subspecies or varieties. These taxa are ranked on the same criteria as G1-G5.
S#B	Refers to the breeding season imperilment of elements that are not residents.
S#N	Refers to the non-breeding season imperilment of elements that are not permanent residents.

Rank	Explanation
	Where no consistent location can be discerned for migrants or non-breeding populations, a rank of SZN is used.
SZ	Migrant whose occurrences are too irregular, transitory, and/or dispersed to be reliably identified, mapped, and protected.
SA	Accidental in the state.
SR	Reported to occur in the state but unverified.
S?	Unranked. Some evidence that species may be imperiled, but awaiting formal rarity ranking.

Note: Where two numbers appear in a state or global rank (for example, S2S3), the actual rank of the element is uncertain, but falls within the stated range.

This single rank system works readily for all species except those that are migratory. Those animals that migrate may spend only a portion of their life cycles within the state. In these cases, it is necessary to distinguish between breeding, non-breeding, and resident species. As noted in Table 1, ranks followed by a "B," for example S1B, indicate that the rank applies only to the status of breeding occurrences. Similarly, ranks followed by an "N," for example S4N, refer to non-breeding status, typically during migration and winter. Elements without this notation are believed to be year-round residents within the state.

Legal Designations for Rare Species

Natural Heritage imperilment ranks should not be interpreted as legal designations. Although most species protected under state or federal endangered species laws are extremely rare, not all rare species receive legal protection. Legal status is designated by either the U.S. Fish and Wildlife Service under the Endangered Species Act or by the Colorado Division of Wildlife under Colorado Statutes 33-2-105 Article 2. In addition, the U.S. Forest Service recognizes some species as “Sensitive,” as does the Bureau of Land Management. Table 2 defines the special status assigned by these agencies and provides a key to abbreviations used by CNHP.

Element Occurrences and their Ranking

Actual locations of elements, whether they are single organisms, populations, or plant communities, are referred to as element occurrences. The element occurrence is considered the most fundamental unit of conservation interest and is at the heart of the Natural Heritage Methodology. To prioritize element occurrences for a given species, an element occurrence rank (EO-Rank) is assigned according to the ecological quality of the occurrences whenever sufficient information is available. This ranking system is designed to indicate which occurrences are the healthiest and ecologically the most viable, thus focusing conservation efforts where they will be most successful. The EO-Rank is based on three factors:

Table B2. Federal and State Agency Special Designations for Rare Species

Federal Status:	
1. U.S. Fish and Wildlife Service (58 Federal Register 51147, 1993) and (61 Federal Register 7598, 1996)	
LE	*Listed Endangered*: defined as a species, subspecies, or variety in danger of extinction throughout all or a significant portion of its range.
LT	*Listed Threatened:* defined as a species, subspecies, or variety likely to become endangered in the foreseeable future throughout all or a significant portion of its range.
P	*Proposed:* taxa formally proposed for listing as Endangered or Threatened (a proposal has been published in the Federal Register, but not a final rule).

Federal Status:

C	*Candidate:* taxa for which substantial biological information exists on file to support proposals to list them as endangered or threatened, but no proposal has been published yet in the Federal Register.
PDL	*Proposed for delisting*.
XN	*Nonessential experimental population*.
2. U.S. Forest Service (Forest Service Manual 2670.5) (noted by the Forest Service as S")	
FS	*Sensitive:* those plant and animal species identified by the Regional Forester for which population viability is a concern as evidenced by: Significant current or predicted downward trends in population numbers or density. Significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.
3. Bureau of Land Management (BLM Manual 6840.06D) (noted by BLM as "S")	
BLM	*Sensitive:* those species found on public lands designated by a State Director that could easily become endangered or extinct in a state. The protection provided for sensitive species is the same as that provided for C (candidate) species.
4. State Status:	
The Colorado Division of Wildlife has developed categories of imperilment for non-game species (refer to the Colorado Division of Wildlife's Chapter 10 – Nongame Wildlife of the Wildlife Commission's regulations). The categories being used and the associated CNHP codes are provided below.	
E	*Endangered:* those species or subspecies of native wildlife whose prospects for survival or recruitment within this state are in jeopardy, as determined by the Commission.
T	*Threatened:* those species or subspecies of native wildlife which, as determined by the Commission, are not in immediate jeopardy of extinction but are vulnerable because they exist in such small numbers, are so extremely restricted in their range, or are experiencing such low recruitment or survival that they may become extinct.
SC	*Special Concern:* those species or subspecies of native wildlife that have been removed from the state threatened or endangered list within the last five years; are proposed for federal listing (or are a federal listing "candidate species") and are not already state listed; have experienced, based on the best available data, a downward trend in numbers or distribution lasting at least five years that may lead to an endangered or threatened status; or are otherwise determined to be vulnerable in Colorado.

Size – a measure of the area or abundance of the element's occurrence. This factor takes into account aspects such as area of occupancy, population abundance, population density, population fluctuation, and minimum dynamic area (which is the area needed to ensure survival or re-establishment of an element after natural disturbance). This factor for an occurrence is evaluated relative to other known, and/or presumed viable, examples.

Condition/Quality – an integrated measure of the composition, structure, and biotic interactions that characterize the occurrence. This includes measures such as reproduction, age structure, biological composition (such as the presence of exotic versus native species), structure (for example, canopy, understory, and ground cover in a forest community), and biotic interactions (such as levels of competition, predation, and disease).

Landscape Context – an integrated measure of two factors: the dominant environmental regimes and processes that establish and maintain the element, and connectivity. Dominant environmental regimes and processes include herbivory, hydrologic and water chemistry regimes (surface and groundwater), geomorphic processes, climatic regimes (temperature and precipitation), fire regimes, and many kinds of natural disturbances. Connectivity includes aspects such as a species having access to habitats and resources needed for life cycle completion, fragmentation of ecological communities and systems, and the ability of the species to respond to environmental change through dispersal, migration, or re-colonization.

Each of these factors is rated on a scale of A through D, with A representing an excellent rank and D representing a poor rank. These ranks for each factor are then averaged to determine an appropriate EO-Rank for the occurrence. If not enough information is available to rank an element occurrence, an EO-Rank of E is assigned. EO-Ranks and their definitions are summarized in Table 3.

Table B3. Element Occurrence Ranks and their Definitions

A	Excellent viability.
B	Good viability
C	Fair viability.
D	Poor viability.
H	Historic: known from historical record, but not verified for an extended period of time.
X	Extirpated (extinct within the state).
E	Extant: the occurrence does exist but not enough information is available to rank.
F	Failed to find: the occurrence could not be relocated.

Anderson, M., P. Bourgeron, M. T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D. H. Grossman, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, L. Sneddon, and A. S. Weakley. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume II. The National Vegetation Classification System: list of types. The Nature Conservancy, Arlington, Virginia.

Appendix D:
Preliminary Classification List

ASSOCIATION NAME
Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest
Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest
Abies concolor - Pseudotsuga menziesii / Erigeron eximius Forest
Abies concolor - Pseudotsuga menziesii / Vaccinium myrtillus Forest
Abies concolor / Galium triflorum Woodland
Abies concolor / Holodiscus dumosus Scree Woodland
Abies concolor / Symphoricarpos oreophilus Forest
Abies lasiocarpa / Acer glabrum Forest
Abies lasiocarpa / Erigeron eximius Forest
Abies lasiocarpa / Juniperus communis Woodland
Abies lasiocarpa / Mertensia ciliata Forest
Abies lasiocarpa / Moss Forest
Abies lasiocarpa / Ribes (*montigenum, lacustre, inerme*) Forest
Abies lasiocarpa / Salix drummondiana Forest
Abies lasiocarpa / Vaccinium myrtillus Forest
Abies lasiocarpa / Vaccinium scoparium Forest
Achnatherum hymenoides - Psoralidium lanceolatum Herbaceous Vegetation
Alnus incana - Salix (*monticola, lucida, ligulifolia*) Shrubland
Alnus incana - Salix drummondiana Shrubland
Alnus incana / Mesic Forbs Shrubland
Alnus incana / Mesic Graminoids Shrubland
Alnus incana- Salix irrorata Shrubland
Aquilegia caerulea - Cirsium scopulorum Scree Herbaceous Vegetation
Calamagrostis canadensis - Carex scopulorum - Mertensia ciliata Herbaceous Vegetation
Calamagrostis canadensis - Senecio triangularis Herbaceous Vegetation
Calamagrostis canadensis Western Herbaceous Vegetation
Calamagrostis stricta Herbaceous Vegetation [Provisional]
Caltha leptosepala - Deschampsia caespitosa Herbaceous Vegetation
Caltha leptosepala - Polygonum bistortoides Herbaceous Vegetation
Caltha leptosepala - Rhodiola rhodantha Herbaceous Vegetation
Caltha leptosepala Herbaceous Vegetation
Cardamine cordifolia - Caltha leptosepala Herbaceous Vegetation
Carex aquatilis - Carex utriculata Herbaceous Vegetation
Carex aquatilis - Pedicularis groenlandica Herbaceous Vegetation
Carex aquatilis Herbaceous Vegetation
Carex elynoides Herbaceous Vegetation
Carex microptera Herbaceous Vegetation
Carex nebrascensis - Catabrosa aquatica Herbaceous Vegetation
Carex nebrascensis Herbaceous Vegetation

Carex pellita Herbaceous Vegetation
Carex scopulorum - Caltha leptosepala Herbaceous Vegetation
Carex scopulorum - Elymus trachycaulus Herbaceous Vegetation
Carex scopulorum Herbaceous Vegetation
Carex simulata Herbaceous Vegetation
Carex utriculata Herbaceous Vegetation
Carex vesicaria Herbaceous Vegetation
Cercocarpus montanus / Muhlenbergia montana Shrubland
Chamerion angustifolium Rocky Mountain Herbaceous Vegetation [Provisional]
Chrysothamnus viscidiflorus / Poa pratensis Semi-natural Shrub Herbaceous Vegetation [Provisional]
Crataegus rivularis Shrubland
Dasiphora fruticosa ssp. *floribunda* Shrubland [Provisional]
Deschampsia caespitosa Herbaceous Vegetation
Distichlis spicata - (*Scirpus nevadensis*) Herbaceous Vegetation
Distichlis spicata Herbaceous Vegetation
Eleocharis palustris Herbaceous Vegetation
Eleocharis quinqueflora Herbaceous Vegetation
Ericameria nauseosa / Bromus tectorum Semi-natural Shrubland
Ericameria nauseosa / Muhlenbergia pungens - Achnatherum hymenoides Shrub Herbaceous Vegetation
Ericameria nauseosa / Sporobolus airoides Shrubland [Provisional]
Ericameria nauseosa Sand Deposit Sparse Shrubland
Ericameria nauseosa Shrubland [Provisional]
Ericameria parryi Shrubland [Provisional]
Festuca arizonica - Muhlenbergia montana Herbaceous Vegetation
Festuca brachyphylla - Geum rossii var. *turbinatum* Herbaceous Vegetation
Festuca thurberi Subalpine Grassland Herbaceous Vegetation
Geum rossii Herbaceous Vegetation
Hesperostipa comata - Achnatherum hymenoides Herbaceous Vegetation
Juncus balticus Herbaceous Vegetation
Kobresia myosuroides - Geum rossii Herbaceous Vegetation
Minuartia obtusiloba Herbaceous Vegetation
Muhlenbergia asperifolia Herbaceous Vegetation
Muhlenbergia filiculmis Herbaceous Vegetation
Myriophyllum sibiricum Herbaceous Vegetation
Nuphar lutea ssp. *polysepala* Herbaceous Vegetation
Paronychia pulvinata - Silene acaulis Dwarf-shrubland
Pascopyrum smithii - Bouteloua gracilis Herbaceous Vegetation
Phalaris arundinacea Western Herbaceous Vegetation
Phippsia algida Herbaceous Vegetation
Picea engelmannii / Heracleum maximum Forest
Picea engelmannii / Moss Forest
Picea engelmannii / Vaccinium myrtillus Forest
Picea pungens / Arctostaphylos uva-ursi Forest
Picea pungens / Carex siccata Forest

Picea pungens / Cornus sericea Woodland
Picea pungens / Erigeron eximius Forest
Picea pungens / Linnaea borealis Forest
Pinus aristata / Festuca arizonica Woodland
Pinus aristata / Ribes montigenum Woodland
Pinus edulis - (*Juniperus monosperma*) */ Bouteloua gracilis* Woodland
Pinus edulis - Juniperus spp. */ Cercocarpus montanus* Woodland
Pinus edulis / Bouteloua curtipendula Woodland
Pinus edulis / Poa fendleriana Woodland
Pinus edulis / Rockland Woodland
Pinus edulis / Sparse Understory Forest
Pinus flexilis / Arctostaphylos uva-ursi Woodland
Pinus ponderosa / Achnatherum hymenoides Sparse Vegetation
Pinus ponderosa / Arctostaphylos uva-ursi Woodland
Pinus ponderosa / Bouteloua gracilis Woodland
Pinus ponderosa / Carex inops ssp. *heliophila* Woodland
Pinus ponderosa / Cercocarpus montanus Woodland
Pinus ponderosa / Festuca arizonica Woodland
Pinus ponderosa / Muhlenbergia montana Woodland
Pinus ponderosa / Rockland Woodland
Polygonum amphibium Permanently Flooded Herbaceous Vegetation [Placeholder]
Populus angustifolia - Juniperus scopulorum Woodland
Populus angustifolia - Picea pungens / Alnus incana Woodland
Populus angustifolia - Pseudotsuga menziesii Woodland
Populus angustifolia / Alnus incana Woodland
Populus angustifolia / Crataegus rivularis Woodland
Populus angustifolia / Salix exigua Woodland
Populus angustifolia Sand Dune Forest
Populus tremuloides - Abies concolor / Symphoricarpos oreophilus Forest
Populus tremuloides - Abies lasiocarpa / Amelanchier alnifolia Forest
Populus tremuloides - Abies lasiocarpa / Carex geyeri Forest
Populus tremuloides - Abies lasiocarpa / Carex rossii Forest
Populus tremuloides - Abies lasiocarpa / Juniperus communis Forest
Populus tremuloides - Abies lasiocarpa / Shepherdia canadensis Forest
Populus tremuloides - Abies lasiocarpa / Symphoricarpos oreophilus / Tall Forbs Forest
Populus tremuloides - Abies lasiocarpa / Tall Forbs Forest
Populus tremuloides - Picea pungens Forest
Populus tremuloides - Pinus flexilis Forest
Populus tremuloides - Pinus ponderosa Rocky Mountain Forest
Populus tremuloides - Pseudotsuga menziesii / Amelanchier alnifolia Forest
Populus tremuloides - Pseudotsuga menziesii / Juniperus communis Forest
Populus tremuloides - Pseudotsuga menziesii / Symphoricarpos oreophilus Forest
Populus tremuloides / Acer glabrum Forest
Populus tremuloides / Calamagrostis canadensis Forest
Populus tremuloides / Carex siccata Forest
Populus tremuloides / Corylus cornuta Forest

Populus tremuloides / Festuca thurberi Forest
Populus tremuloides / Juniperus communis Forest
Populus tremuloides / Lonicera involucrata Forest
Populus tremuloides / Pteridium aquilinum Forest
Populus tremuloides / Ribes montigenum Forest
Populus tremuloides / Senecio bigelovii var. *bigelovii* Forest
Populus tremuloides / Shepherdia canadensis Forest
Populus tremuloides / Symphoricarpos oreophilus / Thalictrum fendleri Forest
Populus tremuloides / Symphoricarpos oreophilus Forest
Populus tremuloides / Vaccinium myrtillus Forest
Potamogeton diversifolius Herbaceous Vegetation
Potamogeton foliosus Herbaceous Vegetation
Potamogeton natans Herbaceous Vegetation
Pseudotsuga menziesii / Betula occidentalis Woodland
Pseudotsuga menziesii / Bromus ciliatus Forest
Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland
Pseudotsuga menziesii / Mahonia repens Forest
Pseudotsuga menziesii / Symphoricarpos oreophilus Forest
Puccinellia nuttalliana Herbaceous Vegetation
Ranunculus aquatilis - Callitriche palustris Herbaceous Vegetation
Redfieldia flexuosa - (*Psoralidium lanceolatum*) Herbaceous Vegetation
Salicornia rubra Herbaceous Vegetation
Salix arctica - Salix nivalis Dwarf-shrubland
Salix boothii / Mesic Forbs Shrubland
Salix boothii / Mesic Graminoids Shrubland
Salix brachycarpa / Carex aquatilis Shrubland
Salix brachycarpa / Mesic Forbs Shrubland
Salix drummondiana / Calamagrostis canadensis Shrubland
Salix drummondiana / Carex utriculata Shrubland
Salix drummondiana / Mesic Forbs Shrubland
Salix exigua - Salix ligulifolia Shrubland
Salix exigua - Salix lucida ssp. *caudata* Shrubland
Salix exigua / Agrostis stolonifera Shrubland
Salix exigua / Elymus x *pseudorepens* Shrubland
Salix exigua / Mesic Forbs Shrubland
Salix exigua / Mesic Graminoids Shrubland
Salix exigua Temporarily Flooded Shrubland
Salix geyeriana / Calamagrostis canadensis Shrubland
Salix geyeriana / Carex aquatilis Shrubland
Salix geyeriana / Carex utriculata Shrubland
Salix geyeriana / Deschampsia caespitosa Shrubland
Salix geyeriana / Mesic Forbs Shrubland
Salix geyeriana / Mesic Graminoids Shrubland
Salix irrorata Shrubland
Salix ligulifolia / Carex utriculata Shrubland [Provisional]
Salix ligulifolia Shrubland

Salix lucida ssp. *caudata / Rosa woodsii* Shrubland
Salix lucida ssp. *caudata* Shrubland [Provisional]
Salix lutea / Calamagrostis canadensis Shrubland
Salix lutea / Carex utriculata Shrubland
Salix lutea / Mesic Forbs Shrubland
Salix monticola / Calamagrostis canadensis Shrubland
Salix monticola / Carex aquatilis Shrubland
Salix monticola / Carex utriculata Shrubland
Salix monticola / Mesic Forbs Shrubland
Salix monticola / Mesic Graminoids Shrubland
Salix monticola Thicket Shrubland
Salix planifolia / Calamagrostis canadensis Shrubland
Salix planifolia / Caltha leptosepala Shrubland
Salix planifolia / Carex aquatilis Shrubland
Salix planifolia / Carex scopulorum Shrubland
Salix planifolia / Deschampsia caespitosa Shrubland
Salix planifolia / Mesic Forbs Shrubland
Salix planifolia Shrubland
Salix wolfii / Carex aquatilis Shrubland
Salix wolfii / Carex utriculata Shrubland
Salix wolfii / Deschampsia caespitosa Shrubland
Salix wolfii / Mesic Forbs Shrubland
Sarcobatus vermiculatus / Artemisia tridentata Shrubland
Sarcobatus vermiculatus / Distichlis spicata Shrubland
Sarcobatus vermiculatus / Juncus balticus Sparse Vegetation
Sarcobatus vermiculatus / Sporobolus airoides Sparse Vegetation
Sarcobatus vermiculatus / Suaeda moquinii Shrubland
Sarcobatus vermiculatus Dune Shrubland
Sarcobatus vermiculatus Shrubland
Schoenoplectus acutus Herbaceous Vegetation
Schoenoplectus maritimus Herbaceous Vegetation
Schoenoplectus pungens Herbaceous Vegetation
Schoenoplectus tabernaemontani Temperate Herbaceous Vegetation
Sibbaldia procumbens - *Polygonum bistortoides* Herbaceous Vegetation
Sparganium angustifolium Herbaceous Vegetation
Sparganium eurycarpum Herbaceous Vegetation
Spartina gracilis Herbaceous Vegetation
Sporobolus airoides - *Distichlis spicata* Herbaceous Vegetation
Sporobolus airoides Monotype Herbaceous Vegetation
Suaeda moquinii Shrubland
Trifolium dasyphyllum Herbaceous Vegetation
Triglochin maritima Herbaceous Vegetation
Typha latifolia Western Herbaceous Vegetation
Un-described community formed by combinations of *Atriplex*, *Sarcobatus*, and *Chrysothamnus*.

Appendix E: Sampling Design Implementation

Classification Phase

The implementation of the GRSA VegMap design includes four major components (given in order of how they are usually done):

1. Office based reconnaissance of all base and a sufficient number of oversample sites;
2. Adjustment of the expected sites to be sampled based on this evaluation;
3. Field evaluation and sampling of design sites;
4. Opportunistic sampling of sites (not specified by the design) needed to satisfy classification and mapping objectives.

Note that for the project the relative priority of steps 3 and 4 is with Opportunistic sampling (step 4), but their order is listed as above because usually Opportunistic samples will be taken while the crews are navigating towards design points. A "Design File" is used to describe each design site and may be used to track the status of each sample. This is an important file to maintain in an organized and current fashion as the project unfolds.

1. Office Reconnaissance

All base sites, plus approximately 5% of oversample sites should be evaluated 'remotely' using the best available GIS data and professional experience with the GRSA area. These evaluations can be cursory, but they will also provide an important background of information such as access routes, land ownership and permission issues for each site evaluated. Each point should be compared to data such as Digital Ortho Quads (DOQQs), aerial photography, topographic maps, existing land cover and vegetation maps, and local experience to classify them into the categories in Table E1. Office evaluations may not be able to classify many sites with a high degree of confidence (some codes may only be applicable with field visits). All evaluations are recorded in the appropriate field in the working version of the Design File maintained by the Crew Leader and when sites are evaluated in the field, in the Evaluation Form.

Table E1. Site status classes.

Name	Code	Meaning
Target	T	Site is a member of the target population (accessible natural vegetation within footprint) that is not oversampled to date.
Unknown	U	Unable to evaluate with office work only
Oversampled	OS	A target site but with a vegetation type that is not needed. See below.
Non-representative	NR	Site is not representative of the surrounding area (the 'stand' or 'patch' - the general area within line of site and/or within a 100m radius)
No Access	NA	Site is target, but unsafe to sample, too costly to access or landowner denied access to the site
Non-natural	NN	Site is in a non-natural (and unsampled) vegetation type.
Target Sampled	TS	Site is a member of the target population (accessible natural vegetation within footprint) *and was successfully sampled*

2. Adjustment of sites to be sampled (Site Replacement)

Oversample sites are used in replacement of non-target base sites. As the crew conducts office-based site-verification, a final list of sites to potentially visit and sample will be generated. [Note that the same process is applied during field visits (but 'on the fly'), with final evaluations of each design site noted on the Evaluation Form]. If the design is to maintain its integrity (a lesser goal than classifying and mapping the vegetation), the cardinal rule is that *non-target sites are replaced in their order within their respective multidensity category oversample list.* The "OverSamp_Order" field in the design file (see below) provides a rank order of the oversample sites within each multidensity category

3. Field Evaluation and Design Sampling

Using the set of sites developed during office reconnaissance, sites may be visited and potentially sampled in any order (e.g., east to west, etc.). However, (if design integrity is to be maintained) any new replacements of a base or 'promoted' oversample must again occur in the order of remaining sites in the oversample lists.

The general process for determining if a design site is can be sampled is as follows:

1. Navigate to the site (following all rules detailed in the Field Manual);
2. The preferred end points of this navigation are (in order): the X-Y centroid of the site, a safe and effective vantage point where the site can be 'seen', or as close as safely possible to the site (e.g., on a edge of a thick impenetrable stand of willow);
3. The site status (e.g., target, non-target) should be confirmed or updated using the same set of categories in Table 6 and noted on the Field Evaluation form;
4. For all design sites that are not to be sampled, a brief description, including a provisional Ecological System type should be noted;
5. For Target sites, implement a full vegetation plot using all rules of adjustment detailed in the Field Manual (e.g., avoiding ecotones, etc.). Note that a site may be moved within the dimensions of the plot (usually 20 meters) and still retain its status as a design site). Be sure to record the correct Design site ID (range is 001 – 1999 for NPS sites and 2001 – 2999 for Other sites) on the Vegetation Plot form;
6. Evaluate if the design site is a candidate for a observation point and if so, conduct this protocol as detailed in the manual;
7. If the site is not to be sampled, proceed with any opportunistic ("Oppo") full plot or observation point sampling in the area (see below).

4. Opportunistic Sampling

Any sampling done outside of a design site is designated as Opportunistic. Given the coarseness of the sample frame and the objectives of the project, full vegetation plot Oppo sites may be more common than design sites. The rules for locating an Oppo site are detailed in the Field Manual. Be sure to ***not*** Use any Site ID number from the Design range detailed above. Each crew will be given a range of numbers (Crew 1: 3001 – 3999; Crew 2: 4001 – 4999) to use for Oppo points. Note that these Site IDs are applied to either a full plot or an observation point (just be sure to track what the next available number for your crew is).

Design File

The list of sites generated through the sample design process is stored in a database known as the design file (GRSA_VegMap.csv). Additional fields may be added (to a working copy) if they will assist in field operations - but they should always be in addition to, not in place of, original data fields. The structural relationships of the cells in a design file should never be altered (e.g., such that a site becomes associated with incorrect attribute fields).

Accuracy Assessment Phase

The ‘final’ design (grsa_aa_uneqldsgn3_final_20080602.*) is a subset of the complete design with only 6821 out of over 45k points in the total design. These points are the base and first 100 oversample points in each map class (see the Panel field). The design does include points for non AA types which can be ignored. The first step in implementing the design is to evaluate the feasibility or appropriateness of the base sample points within each map class (the cost class modifier is ignored). This is primarily done in the office (in conjunction with park staff as needed) although some points would ideally be evaluated with a field recon visit. Because one of the key criteria for an AA point being acceptable is its distance from its closest neighbors (such that AA data are independent) these points were all analyzed for minimum separation distances using both automated and hand procedures. The design order was also used to include points that were lower ordered in this minimum separation distance analysis. Any point that was within the minimum separation distance from its nearest neighbor was labeled as “NS” (non sampleable) in the EvalStat field. All other points kept the default EvalStat label of “NotEval” (not evaluated). These “NotEval” therefore form the points are the candidate points for the AA.

Using these points the primary criteria for site evaluation are design order of each point within its map class (ignoring cost modifier) with lower ordered points having higher priority, and the reality of accessing and safely sampling each site (this also includes sampling sensitive locations and the rare cases of sampling on private land). The automated and hand analysis of nearest neighbor distances discussed above should have dealt with the minimum separation among AA points. *The expected vegetation at the point (i.e., based on what it might look like in imagery or from personal experience), <u>is not</u> used to evaluate the sampleability of each point, rather this is the key response measure of the AA process.*

Point Replacement

Conceptually, the first (with the ordering defined by the design and reflected in the SiteNo or SiteID fields) N points per map class (see Table xx) are the points that should be sampled for AA. However, additional office recon (and perhaps field recon) may determine that some AA points that are likely not sampleable. Moreover, as points are visited in the field and reality rears its head, points will become non sampleable (NS in the EvalStat field). To maintain the needed sample sizes, these points must be replaced.

The cardinal rule for replacing is to replace points within map classes (ignoring the cost modifier) with the lowest SiteNo available oversample point in the design. Because the design has no strata or multiple stages, r*eplacement points can be in very different locations* than the point they replace (or they may be right next door…). Because sites can be actually sampled in the field in any order, with proper planning this is usually not an issue when implementing GRTS designs.

If the number of oversample sites for any map class is not sufficient in grsa_aa_uneqldsgn3_final_20080602.* after all office recon (or during field sampling). B. Schweiger with the ROMN should be contacted for more sites.

The order of field sampling is independent from the design order so points may be put into sample hitches in any sensible operational order as needed. It is advisable to recon points as you travel to other points and it may be useful to sample points (as you travel past them) that will not necessarily to be used in the final analysis.

Tracking Site Status

In all cases site status must be carefully tracked such that sample inclusion probabilities can be adjusted after all sampling is complete.

Points that are deemed by office recon to be likely sampleable should be changed to “TO” (target office). Points that are deemed by office recon to be likely non sampleable because of safety or access should be changed to “NS” (non sampleable), with a note in the EvalStat field explaining that the site is too far away or unsafe or is in an area the park does not want sampled or is on private property and permission was not granted, etc.). Any point that is successfully sampled should be changed to “TS” (target sampled).

Adding Sites

If for some reason, more sites within a map class are needed during field sampling (for example if the base N is determined to be too small) these should be added with the next available oversample sites for the map class (ignoring the cost modifier).

Adjustment or Sliding Sample Points

Each day crews chose points to visit based on logistical factors. Low elevation points were visited early or late in the season, while high elevation sites were only accessible when not covered by snow. Remote sites were visited during backpacking trips, which were planned prior to the start of the field season. Field days were planned around collecting as many primary points as possible; however, when secondary points occurred along a planned route for the day, they were surveyed in anticipation of future points which might be missed. The tally of which points had been collected in each Map Unit was updated throughout the summer. During the last few weeks of the project, areas for the crews to visit were chosen strategically, to assure point coverage across all of the Map Units.

Upon arrival at a point, crews would begin with a broad visual survey of the area. This was done to determine whether vegetation at the point was representative of the Map Unit polygon (ecotone or inclusions). If vegetation was not representative, the crew would move the point to a more representative location within the polygon and record the distance and bearing to the new point. The crew would then visually determine the boundaries of the point to be sampled. The minimum mapping unit is 0.5 ha and this was used as the sample plot. Crews would then use the map unit key and vegetation association keys (Appendix H) to determine both the map unit and association for the visited point. If no Association seemed to fit, the crew would assign an association name to the plot based on the NVC naming conventions for Associations (dominant species of the primary strata). At each plot four pictures were taken in each of the cardinal directions from the plot center. The pictures and the notes that crews collected in the field proved very useful in resolving classification questions later during the AA.

Appendix F:
Field Methods - Field Manual and Forms





FIELD MANUAL FOR SAMPLING AT GREAT SAND DUNES NATIONAL PARK AND PRESERVE, 2006

A Basic Guide for Field Work

USGS/NPS Vegetation Mapping Program

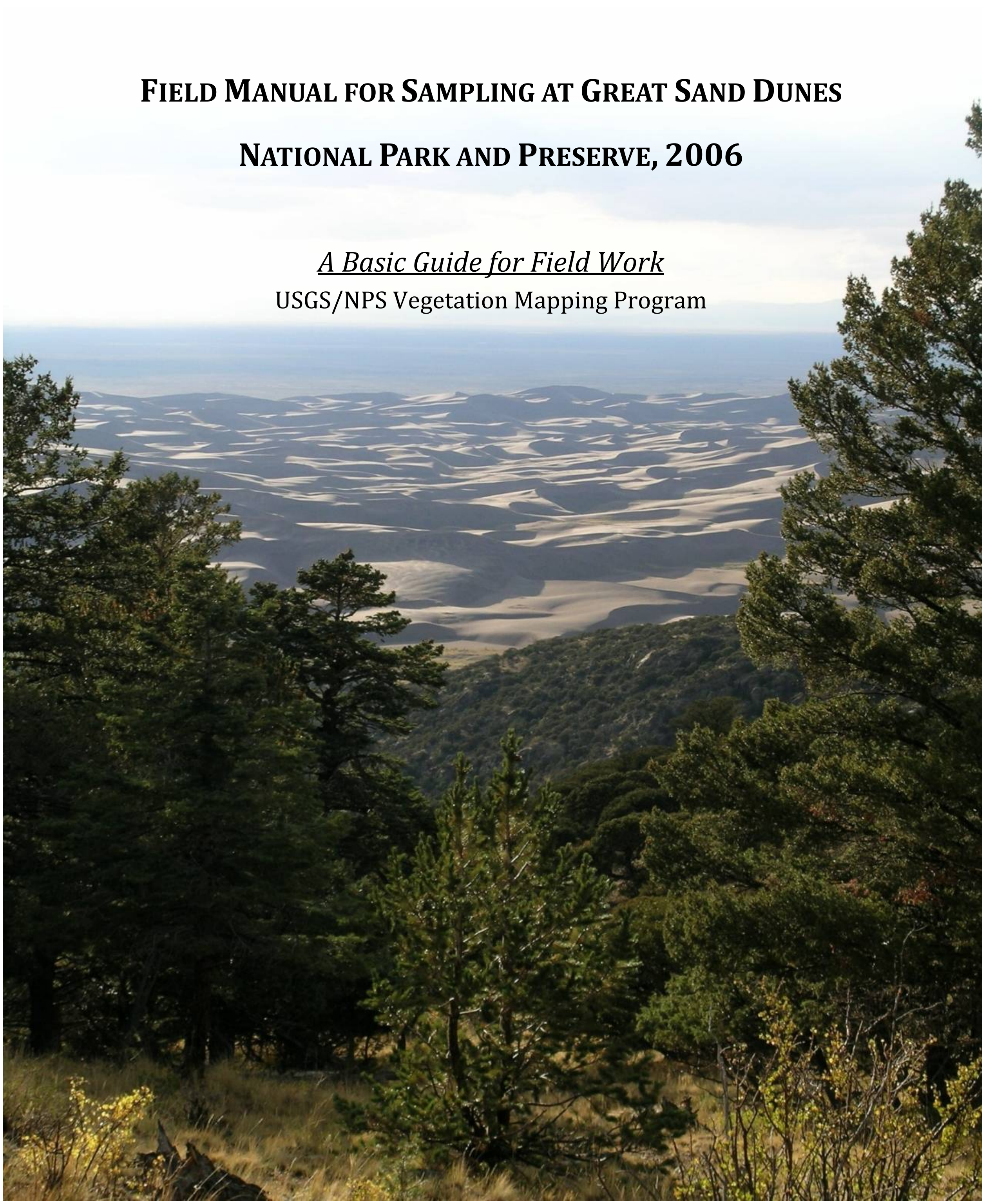


TABLE OF CONTENTS

Background ... 168
Colorado's Natural Heritage Program ... 168
USGS-NPS Vegetation Mapping Program Overview ... 168
The U.S National Vegetation Classification ... 169
Great Sand Dunes Vegetation Mapping Project ... 169
INTRODUCTION TO THE AREA ... 171
Short History ... 171
Amenities ... 171
Transportation ... 172
Communications ... 172
Work Schedule ... 172
FIELD WORK OVERVIEW ... 174
Sampling Design ... 174
Determining Plot Type and Plot Location ... 174
Establishing a Permanent Plot ... 175
Vegetation Survey Form Instructions ... 176
Fuel Inventory Form Instructions ... 187
Field Log ... 188
Data Collection Notes ... 188
Unknown Species ... 188
Voucher Specimen Collection ... 188
Plants New to GRSA ... 189
Noxious Weeds ... 189
Element Occurrences/Rare Plants and Plant Communities ... 189
Useful Field Manuals ... 193
SAFETY ... 193
Data Management and Planning ... 195
Planning for the day ... 195
End of Session ... 196
Use of CNHP and Park Property ... 196
Rules and Regulations ... 197
Literature Cited ... 197
Appendices of the GRSA Field Manual ... 198
Appendix A: Field Forms ... 198
Appendix B: Species New to GRSA from the 2005 Season ... 215
Appendix C: GRSA Ecological Systems ... 222
Appendix D: Safety Information - Lightning ... 231
Appendix E: 4x4 Driving Techniques ... 236
Appendix F: The Natural Heritage Network Ranking System ... 239
Appendix G: GRSA Contact List ... 247
Appendix H: Camera and GPS Settings and GPS-Photo Link ... 248
Appendix I: National Vegetation Classification Principles and Structure ... 251
Appendix J: Provisional Map Units and Associations ... 264

Background

Colorado's Natural Heritage Program

CNHP is the state's primary comprehensive biological diversity data center, gathering information and field observations to help develop statewide conservation priorities. After operating in the Colorado Division of Parks and Outdoor Recreation for 14 years, the Program was relocated to the University of Colorado Museum in 1992, and then to the College of Natural Resources at Colorado State University in 1994, where it has operated since.

The multi-disciplinary team of scientists, planners, and information managers at CNHP gathers comprehensive information on the rare, threatened, and endangered species and significant plant communities of Colorado. Life history, status, and locational data are incorporated into a continually updated data system. Sources include published and unpublished literature, museum and herbaria labels, and field surveys conducted by knowledgeable naturalists, experts, agency personnel, and our own staff of botanists, ecologists, and zoologists.

All Natural Heritage Programs house data about imperiled species and are implementing use of the Biodiversity Tracking and Conservation System (BIOTICS) developed by NatureServe. This database includes taxonomic group, global and state rarity ranks, federal and state legal status, observation source, observation date, county, township, range, watershed, and other relevant facts and observations. BIOTICS also has an ArcView based mapping program for digitizing and mapping occurrences of rare plants, animals, and plant communities. These rare species and plant communities are referred to as "elements of natural diversity" or simply "elements."

Concentrating on site-specific data for each element enables CNHP to evaluate the significance of each location for the conservation of biological diversity in Colorado and in the nation. By using species imperilment ranks and quality ratings for each location, priorities can be established to guide conservation action. A continually updated locational database and priority-setting system such as that maintained by CNHP provides an effective, proactive land-planning tool. **Appendix F** provides more information on CNHP and Natural Heritage Network Ranking System.

USGS-NPS Vegetation Mapping Program Overview

The USGS-NPS Vegetation Mapping Program is a cooperative effort by the U.S. Geological Survey (USGS) and the National Park Service (NPS) to classify, describe, and map vegetation communities in more than 270 national park units across the United States. This landmark program is both the first to provide national-scale descriptions of vegetation for a federal agency and the first to create national vegetation standards for its data products. Its goal is to meet specific information needs identified by the National Park Service.

The vegetation mapping program is an important part of the NPS Inventory and Monitoring Program, a long-term effort to develop baseline data for all national park units that have a natural resource component. It is jointly managed by the USGS Center for Biological Informatics and the National Park Service's Inventory and Monitoring Program.

Program activities are based on peer-reviewed, objective science. Comprehensive vegetation information is provided at national and regional levels, while also serving local management needs of individual parks. Stringent quality control procedures ensure that products are accurate and consistent for initial inventory purposes and replicable for monitoring purposes. The spatially enabled digital products produced by the program are available on the World Wide Web.

Program scientists have developed data collection procedures for classification, mapping, accuracy assessment, and use of existing data. Program products meet Federal Geographic Data Committee standards for vegetation classification and metadata, and national standards for spatial accuracy and data transfer. Standards include a minimum mapping unit of 0.5 hectares and classification accuracy of 80% for each map class. Nature Serve, an important partner in the USGS-NPS Vegetation Mapping program, is the caretaker of the National Vegetation Classification System, which is used by the program to classify vegetation communities.

A report of project methods and results is provided at completion of individual projects. Project results include a rich set of data and information for each park project, as follows:

- Spatial Data
  - Aerial photography
  - Map classification
  - Map classification description and key
  - Spatial database of vegetation communities
  - Hardcopy maps of vegetation communities
  - Metadata for spatial databases
  - Complete accuracy assessment of spatial data
- Vegetation Information
  - Vegetation classification
  - Dichotomous field key of vegetation classes
  - Formal description for each vegetation class
  - Ground photos of vegetation classes
  - Field data in database format

The U.S National Vegetation Classification

The U.S. National Vegetation Classification was constructed to attempt to integrate the features of existing classification systems to best fit the needs of the Nature Conservancy and its partners. Major issues include that the classification: is vegetation-based, uses a systematic approach to classifying a continuum, emphasized natural vegetation, emphasized existing vegetation, uses a combined physiognomic-floristic hierarchy, identifies vegetation units based on both qualitative and quantitative data at a scale that is practical for conservation, and is appropriate for mapping at multiple scales. **Appendix I** is from the document “The National Vegetation Classification System: Development, Status, and Applications.” Chapter three and four are included to explain the guiding principles and the structure of the USNVC (Grossman, et al. 1998)).

Great Sand Dunes Vegetation Mapping Project

The Great Sand Dunes Vegetation Mapping project will complete a vegetation classification and map of the Park and its surrounding landscape. The project team, composed of members listed below, will: define a preliminary classification, target areas of interest for field survey, locate plots in areas of interest, classify plot data, map vegetation using a combination of digital and manual photo interpretation, write a dichotomous key and local descriptions to the classified types, perform an accuracy assessment of the map, and publish final reports and supporting documents.

The project boundary includes the GRSA Park and Preserve, the Baca National Wildlife Refuge, the Medano-Zapata Ranch lands, and portions of USFS, BLM, State, and other private lands totaling ~413,000 acres. It was developed as a “conservation boundary” to incorporate selected ecological and jusrisdictional components and largely follows watershed boundaries. See Figure 1: Map of Project Area.

Vegetation plot data collection began in the summer of 2005. The classification is in a preliminary stage, and there is a working list of potential map classes. Map photo imagery is scheduled to be taken in the summer of 2006, and vegetation plot data collection will be completed by the end of the 2006 field season.

Some basic GRSA project area descriptors

Total Area: 413,036 acres
Elevation gradient: 2058 meters (2289 m to 4347 m)
Multiple 13k+ peaks
Local watersheds:
- San Isabel and Crestone Creeks
- Medano and Sand Creeks
- Zapata Creek

Ecological Systems ranging from Inter-Mountain Basin to Alpine Tundra
~8.8 sq. km of alpine and playa lakes:
- San Luis Lake
- Upper & Lower Sand Creek Lakes

Counties and Municipalities:
- Saguache & Alamosa Counties
- City of Crestone

Landownership

These values are estimates and are subject to change.

Owner/Manager	Acres	Sq. Miles	% of Project Area
National Park Service	149,500	233	37
US Fish and Wildlife Service	92,800	145	22
US Forest Service	59,150	92	14
The Nature Conservancy	54,400	85	13
Private	44,830	70	11
Bureau of Land Management	7,430	12	2
Colorado Division of Wildlife	2,960	5	1
State of Colorado	2,495	4	0.5

Partners for the GRSA Vegetation Mapping project include:

Formal and informal: NPS, Colorado Natural Heritage Program, US Geologic Survey, US Fish and Wildlife Service, US Bureau of Reclamation, The Nature Conservancy, NatureServe, US Forest Service, US Bureau of Land Management, Colorado State Parks, Colorado Forest Service, Multiple local San Luis Valley stakeholders (Baca Grande Property Owners Association, Crestone / Baca Land Trust, San Luis Valley Ecosystem Council, Friends of the Dunes)

Administration for the project

NPS Veg Map Program Oversight: Karl Brown, Chris Lea
GRSA: Phyllis Pineda Bovin, Fred Bunch, and Andrew Valdez
NPS Rocky Mountain Network: Billy Schweiger, Mike Britten
Vegetation Classification by Colorado Natural Heritage Program: Joe Stevens
Imagery interpretation and map production by US Bureau of Reclamation and US Geologic Survey: Dan Cogan, Cogantech, LLC, and Bev Freisen, USGS

INTRODUCTION TO THE AREA

This summer you will be living in, and working in and near, Great Sand Dunes National Park and Preserve (GRSA), which is located on the east side of the San Luis Valley in south central Colorado. The San Luis valley is a large basin, with an average of 8,000 ft. elevation, surrounded by high mountains. To the east, the Sangre de Cristo range towers over the dunes, and to the west one can see the San Juan Mountains. The sand dunes, located at the base of the Sangre de Cristos, are the tallest in North America. About 300,000 visitors come to the park annually, and most visit during the warmer summer months. Summer temperatures at this 8200' (2470 m) elevation average in the 80's F., with lows at night averaging in the 40's F, though temperatures may be much colder in the mountains.

The park Visitor Center is open every day in summer from 9 a.m. to 5 p.m. though longer hours may exist as staffing permits. Call (719) 378-6399 to reach a ranger at the Visitor Center. For more complete information about park rules and regulations, and for general information check out the park website at http://www.nps.gov/grsa/.

Short History

The Great Sand Dunes were first protected in 1932 as a National Monument created by President Hoover in response to citizen concern that mining and sand quarrying would permanently damage the dunes. In 2000 President Clinton, in response to concerns about water and bird protection, signed a bill that expanded the original Monument to include the west side on the Sangre de Cristo Mountains and lands to the north and west of the sand dunes. This bill also changed the status of the dunes from National Monument to National Park, with the mountains designated a National Preserve. The bill took effect in September, 2004.

Amenities

Living Arangements:
You will be living right in the middle of GRSA this summer, in housing provided by the park which will include beds, kitchen, showers and other amenities. There will be 6 crew members in a 3 bedroom house, so everyone will have room mates. The house will be your base for the summer; however you will be camping and backpacking often. The address for the house is:

#6 Pinyon Circle, Great Sand Dunes National Park, Mosca, CO 81146

Food, Towns, Lodging and such:
The Oasis store and restaurant, (719) 378-2222, is located just outside the park entrance. It provides gas, basic groceries, and a restaurant daily during the summer. In the past they have had all-you-can-eat ice cream on Saturday nights, bring your own bowl and spoon. The Great Sand Dunes Lodge, (719) 378-2900, is a modern motel located behind the Oasis. It is the closest lodging to the park. All services and motels are available year-round in Alamosa; shops and motels in Blanca, Mosca, and Hooper are open daily in summer.

The town of Alamosa is the largest in the San Luis Valley, with 7,800 residents. It serves as the commercial center for the valley, and is located about a 35 mile drive from GRSA. The town has grocery stores, including Safeway, City Market, and at least one organic food store, the Valley Food Co-op. The Valley Farmer’s Market begins July 10, and runs every Saturday from 7-2 through October in downtown Alamosa. The town also has many restaurants, bars, and options for lodging. There is one outdoor gear/bike store located next to the Food Co-op. Alamosa is the home of Adams State College, a state school with a student population of about 2,500. The official web site for Alamosa is http://www.alamosachamber.com/.

Mosca is the closest town to GRSA, located about 23 miles west. It has about 250 residents and a post office. Hooper, north of Mosca, has developed hot springs. Blanca is directly south of the park and has about 400 residents and several stores including groceries.

Transportation

Public transportation to and from Alamosa includes air and bus. The airport has several daily flights to Denver International Airport, and these tend to up the total price of your round trip ticket by $150-$200. Greyhound stops in several places in the San Luis Valley, and a shuttle service runs from Durango's airport for something like $100 round trip.

Communications

Though I haven't tried it, this web site, http://www.mountainwireless.com/vzwnews.htm, claims that GRSA is covered by Verizon Wireless. Sprint and other providers will not work in the area. Alamosa has complete cell phone coverage. You will be working in an office building located near the house. The office will have a computer with internet access, and there will be phones in the house and office.

GRSA Office Phone (General Management Building) **719-378-6374**

GRSA Housing Phone (#6 Pinyon Circle) **719-378-_____**

Work Schedule

Work will begin on Monday the 5th of June and work will proceed on a 10 days on, 4 days off schedule all summer until field work is no longer feasible, probably late September or early October. The first two weeks will be mostly orientation and training, after that you will spend the summer collecting plots in the project area. Tentative schedule:
10 days on four days off schedule as follows starting Monday June 5th 2005

Session 1: Orientation and Training	Monday June 5th – Wednesday June 14th
Session 2:	Monday June 19th – Wednesday June 28th
Independence Day	Tuesday July 4th
Session 3:	Wednesday July 5th – Wednesday July 12th
Session 4:	Monday July 17th – Wednesday 26th
Session 5:	Monday July 31st – Wednesday August 9th
Session 6:	Monday August 14th – Wednesday August 23rd
Session 7:	Monday August 28th – Wednesday September 6th
Labor Day	Monday September 4th ?
Session 8:	Monday September 11th – Wednesday September 20th
Session 9:	Monday September 25th – Wednesday October 4th

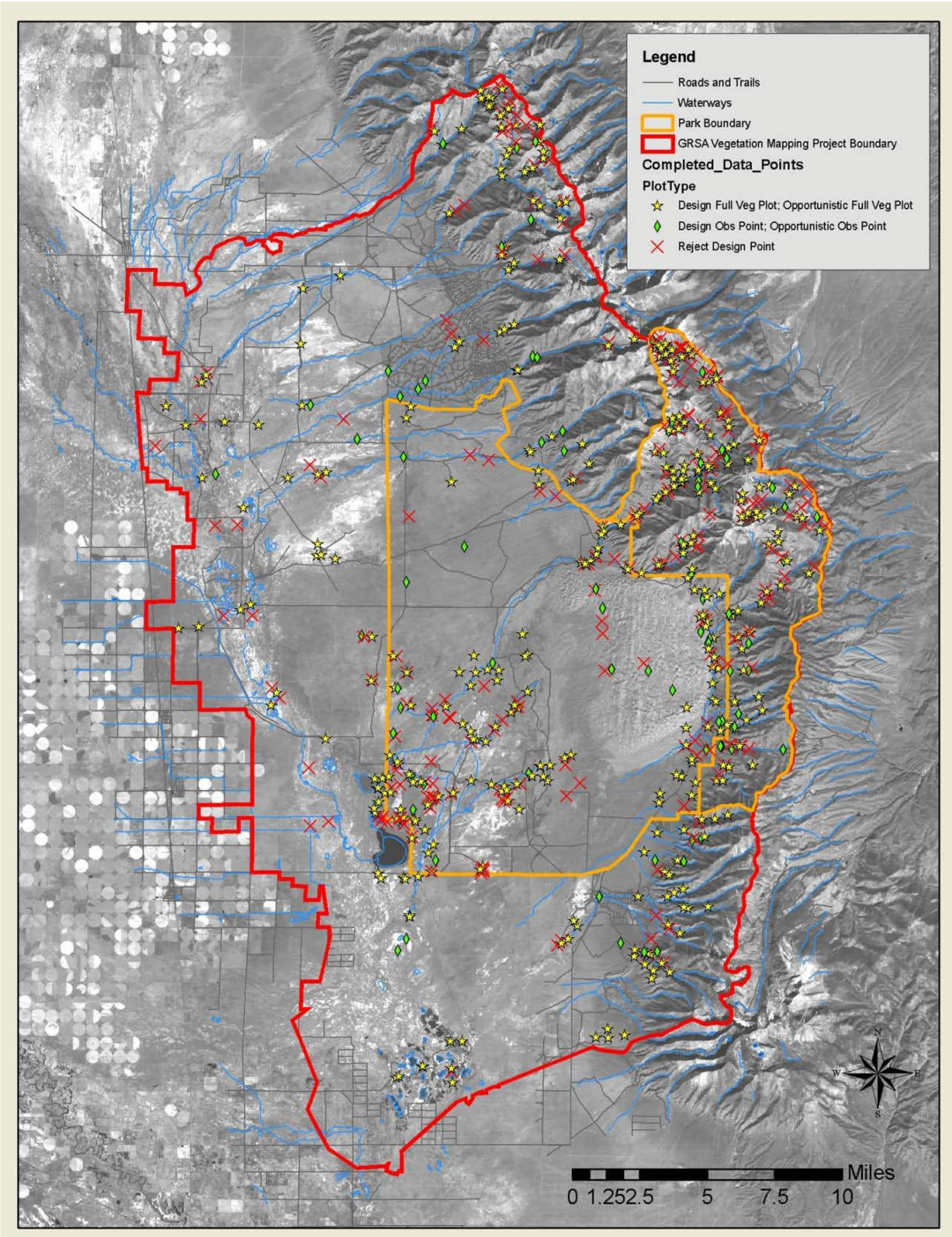


Figure 1: Map of Project Area and Completed Vegetation Plots

FIELD WORK OVERVIEW

This section is intended to give you general instructions and guidelines for conducting your field work in and around Great Sand Dunes National Park and Preserve (GRSA). The data that you collect will be used to create a fine-scale delineation of vegetation pattern in GRSA and its environments, as well as for the modeling of the forest fuels and behavior of potential fires. This section describes the methods for collecting fuels data and vegetation data as well as other data that will aid in park management (eg. weeds, rare elements).

The data you collect will become a historic record of vegetation conditions and will be used by the Park for a number of purposes:

- create a fine scale classification of ecologically distinct vegetation types,
- plan and monitor management activities,
- track long-term changes in vegetation,
- direct searches for rare species and weeds,
- determine forest fuel loads and model fire behavior,
- portray the wealth of natural diversity on Park lands to the public.

Sampling Design

There are approximately 400 preliminary vegetation associations identified as possible to occur in the project area. These are likely to occur across approximately 20-25 ecological system types. We will work to establish plots in these preliminary vegetation associations using a sampling priority list. This list was initially created by NatureServe and CNHP with the aim of optimizing placement of plots across the list of potential types. Throughout the summer, we will be keeping track of vegetation types sampled, and looking specifically for those which have not been sampled yet, including types new to the list.

During the first season of data collection, maps of the project area were stratified by landform and ecological system. Unique combinations of these areas were selected as random design point locations (DPLs) with frequency proportional to the area of the expected vegetation type. The DPLs were used as target points for navigation, and sampled only if they met sampling requirements. Opportunistic plots were established in areas of interest encountered while navigating through the project area. Notes were taken on the ecological system and plant associations present at rejected DPLs. This summer we will again be using the DPLs as targets for navigation, with an emphasis on systems/ areas undersampled in 2005. We aim to sample roughly 300 full plots and 100 observation points.

For each full plot that you establish, you will complete a Vegetation Survey form and a Fuels Inventory form. The Vegetation Survey form contains fields for detailed environmental and vegetation descriptions (including a comprehensive species list), as well as a section for plot identifiers/locators. The Fuels Inventory form will include measurements of surface cover, litter and duff, and canopy fuel loads. Both forms have room for lots of comments and notes. You will also be keeping track of plots taken and points rejected on a Field Log. Forms can be found in **Appendix A**.

Determining Plot Type and Plot Location

The two types of plots you will be establishing this summer are full vegetation plots and observation points. They may be located at either a Design Point Location (within 20m of the DPL) or an opportunistically selected location. The same considerations for plot placement apply to both full plots and observation points. You'll want to place your plots in areas that seem to be both relatively **homogenous** and **representative** of the vegetation as a whole. In other words, avoid areas where the vegetation appears to be transitioning from one type to another and areas with anomalous or heterogeneous structure or species composition.

Also avoid inclusions that are smaller than the minimum mapping unit of 0.5 hectare, or 50x100m. Because these plots will serve as reference points to the photointerpreters, it is important to place them in unambiguous, large patches of similar vegetation. All areas over 0.5 ha will be delineated; anything smaller than 0.5 ha will be lumped in with surrounding vegetation. The map class names of the final map will follow the vegetation classification (**Appendix I**, USNVC), scaled by what is recognizable to the photo interpreters. In most cases, they will be divided into Ecological Systems, Alliances, or groups of Alliances. In some instances it may be possible to identify at the level of Association.

Take some time to pick your sites carefully, as the plots you establish are *permanent!* They may be relocated and resampled over time to determine natural changes and responses to management. Look at *all* the vegetation strata to determine if the area is structurally and floristically uniform and generally try to place your plots at least 30 m from what you see as the ‘boundary’ between this vegetation type and any neighboring, distinctly different types. **During the training period this step will be emphasized and discussed in detail.** However, the rule-of-thumb is to conduct reconnaissance of the plot area as time and topography allow.

Full vegetation plots should be collected when:

1) The association exists within an ecological system or map class larger than ½ hectare, and
2) It is representative of both the surrounding area and the association, and
3) The association is listed as needed on the Sampling Priority table (or it is a new type).

Observation points should be collected when:

1) We want to record an occurrence of a vegetation type for which sufficient full plot data has already been collected, *or*
2) Ground data could be of use to the photo interpreters, *or*
3) You think something is unique but are unsure if it recurs across the landscape.

For each of these types you will collect data using Vegetation Survey and Fuels Inventory forms. For observation points, navigate to the point as usual, scout the area briefly to get a feel for what it is like, and complete an abbreviated version of the Plot Survey and Fuels Inventory forms (skipping the species list and tree inventory). Again, plot center should again be located at least 30 m from the edge of the community.

Stay on the lookout for opportunistic plots. Design points are valuable for future monitoring and modeling, but they won’t catch it all. The goal of this field work is to sample all the different vegetation types that occur in the Park. If, on the way to one vegetation type, you see a vegetation type for which we need plots, or if you see an assemblage of plants that seems unique and that is not included on the list of vegetation types, please document appropriately. You will be better able to recognize these vegetation types as the season progresses and you become more familiar with how they can look on the ground. Additionally, it is important that you document occurrences of rare species or weed species you encounter in the course of your travels. This can only happen if you are being observant as you travel through the sample area.

Establishing a Permanent Plot

Full vegetation plots will usually have a square shape and an area of 400 square meters (see Plot Length and Plot Width in the Vegetation Survey Form Instructions for exceptions). The boundaries of the plot will be laid out with measuring tapes and pin flags. In open communities, it is usually easiest to set up circular plots, measuring a set radius (11.28m) from the center and marking the boundaries with pin flags. There are multiple ways of doing this, the simplest is having one person stand at the plot center holding the tape while the other person walks in a circle with the other end of the tape and a handful of pin flags. This takes less time than shooting azimuths and squaring a rectilinear plot, unless you are in a dense stand of trees. For square plots it works well to measure the diagonals of the square to mark the corners (center to corner = 14.14m for 20m x 20m plots), and then fill in the midpoints using a compass or line of sight. This will be demonstrated during training. Observation points do not have set boundaries and will be based on an estimated area of 0.5 hectare, or 50m x 100m.

All full plots and observation points will be marked with a plot marker. Plot markers consist of a small copper tag inscribed with the project acronym, plot code, and date (for example, GRSA.VMP.312 2005) and attached to a galvanized nail buried at the plot center. (The nail works well for inscribing the copper tag.) If it is not possible to bury the marker at the plot center, select an alternate location as near to the plot center as possible and note the distance and azimuth to the plot center. The plot marker should be buried in the mineral soil just under the bottom of the duff layer, taking care to disturb as small of an area as possible. It should be buried shallow enough to be easily recovered with a metal detector, yet deep enough to remain concealed over time and to be relatively protected from fire. Do not mark plots in shifting environments, such as on the dunes or in floodplains. (Note this on the data sheet.) Remember, if you are unable to place the marker at the plot center you must clearly describe on the plot form where the plot center is in relation to the marker. For example, plot marker located 13.5 m @200 degrees from plot center, or plot marker located in the southwest corner of the plot.

Vegetation Survey Form Instructions

IDENTIFIERS/ LOCATORS

Plot Code

This is the unique identifying code for each plot. For Great Sand Dunes National Park and Preserve, the codes will be “GRSA.VMP.####”. Each crew will be assigned a range of plot numbers for opportunistic plots. Be certain you are not using the same range as another team or repeating plot numbers that have already been used. When switching teams, take note of the last used opportunistic plot number.

Design points: 0001-2999
Crew 3k: new points 3000-3999, GPS, camera and CF card #3000
Crew 4k: new points 4000-4999, GPS, camera and CF card #4000
Crew 5k: new points 5000-5999, GPS, camera and CF card #5000

Survey Date

Date the survey was taken: month/day/year

Surveyors

Record the initials of the surveyors present.

Provisional Map Class

Using the provisional classification, assign the name of the vegetation type that most closely resembles the type you are surveying.

Provisional Association Name

Enter the finest level of the classification possible. If in fact, *none* of the names may be a good fit; you may have found a new type, although this should be the exception and not the rule. If you have a new type, create a provisional name using NVC protocol (**Appendix I**). Make sure to check the “New

Association" box on the Field Log. The **Provisional Association Name** that is assigned will be used to update the tally of plots needed for each vegetation type, and as a starting point in the final classification.

UTM X, UTM Y, and GPS Accuracy

We will be using Garmin GPSMAP 76S units this summer. They will be loaded with done plots, design points and local topographic maps. See **Appendix H** for settings.
When marking Waypoints at the plots, it is important to follow this protocol:

1) Mark the waypoint at plot center.
2) Name the waypoint using the plot number.
3) From anywhere on the Mark Waypoint screen, hit Menu once and select Average Location. Allow it to average for a count of about 60, then note the Estimated Accuracy and hit Enter to Save. The Accuracy will not show up after you Save, so don't forget to write it down at this step!
4) If the accuracy is exceptionally poor, work on the plot for a while, and then try to take the point again. Be sure to take the waypoint BEFORE the plot photos so that they can be easily processed in GPS PhotoLink. If there are absolutely no satellites to be had, estimate UTMs from the topographic map and note on the form that you had to resort to this method

Record UTMs and accuracy on the vegetation survey form, the fuels inventory form, and the field log.

Location comments

Use this space for comments on the plot marker location, navigation to the plot, if the plot was moved from an original design point, if the waypoint was taken anwhere other than plot center, etc.

Plot Length and Plot Width

Full vegetation plots may be circular, rectangle or square. If the plot is rectangular or square, record the azimuth of the long side (any side if square) to help relocate the plot. It may make more sense to establish rectangular plots in linear vegetation types (e.g. riparian or ridgeline types). Standard plot sizes should be as follows:

If you're in a ...	You should usually make your plot...	Giving you a plot area of...
Forest (i.e., trees have their crowns overlapping, usually forming 60-100% cover)	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Woodland (i.e., open stands of trees with crowns usually not touching. Canopy tree cover is 25-60% Or exceeds shrub, dwarf-shrub, herb, and nonvascular cover).	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Shrubland (i.e., shrubs greater than 0.5 m tall are dominant, usually forming more than 25% cover OR exceeding tree, dwarf-shrub, herb, and nonvascular cover)	11.3 m radius OR 20 m x 20 m	400 m^2 400 m^2
Dwarf-shrubland (heath) (i.e., Shrubs less than 0.5 m tall are dominant, usually forming more than 25% cover OR exceeding tree, shrub, herb, and nonvascular cover).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Herbaceous (i.e., Herbs dominant, usually forming more than 25 percent cover OR exceeding tree, shrub, dwarf-shrub, and nonvascular cover).	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Sparse vegetation (i.e., Less than 10% vegetation cover	5.65 m radius OR 10 m x 10 m	100 m^2 100 m^2
Nonvascular (i.e., nonvascular cover dominant, usually forming more than 25% cover).	2.82 m radius OR 5 m x 5 m	25 m^2 25 m^2

Note: You can deviate from the standard plot *shapes* where that makes sense, but the total plot *area* encompassed by the boundaries should be as listed above for each major class of vegetation. For example, forested riparian vegetation, may be sampled in a more linear 10 x 40 m (400 m^2) plot; herbaceous riparian or ridgeline vegetation in a 2 x 50 m (100 m^2) plot. You may also increase the size of the plot to the next standard size if necessary to sample the heterogeneity of the vegetation. Forests, woodlands and shrublands can be increased to 1000 m^2. Please make a note on the vegetation survey form when this is the case.

Camera and Photographs

We will be using Nikon Coolpix5400 digital cameras this summer. These cameras are tough, but not ruggedized; try to keep them out of the sand and rain. See **Appendix H** for settings. Four digital color photos will be taken of the vegetation at each full plot and observation point. Taking pictures of Plots will be one of the most important things you do all summer. Photos may be used to clarify confusing field data or to track changes in vegetation over time. They are of primary importance to the fire management program. Please use care when taking photos.

First, using a dry erase marker, write the plot number (GRSA.VMP.####), date, and direction (N,E,S or W) on the white board. Set, or have your partner hold the board (better) about 5-10ft. away from the camera, adjust the board to reduce glare, make sure the camera is level, then take the picture. Be sure to capture some of the vegetation on the ground in the photo. Photos should be taken from plot center, facing each of the cardinal directions. Plot photos are to always be collected in a clockwise manner beginning with the northern aspect (N-E-S-W).

Once a day you will need to take a picture of the GPS screen showing the time and date. It is best to get in the habit of doing this at the beginning of every day. Do not adjust the camera time after taking this photo, or if you do, take another picture of the GPS display. Also make sure that you **take the plot waypoint before taking the plot photos**. This will enable us to use GPS PhotoLink to link plot photos to plot waypoints. More information will be provided later to help with this program. Make sure to always back up data by recording photo numbers and accurately labeling the dry erase board.

Plot Representativeness

Does this plot represent the full variability of the stand/community? If not, were additional plots taken? Note additional species not seen in the plot in the space provided below. Note: we distinguish in this section the plot's representation of the stand you are sampling and the plot's representation of the range of variability of the association as it exists elsewhere. The former comment may be ascertained by reconnaissance of the stand. The latter comment comes only after some familiarity with the vegetation type throughout the mapping area and may be left blank if you have no opinion at the time of sampling.

ENVIRONMENTAL DESCRIPTION

Elevation

Record the elevation of the center of the plot taken from your GPS. We are recording elevation in meters and your GPS should be set accordingly. If you have to estimate or use feet just make sufficient notes as to what you did.

Slope

Measure the local slope of the plot in **degrees** using a clinometer.

Aspect

Measure the slope aspect using a compass (magnetic declination = **9.7 degrees east** for summer 2006). Note: all compasses should be pre-set to an average declination for the park and thus, readings from the compasses carried by the field crews may be directly noted.

Topographic Position

Topographic position of the plot. Choose one:

INTERFLUVE (crest, summit, ridge). Linear top of ridge, hill, or mountain; the elevated area between two fluves (drainageways) that sheds water to the drainageways.
HIGH SLOPE (shoulder slope, upper slope, convex creep slope). Geomorphic component that forms the uppermost inclined surface at the top of a slope. Includes the transition zone from backslope to summit. Surface is dominantly convex in profile and erosional in origin.
MIDSLOPE (transportational midslope, middle slope). Intermediate slope position.
LOWSLOPE (lower slope, foot slope, colluvial footslope). Inner gently inclined surface at the base of a slope. Surface profile is generally concave and a transition between midslope or backslope, and toeslope. Includes toeslope.
BASIN FLOOR (depression). Nearly level to gently sloping, bottom surface of a basin.

Landform

Following is a list of landforms organized roughly by geomorphic process. Some places will be affected by more than one geomorphic process. Pick the dominant landform, **in bold**, and take notes.

Eolean: Pertaining to material transported and deposited (eolian deposit) by the wind.

- **Sand Sheet**: A large, irregularly shaped, commonly thin, surficial mantle of eolian sand, lacking the discernible slip faces that are common on dunes.
- **Dune Field**: An assemblage of moving and/or stabilized dunes, together with sand plains, interdune areas, and the ponds, lakes, or swamps produced by the blocking of steams by the sand. *Includes stabilized dunes outside of the main dune mass.*
- **Sand Ramp**: A sand sheet blown up onto the lower slopes of a bedrock hill or mountain and forming an inclined plane, sometimes filling small mountain-side valleys and even crossing low passes.

Fluvial: Of or pertaining to rivers or streams; produced by stream or river action.
Fluvial – Basin Processes

- **Bolson -** An alluvium-floored basin, depression, or wide valley, mostly surrounded by mountains and drained by a system that has no surface outlet; an undrained basin. *This is a general term for the basin floor in our study area.*
- **Sabkha**: Sabkha is an Arabic name for a salt-flat ordinarily found nearby sand dunes. These relatively flat and very saline areas of sand or silt form just above the water-table where the sand is cemented together by evaporite salts from seasonal ponds. *Connected to water table. There is a large sabkha region near Hwy. 17 in the western portion of the study area.*
- **Playa**: The usually dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those occurring on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation-runoff events. Playa deposits are fine grained and may or may not have high water table and saline conditions. *Not connected to water table. For our purposes a distinct, saline lake bed with little to no vegetation.*

Fluvial – Stream Processes

- **Channel**: The bed of a single or braided watercourse that commonly is barren of vegetation and is formed of modern alluvium. Channels may be enclosed by banks or splayed across and slightly mounded above a fan surface and include bars and mounds of cobbles and stones.

- **Floodplain**: The nearly level plain that borders a stream and is subject to inundation under flood-stage conditions unless protected artificially. It is usually a constructional landform built of sediment deposited during overflow and lateral migration of the streams.
- **Terrace**: A step-like surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, or lake or sea shore.

Fluvial – Slope Processes

- **Alluvial Fan**: A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes, shaped like an open fan or a segment of a cone, deposited by a stream (best expressed in semiarid regions) at the place where it issues from a narrow mountain or upland valley; or where a tributary stream is near or at its junction with the main stream. *Use where there is a singular fan.*
- **Bajada**: A broad, gently inclined, alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. *There is a well-developed bajada along the base of the Sangre de Cristos.*

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Glacial: Of or relating to the activities of ice and glaciers, as in glacial erosion.

- **Moraine**: A general term for a landform composed mainly of till that has been deposited by a glacier.
- **U-shaped Valley**: A valley having a pronounced parabolic cross profile suggesting the form of a broad letter "U", with steep walls and a broad, nearly flat floor; specifically a valley carved by glacial erosion.
- **Cirque**: A steep-walled, half bowl-like recess or hollow, crescent-shaped or semicircular in plan, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain, and produced by the erosive activity of a mountain glacier. It often contains a small round lake.
- **Lake**: *For our purposes, only high-elevation, glacial lakes. Sand Creek Lakes, for example.*

Mass wasting: A generic term for any process or sediments (mass movement deposit) resulting from the dislodgement and downslope transport of soil and rock material as a unit under direct gravitational stress. The process includes slow displacements such as creep and solifluction, and rapid movements such as landslides, rock slides, and falls, earthflows, debris flows, and avalanches. Agents of fluid transport (water, ice, air) may play an important, if subordinate role in the process.

- **Debris Flow** (source-transport zone-deposit): The process, associated sediments (debris flow deposit) or resultant landform characterized by a very rapid type of *flow* dominated by a sudden downslope movement of a mass of rock, soil, and mud (more than 50% of the particles are > 2mm), and whether saturated or comparatively dry, behaves much as a viscous fluid when moving. *An example of this can be found in Cleveland Gulch, north of the main Sand Creek drainage.*
- **Talus slope**: Rock fragments of any size or shape (usually coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.
- **Scree slope**: A portion of a hillside or mountainslope mantled by scree and lacking an up-slope rockfall source (i.e. cliff). Scree is not a synonym of talus, as scree includes loose, coarse fragment material on slopes without cliffs.
- **Colluvial Slope**: A slope characterized by unconsolidated, unsorted earth material being transported or deposited on sideslopes and/or at the base of slopes by mass movement (e.g. direct gravitational action) and by local, unconcentrated runoff. *This one will be common.*

General Landform terms: These can be influenced by many processes, take notes.

- **Ridge**: A long, narrow elevation of the land surface, usually sharp crested with steep sides and forming an extended upland between valleys. *Use for crest only.*
- **Mountainflank**: A geomorphic component of mountains consisting of the side area of mountains, characterized by very long, complex backslopes with comparatively high slope gradients and composed of highly-diverse, colluvial sediment mantles, complex near-surface hydrology, mass movement processes and features (e.g., creep, landslides); rock outcrops or structural benches may be present. *Use only when nothing else fits, e.g. for a rock outcrop or indistinct landforms.*
- **Valley Floor**: A general term for the nearly level to gently sloping, lowest surface of a valley. Landforms include channel, flood plain, and, in some areas, low terrace surfaces. *Try to use specific landforms if possible.*
- **Cliff**: Any high, very steep to perpendicular or overhanging face of rock or earth; a precipice. *We shouldn't have too many plots in this type.*

Surficial Geology

Note the geologic substrate influencing the plant community (bedrock or surficial materials). Accurately recording the geology at the plot is especially important if the plot is on an inclusion in the type on the geology map.

SURFICIAL GEOLOGY descriptive terms

Igneous rocks: Rock formed by solidification from a molten or partially molten state; major varieties include plutonic and volcanic rocks.

Granite – light grains
Diorite – 50/50
Gabbro – dark grains

Sedimentary rocks: A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under "normal" low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, marine deposits.

Sandstone
Limestone
Siltstone
Conglomerate

Metamorphic rocks: Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth's crust. Nearly all such rocks are crystalline.

Gneiss

Cowardin System

Check one:

UPLAND – Not a wetland

PALUSTRINE – Wetlands, permanent and intermittent, dominated by trees, shrubs or emergent vegetation and smaller than 8 ha. Palustrine wetlands include ponds, marshes, bogs, fens, etc., and can be found on lake shores and flood plains as well as existing in isolation.

RIVERINE – Rivers and streams usually with flowing water; does not include flood plain wetlands.

LACUSTRINE – Lakes, reservoirs and intermittent lakes (including playas) with an **area >8ha**. *Few, if any, lakes or playa lakes in our sample area will be this large.*

Hydrology

Next, assess the hydrologic regime of the plot using the descriptions below (adapted from Cowardin et al. 1979).

PERMANENTLY FLOODED - Water covers the land surface at all times of the year in all years. Equivalent to Cowardin's "permanently flooded."

SEASONALLY FLOODED - Surface water is present for extended periods during the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is very variable, extending from saturated to a water table well below the ground surface. Includes Cowardin's Seasonal, Seasonal-Saturated, and Seasonal-Well Drained modifiers.

SEMIPERMANENTLY FLOODED - Surface water persists throughout growing season in most years except during periods of drought. Land surface is normally saturated when water level drops below soil surface. Includes Cowardin's Intermittently Exposed and Semipermanently Flooded modifiers.

TEMPORARILY FLOODED - Surface water present for brief periods during growing season, but water table usually lies well below soil surface. Often characterizes flood-plain wetlands. Equivalent to Cowardin's Temporary modifier.

INTERMITTENTLY FLOODED - Substrate is usually exposed, but surface water can be present for variable periods without detectable seasonal periodicity. Inundation is not predictable to a given season and is dependent upon highly localized rain storms. This modifier was developed for use in the arid West for water regimes of Playa lakes, intermittent streams, and dry washes but can be used in other parts of the U.S. where appropriate. This modifier can be applied to both wetland and non-wetland situations. Equivalent to Cowardin's Intermittently Flooded modifier.

SATURATED - Surface water is seldom present, but substrate is saturated to surface for extended periods during the growing season. Equivalent to Cowardin's Saturated modifier.

UNKNOWN - The water regime of the area is not known. The unit is simply described as a non-tidal wetland.

Environmental Comments

Enter any additional noteworthy comments on the environmental setting. This field can be used to describe site history such as fire events (date since last fire or evidence of severity) as well as other disturbance or reproduction factors including animal disturbance.

Ground Cover

Estimate ground cover to the nearest percentage by each category, including plant basal area. Total should sum to 100%.

Soil Texture

Using the following key, assess average soil texture. In addition to this key you can choose Peat, Muck or Loam.

Simplified Key to Soil Texture (Brewer and McCann 1982)

A1 Soil does not remain in a ball when squeezed..sand

A2 Soil remains in a ball when squeezed..B

B1 Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger.

Soil makes no ribbon...……………………………loamy sand

B2 Soil makes a ribbon; may be very short..C

C1 Ribbon extends less than 1 inch before breaking..D

C2 Ribbon extends 1 inch or more before breaking..E

D1 Add excess water to small amount of soil
Soil feels at least slightly gritty……………………………………..loam or sandy loam

D2 Soil feels smooth..silt loam

E1 Soil makes a ribbon that breaks when 1 2 inches long;
cracks if bent into a ring...F

E2 Soil makes a ribbon 2+ inches long; does not crack when bent into a ring……………..…G

F1 Add excess water to small amount of soil;
soil feels at least slightly gritty.......……………...................sandy clay loam or clay loam

F2 Soil feels smooth..silty clay loam or silt

G1 Add excess water to a small amount of soil;
soil feels at least slightly gritty...............……………………………sandy clay or clay

G2 Soil feels smooth...silty clay

Soil Drainage

The soil drainage classes are defined in terms of (1) actual moisture content (in excess of field moisture capacity) and (2) the extent of the period during which excess water is present in the plant-root zone. It is recognized that permeability, level of groundwater, and seepage are factors affecting moisture status. However, because these are not easily observed or measured in the field, they cannot generally be used as criteria of moisture status. It is further recognized that soil profile morphology, for example mottling, normally, but not always, reflects soil moisture status. Although soil morphology may be a valuable field indication of moisture status, it should not be the overriding criterion. Soil drainage classes cannot be based solely on the presence or absence of mottling. Topographic position and vegetation as well as soil morphology are useful field criteria for assessing soil moisture status.

RAPIDLY DRAINED - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water addition. Soils are free from any evidence of gleying throughout the profile. Rapidly drained soils are commonly coarse textured or soils on steep slopes.

WELL DRAINED - The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year. Soils are usually free from mottling in the upper 3 feet, but may be mottled below this depth. B horizons, if present, are reddish, brownish, or yellowish.

MODERATELY WELL DRAINED - The soil moisture in excess of field capacity remains for a small but significant period of the year. Soils are commonly mottled (chroma < 2) in the lower B and C horizons or below a depth of 2 feet. The Ae horizon, if present, may be faintly mottled in fine-textured soils and in medium-textured soils that have a slowly permeable layer below the solum. In grassland soils the B and C horizons may be only faintly mottled and the A horizon may be relatively thick and dark.

SOMEWHAT POORLY DRAINED - The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year. Soils are commonly mottled in the B and C horizons; the Ae horizon, if present, may be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.

POORLY DRAINED - The soil moisture in excess of field capacity remains in all horizons for a large part of the year. The soils are usually very strongly gleyed. Except in high-chroma parent materials the B, if present, and upper C horizons usually have matrix colors of low chroma. Faint mottling may occur throughout.

VERY POORLY DRAINED - Free water remains at or within 12 inches of the surface most of the year. The soils are usually very strongly gleyed. Subsurface horizons usually are of low chroma and yellowish to bluish hues. Mottling may be present but at the depth in the profile. Very poorly drained soils usually have a mucky or peaty surface horizon.

VEGETATION DESCRIPTION

Leaf Phenology

Select one value which best describes the leaf phenology of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% cover.

EVERGREEN - Greater than 75% of the total woody cover is never without green foliage.

COLD DECIDUOUS – More than 75% of the total woody cover sheds its foliage in connection with an unfavorable season mainly characterized by winter frost.

MIXED EVERGREEN - COLD DECIDUOUS - Evergreen and deciduous species generally contribute 25-75% of the total woody cover. Evergreen and cold-deciduous species admixed.

PERENNIAL - Herbaceous vegetation composed of more than 50% perennial species.

ANNUAL - Herbaceous vegetation composed of more than 50% annual species.

Leaf Type

Select one value which best describes the leaf form of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% cover.

BROAD-LEAVED - Woody vegetation primarily broad-leaved (generally contributes greater than 50 percent of the total woody cover).

NEEDLE-LEAVED - Woody vegetation primarily needle-leaved (generally contributes greater than 50 percent cover).

MICROPHYLLOUS - Woody cover primarily microphyllous.
GRAMINOID - Herbaceous vegetation composed of more than 50 percent graminoid/stipe leaf species.
FORB (BROAD-LEAF-HERBACEOUS) - Herbaceous vegetation composed of more than 50% broad-leaf forb species.
PTERIDOPHYTE - Herbaceous vegetation composed of more than 50 percent species with frond or frond-like leaves.

Physiognomic Class

Choose one:

FOREST - Trees with their crowns overlapping (generally forming 60-100% cover).
WOODLAND - Open stands of trees with crowns not usually touching (generally forming 25-60% cover). Canopy tree cover may be less than 25% in cases where it exceeds shrub, dwarf-shrub, herb, and nonvascular cover, respectively.
SHRUBLAND - Shrubs generally greater than 0.5 m tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 25% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover, respectively. Vegetation dominated by woody vines is generally treated in this class.
DWARF-SHRUBLAND - Low-growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and tall shrubs generally less than 25% cover). Dwarf-shrub cover may be less than 25% where it exceeds tree, shrub, herb, and nonvascular cover, respectively
HERBACEOUS - Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 25% cover; trees, shrubs, and dwarf-shrubs generally with less than 25% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover, respectively.
NONVASCULAR - Nonvascular cover (bryophytes, non-crustose lichens, and algae) dominant (generally forming at least 25% cover). Nonvascular cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and herb cover, respectively.
SPARSE VEGETATION - Abiotic substrate features dominant. Vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources (total vegetation cover is typically less than 10% and greater than 0%).

Strata/Lifeform, Height, Cover, Diagnostic Species

Visually divide the community into vegetation layers (strata). Indicate the **average** height class of the stratum in the first column, using the Height Class Scale on the form. Enter the average percent cover class of the whole stratum in the second column, using the Cover Class Scale on the form. List only strata with significant cover, usually at least 10%. Many plots will have only a few of the possible layers. Then list a few of the most common species in each stratum, marking diagnostic or dominant species with an asterisk.

T (1,2,3): Trees are defined as single- or few-stemmed woody plants, generally greater than 5 m in height and 10 cm DBH at maturity and under optimal growing conditions. Individuals can be determined relatively easily.

T1: Emergent
T2: Canopy
T3: Sub-canopy

S (1,2,3): Shrubs are defined as multiple-stemmed woody plants generally less than 5 m in height at maturity and under optimal growing conditions, and determining individuals can sometimes be difficult.

- S1: Tall Shrub, >2m tall
- S2: Short Shrub, 0.5m – 2m
- S3: Dwarf Shrub, <0.5m

Ht (H(1,2,3,4)): The herbaceous layer is non-woody and can be listed as one layer or split depending on complexity and cover. Always list the total cover class in the Ht row.

- H1: Graminoids (grass, sedge, rush)
- H2: Forbs (non-graminoid flowering herbaceous)
- H3: Ferns and Fern Allies
- H4: Tree Seedlings (generally less than 1.5 m, this year's sprout.)

N: Nonvascular (lichens and mosses)
V: Vine/liana
E: Epiphyte

Cover Class Scale		Height Class Scale	
T	0-1%	01	<0.5 m
P	>1-5%	02	0.5-1m
1 +/-	>5-15%	03	1-2 m
2	>15-25%	04	2-5 m
3	>25-35%	05	5-10 m
4	>35-45%	06	10-15 m
5	>45-55%	07	15-20 m
6	>55-65%	08	20-35 m
7	>65-75%	09	35 - 50 m
8	>75-85%	10	>50 m
9	>85-95%		
10	>95-		

Vegetation Comments

Record comments on the vegetation, including community structure, composition, damage to certain species, vigor, etc. Record any thoughts about the make up of the strata. This is a good place to add any other basic comments as well.

SPECIES LIST, PAGE 3

Starting with the uppermost stratum, list all the species present (record the full latin name and not a code) and cover class (using the 12 point scale, same as for the Vegetation Description) and percent cover of each species in that particular stratum. Indicate strata in the left-hand columns.

Make sure to double check with the dominant strata list and make sure all species that you said were part of the dominant strata are present in the species list. This is especially important if different people are working on the lists. Make a habit of comparing lists before leaving the plot.

For plots with trees, estimate cover of seedlings, saplings, mature (all others), and total cover for each tree species. Use a separate line for each and assign the most appropriate strata class (by height).

Fuel Inventory Form Instructions

Identifiers
Fill out the top table with information matching the Plot Survey form.

Surface Cover
Visually examine the plot and record relative %cover of each of the possible cover types, starting with the uppermost stratum at the top of the list. Total cover should be 100%. If one type covers another (shrub over a forb) record only the upper one, then record the %cover of the lower type where it is not covered up. Long needle conifer litter is PIPO only. Woody debris is greater than 1 centimeter in diameter and within 2 meters of the ground. Record to the nearest 1%. *Opuntia polycantha* is recorded as “other”.

Litter and Duff Loading
Litter is leaf material which is on the ground and has not decomposed enough to loose its shape. Duff is usually located under the litter and has begun to break into pieces and to decompose into soil. Dig a small hole at plot center and measure (in centimeters) the depth of litter and duff covering the ground. Do the same 10 meters north of plot center and again 10 m west, south and east (plot perimeters).

Canopy Fuel Load Table
All trees above 3 cm diameter should be recorded. For multi-stemmed individuals, take multiple measures if the connection is not visible above the ground. If the connection is visible above ground only take one measure. If needed measure the diameter at the base (DAB) and make sure to record the diameter in the correct column. If the number of trees with a DBH greater than 3 cm is more than about 25, divide the plot into quarters and measure the trees in the southeast quadrant, or the quadrant nearest southeast. CLEARLY NOTE on the form what the sub-plot dimensions are.

Species
Record the tree species. Four-letter codes are okay.

Tree Height
Record the tree height to the nearest one meter. Use a clinometer on trees to get a sense of the stand height, and then estimate for individual trees.

Alive or Dead
Simply indicate if the tree is alive or dead.

Crown Ratio
The percent of the compacted portion of the tree bole or shrub supporting green, live, healthy foliage when compared to the total length or height.

Tree Structure Stage
1: Dominant; emergent
2: Co-dominant; part of the main canopy
3: Intermediate
4: Sub-canopy; part of the sub-canopy
5: Open Growth; rounded, spreading, open-growth form

Comments
Make comments on if the tree is multi-stemed, diseased, home to animals, etc.

Field Log
Record every plot visited on the field log, including rejected design points. It is useful for the mappers to have provisional names assigned to the rejected design points. List the UTMs the same as on the Vegetation Survey/ Fuel Inventory (blank for rejects), and be sure to check all appropriate boxes. Take good notes.

Data Collection Notes
As you begin field work, keep these rules in mind—they will speed your data collection considerably:

1) Except in very diverse plots, don’t spend more than **20 minutes** looking for new and different species to record. Remember that these plot data are to be used to classify the overall vegetation of the Park, not to make a complete species list for it. If you had to spend much more than 20 minutes to *find* a species, it isn’t important to characterizing the vegetation type. For diverse plots with over 25 taxa you may take up to 30 minutes on the listing process.

2) Prioritize your identification. If you need the species identified right away because it appears to be dominant or diagnostic (you’re seeing it all over the place or you’re seeing much more in this particular vegetation type than in others), attempt to key it out on site or later the same day. If you don’t need the plant keyed right away, save your notes and pressed specimens for back at the lab. In general, species with higher cover value (>1%) are higher priority. Don’t let overzealous plant keying get in the way of your primary responsibility: *field data collection.*

3) **Notes, notes, notes!!** Okay, this might not make things go faster for you in the field, but it will save us time and difficult puzzling later on. Take copious notes on anything that seems confusing, and especially on anything that might be difficult for mappers. Note small patches of unusual vegetation near your plot, mosaics of different vegetation types, standing dead trees, bodies of water, roads, trails, human artifacts and anything else that seems interesting to you. Also note any unique field conditions at the time you are there (eg saturated soils, running water, insect outbreaks, trampled vegetation, etc.) Make use of your field notebook for things like unkowns, potential areas to visit, and anything else remarkable that won’t fit neatly on the plot forms.

Unknown Species
If you can’t identify a plant to species, record it on your form as “unknown forb 1,” “unknown POACEAE 2,” “unknown Carex sp. 1,” etc. This is important, as diversity data is lost when unknown species are lumped together as, for example, *Carex spp*. Record associated cover class and other data for the unknown as you would for any other species. Describe and collect vouchers and photographs if appropriate (see below).

Voucher Specimen Collection
Use discretion when collecting:

- Do not collect threatened and endangered species.
- Do not collect if only one plant can be found in the vicinity. Describe the plant in detail on the back of the species list or in your field notebook, including sketches and possible names. Photograph if possible and record the photo numbers in your notes.
- If there is only a small population (3-5 individuals), collect only pieces of one plant that will aid in identification. Take notes and photograph.

- Try to collect from outside of plots.

Collect a full voucher specimen only if there is a fairly large population and the species is not threatened or endangered. Be sure to collect all parts of the plant necessary for identification; dig up some roots and try to find individuals with flowers and/or fruit. Describe characteristics that may change upon drying, such as flower color and milky sap. Place the sample in a field press or a plastic bag and label the bag (or specimen) with the plot code and the name you gave it on the data form, as well as the cover class you placed it in. Store specimens in a cool, dry place. Bagged specimens will keep fresh longer in the refrigerator or ice chest until pressed or identified.

Plants New to GRSA

GRSA is interested in documenting any new species found within the park boundary. A list of species from the 2005 field season which were new to the park can be found in **Appendix B**. If you encounter a plant which is on this list and it is growing ***within the NPS boundary (see Figure 2)***, please make a note on your field form and if possible make a good collection. Press a quality voucher specimen, and if the collection is not associated with a plot, record enough information to make a herbarium label. This information includes:

- **Plant Name**
- **Your Name**
- **Date**
- **Location** (UTM's)
- **Location** using names of places located on a Quad Map with directions (this can be added later using UTM's)
- **Plot Number** (if it was in a plot)
- **Other species in the area**
- **General habitat** (by a stream, ridge, etc…)

Mark pressed specimens "New to GRSA."

Noxious Weeds

If you see a noxious weed, either in a plot or anywhere you happen to be in the study area, please record it on the **Weed Log** (form found in **Appendix A**). Refer to the Weed Log or the Noxious Weed Management pamphlet published by the San Luis Valley Weed Committee for a list of weeds to look out for. Make use of the comments box for any notes on vigor, distribution, flowers or seeds, etc.

Element Occurrences/Rare Plants and Plant Communities

CNHP will provide you with a list of plants and communities to look out for. These are rare or endangered plants or communities that CNHP keeps track of. If you encounter one of these in a plot or elsewhere, please take the time to fill out a reduced Element Occurrence Report (EOR). Forms are located in **Appendix A**. You will also be provided with a map of existing rare plant populations which you may be asked to visit over the summer, and which you may visit to see examples of rare plants you are likely to encounter in the area.

Element Occurrences and their Ranking

Actual locations of elements, whether they are single organisms, populations, or plant communities, are referred to as element occurrences. The element occurrence is considered the most fundamental unit of conservation interest and is at the heart of the Natural Heritage Methodology. To prioritize element occurrences for a given species, an element occurrence rank (EO-Rank) is assigned according to the ecological quality of the occurrences whenever sufficient information is available. This ranking system is designed to indicate which occurrences are the healthiest and ecologically the most viable, thus focusing conservation efforts where they will be most successful. The EO-Rank is based on three factors:

Size – a measure of the area or abundance of the element's occurrence. Takes into account factors such as area of occupancy, population abundance, population density, population fluctuation, and minimum dynamic area (which is the area needed to ensure survival or re-establishment of an element after natural disturbance). This factor for an occurrence is evaluated relative to other known, and/or presumed viable, examples.

Condition/Quality – an integrated measure of the composition, structure, and biotic interactions that characterize the occurrence. This includes measures such as reproduction, age structure, biological composition (such as the presence of exotic versus native species), structure (for example, canopy, understory, and ground cover in a forest community), and biotic interactions (such as levels of competition, predation, and disease).

Landscape Context – an integrated measure of two factors: the dominant environmental regimes and processes that establish and maintain the element, and connectivity. Dominant environmental regimes and processes include herbivory, hydrologic and water chemistry regimes (surface and groundwater), geomorphic processes, climatic regimes (temperature and precipitation), fire regimes, and many kinds of natural disturbances. Connectivity includes such factors as a species having access to habitats and resources needed for life cycle completion, fragmentation of ecological communities and systems, and the ability of the species to respond to environmental change through dispersal, migration, or re-colonization.

Each of these factors is rated on a scale of A through D, with A representing an excellent rank and D representing a poor rank. These ranks for each factor are then averaged to determine an appropriate EO-Rank for the occurrence. If not enough information is available to rank an element occurrence, an EO-Rank of E is assigned. EO-Ranks and their definitions are summarized in the following Table.

Table. Element Occurrence Ranks and their Definitions

A	Excellent viability.
B	Good viability
C	Fair viability.
D	Poor viability.
H	Historic: known from historical record, but not verified for an extended period of time.
X	Extirpated (extinct within the state).
E	Extant: the occurrence does exist but not enough information is available to rank.
F	Failed to find: the occurrence could not be relocated.

Completing CNHP Plant or Natural Community EOR Field Forms

- These instructions are to accompany the provided CNHP EOR field forms for GRSA (natural community or plant element). The pages after this include EOR forms (one for plant element and one for a natural community).
- When filling them out try to not leave any blanks. If there is something you must leave blank you should be able to figure it out and record it for data entry later.
- If you are visiting a current EOR then you will be doing an "update" and you should fill in the EO ID for the EOR that you are updating. The EO ID can be found on the back of the "Current EOR's" map.
- If you are doing a plot and notice a tracked plant or natural community you should complete a "new" EOR, and reference your plot # throughout the EOR form.
- The only time that you will need to fill out the form in its entirety (the species composition) and not have a plot to reference is if you find a new occurrence or an update and are not going to do a plot for the area.

General
Fill in the date and the observer's names.

Taxonomy
Fill in the complete scientific name of the plant or natural community.

Locational Information
You can take track points to make a polygon of the community with your GPS. Indicate the name of the track points file and where it is located. You can also provide boundaries by drawing a map.
List the Quad name if known.
List the elevation range, even if just an approximate value
List the UTM coordinates (you can record the accuracy on the next page in the locational accuracy and mapping data)
All GRSA data will be in NAD83

Directions
Because there are UTM/GPS coordinates you should not go into too much detail for the directions. Just add a simple sentence to help someone be able to find the site again. Major landmarks such as large trees, or streams and ditches are good examples.

Survey information
Qualitative ground survey is simply an observation point and a quantitative ground survey is when the survey is a plot.
If you are updating an EOR for which you will also take a plot, then you would check that it is a quantitative ground survey.
If you are simply updating the EOR because you came across an existing EOR, then check qualitative ground survey.

Locational Accuracy and mapping data
Simply check if the community or plant occurrence is small (a point), linear (if it's a line/stream etc.), or large area if it is a polygon.
Measure the length and width if it is linear, or the acres, sq meters, or sq. miles if it is a polygon. This can be an approximation, if necessary.
When getting coordinates from your GPS, record the accuracy in the space provided.

This is the end of the first page for both the plant element occurrence form and the natural community occurrence form. The differences in the forms are only in the "Element occurrence data and ranking factors" and the "Community information and data" or "General habitat description" on the plant form.

Element occurrence data and ranking factors

Use the ranking methodology and your best judgment to rank the size, condition, and landscape context. Refer to the CNHP methodology in the appendix of the manual for specific criteria to use.
There are additional spaces to fill in more information on the plant element occurrence form, these blanks are self-explanatory – enter the subpopulation number, the percent of flowering plants etc.
Try to add comments as you see fit.

Values:
A = excellent
B = good
C = fair
D = poor

Community information and data (Natural community form)

Enter the general description of the occurrence here.
For the rest of the form if you are completing a plot you can refer to the plot form Instead of going through the topographic position, aspect, etc. again. If you are doing an observation point and will not have a plot for the area then it is a simple check off form.
You will only fill in the species composition, unvegetated surface, and general community structure if there is not a plot associated with the EOR

Species Composition

Document the species composition of the community on the species composition table. Use the provided list of stratum and lifeform codes. Select the cover class from table A. Add any notes you feel are applicable. The scientific name should be written out, or if you know the symbol/code for the species then you can use that too.

Unvegetated surface

Fill out this table for any unvegetated surface. Only fill in the percent cover for surfaces that are present. Use table B to insert the specific code corresponding to the percent, do not enter a percent number, choose a code from the list.

General Community Structure

Fill in this table for all that applies. Use the list for the lifeform codes, and use the height class ranges that are provided.

General Habitat description (Plant element occurrence form)

This field is similar to the "community information and data" field for the natural community forms.
Enter comments about the habitat of the element.
Enter a list (rather than having species composition, unvegetated surface, and general community structure) of the dominant species present.
Also enter any additional plant associations if applicable.

Useful Field Manuals

Beidleman, Linda H., Biedleman, Richard G., & Willard, Beatrice E. (2000). *Plants of Rocky Mountain National Park*. Helena, MT: Falcon Publishing, Inc.

Though this book was written for RMNP, it will be useful for the montane and alpine regions of GRSA. This book is easy to use and has lovely color pictures.

Dixon, Hobey. Draft. *Key to the Vegetation of the San Luis Valley.* This will be provided generously by Hobey.

Any comments or suggestions you can think of this summer would be appreciated.

Hitchcock, A.S. 1971. *Manual of the Grasses of the United States, Volumes I and II*. New York: Dover Publications, Inc.

This large two volume set includes all the grasses in the USA.

Weber, William A. 1987. *Colorado Flora; Western Slope*. Boulder, Colorado: Colorado Associated University Press.

*Weber, William A. 1990. *Colorado Flora: Eastern Slope*, University of Colorado Press.

Weber's floras are comprehensive for Colorado, and are the standard reference; however, Weber does not use Kartez's naming system, which is the standard for this project, so when using this key you will have to cross reference plant names using the species list provided, or the PLANTS online database.

Wingate, Janet L. 1994. *Illustrated Keys to the Grasses of Colorado*. Denver: Wingate Consulting.

This small field key is much easier to use than Hitchcock and specific to the region. Not widely available for purchase; there will be one provided for each crew.

*You should have this one.

SAFETY

Lightning

July and August can bring heavy afternoon rainstorms with lightning. Plan to hike on the dunes in morning or evening to avoid these storms, and to avoid the hot mid-day sand surface. See the NOLS lightning guide, **Appendix D**, for in depth information on lightning. .

Black Bears

The following is from the Yosemite National Park Website, (http://www.nps.gov/yose/wilderness/bsafety.htm), they ought to know!
"Never approach a bear regardless of its size. If you encounter a bear, act immediately: throw small stones or sticks toward the bear from a safe distance. Yell, clap hands, and/or bang pots together. If there is more than one person, stand together to present a more intimidating figure, but do not surround the bear. Use caution if you see cubs, as a mother may act aggressively to defend them.

"When done immediately, these actions have been successful in scaring bears away. Never try and retrieve anything once a bear has it. Report all incidents to a park ranger."

The group Citizens for Responsible Wildlife Management has a good web page with tips for handling a bear encounter. Check it out if you want more information.
http://www.responsiblewildlifemanagement.org/bear_safety.htm

Mountain Lions

The following is from the Yosemite National Park Website,
(http://www.nps.gov/yose/wilderness/bsafety.htm).
Although lion sightings and attacks are rare in the area, they are possible, as is injury from any wild animal. We offer the following recommendations to increase your safety: Avoid walking alone, especially around dawn and dusk. Be aware of your surroundings and how you appear if you are being stalked.
“What should you do if you meet a mountain lion?”
Never approach a mountain lion, especially one that is feeding or with kittens. Most mountain lions will try to avoid confrontation. Always give them a way to escape. Don't run. Stay calm. Hold your ground or back away slowly. Face the lion and stand upright. Do all you can to appear larger. Grab a stick. Raise your arms. If the lion behaves aggressively, wave your arms, shout and throw objects at it. The goal is to convince it that you are not prey and may be dangerous yourself. If attacked, fight back!

”Generally, mountain lions are calm, quiet, and elusive. The chance of being attacked by a mountain lion is quite low compared to many other natural hazards. There is, for example, a far greater risk of being struck by lightning than being attacked by a mountain lion.”

Hiking during hunting season

Because of a long history of hunting in the Sangre de Cristo Mountains prior to the creation of the Preserve areas, hunting is allowed in the Preserve portion of GRSA only. Hunting is also allowed on the National Forest lands to the north and south of GRSA, and on private lands. During field work you should be aware of the potential for hunting on the lands in which you are working. The best thing to do is to be aware of the hunting dates and to wear orange when necessary. Very few hunters were encountered during the 2005 field season and it is not anticipated to be of great concern this year. Most of the project area falls into Game Unit 82.

2006 Season Dates	
ARCHERY	
Deer/elk: west of I-25 (and unit 140):	Aug. 26-Sept. 24
Pronghorn - Unlimited Licenses/Limited Licenses	
• Bucks only:	Aug. 15-31
• Either sex:	Sept. 1-20
Moose	Sept. 9-24
Rocky Mountain Bighon Sheep	
MUZZLELOADING RIFLE	
• Deer/elk (by drawing only)	Sept. 9-17
• Pronghorn (Either sex)	Oct. 21-29
• Moose	Sept. 9-17
• Bear	Sept. 9-17
RIFLE COMBINED DEER/ELK	Oct. 21- 29
SEPARATE LIMITED ELK	Oct. 14-18
RIFLE Pronghorn	Oct. 7-13
RIFLE MOOSE	Oct. 1-9

Data Management and Planning

Planning and effective data management will be essential to collecting the correct plots and the correct numbers of plots. Managing the data and being able to easily determine what plots we have already collected will make our work easier and more successful. Use these lists as procedural guidelines.

Planning for the day

Go over this list of considerations and materials with your partner before heading out for the day.

1. Safety and sustenance issues: plenty of food and water, proper clothing, first-aid kit – Bring a water filter if the hike is long and steep and water can be obtained as needed.
2. Terrain considerations: topography, existing access routes, density and complexity of vegetation (more time for forest and woodland plots, less for herbaceous and scrub),
3. Sampling considerations: priority needs, and possible redundancy of other teams (adequate alternative samples)
4. **Materials checklist**
    1. Road / trail maps
    2. Plot target maps and DOQQ's with map case
    3. GPS with sufficient **batteries**, available memory, and Design plot waypoints loaded
    4. Camera with sufficient **batteries** and photo card space
    5. Two 50 m measuring tapes
    6. Compass
    7. Clinometer
    8. 10 Pin flags
    9. DBH tape
    10. Field Notebook
    11. Plant collecting supplies: plastic bags, masking tape and sharpies for labeling, trowel, press
    12. Field guides: (Weber, Hobey, Wingate, etc.)
    13. Hand lens

    Field folder including:

    14. Sufficient forms for all possible samples:
        - Plot Survey forms
        - Fuel Inventory forms
        - Field Log
        - Weed Log
        - EOR forms
    15. Provisional classification of the Park, with the Sampling Priority list (updated weekly)
    16. Field key to ecological systems/ map classes
    17. Dry-erase markers (for photo placard)
    18. Species List
    19. Permits
    20. Cheat sheet
    21. Sampling protocol
    22. Permanent plot markers: nails and copper plot ID tag (1 per plot, plus extra)

End of Session

Office Work Checklist

- Check through datasheets and correct errors
- Photocopy all datasheets and group copies with corresponding Field Logs (by crew)
- File originals by plot number
- Photolink all plot photos
- Enter all Field Logs in the Geodatabase
- Print updated Sampling Priority Lists from the Geodatabase
- Restock field folders (make sure there are enough copies of data sheets for the next session, RIR and regular paper)
- Return equipment to crew boxes
- Work on identifying unknown plants

Meet to plan the next session:

- Discuss progress, classification questions, possible new community types, tricky unknown species, field notes, road conditions, etc.
- Identify Target Areas / Associations
- Print maps and pick crews for next session's trips

Use of CNHP and Park Property

You will be using equipment and property over the summer which belongs to other people and organizations and will be returned to them at the end of the summer. These things include your housing and vehicles as well as field gear. The general rule is that you should try to return these things in a condition similar to or better than you received it. General wear and tear is expected, but try to take good care of everything.

Vehicles

Care and Maintenance: Please keep cars clean and tidy. Have the oil changed if needed, and contact the agency that the vehicle belongs to (USFS or CNHP) if any further maintenance or repairs are needed. Please report accidental damage to a vehicle immediately so that needed repairs can be made and insurance claims filed. Failure to do so may result in denial of an insurance claim and may result in you becoming liable! The park presents a wide range of challenging off road driving situations requiring care and responsibility. A list of tips for 4x4 driving in different situations is located in **Appendix E**.

House

Please keep the house clean and tidy. The housing is provided to you free of charge and is for the benefit of the whole crew. Be respectful and treat it as you would like to have someone treat your own home.

Field Gear

The field gear you will be using this summer belongs to CNHP. It is essential that you take good care of it. Sand can be very damaging to field equipment, especially cameras and other electronic gear. Always take the care to keep equipment out of the sand and otherwise protect it from damagaging elements. Please return it at the end of the summer in good working condition so that it can be used for future crews. If equipment breaks or gets damaged, please notify the supervisor so that it can be repaired or replaced promptly.

Rules and Regulations

Permits for Work and Access

The Parks Service, The Nature Conservancy, and the Fish and Wildlife Service all require some sort of permit or permission to do work on their land. For The Nature Conservancy you must get prior authorization from Jeff Gossage, TNC 719-378-2904; he's the Medano-Zapata Ranch Manager. All you have to do is give him a call and let him know when and where you will be. There are special written permits that are needed for the USFWS and NPS, which will be handed out and filled out separately from this manual. These written permits are very important and must be on your person at all times.

Private Land Access

Private land may not be a serious issue, but you may need to cross private land to access some parts of the study area. To conduct field work on private land, CNHP requires that you use their forms to gain permission. At GRSA, you may be able to avoid this by contacting the agencies bordering the private land. The agencies often have agreements with land owners that you can take advantage of. To simply cross the land, you should contact to land owner prior to arrival at that property.

Under no circumstances will CNHP staff go onto private land to collect data without the landowners' permission. Two copies of the 'Permission to Access Land and Release of Liability' form must be completed and signed. This form can be found in **Appendix A**. One must be left with the landowner and one must be given to the Director of CNHP.

We hope you find your field season at Great Sand Dunes National Park and Preserve enjoyable and rewarding. Best of luck!

Literature Cited

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Appendices of the GRSA Field Manual

Appendix A: Field Forms

GRSA CODE LIST –cheatsheet

Topographic Position – pick one
Look at the local topography. A low slope in a high mountain valley would still be a low slope.

Interfluve
High Slope
Midslope
Low Slope
Basin

Surficial Geology – descriptive
Bedrock and large rocks
- Igneous rocks
  - Granite - light
  - Diorite - 50/50
  - Gabbro - dark
- Sedimentary rocks
  - Sandstone
  - Limestone
  - Siltstone
  - Conglomerate
- Metamorphic rocks
  - Gneiss

Other…

Landform by Geomorphic Process– pick one
Some places will be affected by more than one geomorphic process. Pick the dominant landform and take notes.

<u>Eolean</u>
- **Sand Sheet** – w/o dunes
- **Dune Field** – w/dunes
- **Sand Ramp –** up the mountain

<u>Fluvial – Basin Processes</u>
- **Bolson** – general term for the basin floor in our study area
- **Sabkha** – groundwater fed
- **Playa** – surfacewater fed

<u>Fluvial – Stream Processes</u>
- **Channel** – active
- **Floodplain** – regularly flooded
- **Terrace** – abandoned floodplain

<u>Fluvial – Slope Processes</u>
- **Alluvial Fan** – at the base of canyons
- **Bajada** – joined adjacent alluvial fans

<u>Glacial</u>
- **Moraine** – glacial deposit, till
- **U-shaped Valley** – carved by glaciers
- **Cirque** – bottom and headwall
- **Lake** – (glacial)

<u>Mass wasting</u>
- **Debris Flow -** (source-transport zone-deposit)
- **Talus slope** – with cliff source
- **Scree slope** – without cliff source
- **Colluvial slope** – general, unconsolidated

<u>General Landscape Terms</u>
- **Ridge** – ridge top, not side
- **Mountainflank** – use when nothing else fits
- **Valley floor** – in the mountains
- **Cliff** – not common for plots

Simplified Key to Soil Texture (Brewer and McCann 1982)

A1 Soil does not remain in a ball when squeezed..sand

A2 Soil remains in a ball when squeezed..B

B1 Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger.

Soil makes no ribbon.......................................……………………………loamy sand

B2 Soil makes a ribbon; may be very short...C

C1 Ribbon extends less than 1 inch before breaking..D

C2 Ribbon extends 1 inch or more before breaking...E

D1 Add excess water to small amount of soil
Soil feels at least slightly gritty……………………………………..loam or sandy loam

D2 Soil feels smooth..silt loam

E1 Soil makes a ribbon that breaks when 1 2 inches long;
cracks if bent into a ring..F

E2 Soil makes a ribbon 2+ inches long; does not crack when bent into a ring……………..…G

F1 Add excess water to small amount of soil;
soil feels at least slightly gritty.......……………....................sandy clay loam or clay loam

F2 Soil feels smooth..silty clay loam or silt

G1 Add excess water to a small amount of soil;
soil feels at least slightly gritty................……………………………sandy clay or clay

G2 Soil feels smooth..silty clay

COWARDIN SYSTEM

RIVERINE – Rivers and streams usually with flowing water, does not include flood plain wetlands.

LACUSTRINE – Lakes, reservoirs and intermittent lakes (including playas) with an area greater than **8 ha**.

PALUSTRINE – Wetlands, permanent and intermittent, dominated by trees, shrubs or emergent vegetation and smaller than 8 ha. Palustrine wetlands include ponds, marshes, bogs, fens, etc., and can be found on lakes shores and flood plains as well as existing in isolated occurrences.

UPLAND – Not a wetland.

SOIL DRAINAGE

RAPIDLY DRAINED - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water addition. Soils are free from any evidence of gleying throughout the profile. Rapidly drained soils are commonly coarse textured or soils on steep slopes.

WELL DRAINED - The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year. Soils are usually free from mottling in the upper 3 feet, but may be mottled below this depth. B horizons, if present, are reddish, brownish, or yellowish.

MODERATELY WELL DRAINED - The soil moisture in excess of field capacity remains for a small but significant period of the year. Soils are commonly mottled (chroma < 2) in the lower B and C horizons or below a depth of 2 feet. The Ae horizon, if present, may be faintly mottled in fine-textured soils and in medium-textured soils that have a slowly permeable layer below the solum. In grassland soils the B and C horizons may be only faintly mottled and the A horizon may be relatively thick and dark.

SOMEWHAT POORLY DRAINED - The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year. Soils are commonly mottled in the B and C horizons; the Ae horizon, if present, may be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.

POORLY DRAINED - The soil moisture in excess of field capacity remains in all horizons for a large part of the year. The soils are usually very strongly gleyed. Except in high-chroma parent materials the B, if present, and upper C horizons usually have matrix colors of low chroma. Faint mottling may occur throughout.

VERY POORLY DRAINED - Free water remains at or within 12 inches of the surface most of the year. The soils are usually very strongly gleyed. Subsurface horizons usually are of low chroma and yellowish to bluish hues. Mottling may be present but at the depth in the profile. Very poorly drained soils usually have a mucky or peaty surface horizon.

HYDROLOGY

PERMANENTLY FLOODED - Water covers the land surface at all times of the year in all years.

SEASONALLY FLOODED - Surface water is present for extended periods during the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is very variable, extending from saturated to a water table well below the ground surface.

SEMIPERMANENTLY FLOODED - Surface water persists throughout growing season in most years except during periods of drought. Land surface is normally saturated when water level drops below soil surface.

TEMPORARILY FLOODED - Surface water present for brief periods during growing season, but water table usually lies well below soil surface. Often characterizes flood-plain wetlands.

INTERMITTENTLY FLOODED - Substrate is usually exposed, but surface water can be present for variable periods without detectable seasonal periodicity. Inundation is not predictable to a given season and is dependent upon highly localized rain storms. This modifier was developed for use in the arid West for water regimes of Playa lakes, intermittent streams, and dry washes but can be used in other parts of the U.S. where appropriate. This modifier can be applied to both wetland and non-wetland situations.

SATURATED - Surface water is seldom present, but substrate is saturated to surface for extended periods during the growing season.

UNKNOWN - The water regime of the area is not known. The unit is simply described as a non-tidal wetland.

NPS VEGETATION MAPPING PROGRAM: GREAT SAND DUNES NATIONAL PARK AND PRESERVE **VEGETATION SURVEY FORM**

IDENTIFIERS/LOCATORS

Plot Code: GRSA.VMP.____________ ☐ Observation Plot Survey Date: _____/_____/ 2006 Surveyors: ___________________________

Provisional Map Unit Name: ____

Provisional Association Name: ____

UTM Zone: 13 UTM X: ___ ___ ___ ___ ___ ___ ___ (m E) UTM Y: ___ ___ ___ ___ ___ ___ ___ ___ (m N) Accuracy ___________m

Location Comments:

Plot length(m):______ Plot width(m):______

Azimuth: ________° Radius(m):________

Camera #: ______________ CF Card #: _____________

Photo #: N____________ E___________ S____________ W____________

Plot representativeness (discuss decisions for placement and/or reasons for non-representativeness)

a. Representativeness of association (if known):

b. Representativeness of plot in stand:

ENVIRONMENTAL DESCRIPTION

Elevation __________________m Slope ____________________° Aspect_________________________°

Topographic Position (see cheat sheet)___________________________ Landform (see cheat sheet)________________________________

Surficial Geology (see cheat sheet)____

Cowardan System:	Soil Texture:	Soil Drainage:	% Ground Cover: *(Sum = 100%)*
___ Upland	___ sand	___ Rapidly drained	___ Litter / duff
___ Palustrine	___ loamy sand	___ Well drained	___ Wood (> 1 cm)
___ Riverine	___ sandy loam	___ Moderately well drained	___ Bare soil
___ Lacustrine	___ silt loam	___ Somewhat poorly drained	___ Sand (0.1-2 mm)
	___ sandy clay loam	___ Poorly drained	___ Small rocks (0.2-10 cm)
Hydrology:	___ clay loam	___ Very poorly drained	___ Large rocks (> 10 cm)
___Permanently Flooded	___ silty clay loam		___ Bedrock
___Seasonally Flooded	___ silt		___ Water
___Semi-permanently Flooded	___ sandy clay		___ Moss
___Temporarily Flooded	___ clay		___ Lichen
___Intermittently Flooded	___ silty clay		___ Cryptogam
___Saturated	___ peat		___ Basal area
___Unknown	___ muck		___ Other: _______________
	___ loam		

Environmental Comments (dynamic stage, fire history, insect damage, animal use evidence, natural or anthropogenic disturbance, geology, etc.):

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic class	Height Class Scale	Cover Class Scale
<u>Trees and Shrubs</u> __Evergreen __Cold-deciduous __Mixed evergreen-cold-deciduous <u>Herbs</u> ___Annual ___Perennial	___Broad-leaved ___Needle-leaved ___Microphyllous ___Graminoid ___Forb ___Pteridophyte	___Forest ___Woodland ___Shrubland ___Dwarf Shrubland ___Herbaceous ___Nonvascular ___Sparsely Vegetated	01 <0.5 m 02 0.5-1m 03 1-2 m 04 2-5 m 05 5-10 m 06 10-15 m 07 15-20 m 08 20-35 m 09 35 – 50 m 10 >50 m	T 0-1% P >1-5% 1 >5-15% +/- 2 >15-25% 3 >25-35% 4 >35-45% 5 >45-55% 6 >55-65% 7 >65-75% 8 >75-85% 9 >85-95% 10 > 95%

	Height Class	Cover Class	Dominant Species (mark Diagnostics with *)
T1 Emergent	_______	_______	______________________________
T2 Canopy	_______	_______	______________________________
T3 Sub-canopy	_______	_______	______________________________
S1 Tall shrub	_______	_______	______________________________
S2 Short Shrub	_______	_______	______________________________
S3 Dwarf-shrub	_______	_______	______________________________
Ht Herbaceous	_______	_______	______________________________
H1 Graminoids	_______	_______	______________________________
H2 Forbs	_______	_______	______________________________
H3 Ferns	_______	_______	______________________________
H4 Seedlings	_______	_______	______________________________
N Non-vascular	_______	_______	______________________________
V Vine/liana	_______	_______	______________________________
E Epiphyte	_______	_______	______________________________

Vegetation Comments:

SPECIES LIST

PlotCode GRSA.VMP.______________________

Stratum Codes			
T1 Emergent	S1 Tall Shrub	H1 Graminoids	N Non-vascular
T2 Canopy	S2 Short Shrub	H2 Forbs	V Vine/liana
T3 Sub-canopy	S3 Dwarf-shrub	H3 Ferns	E Epiphyte
		H4 Seedlings	

Cover Class Scale			
T	0-1%	5	>45-55%
P	>1-5%	6	>55-65%
1	>5-15% +/-	7	>65-75%
2	>15-25%	8	>75-85%
3	>25-35%	9	>85-95%
4	>35-45%	10	> 95%

Stratum	Species Name	CoverClass	Stratum	Species Name	CoverClass
				Species outside plot:	

Great Sand Dunes National Park and Preserve Vegetation Mapping Fuels Inventory

GRSA Plot #	**Date** ___/___/2006	**Surveyors**
UTM X: _ _ _ _ _ _ _ (mE)	**UTM Y: _ _ _ _ _ _ _ _ (mN)**	**Accuracy ____________(m)**

SURFACE COVER	**% COVER (absolute)**
Shrubs > 1 m	
Shrubs 0.3 - 1 m	
Shrubs <= 0.3m	
Grass or forbs > 0.6 m	
Grass or forbs 0.3 – 0.6 m	
Grass or forbs <= 0.3 m	
Long needle conifer litter (PIPO only)	
Short needle conifer litter	
Deciduous litter	
Woody debris (>1 cm; within 2m of ground)	
Un burnable (rock, sand, etc.)	
Other	
	100%

LITTER AND DUFF LOADING: 5 measurements, to be taken at plot center and 10 m from origin to the North, East, South, &West

Location	**Litter Depth (cm)**	**Duff Depth (cm)**
Plot Center		
10 m North		
10 m East		
10 m South		
10 m West		

Notes:

Plot # VMP.GRSA.	Date ___/___/2006	Surveyors	DBH Sheet ___ of ___

Plot Dimensions: ___________M x_______________M_______________ **Sub-sampled portion:** _______________M x_______________M_______________

CANOPY FUEL LOAD:

Tree #	DBH (~ 3 cm)	DAB (~ 3 cm)	Species	Tree Height (nearest 2 m)	Live (y or n)	Crown Ratio	Tree Structure Stage *	COMMENTS (fire scar, charred logs, etc.)

* Tree Structure Stage = one of the following for live trees: 1 Dominant, 2 Co-dominant, 3 Intermediate, 4 Sub-canopy, or 5 Open Grown

WEED LOG

Species of concern:

Acroptilon repens (ACRE3)	Cardaria draba (CADR)	Euphorbia esula (EUES)
Centaurea solstitalis (CESO3)	Convolvulus arvensis (COAR4)	Linaria vulgaris (LIVU2)
Circium arvense (CIAR4)	Hysoscymas niger (HYNI)	Lepidium latifolium (LELA)
Carduus nutans (CANU4)	Cynglossum officinale (CYOF)	Tamarix ramosissima (TARA)

Date	UTM X	UTM Y	Ownership/ Location	Species (code)	Area / # of plants	% Cover	Photo	Comments (vigor, distribution etc.)
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	
__/__ / 06							☐	

COLORADO NATURAL HERITAGE PROGRAM

NATURAL COMMUNITY OCCURRENCE FIELD FORM

General
Survey Date: 2006-________-________ (yr-m-d) Observer(s) Name(s):______________________________

Taxonomy
Element Scientific Name: ______________________________

Locational Information
Boundaries provided: ☐ Map ☐ GPS file name:______________________________
Surveysite Name (from 7.5' quad): __________________ Elevation (range if applicable): ___________________ meters
Coordinates: UTM NAD 83, Zone: 13N, Northing:_____________________ Easting: ______________________

Directions
Brief directions and prominent topographical features.______________________________
____

Survey Information
Survey Type: ☐ Qualitative ground survey (observation point) ☐ Quantitative ground survey (Plot)

Locational Accuracy and Mapping Data
Size of community is…
☐ **Small Area** (<12.5 m in length and width) ☐ **Linear Area** (> 12.5 m long & < 12.5 m wide) Length:______ (m) Width:____ (m)
☐ **Large Area** (>12.5 m in diameter)______________sq. meters/ha
Locational Uncertainty: Amount of variability between actual and recorded location of observation is…
☐ **Areal Estimated** (>negligible, varies in 2 dimensions (any direction), & boundaries **can not** be drawn)
☐ **Areal Delimited** (>negligible, varies in 2 dimensions (any direction), & boundaries **can** be drawn)
☐ **Linear** (>negligible & varies in 1 dimension with uncertain endpoints)
☐ **Negligible** (entire feature (all boundaries) accurate within ≤ 6.25 meters; rarely used unless diff corrected GPS)
If **Areal Delimited** and no map provided, delimited by what? (stream, road, political jurisdiction, etc.):______________________
If **Areal Estimated**, Estimated Uncertainty Distance:
GPS accuracy _________ meters *If not using GPS:* You are accurate to within_________**m** of the actual location.
Confidence Extent: ☐ Y= Confident that full extent of the Element Occurrence **is** known.
☐ N= Confident that full extent of the Element Occurrence **is not** known.
☐ ? = **Uncertain** whether full extent of the Element Occurrence is known.

Element Occurrence Data and Ranking Factors
SIZE: Size of Observed Feature: _________ **acres** Size Rank: ☐A ☐B ☐C ☐D
Comments:______________________________
CONDITION (development/maturity, weedy, etc.): Condition Rank: ☐A ☐B ☐C ☐D
Comments: ______________________________

LANDSCAPE CONTEXT (structure, condition, development/maturity and extent of surrounding landscape; abiotic physical/chemical factors):
Landscape Context Rank: ☐A ☐B ☐C ☐D
Comments: ______________________________
EO RANK SUMMARY COMMENTS:______________________________
____
______________________________**Eorank:** ☐A ☐B ☐C ☐D

Community Information & Data
General Description (general surroundings description, environmental information, etc.):______________________________
____
____
____
____

Natural Disturbance Comments:______________________________
____
Anthropogenic Disturbance Comments:______________________________
____

See Plot Form:__________
Topographic Position:________________________Aspect:____________________% Slope: ________________________
Slope Shape: ☐ Concave ☐ Convex ☐ Straight ☐ Other ________________________
Light Exposure: ☐ Open ☐ Shaded ☐ Partial shade ☐ Other ________________________
Moisture: ☐ Dry ☐ Moist ☐ Saturated ☐ Inundated ☐ Seasonal seepage ☐ Other________________________
Environment Notes:______________________________

Geology Comments:______________________________
Soil Type:______________________________
Soil Comments:______________________________
Environment Comments:______________________________
Physiognomic Comments:______________________________

Species

Scientific Name (or symbol/code)	Stratum (use list)	Lifeform (use list)	Dominant (Y or N)	% Cover (**Table A**)	Notes	**Table A**
						7 = 75-100% 6 = 50-75% 5 = 25-50% 4 = 10-25% 3 = 5-10% 2 = 1-5% 1 = <1% U =cover unknown

Unvegetated Surface

Unvegetated Surface	% Cover – **Table B**
Bedrock	
Large rocks	
Small rocks	
Sand	
Bare soil	
Litter and duff	
Wood	
Water	
Other	
Unspecific	

General Community Structure

Stratum	Lifeform (use list)	Height Class (use list)	% Cover – **Table B**
T1 = Tree (canopy & subcanopy)			
T2 = Tree canopy			
T3 = Tree subcanopy			
S1 = Tall shrub/sapling			
S2 = Short shrub/sapling			
H = Herb (field), Nonvascular			
A1 = Floating aquatic			
A2 = Submerged aquatic			

Table B:	**Lifeform:**		**Stratum:**	**Height class:**
10=95-100% 9=85-95% 8=75-85% 7=65-75% 6=55-65% 5=45-55% 4=35-45% 3=25-35% 2=15-25% 1=5-15% P=1-5% T=<1% (trace) U= cover unknown	1 = All 2 = Needle-leaved tree 3 = Broad-leaved deciduous tree 4 = Broad-leaved evergreen tree 5 = Thorn tree 11 = Needle-leaved shrub 12 = Broad-leaved deciduous shrub 13 = Broad-leaved evergreen shrub 14 = Thorn shrub 16 = Succulent shrub 17 = Dwarf-shrub 18 = Semi-shrub 20 = Other shrub	21 = Forb 22 = Graminoid 23 = Fern 24 = Succulent forb 25 = Aquatic herb (floating/submrgt) 26 = Other herbaceous 27 = Moss 28 = Liverwort/hornwort 29 = Lichen 30 = Algae 31 = Epiphyte 32 = Vine/liana 33 = Other/unknown	T1 = Tree (canopy & subcanopy) T2 = Tree canopy T3 = Tree subcanopy S1 = Tall shrub/sapling S2 = Short shrub/sapling H = Herb (field), Nonvascular A1 = Floating aquatic A2 = Submerged aquatic	>50m 35-50m 25-35m 20-35m 15-20m 10-15m 5-10m 2-5m 1-2m 0.5-1m <0.5m.

COLORADO
NATURAL
HERITAGE
PROGRAM

Project name: Great Sand Dunes Veg. Mapping **GRSA Plot #:**________

New or **Update** to **EO ID:** _____________

PLANT ELEMENT OCCURRENCE FIELD FORM

General
Survey Date: 2006-________-________ (yr-m-d) Observer(s) Name(s):____________________________

Taxonomy
Element Scientific Name: ____

Locational Information
Boundaries provided: ☐ Map ☐ GPS file name:____
Surveysite Name (from 7.5' quad):____
Elevation (range if applicable): __________________ meters

Coordinates: UTM NAD 83, Zone: 13N, Northing:________________ Easting: ____________________________

Directions
Brief directions and prominent topographical features.____
____

Survey Information
Survey Type: ☐ Qualitative ground survey (Observation Point) ☐ Quantitative ground survey (Plot)

Locational Accuracy and Mapping Data
Size of community is…
☐ **Small Area** (<12.5 m in length and width)
☐ **Linear Area** (> 12.5 m long and < 12.5 m wide) Length: _______ (m) Width:____ (m)
☐ **Large Area** (>12.5 m in diameter)____________sq. meters/ha

Locational Uncertainty: Amount of variability between actual and recorded location of observation is…
☐ **Areal Estimated** (>negligible, varies in 2 dimensions (any direction), & boundaries **can not** be drawn)
☐ **Areal Delimited** (>negligible, varies in 2 dimensions (any direction), & boundaries **can** be drawn)
☐ **Linear** (>negligible & varies in 1 dimension with uncertain endpoints)
☐ **Negligible** (entire feature (all boundaries) accurate w/i ≤ 6.25 m; rarely used unless diff corrected GPS)
If **Areal Delimited** and no map provided, delimited by what? (stream, road, political jurisdiction, etc.):__________________
____
If **Areal Estimated**, Estimated Uncertainty Distance:
GPS accuracy_______ meters
If not using GPS:
You are accurate to within____________ **meters** of the actual location.

Confidence Extent: ☐ Y= Confident that full extent of the Element Occurrence **is** known.
☐ N= Confident that full extent of the Element Occurrence **is not** known.
☐ ? = **Uncertain** whether full extent of the Element Occurrence is known.

Element Occurrence Data and Ranking Factors

SIZE/POPULATION BIOLOGY (area of occupancy, population abundance, density, fluctuation):
Estimated Number of Individuals (or exact count, if feasible; if plants are spreading vegetatively, indicate number of aerial stems): ________________

Estimated Population Size:_______________

Number of Subpopulations (if applicable): _________

Size of Area Covered by Population: _____________ **acres** **Size Rank:** ☐ A ☐ B ☐ C ☐ D
Comments: ____
____

CONDITION (productivity, vigor/health; evidence of reproduction, health of population, degree of anthropogenic disturbance, naturalness of hydrology, and other ecological processes):
Phenology: Vegetative: __________% Flower: _______% Fruit: _________%

Reproductive Success: (evidence of seed dispersal and establishment):_______________________________________
Age Classes Present: ____

Symbiotic or Parasitic Relationships (e.g. pollinators): ____
Evidence of Disease, Predation or Injury: ____
Condition Rank: ☐ A ☐ B ☐ C ☐ D
Comments:

LANDSCAPE CONTEXT (biological structure, species composition, degree of fragmentation and connectivity , condition,

and extent **of surrounding landscape**; abiotic physical/chemical factors):

Landscape Context Rank: ☐ A ☐ B ☐ C ☐ D
Comments: ____
____

EO RANK SUMMARY COMMENTS: ____
____
____**EORANK:** ☐ A ☐ B ☐ C ☐ D

General Habitat Description
General Habitat Comments (describe the general landscape surrounding the EO): ________________________________
____
____
____
Dominant Plant Community (list dominant species currently present, include age structure if known): ________________
____
____
____
____
Additional Associated Plant Species: ____
____

See Plot Form:__________________
Topographic Position: __________________________Aspect:__________________ % Slope:___________________________
Slope Shape: ☐ Concave ☐ Convex ☐ Straight ☐ Other ______________________________
Light Exposure: ☐ Open ☐ Shaded ☐ Partial shade ☐ Other ____________________________
Moisture: ☐ Dry ☐ Moist ☐ Saturated ☐ Inundated ☐ Seasonal seepage ☐ Other __________
Parent Material: ________________________ Soil Texture: _______________________________________
Geomorphic Land Form (e.g., glaciated mountain slopes and ridges, alpine glacial valley, rolling uplands, breaklands, alluvial-colluvial-lacsutrine, rockslides, etc.): ____________________________________

Colorado State University
Knowledge to Go Places

USE OF INFORMATION REGARDING YOUR PROPERTY

The biological inventory being conducted by the Colorado Natural Heritage Program in your area will provide vital ecological data on plant and animal species, and important natural communities in Colorado.

The information collected as part of this project will be entered into a database at Colorado State University. Generalized information about the biological resources that we find on your property and other properties in the area will be available to the public. However, specific information about the exact location of these resources will not be released to the public, unless required by law or court order.

Colorado State University may, from time to time, enter into legally-binding, cooperative agreements with other organizations to provide more detailed information. These organizations who receive this information are not permitted to release it to any other parties, unless required by law or a court order.

The information collected by CNHP is typically used to:

- Provide landowners like you with important ecological information on the plants, animals and natural communities found on their own property;
- Enhance planning for the management of open space and wildlife habitat in your local area;
- Provide information to the public to encourage the voluntary conservation of areas that have statewide biological significance.

For more information, please contact:

Colorado Natural Heritage Program
254 General Services Building
Colorado State University
Fort Collins, CO 80523

phone: (970) 491-1309 fax: (970) 491-3349
email: heritage@lamar.colostate.edu
website: www.cnhp.colostate.edu

Permission to Access Land and Release of Liability

This form documents agreement by and between _________________________ (landowner) and the Colorado Natural Heritage Program and Colorado State University (CNHP-CSU) that CNHP representatives have requested, and have been granted, permission to enter properties (herein referred to as "Property") owned, managed and/or occupied by the landowner. CNHP has requested access for the purposes described below that are related to the CNHP's research at Colorado State University.

The landowner and CNHP-CSU agree as follows:

1. Description of Property. This agreement concerns the following property: [enter address and complete spatial description of property to be accessed; attach map if possible]
   ____
   ____.

2. Effective Dates. This agreement shall be effective beginning on [date] _______________ and shall be in effect for a period of [specify number of days or months] _______________.

3. Purpose. This agreement applies to CNHP-CSU, for the purpose of conducting the following activities:

   a. ____
   b. ____
   c. ____
   d. ____

This agreement shall be non-exclusive and non-transferable, and can be terminated upon written notice to CNHP-CSU.

4. Release of Liability. CNHP-CSU releases the landowner from all liability or responsibility for injury that CNHP representative(s) may suffer as a result of or in connection with his/her entering upon the Property (except for injuries caused by the willful or malicious acts of the landowner).

5. Non-Assignment. CNHP-CSU shall not transfer, assign, or otherwise convey the rights granted in this agreement to any other person or party without the express prior written consent of the landowner(s). Any such conveyance in violation of this paragraph shall deem this agreement null and void.

The parties enter into this agreement on this _____ day of ____________, 20____.

The landowner(s) consent(s) to CNHP's request are subject to the completion of this License agreement, as indicated by signatures below:

Landowner(s):

By:______________________________
Name: ___________________________
Address: _________________________
____
____
Telephone: _______________________

By:______________________________
Name: ___________________________
Address: _________________________
____
____
Telephone: _______________________

Primary contact: ___________________
Telephone: _______________________

CNHP-CSU representative(s):

By:______________________________
Name: ___________________________
By:______________________________
Name: ___________________________
By:______________________________
Name: ___________________________

Colorado Natural Heritage Program
Colorado State University
254 General Services Building
Fort Collins CO 80523
(970) 491 1309

Appendix B: Species New to GRSA from the 2005 Season

This list was generated from the list of 640 species identified in the vegetation mapping plot data collected by CNHP crews during the summer of 2005. The species on this list have not been verified and should be viewed as target species needing verification and collection of a voucher specimen. These species should not be added to the Park's List of Plant Species before they have been verified and vouchered. Approximately 400 person-days of effort were expended in completing the plot work that generated this list. That level of effort included travel time and collection of other plot related data. In comparison, Spackman et al. 2004 was based on approximately 21 person-days of direct field survey effort.

This list was generated by comparing the species identified from the 2005 VM plot data, with the list of vouchered species known to occur in the Park and Preserve as given in Spackman et al. 2004. Depending on the location of the 2005 plot(s) in which each species was identified, some of these species may have been identified from outside of the Park boundary (but still within the larger boundary of the vegetation mapping project). Because of the proximity of the entire project area to the GRSA boundary it is likely that any of these species would occur in both areas.

Nomenclature for all species names is based on the accepted names used in the USDA PLANTS database. All names on the Spackman et al. 2004 list were converted to accepted PLANTS names. Species whose status is shown as "Verification and voucher specimen needed" were not previously on the Park list in any form (binomial or trinomial). Due to taxonomic uncertainty and differences in naming conventions, a total of 61 species appear toward the bottom of the list as possibly taxonomicaly distinct (e.g. ssp., var., etc.). Further research and discussion is needed to determine the actual differences, if any, between the species listed as possibly distinct and the reasons they are currently listed at the infra-specific level.

	TSN	PLANTS Code	Species Name GRSA VM 2005	Status
1	181830	ABLA	*Abies lasiocarpa*	Verification and voucher specimen needed
2	507946	ACLE9	*Achnatherum lettermanii*	Verification and voucher specimen needed
3	507954	ACPI2	*Achnatherum pinetorum*	Verification and voucher specimen needed
4	40372	AGDE2	*Agropyron desertorum*	Verification and voucher specimen needed
5	40414	AGGI2	*Agrostis gigantea*	Verification and voucher specimen needed
6	182507	AGME3	*Agrostis mertensii*	Verification and voucher specimen needed
7	38896	ALGR	*Alisma gramineum*	Verification and voucher specimen needed
8	19581	ALIN	*Allionia incarnata*	Verification and voucher specimen needed
9	42670	ALTE	*Allium textile*	Verification and voucher specimen needed
10	23931	ANCH	*Androsace chamaejasme*	Verification and voucher specimen needed
11	565003	ANMU	*Anemone multifida*	Verification and voucher specimen needed
12	18433	ANPA	*Anemone parviflora*	Verification and voucher specimen needed
13	36739	ANMA5	*Antennaria marginata*	Verification and voucher specimen needed
14	22695	ARGL	*Arabis glabra*	Verification and voucher specimen needed
15	35432	ARAR9	*Artemisia arctica*	Verification and voucher specimen needed
16	35472	ARLO7	*Artemisia longifolia*	Verification and voucher specimen needed
17	20575	ATTR	*Atriplex truncata*	Verification and voucher specimen needed
18	41325	BESY	*Beckmannia syzigachne*	Verification and voucher specimen needed
19	33495	BEAL	*Besseya alpina*	Verification and voucher specimen needed
20	36866	BRCA3	*Brickellia californica*	Verification and voucher specimen needed
21	36875	BREU	*Brickellia eupatorioides*	Verification and voucher specimen needed

	TSN	PLANTS Code	Species Name GRSA VM 2005	Status
22	501066	BRCA6	*Bromus catharticus*	Verification and voucher specimen needed
23	501071	BRLA6	*Bromus lanatipes*	Verification and voucher specimen needed
24	40566	CASC	*Calamagrostis scopulorum*	Verification and voucher specimen needed
25	501143	CAPA52	*Callitriche palustris*	Verification and voucher specimen needed
26	30689	CASI10	*Calystegia silvatica*	Verification and voucher specimen needed
27	23072	CADR	*Cardaria draba*	Verification and voucher specimen needed
28	39445	CAAU3	*Carex aurea*	Verification and voucher specimen needed
29	39452	CABU6	*Carex buxbaumii*	Verification and voucher specimen needed
30	39447	CACA11	*Carex canescens*	Verification and voucher specimen needed
31	39540	CACA12	*Carex capillaris*	Verification and voucher specimen needed
32	39607	CAFO3	*Carex foenea*	Verification and voucher specimen needed
33	527095	CAFOF	*Carex foenea* var. *foenea*	Verification and voucher specimen needed
34	39613	CAGE2	*Carex geyeri*	Verification and voucher specimen needed
35	39712	CANE3	*Carex nelsonii*	Verification and voucher specimen needed
36	39725	CAOB4	*Carex obtusata*	Verification and voucher specimen needed
37	39753	CAPH2	*Carex phaeocephala*	Verification and voucher specimen needed
38	39788	CARU3	*Carex rupestris*	Verification and voucher specimen needed
39	527143	CARUD	*Carex rupestris* var. *drummondiana*	Verification and voucher specimen needed
40	39431	CASA10	*Carex saxatilis*	Verification and voucher specimen needed
41	39432	CASC11	*Carex scoparia*	Verification and voucher specimen needed
42	33139	CALI5	*Castilleja lineata*	Verification and voucher specimen needed
43	33069	CAMI12	*Castilleja miniata*	Verification and voucher specimen needed
44	33083	CASU12	*Castilleja sulphurea*	Verification and voucher specimen needed
45	19944	CEBE2	*Cerastium beeringianum*	Verification and voucher specimen needed
46	501448	CHPA28	*Chamaesyce parryi*	Verification and voucher specimen needed
47	20606	CHFO2	*Chenopodium foliosum*	Verification and voucher specimen needed
48	23769	CHUM	*Chimaphila umbellata*	Verification and voucher specimen needed
49	37089	CHVA2	*Chrysothamnus vaseyi*	Verification and voucher specimen needed
50	20391	CLME	*Claytonia megarhiza*	Verification and voucher specimen needed
51	37191	CRNA	*Crepis nana*	Verification and voucher specimen needed
52	22821	DECA6	*Descurainia californica*	Verification and voucher specimen needed
53	502005	DERA2	*Descurainia ramosissima*	Verification and voucher specimen needed
54	502124	DRHE	*Draba helleriana*	Verification and voucher specimen needed
55	502240	ELQU2	*Eleocharis quinqueflora*	Verification and voucher specimen needed
56	27283	EPAN4	*Epilobium anagallidifolium*	Verification and voucher specimen needed
57	27288	EPBR3	*Epilobium brachycarpum*	Verification and voucher specimen needed
58	27304	EPHA	*Epilobium halleanum*	Verification and voucher specimen needed
59	17154	EQHY	*Equisetum hyemale*	Verification and voucher specimen needed
60	35869	ERFO3	*Erigeron formosissimus*	Verification and voucher specimen needed
61	35873	ERGL2	*Erigeron glabellus*	Verification and voucher specimen needed
62	35809	ERPH	*Erigeron philadelphicus*	Verification and voucher specimen needed
63	35948	ERSI3	*Erigeron simplex*	Verification and voucher specimen needed
64	35966	ERUR2	*Erigeron ursinus*	Verification and voucher specimen needed
65	21266	ERUM	*Eriogonum umbellatum*	Verification and voucher specimen needed
66	40096	ERGR8	*Eriophorum gracile*	Verification and voucher specimen needed

	TSN	PLANTS Code	Species Name GRSA VM 2005	Status
67	31904	ERNA	*Eritrichium nanum*	Verification and voucher specimen needed
68	40794	FEBR	*Festuca brachyphylla*	Verification and voucher specimen needed
69	40801	FEDA	*Festuca dasyclada*	Verification and voucher specimen needed
70	40816	FEID	*Festuca idahoensis*	Verification and voucher specimen needed
71	502610	FEMI3	*Festuca minutiflora*	Verification and voucher specimen needed
72	34806	GATR2	*Galium trifidum*	Verification and voucher specimen needed
73	29980	GEPA	*Gentiana parryi*	Verification and voucher specimen needed
74	30079	GEBA2	*Gentianopsis barbellata*	Verification and voucher specimen needed
75	30090	GETH	*Gentianopsis thermalis*	Verification and voucher specimen needed
76	40833	GLST	*Glyceria striata*	Verification and voucher specimen needed
77	43593	GOOB2	*Goodyera oblongifolia*	Verification and voucher specimen needed
78	20692	HAGL	*Halogeton glomeratus*	Verification and voucher specimen needed
79	37597	HEQU2	*Helianthella quinquenervis*	Verification and voucher specimen needed
80	36616	HEAN3	*Helianthus annuus*	Verification and voucher specimen needed
81	36653	HEMA2	*Helianthus maximiliani*	Verification and voucher specimen needed
82	502974	HEPU14	*Heterotheca pumila*	Verification and voucher specimen needed
83	27069	HIVU2	*Hippuris vulgaris*	Verification and voucher specimen needed
84	39229	JUCA6	*Juncus castaneus*	Verification and voucher specimen needed
85	39260	JUCO	*Juncus compressus*	Verification and voucher specimen needed
86	39320	JUTO	*Juncus torreyi*	Verification and voucher specimen needed
87	39239	JUTR4	*Juncus triglumis*	Verification and voucher specimen needed
88	40140	KOMY	*Kobresia myosuroides*	Verification and voucher specimen needed
89	20694	KOAM	*Kochia americana*	Verification and voucher specimen needed
90	26754	KRLA	*Krameria lanceolata*	Verification and voucher specimen needed
91	25856	LALA4	*Lathyrus latifolius*	Verification and voucher specimen needed
92	503361	LEMI6	*Lemna minuta*	Verification and voucher specimen needed
93	42595	LETR	*Lemna trisulca*	Verification and voucher specimen needed
94	503372	LEAL4	*Lepidium alyssoides*	Verification and voucher specimen needed
95	22960	LEDE	*Lepidium densiflorum*	Verification and voucher specimen needed
96	503379	LELA2	*Lepidium latifolium*	Verification and voucher specimen needed
97	20486	LEPY2	*Lewisia pygmaea*	Verification and voucher specimen needed
98	35314	LIBO3	*Linnaea borealis*	Verification and voucher specimen needed
99	42750	LLSE	*Lloydia serotina*	Verification and voucher specimen needed
100	503534	LODI	*Lomatium dissectum*	Verification and voucher specimen needed
101	37980	MABI	*Machaeranthera bigelovii*	Verification and voucher specimen needed
102	529066	MABIB	*Machaeranthera bigelovii* var. *bigelovii*	Verification and voucher specimen needed
103	38002	MAPA	*Machaeranthera parviflora*	Verification and voucher specimen needed
104	41846	MEPO	*Melica porteri*	Verification and voucher specimen needed
105	33236	MIGU	*Mimulus guttatus*	Verification and voucher specimen needed
106	503850	MITI	*Mimulus tilingii*	Verification and voucher specimen needed
107	19999	MIMA3	*Minuartia macrantha*	Verification and voucher specimen needed
108	20003	MINU4	*Minuartia nuttallii*	Verification and voucher specimen needed
109	41911	MUFI	*Muhlenbergia filiculmis*	Verification and voucher specimen needed
110	41938	MURI	*Muhlenbergia richardsonis*	Verification and voucher specimen needed
111	503886	MUTO2	*Muhlenbergia torreyi*	Verification and voucher specimen needed

	TSN	PLANTS Code	Species Name GRSA VM 2005	Status
112	518156	PAPS5	*Packera pseudaurea*	Verification and voucher specimen needed
113	565383	PAPU2	*Paronychia pulvinata*	Verification and voucher specimen needed
114	33698	PEGR6	*Penstemon grahamii*	Verification and voucher specimen needed
115	33700	PEHA10	*Penstemon harbourii*	Verification and voucher specimen needed
116	33937	PELI2	*Penstemon linarioides*	Verification and voucher specimen needed
117	34013	PEVI3	*Penstemon virens*	Verification and voucher specimen needed
118	31529	PHHA	*Phacelia hastata*	Verification and voucher specimen needed
119	30948	PHHO	*Phlox hoodii*	Verification and voucher specimen needed
120	30964	PHMU3	*Phlox multiflora*	Verification and voucher specimen needed
121	504377	PHAL10	*Physaria alpina*	Verification and voucher specimen needed
122	25280	PHMA5	*Physocarpus malvaceus*	Verification and voucher specimen needed
123	504434	PLER	*Plantago eriopoda*	Verification and voucher specimen needed
124	43425	PLDI3	*Platanthera dilatata*	Verification and voucher specimen needed
125	41076	POAL2	*Poa alpina*	Verification and voucher specimen needed
126	41107	POAN	*Poa annua*	Verification and voucher specimen needed
127	41077	POAR2	*Poa arctica*	Verification and voucher specimen needed
128	41109	POAR3	*Poa arida*	Verification and voucher specimen needed
129	526419	POCUE2	*Poa cusickii* ssp. *epilis*	Verification and voucher specimen needed
130	41151	POPA2	*Poa palustris*	Verification and voucher specimen needed
131	504473	PORE	*Poa reflexa*	Verification and voucher specimen needed
132	41103	POSE	*Poa secunda*	Verification and voucher specimen needed
133	41100	POTR	*Poa tracyi*	Verification and voucher specimen needed
134	20873	POAR5	*Polygonum argyrocoleon*	Verification and voucher specimen needed
135	20915	POPE3	*Polygonum persicaria*	Verification and voucher specimen needed
136	24700	POCO13	*Potentilla concinna*	Verification and voucher specimen needed
137	24708	POFI3	*Potentilla fissa*	Verification and voucher specimen needed
138	24017	PRAN	*Primula angustifolia*	Verification and voucher specimen needed
139	24029	PRPA	*Primula parryi*	Verification and voucher specimen needed
140	504629	PSJU3	*Psathyrostachys juncea*	Verification and voucher specimen needed
141	23760	PYMI	*Pyrola minor*	Verification and voucher specimen needed
142	504694	PYCL2	*Pyrrocoma clementis*	Verification and voucher specimen needed
143	504695	PYCR2	*Pyrrocoma crocea*	Verification and voucher specimen needed
144	504699	PYLA	*Pyrrocoma lanceolata*	Verification and voucher specimen needed
145	24473	RIIN2	*Ribes inerme*	Verification and voucher specimen needed
146	24476	RILA	*Ribes lacustre*	Verification and voucher specimen needed
147	24512	RIWO	*Ribes wolfii*	Verification and voucher specimen needed
148	23006	ROPA2	*Rorippa palustris*	Verification and voucher specimen needed
149	530189	RUAQF	*Rumex aquaticus* var. *fenestratus*	Verification and voucher specimen needed
150	20971	RUPA6	*Rumex paucifolius*	Verification and voucher specimen needed
151	20035	SASA	*Sagina saginoides*	Verification and voucher specimen needed
152	20651	SARU	*Salicornia rubra*	Verification and voucher specimen needed
153	504965	SAGE2	*Salix geyeriana*	Verification and voucher specimen needed
154	22482	SAGL	*Salix glauca*	Verification and voucher specimen needed
155	22555	SALU2	*Salix lutea*	Verification and voucher specimen needed
156	22489	SARE2	*Salix reticulata*	Verification and voucher specimen needed

	TSN	PLANTS Code	Species Name GRSA VM 2005	Status
157	504980	SASC	*Salix scouleriana*	Verification and voucher specimen needed
158	24268	SAFL6	*Saxifraga flagellaris*	Verification and voucher specimen needed
159	24294	SARH2	*Saxifraga rhomboidea*	Verification and voucher specimen needed
160	24245	SARI8	*Saxifraga rivularis*	Verification and voucher specimen needed
161	508141	SCAM6	*Schoenoplectus americanus*	Verification and voucher specimen needed
162	521093	SCMA8	*Schoenoplectus maritimus*	Verification and voucher specimen needed
163	36116	SECR	*Senecio crassulus*	Verification and voucher specimen needed
164	36148	SEIN2	*Senecio integerrimus*	Verification and voucher specimen needed
165	36189	SETA	*Senecio taraxacoides*	Verification and voucher specimen needed
166	36196	SEWO	*Senecio wootonii*	Verification and voucher specimen needed
167	565517	SILA21	*Silene latifolia*	Verification and voucher specimen needed
168	20117	SISC7	*Silene scouleri*	Verification and voucher specimen needed
169	20120	SISCH	*Silene scouleri* ssp. *hallii*	Verification and voucher specimen needed
170	42316	SPEU	*Sparganium eurycarpum*	Verification and voucher specimen needed
171	42138	SPGI	*Sporobolus giganteus*	Verification and voucher specimen needed
172	20183	STIR	*Stellaria irrigua*	Verification and voucher specimen needed
173	20169	STME2	*Stellaria media*	Verification and voucher specimen needed
174	505404	SUMO	*Suaeda moquinii*	Verification and voucher specimen needed
175	35338	SYOR2	*Symphoricarpos oreophilus*	Verification and voucher specimen needed
176	522188	SYCA3	*Symphyotrichum campestre*	Verification and voucher specimen needed
177	522202	SYER	*Symphyotrichum ericoides*	Verification and voucher specimen needed
178	522249	SYSP	*Symphyotrichum spathulatum*	Verification and voucher specimen needed
179	36206	TAER2	*Taraxacum eriophorum*	Verification and voucher specimen needed
180	36210	TALA2	*Taraxacum laevigatum*	Verification and voucher specimen needed
181	38510	TEBR	*Tetraneuris brandegeei*	Verification and voucher specimen needed
182	18661	THAL	*Thalictrum alpinum*	Verification and voucher specimen needed
183	18679	THSP	*Thalictrum sparsiflorum*	Verification and voucher specimen needed
184	508158	THMO6	*Thermopsis montana*	Verification and voucher specimen needed
185	531133	TOPAP3	*Torreyochloa pallida* var. *pauciflora*	Verification and voucher specimen needed
186	26270	TRLO	*Trifolium longipes*	Verification and voucher specimen needed
187	26296	TRNA2	*Trifolium nanum*	Verification and voucher specimen needed
188	41312	TRWO3	*Trisetum wolfii*	Verification and voucher specimen needed
189	42327	TYDO	*Typha domingensis*	Verification and voucher specimen needed
190	565591	VACA13	*Vaccinium caespitosum*	Verification and voucher specimen needed
191	35353	VAAR3	*Valeriana arizonica*	Verification and voucher specimen needed
192	181889	ALINT	*Alnus incana ssp. tenuifolia*	Listed in Spackman et al 2004 as binomial
193	184331	ARFEF	*Arabis fendleri* var. *fendleri*	Listed in Spackman et al 2004 as binomial
194	523825	CEARS2	*Cerastium arvense* ssp. *strictum*	Listed in Spackman et al 2004 as binomial
195	527384	CITIC	*Cirsium tioganum* var. *coloradense*	Listed in Spackman et al 2004 as binomial
196	195419	ERALA2	*Eriogonum alatum* var. *alatum*	Listed in Spackman et al 2004 as binomial
197	531286	ERCAP3	*Erysimum capitatum* var. *purshii*	Listed in Spackman et al 2004 as binomial
198	530463	SOMUS	*Solidago multiradiata* var. *scopulorum*	Listed in Spackman et al 2004 as binomial
199	524741	TAOFC	*Taraxacum officinale* ssp. *ceratophorum*	Listed in Spackman et al 2004 as binomial

	TSN	PLANTS Code	Species Name GRSA VM 2005	Status
200	35423	ACMI2	*Achillea millefolium*	Listed in Spackman et al 2004 as ...var. …
201	20245	ARFE3	*Arenaria fendleri*	Listed in Spackman et al 2004 as ...var. …
202	39635	CAHE8	*Carex heteroneura*	Listed in Spackman et al 2004 as ...var. …
203	501822	CRCI3	*Cryptantha cinerea*	Listed in Spackman et al 2004 as ...var. …
204	507596	ERPA30	*Ericameria parryi*	Listed in Spackman et al 2004 as ...var. …
205	24660	GERO2	*Geum rossii*	Listed in Spackman et al 2004 as ...var. …
206	37603	HEMU3	*Heliomeris multiflora*	Listed in Spackman et al 2004 as ...var. …
207	503329	LAOC3	*Lappula occidentalis*	Listed in Spackman et al 2004 as ...var. …
208	43427	PLHY2	*Platanthera hyperborea*	Listed in Spackman et al 2004 as ...var. …
209	20865	POAM8	*Polygonum amphibium*	Listed in Spackman et al 2004 as ...var. …
210	18578	RATR	*Ranunculus trichophyllus*	Listed in Spackman et al 2004 as ...var. …
211	36775	RULA3	*Rudbeckia laciniata*	Listed in Spackman et al 2004 as ...var. …
212	35326	SARA2	*Sambucus racemosa*	Listed in Spackman et al 2004 as ...var. …
213	507785	SCAC3	*Schoenoplectus acutus*	Listed in Spackman et al 2004 as ...var. …
214	36093	SEAM	*Senecio amplectens*	Listed in Spackman et al 2004 as ...var. …
215	36103	SEBI2	*Senecio bigelovii*	Listed in Spackman et al 2004 as ...var. …
216	36127	SEER2	*Senecio eremophilus*	Listed in Spackman et al 2004 as ...var. …
217	36135	SEFR3	*Senecio fremontii*	Listed in Spackman et al 2004 as ...var. …
218	20041	SIAC	*Silene acaulis*	Listed in Spackman et al 2004 as ...var. …
219	20066	SIDR	*Silene drummondii*	Listed in Spackman et al 2004 as ...var. …
220	43044	STAM2	*Streptopus amplexifolius*	Listed in Spackman et al 2004 as ...var. …
221	38508	TEAC	*Tetraneuris acaulis*	Listed in Spackman et al 2004 as ...var. …
222	23605	VAMY2	*Vaccinium myrtillus*	Listed in Spackman et al 2004 as ...var. …
223	35352	VAAC	*Valeriana acutiloba*	Listed in Spackman et al 2004 as ...var. …
224	523668	ARCAB2	*Artemisia campestris* ssp. *borealis*	Listed in Spackman et al 2004 as ...ssp. … var.
225	523702	BRINP	*Bromus inermis* ssp. *pumpellianus*	Listed in Spackman et al 2004 as ...ssp. … var.
226	507594	ERNA10	*Ericameria nauseosa*	Listed in Spackman et al 2004 as ...ssp. … var.
227	525040	ERNAN3	*Ericameria nauseosa* ssp. *nauseosa*	Listed in Spackman et al 2004 as ...ssp. … var.
228	38005	MAPI	*Machaeranthera pinnatifida*	Listed in Spackman et al 2004 as ...ssp. … var.
229	505288	SOSI3	*Solidago simplex*	Listed in Spackman et al 2004 as ...ssp. … var.
230	18723	ACRU2	*Actaea rubra*	Listed in Spackman et al 2004 as ...ssp. …
231	39650	CAIN9	*Carex inops*	Listed in Spackman et al 2004 as ...ssp. …
232	501458	CHSE6	*Chamaesyce serpyllifolia*	Listed in Spackman et al 2004 as ...ssp. …
233	501637	COSE16	*Cornus sericea*	Listed in Spackman et al 2004 as ...ssp. …
234	37203	CRRU3	*Crepis runcinata*	Listed in Spackman et al 2004 as ...ssp. …
235	502003	DEIN5	*Descurainia incana*	Listed in Spackman et al 2004 as ...ssp. …
236	24619	DROC	*Dryas octopetala*	Listed in Spackman et al 2004 as ...ssp. …
237	502264	ELEL5	*Elymus elymoides*	Listed in Spackman et al 2004 as ...ssp. …
238	502267	ELLA3	*Elymus lanceolatus*	Listed in Spackman et al 2004 as ...ssp. …
239	35921	ERPE3	*Erigeron peregrinus*	Listed in Spackman et al 2004 as ...ssp. …
240	24634	FRVE	*Fragaria vesca*	Listed in Spackman et al 2004 as ...ssp. …
241	24639	FRVI	*Fragaria virginiana*	Listed in Spackman et al 2004 as ...ssp. …
242	30058	GEAM3	*Gentianella amarella*	Listed in Spackman et al 2004 as ...ssp. …
243	507974	HECO26	*Hesperostipa comata*	Listed in Spackman et al 2004 as ...ssp. …

	TSN	PLANTS Code	Species Name GRSA VM 2005	Status
244	503655	MARA7	*Maianthemum racemosum*	Listed in Spackman et al 2004 as ...ssp. …
245	34291	ORLU	*Orobanche ludoviciana*	Listed in Spackman et al 2004 as ...ssp. …
246	566275	PADII4	*Packera dimorphophylla* var. *intermedia*	Listed in Spackman et al 2004 as ...ssp. …
247	504467	POFE	*Poa fendleriana*	Listed in Spackman et al 2004 as ...ssp. …
248	41146	PONE	*Poa nemoralis*	Listed in Spackman et al 2004 as ...ssp. …
249	31023	POPU3	*Polemonium pulcherrimum*	Listed in Spackman et al 2004 as ...ssp. …
250	22554	SALU	*Salix lucida*	Listed in Spackman et al 2004 as ...ssp. …
251	18806	TRLA14	*Trollius laxus*	Listed in Spackman et al 2004 as ...ssp. …
252	43158	ZIEL2	*Zigadenus elegans*	Listed in Spackman et al 2004 as ...ssp. …

Appendix C: GRSA Ecological Systems

From: Preliminary Classification for Great Sand Dunes National Park Vegetation Mapping Project Area, by Colorado Natural Heritage Program and NatureServe

NatureServe. 2004. International Ecological Classification Standard: Terrestrial Ecological Classifications. Great Sand Dunes NP vegetation mapping project area. NatureServe Central Databases. Arlington, VA and NatureServe, Boulder, CO. Data current as of 20 April 2005.

Ecological Systems

Inter-Mountain Basins Active and Stabilized Dune
Inter-Mountain Basins Greasewood Flat
Inter-Mountain Basins Interdunal Swale
Inter-Mountain Basins Playa
Inter-Mountain Basins Semi-Desert Grassland
Inter-Mountain Basins Semi-Desert Shrub Steppe
Inter-Mountain West Aspen-Mixed Conifer Forest and Woodland Complex
North American Arid West Emergent Marsh
Rocky Mountain Alpine Bedrock and Scree
Rocky Mountain Alpine Fell-Field
Rocky Mountain Alpine-Montane Wet Meadow
Rocky Mountain Aspen Forest and Woodland
Rocky Mountain Cliff and Canyon
Rocky Mountain Dry Tundra
Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland
Rocky Mountain Lower Montane Riparian Woodland and Shrubland
Rocky Mountain Lower Montane-Foothill Shrubland
Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland
Rocky Mountain Ponderosa Pine Woodland
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
Rocky Mountain Subalpine Mesic Meadow
Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
Rocky Mountain Subalpine-Montane Riparian Shrubland
Rocky Mountain Subalpine-Montane Riparian Woodland
Southern Rocky Mountain Montane-Subalpine Grassland
Southern Rocky Mountain Pinyon-Juniper Woodland
Inter-Mountain Basins Mesic Meadow
Open Water
Dead and Down
Agriculture
Chained Pinyon-Juniper Areas
Recently Mined or Quarried Areas
Invasive Annual Grassland
Invasive Perennial Grassland
Invasive Forbland

CES304.775 INTER-MOUNTAIN BASINS ACTIVE AND STABILIZED DUNE
Concept Summary: This ecological system occurs in Intermountain West basins and is composed of unvegetated to moderately vegetated (<10-30% plant cover) active and stabilized dunes and sandsheets. Species occupying these environments are often adapted to shifting, coarse-textured substrates (usually quartz sand) and form patchy or open

grasslands, shrublands or steppe composed of Achnatherum hymenoides, Artemisia filifolia, Artemisia tridentata ssp. tridentata, Atriplex canescens, Ephedra spp., Coleogyne ramosissima, Ericameria nauseosa, Leymus flavescens, Prunus virginiana, Psoralidium lanceolatum, Purshia tridentata, Sporobolus airoides, Tetradymia tetrameres, or Tiquilia spp.

CES304.786 INTER-MOUNTAIN BASINS PLAYA
Concept Summary: This ecological system is composed of barren and sparsely vegetated playas (generally <10% plant cover) found in the intermountain western U.S. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water is prevented from percolating through the soil by an impermeable soil subhorizon and is left to evaporate. Soil salinity varies greatly with soil moisture and greatly affects species composition. Characteristic species may include Allenrolfea occidentalis, Sarcobatus vermiculatus, Grayia spinosa, Puccinellia lemmonii, Leymus cinereus, Distichlis spicata, and/or Atriplex spp.

CES304.788 INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB-STEPPE
Concept Summary: This ecological system occurs throughout the intermountain western U.S., typically at lower elevations on alluvial fans and flats with moderate to deep soils. This semi-arid shrub-steppe is typically dominated by graminoids (>25% cover) with an open shrub layer. Characteristic grasses include Achnatherum hymenoides, Bouteloua gracilis, Distichlis spicata, Hesperostipa comata, Pleuraphis jamesii, Poa secunda, and Sporobolus airoides. The woody layer is often a mixture of shrubs and dwarf-shrubs. Characteristic species include Atriplex canescens, Artemisia tridentata, Chrysothamnus greenei, Chrysothamnus viscidiflorus, Ephedra spp., Ericameria nauseosa, Gutierrezia sarothrae, and Krascheninnikovia lanata. Artemisia tridentata may be present but does not dominate. The general aspect of occurrences may be either open shrubland with patchy grasses or patchy open herbaceous layer. Disturbance may be important in maintaining the woody component. Microphytic crust is very important in some stands.

CES304.787 INTER-MOUNTAIN BASINS SEMI-DESERT GRASSLAND
Concept Summary: This widespread ecological system occurs throughout the intermountain western U.S. on dry plains and mesas, at approximately 1450 to 2320 m (4750-7610 feet) elevation. These grasslands occur in lowland and upland areas and may occupy swales, playas, mesatops, plateau parks, alluvial flats, and plains, but sites are typically xeric. Substrates are often well-drained sandy or loamy-textured soils derived from sedimentary parent materials but are quite variable and may include fine-textured soils derived from igneous and metamorphic rocks. When they occur near foothill grasslands they will be at lower elevations. The dominant perennial bunch grasses and shrubs within this system are all very drought-resistant plants. These grasslands are typically dominated or codominated by Achnatherum hymenoides, Aristida spp., Bouteloua gracilis, Hesperostipa comata, Muhlenbergia sp., or Pleuraphis jamesii and may include scattered shrubs and dwarf-shrubs of species of Artemisia, Atriplex, Coleogyne, Ephedra, Gutierrezia, or Krascheninnikovia lanata.

CES304.780 INTER-MOUNTAIN BASINS GREASEWOOD FLAT
Concept Summary: This ecological system occurs throughout much of the western U.S. in Intermountain basins and extends onto the western Great Plains. It typically occurs near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas. Sites typically have saline soils, a shallow water table and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations. This system usually occurs as a mosaic of multiple communities, with open to moderately dense shrublands dominated or codominated by Sarcobatus vermiculatus. Atriplex canescens, Atriplex confertifolia, or Krascheninnikovia lanata may be present to codominant. Occurrences are often surrounded by mixed salt desert scrub. The herbaceous layer, if present, is usually dominated by graminoids. There may be inclusions of Sporobolus airoides, Distichlis spicata (where water remains ponded the longest), or Eleocharis palustris herbaceous types.

CES304.776 INTER-MOUNTAIN BASINS ASPEN-MIXED CONIFER FOREST AND WOODLAND
Concept Summary: This ecological system occurs on montane slopes and plateaus in Utah, western Colorado, northern Arizona, eastern Nevada, southern Idaho and western Wyoming. Elevations range from 1700 to 2800 m. Occurrences are typically on gentle to steep slopes on any aspect but are often found on clay-rich soils in intermontane valleys. Soils are derived from alluvium, colluvium and residuum from a variety of parent materials

but most typically occur on sedimentary rocks. The tree canopy is composed of a mix of deciduous and coniferous species, codominated by Populus tremuloides and conifers, including Pseudotsuga menziesii, Abies concolor, Abies lasiocarpa, Picea engelmannii, Picea pungens, Pinus contorta, Pinus flexilis, and Pinus ponderosa. As the occurrences age, Populus tremuloides is slowly reduced until the conifer species become dominant. Common shrubs include Amelanchier alnifolia, Prunus virginiana, Acer grandidentatum, Symphoricarpos oreophilus, Juniperus communis, Paxistima myrsinites, Rosa woodsii, Spiraea betulifolia, Symphoricarpos albus, or Mahonia repens. Herbaceous species include Bromus carinatus, Calamagrostis rubescens, Carex geyeri, Elymus glaucus, Poa spp., and Achnatherum, Hesperostipa, Nassella, and/or Piptochaetium spp. (= Stipa spp.), Achillea millefolium, Arnica cordifolia, Asteraceae spp., Erigeron spp., Galium boreale, Geranium viscosissimum, Lathyrus spp., Lupinus argenteus, Mertensia arizonica, Mertensia lanceolata, Maianthemum stellatum, Osmorhiza berteroi (= Osmorhiza chilensis), and Thalictrum fendleri. Most occurrences at present represent a late-seral stage of aspen changing to a pure conifer occurrence. Nearly a hundred years of fire suppression and livestock grazing have converted much of the pure aspen occurrences to the present-day aspen-conifer forest and woodland ecological system.

CES304.785 INTER-MOUNTAIN BASINS MONTANE SAGEBRUSH STEPPE
Concept Summary: This ecological system includes sagebrush communities occurring at montane and subalpine elevations across the western U.S. from 1000 m in eastern Oregon and Washington to over 3000 m in the southern Rockies. In British Columbia, it occurs between 450 and 1650 m in the southern Fraser Plateau and the Thompson and Okanagan basins. Climate is cool, semi-arid to subhumid. This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. In general this system shows an affinity for mild topography, fine soils, and some source of subsurface moisture. It is composed primarily of Artemisia tridentata ssp. vaseyana (mountain sagebrush) and related taxa such as Artemisia tridentata ssp. spiciformis (= Artemisia spiciformis). Purshi tridentata may codominate or even dominate some stands. Other common shrubs include Symphoricarpos spp., Amelanchier spp., Ericameria nauseosa, Peraphyllum ramosissimum, Ribes cereum, and Chrysothamnus viscidiflorus. Most stands have an abundant perennial herbaceous layer (over 25% cover), but this system also includes Artemisia tridentata ssp. vaseyana shrublands. Common graminoids include Festuca arizonica, Festuca idahoensis, Hesperostipa comata, Poa fendleriana, Elymus trachycaulus, Bromus carinatus, Poa secunda, Leucopoa kingii, Deschampsia caespitosa, Calamagrostis rubescens, and Pseudoroegneria spicata. In many areas, frequent wildfires maintain an open herbaceous-rich steppe condition, although at most sites, shrub cover can be unusually high for a steppe system (>40%), with the moisture providing equally high grass and forb cover.

CES300.729 NORTH AMERICAN ARID WEST EMERGENT MARSH
Concept Summary: This widespread ecological system occurs throughout much of the arid and semi-arid regions of western North America, typically surrounded by savanna, shrub steppe, steppe, or desert vegetation. Natural marshes may occur in depressions in the landscape (ponds, kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers (such riparian marshes are also referred to as sloughs). Marshes are frequently or continually inundated, with water depths up to 2 m. Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Water chemistry may include some alkaline or semi-alkaline situations, but the alkalinity is highly variable even within the same complex of wetlands. Marshes have distinctive soils that are typically mineral, but can also accumulate organic material. Soils have characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features). The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation includes species of Scirpus and/or Schoenoplectus, Typha, Juncus, Potamogeton, Polygonum, Nuphar, and Phalaris. This system may also include areas of relatively deep water with floating-leaved plants (Lemna, Potamogeton, and Brasenia) and submergent and floating plants (Myriophyllum, Ceratophyllum, and Elodea).

CES306.813 ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND
Concept Summary: This widespread ecological system is more common in the southern and central Rocky Mountains, but occurs throughout much of the western U.S. and north into Canada, in the montane and subalpine zones. Elevations generally range from 1525 to 3050 m (5000-10,000 feet), but occurrences can be found at lower elevations in some regions. Distribution of this ecological system is primarily limited by adequate soil moisture required to meet its high evapotranspiration demand, and secondarily is limited by the length of the growing season or low temperatures. These are upland forests and woodlands dominated by Populus tremuloides without a significant conifer component (<25% relative tree cover). The understory structure may be complex with multiple shrub and herbaceous layers, or simple with just an herbaceous layer. The herbaceous layer may be dense or sparse,

dominated by graminoids or forbs. Associated shrub species include Symphoricarpos spp., Rubus parviflorus, Amelanchier alnifolia, and Arctostaphylos uva-ursi. Occurrences of this system originate and are maintained by stand-replacing disturbances such as avalanches, crown fire, insect outbreak, disease and windthrow, or clearcutting by man or beaver, within the matrix of conifer forests.

CES306.823 ROCKY MOUNTAIN DRY-MESIC MONTANE MIXED CONIFER FOREST AND WOODLAND
Concept Summary: This is a highly variable ecological system of the montane zone of the Rocky Mountains. It occurs throughout the southern Rockies, north and west into Utah, Nevada, western Wyoming and Idaho. These are mixed-conifer forests occurring on all aspects at elevations ranging from 1200 to 3300 m. Rainfall averages less than 75 cm per year (40-60 cm) with summer "monsoons" during the growing season contributing substantial moisture. The composition and structure of overstory is dependent upon the temperature and moisture relationships of the site, and the successional status of the occurrence. Pseudotsuga menziesii and Abies concolor are most frequent, but Pinus ponderosa may be present to codominant. Pinus flexilis is common in Nevada. Pseudotsuga menziesii forests occupy drier sites, and Pinus ponderosa is a common codominant. Abies concolor-dominated forests occupy cooler sites, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and north- and east-facing slopes which burn somewhat infrequently. Picea pungens is most often found in cool, moist locations, often occurring as smaller patches within a matrix of other associations. As many as seven conifers can be found growing in the same occurrence, and there are a number of cold-deciduous shrub and graminoid species common, including Arctostaphylos uva-ursi, Mahonia repens, Paxistima myrsinites, Symphoricarpos oreophilus, Jamesia americana, Quercus gambelii, and Festuca arizonica. This system was undoubtedly characterized by a mixed severity fire regime in its "natural condition," characterized by a high degree of variability in lethality and return interval.

CES306.825 ROCKY MOUNTAIN MESIC MONTANE MIXED CONIFER FOREST AND WOODLAND
Concept Summary: These are mixed-conifer forests of the Rocky Mountains west into the ranges of the Great Basin, occurring predominantly in cool ravines and on north-facing slopes. Elevations range from 1200 to 3300 m. Occurrences of this system are found on cooler and more mesic sites than Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland (CES306.823). Such sites include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions and north- and east-facing slopes which burn somewhat infrequently. Pseudotsuga menziesii and Abies concolor are most common canopy dominants, but Picea engelmannii, Picea pungens, or Pinus ponderosa may be present. This system includes mixed conifer/Populus tremuloides stands. A number of cold-deciduous shrub species can occur, including Acer glabrum, Acer grandidentatum, Alnus incana, Betula occidentalis, Cornus sericea, Jamesia americana, Physocarpus malvaceus, Robinia neomexicana, Vaccinium membranaceum, and Vaccinium myrtillus. Herbaceous species include Bromus ciliatus, Carex geyeri, Carex rossii, Carex siccata, Muhlenbergia virescens, Pseudoroegneria spicata, Erigeron eximius, Fragaria virginiana, Luzula parviflora, Osmorhiza berteroi, Packera cardamine, Thalictrum occidentale, and Thalictrum fendleri.
Naturally occurring fires are of variable return intervals, and mostly light, erratic, and infrequent due to the cool, moist conditions.

CES306.828 ROCKY MOUNTAIN SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND
Concept Summary: Engelmann spruce and subalpine fir forests comprise a substantial part of the subalpine forests of the Cascades and Rocky Mountains from southern British Columbia east into Alberta, south into New Mexico and the Intermountain region. They are the matrix forests of the subalpine zone, with elevations ranging from 1275 m in its northern distribution to 3355 m in the south (4100-11,000 feet). They often represent the highest elevation forests in an area. Sites within this system are cold year-round, and precipitation is predominantly in the form of snow, which may persist until late summer. Snowpacks are deep and late-lying, and summers are cool. Frost is possible almost all summer and may be common in restricted topographic basins and benches. Despite their wide distribution, the tree canopy characteristics are remarkably similar, with Picea engelmannii and Abies lasiocarpa dominating either mixed or alone. Pseudotsuga menziesii may persist in occurrences of this system for long periods without regeneration. Pinus contorta is common in many occurrences, and patches of pure Pinus contorta are not uncommon, as well as mixed conifer/Populus tremuloides stands. In some areas, such as Wyoming, Picea engelmannii-dominated forests are on limestone or dolomite, while nearby codominated spruce-fir forests are on granitic or volcanic rocks. Xeric species may include Juniperus communis, Linnaea borealis, Mahonia repens, or Vaccinium scoparium. More northern occurrences often have taller, more mesic shrub and herbaceous species, such

as Empetrum nigrum, Rhododendron albiflorum, and Vaccinium membranaceum. Disturbance includes occasional blow-down, insect outbreaks and stand-replacing fire.

CES306.830 ROCKY MOUNTAIN SUBALPINE MESIC SPRUCE-FIR FOREST AND WOODLAND
Concept Summary: This is a high-elevation system of the Rocky Mountains, dominated by Picea engelmannii and Abies lasiocarpa. It extends eastward into the northeastern Olympic Mountains and the northeastern side of Mount Rainier in Washington. Occurrences are typically found in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, such as north-facing slopes and high-elevation ravines. They can extend down in elevation below the subalpine zone in places where cold-air ponding occurs; northerly and easterly aspects predominate. These forests are found on gentle to very steep mountain slopes, high-elevation ridgetops and upper slopes, plateau-like surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. In the Olympics and northern Cascades, the climate is more maritime than typical for this system, but due to the lower snowfall in these rainshadow areas, summer drought may be more significant than snowpack in limiting tree regeneration in burned areas. Picea engelmannii is rare in these areas. Mesic understory shrubs include Menziesia ferruginea, Vaccinium membranaceum, Rhododendron albiflorum, Amelanchier alnifolia, Rubus parviflorus, Ledum glandulosum, Phyllodoce empetriformis, and Salix spp. Herbaceous species include Actaea rubra, Maianthemum stellatum, Cornus canadensis, Erigeron eximius, Gymnocarpium dryopteris, Rubus pedatus, Saxifraga bronchialis, Tiarella spp., Lupinus arcticus ssp. subalpinus, Valeriana sitchensis, and graminoids Luzula glabrata var. hitchcockii or Calamagrostis canadensis. Disturbances include occasional blow-down, insect outbreaks and stand-replacing fire.

CES306.819 ROCKY MOUNTAIN SUBALPINE-MONTANE LIMBER-BRISTLECONE PINE WOODLAND
Concept Summary: This ecological system occurs throughout the Rocky Mountains on dry, rocky ridges and slopes near upper treeline above the matrix spruce-fir forest. It extends down to the lower montane in the central and northern Rocky Mountains and northeastern Great Basin mountains where dominated by Pinus flexilis, particularly along the Front Range north into Canada. Sites are harsh, exposed to desiccating winds, with rocky substrates and a short growing season that limit plant growth. Higher-elevation occurrences are found well into the subalpine-alpine transition on wind-blasted, mostly west-facing slopes and exposed ridges. Calcareous substrates are important for Pinus flexilis-dominated communities in the northern Rocky Mountains and possibly elsewhere. The open tree canopy is often patchy and is strongly dominated by Pinus flexilis or Pinus aristata with the latter restricted to southern Colorado, northern New Mexico and the San Francisco Mountains in Arizona. In the northern Rockies and northern Great Basin, Pinus albicaulis is found in some occurrences. Other trees such as Juniperus spp., Pinus contorta, Pinus ponderosa, or Pseudotsuga menziesii are occasionally present. Arctostaphylos uva-ursi, Cercocarpus ledifolius, Juniperus communis, Mahonia repens, Purshia tridentata, Ribes montigenum, or Vaccinium spp. may form an open shrub layer in some stands. The herbaceous layer, if present, is generally sparse and composed of xeric graminoids, such as Calamagrostis purpurascens, Festuca arizonica, Festuca idahoensis, Festuca thurberi, or Pseudoroegneria spicata, or more alpine plants.

CES306.835 SOUTHERN ROCKY MOUNTAIN PINYON-JUNIPER WOODLAND
Concept Summary: This southern Rocky Mountain ecological system occurs on dry mountains and foothills in southern Colorado east of the Continental Divide, in mountains and plateaus of north-central New Mexico, and extends out onto limestone breaks in the southeastern Great Plains. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. Soils supporting this system vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. Pinus edulis and/or Juniperus monosperma dominate the tree canopy. Juniperus scopulorum may codominate or replace Juniperus monosperma at higher elevations. Stands with Juniperus osteosperma are representative the Colorado Plateau and are not included in this system. In southern transitional areas between Madrean Pinyon-Juniper Woodland (CES305.797) and Southern Rocky Mountain Pinyon-Juniper Woodland (CES306.835) in central New Mexico, Juniperus deppeana becomes common. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent. Associated species are more typical of southern Rocky Mountains than the Colorado Plateau and include Artemisia bigelovii, Cercocarpus montanus, Quercus gambelii, Achnatherum scribneri, Bouteloua gracilis, Festuca arizonica, or Pleuraphis jamesii.

CES306.032 SOUTHERN ROCKY MOUNTAIN PONDEROSA PINE WOODLAND
Concept Summary: This very widespread ecological system is most common throughout the cordillera of the Rocky Mountains, from the Greater Yellowstone region south. It is also found in the Colorado Plateau region, west into scattered locations in the Great Basin, and in the Black Hills of South Dakota and Wyoming. These woodlands occur at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from less than 1900 m in northern Wyoming to 2800 m in the New Mexico mountains. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. This ecological system generally occurs on igneous, metamorphic, and sedimentary material derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acid pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. Northern Rocky Mountain Ponderosa Pine Woodland (CES306.030) in the eastern Cascades, Okanagan and northern Rockies regions receives winter and spring rains, and thus has a greater spring "green-up" than the drier woodlands in the central Rockies. Pinus ponderosa (primarily var. scopulorum and var. brachyptera) is the predominant conifer; Pseudotsuga menziesii, Pinus edulis, and Juniperus spp. may be present in the tree canopy. The understory is usually shrubby, with Artemisia nova, Artemisia tridentata, Arctostaphylos patula, Arctostaphylos uva-ursi, Cercocarpus montanus, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Symphoricarpos oreophilus, Prunus virginiana, Amelanchier alnifolia, and Rosa spp. common species. Pseudoroegneria spicata and species of Hesperostipa, Achnatherum, Festuca, Muhlenbergia, and Bouteloua are some of the common grasses. Mixed fire regimes and ground fires of variable return intervals maintain these woodlands, depending on climate, degree of soil development, and understory density.

CES306.822 ROCKY MOUNTAIN LOWER MONTANE-FOOTHILL SHRUBLAND
Concept Summary: This ecological system is found in the foothills, canyon slopes and lower mountains of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico extending north into Wyoming, and west into the Intermountain region. These shrublands occur between 1500-2900 m elevations and are usually associated with exposed sites, rocky substrates, and dry conditions, which limit tree growth. It is common where Quercus gambelii is absent such as the northern Colorado Front Range and in drier foothills and prairie hills. This system is generally drier than Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818), but may include mesic montane shrublands where Quercus gambelii does not occur. Scattered trees or inclusions of grassland patches or steppe may be present, but the vegetation is typically dominated by a variety of shrubs including Amelanchier utahensis, Cercocarpus montanus, Purshia tridentata, Rhus trilobata, Ribes cereum, Symphoricarpos oreophilus, or Yucca glauca. In northeastern Wyoming and north into adjacent Montana, Cercocarpus ledifolius, usually with Artemisia tridentata, is the common dominant shrub. Grasses are represented as species of Muhlenbergia, Bouteloua, Hesperostipa, and Pseudoroegneria spicata. Fires play an important role in this system as the dominant shrubs usually have a severe die-back, although some plants will stump sprout. Cercocarpus montanus requires a disturbance such as fire to reproduce, either by seed sprout or root crown sprouting. Fire suppression may have allowed an invasion of trees into some of these shrublands, but in many cases sites are too xeric for tree growth.

CES306.811 ROCKY MOUNTAIN ALPINE FELL-FIELD
Concept Summary: This ecological system is found discontinuously at alpine elevations throughout the Rocky Mountains, west into the mountainous areas of the Great Basin, and north into the Canadian Rockies. Small areas are represented in the westside of the Okanagan Ecoregion in the eastern Cascades. These are wind-scoured fell-fields that are free of snow in the winter, such as ridgetops and exposed saddles, exposing the plants to severe environmental stress. Soils on these windy unproductive sites are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement. Most fell-field plants are cushioned, or matted, frequently succulent, flat to the ground in rosettes and often densely haired and thickly cutinized. Plant cover is 15-50%, while exposed rocks make up the rest. Fell-fields are usually within or adjacent to alpine tundra dry meadows. Common species include Arenaria capillaris, Carex albonigra, Carex paysonis, Geum rossii, Kobresia myosuroides, Minuartia obtusiloba, Myosotis asiatica, Paronychia pulvinata, Phlox pulvinata, Sibbaldia procumbens, and Silene acaulis.

CES306.816 ROCKY MOUNTAIN DRY TUNDRA
Concept Summary: This widespread ecological system occurs above upper treeline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and isolated alpine sites in the northeastern

Cascades. It is found on gentle to moderate slopes, flat ridges, valleys, and basins, where the soil has become relatively stabilized and the water supply is more or less constant. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This system is characterized by a dense cover of low-growing, perennial graminoids and forbs. Rhizomatous, sod-forming sedges are the dominant graminoids, and prostrate and mat-forming plants with thick rootstocks or taproots characterize the forbs. Dominant species include Artemisia arctica, Carex elynoides, Carex siccata, Carex scirpoidea, Carex nardina, Carex rupestris, Deschampsia caespitosa, Festuca brachyphylla, Festuca idahoensis, Geum rossii, Kobresia myosuroides, Phlox pulvinata, and Trifolium dasyphyllum. Although alpine tundra dry meadow is the matrix of the alpine zone, it typically intermingles with alpine bedrock and scree, ice field, fell-field, alpine dwarf-shrubland, and alpine/subalpine wet meadow systems.

CES306.829 ROCKY MOUNTAIN SUBALPINE MESIC MEADOW
Concept Summary: This Rocky Mountain ecological system is restricted to sites in the subalpine zone where finely textured soils, snow deposition, or wind-swept dry conditions limit tree establishment. It is found typically above 3000 m in elevation in the southern part of its range and above 1500 m in the northern part. These upland communities occur on gentle to moderate-gradient slopes. The soils are typically seasonally moist to saturated in the spring, but if so will dry out later in the growing season. These sites are not as wet as those found in Rocky Mountain Alpine-Montane Wet Meadow (CES306.812). Vegetation is typically forb-rich, with forbs contributing more to overall herbaceous cover than graminoids. Important taxa include Erigeron spp., Asteraceae spp., Mertensia spp., Penstemon spp., Campanula spp., Lupinus spp., Solidago spp., Ligusticum spp., Thalictrum occidentale, Valeriana sitchensis, Balsamorhiza sagittata, Wyethia spp., Deschampsia caespitosa, Koeleria macrantha, and Dasiphora fruticosa. Burrowing mammals can increase the forb diversity.

CES306.824 SOUTHERN ROCKY MOUNTAIN MONTANE-SUBALPINE GRASSLAND
Concept Summary: This Rocky Mountain ecological system typically occurs between 2200 and 3000 m on flat to rolling plains and parks or on lower sideslopes that are dry, but it may extend up to 3350 m on warm aspects. Soils resemble prairie soils in that the A-horizon is dark brown, relatively high in organic matter, slightly acid, and usually well-drained. An occurrence usually consists of a mosaic of two or three plant associations with one of the following dominant bunch grasses: Danthonia intermedia, Danthonia parryi, Festuca idahoensis, Festuca arizonica, Festuca thurberi, Muhlenbergia filiculmis, or Pseudoroegneria spicata. The subdominants include Muhlenbergia montana, Bouteloua gracilis, and Poa secunda. These large-patch grasslands are intermixed with matrix stands of spruce-fir, lodgepole, ponderosa pine, and aspen forests. In limited circumstances (e.g., South Park in Colorado), they form the "matrix" of high-elevation plateaus.

CES306.821 ROCKY MOUNTAIN LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND
Concept Summary: This system is found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevation range from approximately 900 to 2800 m. This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. This system is dependent on a natural hydrologic regime, especially annual to episodic flooding. Occurrences are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. They can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. Dominant trees may include Acer negundo, Populus angustifolia, Populus balsamifera, Populus deltoides, Populus fremontii, Pseudotsuga menziesii, Picea pungens, Salix amygdaloides, or Juniperus scopulorum. Dominant shrubs include Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Crataegus rivularis, Forestiera pubescens, Prunus virginiana, Rhus trilobata, Salix monticola, Salix drummondiana, Salix exigua, Salix irrorata, Salix lucida, Shepherdia argentea, or Symphoricarpos spp. Exotic trees of Elaeagnus angustifolia and Tamarix spp. are common in some stands. Generally, the upland vegetation surrounding this riparian system is different and ranges from grasslands to forests.

CES306.832 ROCKY MOUNTAIN SUBALPINE-MONTANE RIPARIAN SHRUBLAND
Concept Summary: This system is found throughout the Rocky Mountain cordillera from New Mexico north into Montana, and also occurs in mountainous areas of the Intermountain region and Colorado Plateau. These are montane to subalpine riparian shrublands occurring as narrow bands of shrubs lining streambanks and alluvial terraces in narrow to wide, low-gradient valley bottoms and floodplains with sinuous stream channels. Generally it

is found at higher elevations, but can be found anywhere from 1700-3475 m. Occurrences can also be found around seeps, fens, and isolated springs on hillslopes away from valley bottoms. Many of the plant associations found within this system are associated with beaver activity. This system often occurs as a mosaic of multiple communities that are shrub- and herb-dominated and includes above-treeline, willow-dominated, snowmelt-fed basins that feed into streams. The dominant shrubs reflect the large elevational gradient and include Alnus incana, Betula nana, Betula occidentalis, Cornus sericea, Salix bebbiana, Salix boothii, Salix brachycarpa, Salix drummondiana, Salix eriocephala, Salix geyeriana, Salix monticola, Salix planifolia, and Salix wolfii. Generally the upland vegetation surrounding these riparian systems are of either conifer or aspen forests.

CES306.833 ROCKY MOUNTAIN SUBALPINE-MONTANE RIPARIAN WOODLAND
Concept Summary: This riparian woodland system is comprised of seasonally flooded forests and woodlands found at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, and west into the Intermountain region and the Colorado Plateau. It occurs throughout the interior of British Columbia and the eastern slopes of the Cascade Mountains. This system contains the conifer and aspen woodlands that line montane streams. These are communities tolerant of periodic flooding and high water tables. Snowmelt moisture in this system may create shallow water tables or seeps for a portion of the growing season. Stands typically occur at elevations between 1500 and 3300 m (4920-10,830 feet), farther north elevation ranges between 900 and 2000 m. This is confined to specific riparian environments occurring on floodplains or terraces of rivers and streams, in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate-wide valley bottoms on large floodplains along broad, meandering rivers, and on pond or lake margins. Dominant tree species vary across the latitudinal range, although it usually includes Abies lasiocarpa and/or Picea engelmannii; other important species include Pseudotsuga menziesii, Picea pungens, Picea engelmannii X glauca, Populus tremuloides, and Juniperus scopulorum. Other trees possibly present but not usually dominant include Alnus incana, Abies concolor, Abies grandis, Pinus contorta, Populus angustifolia, Populus balsamifera ssp. trichocarpa, and Juniperus osteosperma.

CES306.812 ROCKY MOUNTAIN ALPINE-MONTANE WET MEADOW
Concept Summary: These are high-elevation communities found throughout the Rocky Mountains and Intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from montane to alpine (1000-3600 m). These types occur as large meadows in montane or subalpine valleys, as narrow strips bordering ponds, lakes, and streams, and along toeslope seeps. They are typically found on flat areas or gentle slopes, but may also occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late-melting snow patches or on snowbeds. Soils of this system may be mineral or organic. In either case, soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. This system often occurs as a mosaic of several plant associations, often dominated by graminoids, including Calamagrostis stricta, Caltha leptosepala, Cardamine cordifolia, Carex illota, Carex microptera, Carex nigricans, Carex scopulorum, Carex utriculata, Carex vernacula, Deschampsia caespitosa, Eleocharis quinqueflora, Juncus drummondii, Phippsia algida, Rorippa alpina, Senecio triangularis, Trifolium parryi, and Trollius laxus. Often alpine dwarf-shrublands, especially those dominated by Salix, are immediately adjacent to the wet meadows. Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding.

CES306.809 ROCKY MOUNTAIN ALPINE BEDROCK AND SCREE
Concept Summary: This ecological system is restricted to the highest elevations of the Rocky Mountains, from Alberta and British Columbia south into New Mexico, west into the highest mountain ranges of the Great Basin. It is composed of barren and sparsely vegetated alpine substrates, typically including both bedrock outcrop and scree slopes, with nonvascular- (lichen) dominated communities. Exposure to desiccating winds, rocky and sometimes unstable substrates, and a short growing season limit plant growth. There can be sparse cover of forbs, grasses, lichens and low shrubs.

CES306.815 ROCKY MOUNTAIN CLIFF AND CANYON
Concept Summary: This ecological system of barren and sparsely vegetated landscapes (generally <10% plant cover) is found from foothill to subalpine elevations on steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. It is located throughout the Rocky Mountains and

northeastern Cascade Ranges in North America. Also included are unstable scree and talus slopes that typically occur below cliff faces. There may be small patches of dense vegetation, but it typically includes scattered trees and/or shrubs. Characteristic trees includes species from the surrounding landscape, such as Pseudotsuga menziesii, Pinus ponderosa, Pinus flexilis, Populus tremuloides, Abies concolor, Abies lasiocarpa, or Pinus edulis and Juniperus spp. at lower elevations. There may be scattered shrubs present, such as species of Holodiscus, Ribes, Physocarpus, Rosa, Juniperus, and Jamesia americana, Mahonia repens, Rhus trilobata, or Amelanchier alnifolia. Soil development is limited, as is herbaceous cover.

Appendix D: Safety Information - Lightning

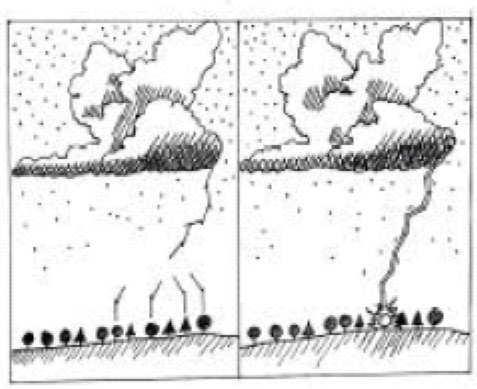
NOLS Backcountry Lightning Safety Guidelines

John Gookin,, NOLS Curriculum Manager

This paper discusses the phenomenon of lightning as it typically happens; how to seek relative safety when caught in a backcountry lightning storm; typical lightning injuries; some tips on teaching lightning risk management in the backcountry; an overview of first aid, and incident reporting guidelines. It can not be emphasized enough, that **being outdoors exposes us to random lightning hazard, no matter what actions we take.**

How Does Lightning Strike?

Lightning strikes fast: the whole process usually takes a few milliseconds. Stepped leaders leave a cumulonimbus cloud and some leaders move toward the ground. They appear as many branches, but only 1-2 branches will reach the ground. Approximately every 50 meters[1] a new step leaves each leader and heads in a fairly random direction. If a leader gets 100m from the ground, positively charged streamers start rising from the closest grounded objects towards the negatively charged leader. As soon as the leader is close enough to a streamer[2], it shoots directly to that streamer and "blazes a trail" for a significant charge (a return stroke) to shoot from the ground to the cloud[3]. This leader search distance concept is important to understand to avoid direct strikes.



Illustrations by Rob MacLean

Figure 1 Left: a stepped leader moves down in 50 m steps and multiple streamers rise from tall objects near the leader.
Right: a single return stroke from a tree is the most obvious part we see.
Note the leader connected with the streamer that happened to be closest to it during the final step.

Most ground strikes occur immediately below a cumulonimbus cloud. Rarely, a bolt of lightning can move horizontally and strike somewhere "out of the blue" (out of the blue sky) as far as 10 miles (16km) away. These horizontal strikes are rare and unpredictable, so they shouldn't affect our decisions.

Using the 50 m search distance of stepped leaders (see above) lightning tends to hit the closest object within range at the end of the last step. Lightning tends to hit elevated sharp terrain features like mountain tops. Lightning tends to hit tall trees in open areas, with objects twice as high receiving roughly 4X the strikes[4]. Lightning tends to hit bushes in the desert if the bush is sticking up higher than the flat ground around it. Lightning tends to hit a boat on the water, especially if it has a tall mast. Lightning can still hit flat ground or water, but more randomly than it hits elevated objects.

Even a few less feet of height can make a difference in improving your odds of NOT being the struck object. This is why the first part of getting into the lightning position is lowering yourself down to decrease your height.

Lightning tends to hit long electrical conductors. Metal fences, power lines, phone lines, handrails, measuring tapes, bridges and other long metallic objects can concentrate currents. Wet ropes also conduct current and should be treated with the same respect as wires. Longer objects tend to concentrate more current and reach more strike points.

How Can Lightning Hurt Us?

Lightning throws an ensemble of deadly and injurious threats our way. All of these effects happen in the same few milliseconds, but none of the threats linger after each strike.

Direct strike: this means the stepped leader connected with a streamer coming out of your body, then the return stroke passed through you or over your body's surface. The return stroke is the most significant electrical event of a lightning strike and has a typical current of 30,000 amps[5] (household current is 15 amps). You greatly reduce the chances of receiving a direct strike by being inside a substantial building or a metal-topped vehicle. In the backcountry you should avoid high places and open ground and assume the lightning position[6] to decrease risk.

Streamer Currents: fast high current pulses are launched from the tops of many elevated objects near each leader as it approaches the ground (see Fig.1.) These are launched in response to the tremendously high electric field that exists, momentarily under each tip of the stepped leader. Since the tips of several or many leaders may approach the ground at about the same time, you do not have to be very near the actual ground strike point to be involved in a streamer current. Streamer currents, while much smaller than the return stroke current, are still large enough to cause injury or death to humans. You suppress the tendency to launch streamer currents from your person by crouching into a tight ball as close to the ground as possible. You avoid this possibility by avoiding high locations.

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[1] Yards and meters can be used interchangeably. One meter = 1.1 yards.
[2] This "strike distance" can vary by 10X according to Uman in The Lightning Discharge, 1987.
[3] Return strokes of the opposite polarity tend to occur at the end of storms and under collapsed anvils. In some areas, multiple ground strike points in the same flash are common.
[4] "Towers, Lightning & Human Affairs." LG Byerley 3rd, WA Brooks, RC Noggle & KL Cummins. 11th Intl Conf on Atmospheric Electricity. 1999.
[5] Figures vary from 1-200kA, with most strikes in the 10-50kA range.
[6] This has formerly been called the lightning "safety" position and is explained later in this paper.

Ground Currents: ground currents occur with each strike and cause roughly half of all lightning injuries. Ground currents are driven by the enormous potential differences[7] that appear in the Earth near the ground strike point. Typical lightning-to-ground strikes inject roughly 30,000 amps into the Earth: since the Earth resists electrical flow, large potential differences will appear in the ground all around the strike point. How far the current flows varies wildly since strike current and ground conductance easily vary by orders of magnitude. But the closer you are to the direct strike, the stronger the ground current. If you are standing with your legs separated, if you are on all fours, if you are in a prone position on the ground, or if you are touching a long metallic object, you maximize your exposure to potential differences that arise from ground currents. The potential difference that appears between your legs or across your prone body can drive significant currents through and over your body. You can minimize your exposure to ground potential differences and ground currents by: keeping your feet close together, by NOT getting in a prone position, by assuming the lightning position on additional insulation such as a foam pad, and by not removing your shoes with thick rubber soles. These actions can help minimize the amount of ground current going through your body, but some experts think these efforts are moot compared to getting to a safer location. We need to be careful that we don't give students a false sense of security by getting in this defensive position.

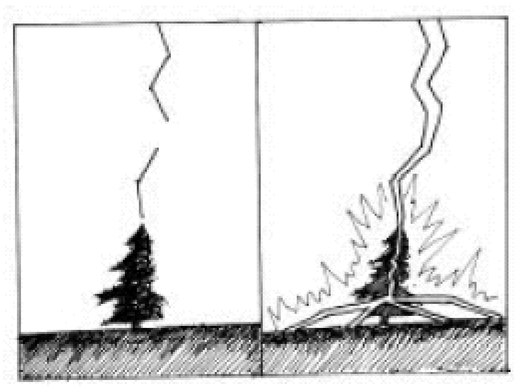

Figure 2: Left: tree with a streamer and a stepped leader.
Right: tree with return stroke, surface arcs, and electrostatic field.

Surface Arcs: high current surface arcs appear to be associated with some fraction of all cloud-to-ground discharges, during the return stroke. They appear in photographs as bright arcs of light radiating from a strike point like spokes of a wheel, in the air just above the ground's surface. (See figure 2.) These long hot horizontal currents have been measured up to 20 meters in length and may get longer. If you are in the path of a surface arc you are likely to conduct some of the surface arc current through or over your body. Since surface arcs emanate from the base of trees struck by lightning, **never seek shelter near a tree.**

Radiation: the visible, infrared and ultraviolet radiation near the strike point can damage your vision.

Sound: the thunder pulse can damage hearing temporarily and possibly permanently.

Electrostatic Field Changes: there is a large change in the electrostatic field out to 30m from the ground strike point. If you are standing, then you maximize the voltage across your body, which in turn maximizes currents that pass through and over your body. It takes very little current to interrupt heart function. Minimizing your height by assuming the lightning position is one way to minimize the field change across the length of your body.

Corona: During any stage of a thunderstorm, the electrostatic field can be enhanced enough around grounded objects to cause brush or point discharge (corona). At night, you may be able to see corona as a faint glow from sharp rock outcrops or the tops of bushes or trees — sometimes even from the fingers of your outstretched hand. You may hear corona as a sizzling or buzzing sound. Even if you can't see or hear corona, you might smell ozone, one of the chemical products of point discharge in air. Ozone has an irritating, acrid "swimming pool" smell.

On land it is unusual to have optimum conditions for sensing corona. If you feel hairs on your head, leg or arms tingling and standing on end, you are in an extremely high electric field. If you or any member of your group experiences any of these signs, it should be taken as an indication of immediate and severe danger. The response to any of these signs should be to instantly (seconds matter) drop and move away from all packs, remove metal shoe fittings, spread out, and adopt the lightning position. Do not ignore these signs and do not try to run to safety, unless safety is literally seconds away. If any of these signs are detected, the probability of a close discharge is high and every effort should be made to minimize injuries and the number of injured.

How Can We Reduce Lightning Risk In The Backcountry?

Backcountry lightning safety data is sparse, so these suggestions are "best hunches" by experts who study lightning safety. Random circumstance is a significant factor in where lightning might strike, meaning that these behaviors help reduce your "Las Vegas" odds of lightning injury, but can never make you safe. If you need to stay safe, you need to remain indoors in well protected buildings.

There are things you can do to reduce risk during a thunderstorm, but you can never get as safe as you could be in town. Ron Holle of the National Severe Storm Lab uses a 10-scale for lightning safety. (Going into a modern building and avoiding metal is as safe as it gets at 10, being in a hard-topped car is a 5, sitting on a steel tower on a mountaintop is a 0.) Ron thinks backcountry precautions only move you up .1 on this scale. Other scientists say they think these precautions move you up 4 points on Ron's 10-scale. Some risk reduction factors, like taking off a metallic belt buckle, might reduce burns but have little to do with avoiding becoming a fatality from a direct strike or ground currents. But there are five actions that can reduce your risk, in order:

- **time visits to high risk areas with weather patterns**

[7] Potential difference: if your feet are touching the ground in two different spots, each has a certain electrical **potential** based on the current flowing there. But it is the **difference** between these potentials that will drive current in one foot and out the other.

- **find safer terrain if you hear thunder**
- **avoid trees**
- **avoid long conductors**
- **get in the lightning position.**

Timing activities with safe weather requires knowledge of typical and recent local weather patterns. There is no such thing as a surprise storm. You need to set turnaround times that will get you off of exposed terrain before storms hit. You need to observe the changing weather and discuss its status with your group. Logistical problems en route should alter whether you complete the paddle or the climb, not whether you get exposed during a storm.

Begin your turnaround if you hear thunder (which means lightning is one to ten miles away.) In calm air you can hear thunder for about ten miles. In turbulent air you can hear the thunder for about five miles[8]. In a driving storm you may only hear it out to one mile. Some parties in rain storms have been struck before they heard any thunder at all.

Safer terrain in the backcountry can decrease your chances of being struck. High pointed terrain attracts lightning to the high points, and even to the terrain around it. Avoid peaks, ridges, and significantly higher ground during an electrical storm. If you have a choice, descend a mountain on the side that has no clouds over it, since strikes will be rare on that side until the clouds move over it. Once you get down to low rolling terrain, strikes are so random you shouldn't worry about terrain as much. If you are exposed to lightning, you need to get in the lightning position as soon as possible, which obviously means you stop moving to safer terrain at that point. Many people have died while upright and walking to safer terrain, but no one has died while stopped in the lightning position. Move to safer terrain as soon as you hear thunder, not when the storm is upon you.

Tents may actually increase the likelihood of lightning hitting that spot if they are higher than nearby objects. Metal tent poles conduct ground current and may generate streamers. Use your understanding of terrain and lightning to select tent sites that may reduce your chances of being struck or affected by ground current. If you are in a tent in "safer terrain" and you hear thunder, you at least need to be in the lightning position. But if your tent is in an exposed location, such as on a ridge, in a broad open area, or near a tall tree, you need to get out of the tent and get into the lightning position before the storm starts, and stay out until it has passed. It would be wise to anticipate additional hazards of getting out of tents in the dark of night during a storm. Determine a meeting spot, have rain gear and flashlights accessible, and have a plan for managing the group during this time.

In gently rolling hills the lower flat areas are probably not safer than the higher flat areas because none of the gentle terrain attracts leaders. Strikes are random in this terrain. Look for a dry ravine or other significant depression to reduce risk.

Wide open ground offers high exposure during an electrical storm. Avoid trees and bushes that raise above the others, since the highest objects around tend to generate streamers. Your best bet is to look for an obvious ravine or depression before the storm hits, but when the cloud is over you, spread out your group at 50' intervals to reduce multiple injuries and assume the lightning position.

Naturally wet ground, like damp ground next to a stream, isn't any more dangerous than dry ground, so don't worry about this. It used to be said that wet ground was more dangerous, because it conducted more ground current, but wet ground actually dissipates ground current faster. Neither wet nor dry is considered more dangerous than the other. Standing *in* water should be avoided.

Dry snow is an insulator, but wet snow is a conductor. This should make travel on dry snow safer than on bare ground, because it will be harder for a person to generate streamers or conduct ground current.

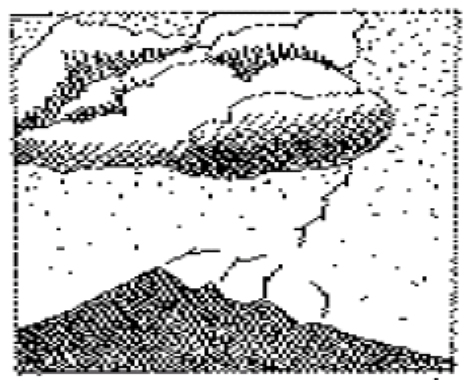

Figure 3: terrain with streamers and a stepped leader. Where do you think the strike will occur?

Avoid cave entrances. Small overhangs can allow arcs to cross the gap. Natural caves that go well into the ground can be struck, either via the entrance or through the ground: cavers should avoid being inside a cave, near an entrance, during a thunderstorm[9]. You should never be anywhere near any metal handrail, wire or cable during a storm. People who have been shocked standing in water deep inside caves cite weak charges, indicating that deep within a cave is safer than being on the surface. If you are near an entrance during electrical activity, don't stand in water, avoid metal conductors, and avoid bridging the gap between ceiling and floor. Move quickly through the entrance (in or out) to minimize the time of your exposure. If you are stopped waiting for others near an entrance area, assume the lightning position.

Boaters should start to get off of the water as soon as they hear thunder. There are no reported incidents of lightning accidents on rivers in canyons, probably because the higher terrain above the canyon attracts the leaders. But there is ample lightning injury data for boaters on rivers in flat terrain, on lakes, and on the ocean. When you get to shore, look for protective terrain to wait out the storm. Be especially cautious of trees at the edge of the water because they might be the tallest objects around the body of water. Boats that can't get off the water in lightning-

[8] Use the 5 sec/ mile (3sec/km) flash-bang rule to measure the distance in ideal conditions, but this can distract people from the big picture.

[9] This is anecdotal data from Cavers' Digest.

prone areas should have lightning protection: see this website http://www.cdc.gov/niosh/nasd/docs/as04800.html

Avoid trees because they are taller than their surroundings. Tall trees are especially adept at generating streamers that attract strikes. If you need to move through a forest while seeking safer terrain, stay away from the tree trunks as you move. You should also avoid open areas that are 100 m wide or wider. Lone trees are especially dangerous: the laws of probability say you are hundreds of times safer in a forest with hundreds of trees than you are near a lone tree in an open space.

"Cone of protection" from trees and cliffs is an arguable concept and has no place in lightning safety education anymore. Lightning has been photographed striking 100 m from 200 m towers, and surface arcs have been photographed exactly where "cones of protection" inferred we were all safe. Instead we need to teach the 50 m leader search distance concept (see the first paragraph of this paper.) If someone is within 50 m of a significantly higher object, they have a greatly reduced chance of being struck directly. You can still be struck, especially indirectly, but the chances are reduced. The 50 m concept works best with cliffs and other steep terrain that provide protection without directing the strike toward you. The 50 m concept does not work well for trees because the base of the tree may send out surface arcs. (see figure 2)

Avoid long conductors. Lightning currents tend to pass in long electrical conductors — particularly ones that are on or near the surface of the Earth. Metal fences, power lines, phone lines, railway tracks, handrails, measuring tapes, bridges, and other metal objects can carry significant lightning current even if these objects are at some distance from the lightning ground strike point. Near the ground strike point of a lightning discharge, wet ropes can conduct lethal currents. During a thunderstorm, wet, extended ropes should be regarded as equivalent in risk and danger to metal wires.

Assume the lightning position[10] when at risk. This will reduce the chances of getting a direct strike and it may reduce the other effects of lightning, but it offers no guarantees. Some scientists argue that it only moves you up to 0.1 on the 10-scale; others argue that it is much more valuable because the data says that no one in this position has ever been hurt. This position includes squatting (or sitting) and balling up so you are as low as possible without getting prone. Wrap your arms around your legs, both to offer a safer path than your torso for electrons to flow from the ground, and to add enough comfort that you will choose to hold the position longer. Close your eyes.

Figure 4: The lightning position: squat or sit, ball up, put feet together, wrap arms around legs.

While the prone position is lower, being spread out increases potential for ground current to flow through or across you. Keep your feet together so you don't create potential for current to flow in one foot and out the other. If you have any insulated objects handy, like a foam pad or a soft pack full of clothes, sit on them. Avoid backpacks with frames since the frame may concentrate current. Don't touch metallic objects like ice axes, crampons, tent poles or even jewelry. You won't get a warning that a strike is imminent because the lightning event from cloud to ground and back occurs faster than you can blink an eye, so stay in the lightning position until the storm passes. The lightning position reduces the chances of lightning injuring you as badly as if you were standing, but is no substitute for getting to safer terrain or structure if it is immediately available. A dangerously close strike actually offers a moment of opportunity to move, while the electrical field rebuilds itself. But in wide open country or gentle rolling terrain there are no simple terrain advantages, so use this position to reduce exposure. If you are concerned enough to assume the lightning position, you should have your group dispersed at least 50' apart to reduce the chances of multiple injuries.

Ground current may spontaneously trigger your leg muscles to jump while in the lightning position, so take care to avoid being near hazards when you drop into this position.

Anecdotal injury data shows that persons with metal cleats on their shoes are more prone to injury. So take crampons off while in the lightning position. But if taking crampons off will slow your descent from a hazardous spot, leave them on to reach safer terrain faster, since terrain is a much better protector than the lightning position is.

The Effects Of Lightning Strikes On Humans

There are three ways lightning hurts us:

1. Electrical shock
2. Secondary heat production
3. Explosive force[11].

Neuro-electrical Damage: Current through the torso or brain can stop the heart or stop breathing. Hearts often restart themselves quickly, but it can take the breathing control center longer to recover. Cardiac or respiratory arrest that isn't restarted quickly will eventually cause anaerobic conditions that make recovery problematic. Current through the tissues can also lead to numbness, paralysis or other nervous system dysfunction.

Burns: Lightning victims can get burned from the high current electricity that turns into heat in conductors that resist its flow. Strike victims can get linear burns from head to feet along the skin, punctate (spotted) burns, or feathering skin marks (not really burns) from the charge flowing over their skin. They can get secondary burns from metallic objects like belt buckles and jewelry that heat up from the current. Burns can also occur from lightning-ignited clothing.

[10] We used to call this the lightning SAFETY position, but this name easily allows the illusion of safety.

[11] Cooper, Mary Ann, MD. Ch 7: Lightning Injuries. In Paul Auerbach MD's Wilderness Medicine: Management Of Wilderness And Environmental Emergencies, 3rd ed. 1995.

Large entry and exit burn wounds from lightning strikes are rare. Most victims have a flashover effect (current travels over their skin) that saves them from the more severe wounds: these people can get linear or punctate burns or feathering patterns. But flashover can also travel into orifices, which may explain the many ear and eye problems that result from lightning strikes.

Wet people may carry more current over their skin, instead of through their bodies, reducing their injuries. It is not suggested that you intentionally get wet in case you are struck, but it does mean you shouldn't be scared that being wet will increase the risk for you.

Trauma: The explosive force of lightning can result in direct or indirect trauma resulting in fractures or soft tissue injuries. Watch for explosive injuries at the feet. The high current can also trigger significant muscle spasms that can fracture bones.

Psychological Effects: Electrical injury can injure the brain. Immediate problems may include altered consciousness, confusion, disorientation or amnesia. Long term problems may include anything from headaches and distractibility to persistent psychiatric disorders and dementia[12].

First Aid For Lightning Victims

Medical aspects of lightning injury are covered in "NOLS Field Medical And Drug Protocols 2000" and in Ch 4 of the NOLS Wilderness First Aid[13] text 3rd ed. The following overview does not supercede those documents.

All patients require a complete body survey and careful evaluation for head, spinal, long bone, or cardiac injuries; peripheral pulses and sensory and motor status should be assessed. Check the skin for small hidden burns. The patient in cardiopulmonary arrest may require prolonged CPR, especially **respiratory support** if spontaneous pulse and blood pressure return. *Unlike normal triage protocols*, first attention and resources should be directed to those who appear dead and those requiring immediate support of airway and breathing. Any patient who has shown any signs and symptoms of lightning injury should be evacuated for further evaluation and treatment.

Teaching Lightning Risk Management

Teaching backcountry lightning safety has the risk that our students will defer to these techniques when civilization offers significantly better options. There are two things we can do to mitigate this possibility.

1) When we are in town, if lightning hazards present themselves, it is important that we model the reaction to seek safety in buildings or vehicles[14]. Once inside, we need to avoid pipes, wires and other metallic objects that could conduct a strike. If you aren't sure whether to "do the drill," err on the side of caution for the sake of having your students practice the routine. Just like CPR, emergency actions are best learned in the kinesthetic mode rather than an intellectual one, so they will be more memorable in times of stress.

2) We can easily teach non-wilderness lightning safety techniques during a wilderness program, since the intown choices are so simple and so effective. Getting in a modern building or inside a car during an electrical storm are the only reasonable options when they are available. Indeed, we can use the relative ease of good choices while in town, and the comparatively high risk of backcountry options, to help our backcountry students default on the side of conservatism when it comes to getting up peaks by noon, getting off the water, choosing safe campsites and generally avoiding exposed terrain when storms threaten us.

Record Keeping For Lightning Incidents

Normal near-miss forms need to be completed quickly to accurately document any near miss. Near misses are used to inform others what hazards to be careful of, and to help predict accident types. Any lightning incident also needs a record of actions taken to avoid the hazard before the incident, weather observations, and thunder and lightning observations before the incident. You should sketch who was where relative to surrounding terrain and vegetation, with estimated distances, heights and elevations, a North arrow, and at least one definitive landmark. If you have time for a detailed sketch, measure using paces that you can convert to meters later. Be sure to record people who were and were not injured by the strike. A precise record of the time[15] and location of the ground strike may help lightning scientists give you some data about that actual strike[16].

Thank you to Mary Ann Cooper MD, Ron Holle, Martin Uman and others for their tremendous contributions to the field and to this collection of information. Lightning scientists do not all agree on these adaptations of their careful scientific studies. Any misrepresentation or maladaptation of their material is my fault, not theirs. JTG

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[12] "Behavioral Consequences of Lightning and Electrical Injury". Margaret Primeau, Ph.D., Gerolf H. Engelstatter, Ph.D. and Kimberly K Bares, M.S. Seminars in Neurology, V15, N3, Sept 1995.
[13] Schimelpfenig & Lindsey, NOLS Wilderness First Aid, 3rd ed, Stackpole, 2000.

[14] See http://www.uic.edu/~macooper/faq1.htm for recommendations of the Lightning Safety Group.
[15] Check watches to the nearest second, then calibrate them with an atomic clock, available at any Radio Shack.
[16] The National Lightning Data System records most strikes in the continental US. Buy data at www.lightningstorm.com

Appendix E: 4x4 Driving Techniques

The Basics

- **Wear Seatbelts:** Put on your seatbelt, and instruct passengers to put them on as well. A good belt will help restrain you when driving difficult terrain, and can save your life in case of a rollover or other accident.

- **Lock the Hubs:** the first thing to do when you get in the dirt is to put the transfer case in four-wheel drive and lock the hubs—if your vehicle is so equipped. With all four wheels hooked together, your control is increased, braking is improved, and you won't get stuck as fast when you make a mistake. This also spreads the tractive force over four tires instead of two, minimizing breakage of drivetrain parts. However, with practice, flipping back and forth between 2WD and 4WD can be advantageous for turning, sliding, and other advanced maneuvers, but it's best to learn while in four-wheel drive.

- **Use 4 Low:** Using low range in the transfer case is important. In low range the available power is greater, and the speed with which you can drive is diminished. By driving slowly over obstacles rather than pretending you're in a SUV commercial and flying over them, you're more likely to make it to the other side instead of breaking your rig or yourself. Going downhill is also easier in low range, as compression braking from the engine is increased. This allows you to stay off the brake more often for optimum control.

- **Hold the Wheel:** While gripping the steering wheel, make sure that your thumbs aren't wrapped around it. If the wheel should suddenly whip around from a tire hitting a rock, your thumbs won't get broken or mangled.

- **Listen to the car:** Turn your stereo off, so you can hear what your vehicle is telling you. The sounds of slipping tires, scraping metal, and engine rpm can all help you be a better driver, but not if you can't hear them. Just like drinking and driving, distractions from what is happening with your vehicle can distract you at the wrong time.

- **Know the car:** Know your rig inside and out. This means being familiar with all of the controls in the cab, as well as how to use them for what purpose. On the outside, make a mental note of what hangs down underneath, and what side the front differential is on so you won't bang the underside on obstacles.

- **Don't ride the clutch:** Staying off the clutch unless you need it is important in many situations. While automatic-equipped 4x4s can have an easier time crawling over things, a manual transmission rig is capable of outdoing an auto as long as the clutch isn't always used. Try driving with your feet on the floor for practice, and see what your rig can do. Once you push in the clutch you've unhooked the drivetrain, and only your brakes will be holding you on a hill.

- **Lower tire pressure:** Consider lowering your tire pressure according to the terrain and speed. Tire pressure lower than the manufacturer's recommendations can provide greater tire traction, flexibility, flotation, and smoother ride. Because the tire will tend to spread out at lower pressures, a bigger footprint is formed, but the tire is more susceptible to sidewall damage. Never air down farther than what you are comfortable with, and remember to air them back up before you hit the pavement.

- **Get a spotter:** If you're unsure of what you're doing while driving an obstacle, ask someone to spot you over the tough areas. An experienced spotter can be your best ally and can make you look like a pro. Remember, though, that you as the driver are the one in command, and it's your decision to trust the spotter or not.

- **Study the area:** Watch the driver in front of you and see how he makes it through. You can learn a lot on what to do and what not to do. Get out and walk the trail or examine the obstacle before you drive through. This allows you to get a mental picture of where you will place your tires before you go. Just as a golfer examines the green before that game-winning putt, you need to know what's ahead of you so you don't get into trouble. Walk ahead and look back; the view is different from the other direction, and other features of the terrain become apparent.

Hills and Dirt

Climbing hills and going back down them is older even than four-wheeling. Usually a steady speed with momentum is adequate, depending on the surface. An occasional blip of the throttle can bump you over some ledges, but rarely will a full-throttle attack do much more than break stuff.

When climbing or descending a hill, keep straight up or down, and don't turn around on the side of a hill. The propensity to roll is far greater, and any stored inertia can send the rig tumbling. Know when to quit and how to back down in a straight line.

The steering seems much more sensitive (and backwards) when you are backing down a hill, and miscues and rolls are common. If you traverse a side hill and are off camber, you need to go slowly to prevent sudden shift of vehicle or cargo weight. A rock on the high side or a hole on the low side can tend to tip you in the wrong direction, as in downhill.

Likewise, spinning the tires on a loose surface when on a side hill breaks traction, causing gravity to pull you off the trail and possibly over the edge. Descending a hill is best done in the lowest gear, for maximum compression braking. Even automatic transmissions will have some compression braking, and a light foot on the brakes is better than locking them up and sliding.

The tires must be rolling to have control, so if you start to slide you need to give it a little gas and be easy on the brake pedal. Easy movements of the steering wheel can help you keep directional control, while whipping the wheel can cause the tires to slide sideways, right into what you are trying to avoid.

Rocks

Lowering the air pressure and going slowly is the best recommendation for rocky trails or hard-core rockcrawling. Tires should be placed on top of the rocks, which allows the axle and undercarriage to avoid hitting the boulders. On IFS rigs or Hummers, for example, the available clearance in the center of the undercarriage is sometimes better, but straddling rocks can still get you stuck in any case.

Your lowest speed that keeps your momentum going is usually the best. If you go too fast you end up bashing and crashing while hurting your rig and generally getting stuck. Rockcrawling is truly the home of elegant driving as coined by the late great Granville King. By making this activity a true art form of fluid motion like a mechanical ballet, a greater amount of obstacles can be scaled with less damage to yourself and the vehicle.
Likewise, raw power and speed can jet you over the boulders, but the hopping and flopping action of bashing and crashing your way through a canyon of boulders is in no sense of the word elegant, and it'll cost you more in the long run. One way to stay in control with an automatic transmission is to use one foot on the brake and one on the gas. On a stick-equipped rig the engine compression braking gives you greater control, but using the two-foot method on an auto will mimic this action.

Sand

Higher gears are great for sand, as speed and momentum keeps you flying on top rather than sinking in. Depending on the type of sand—from fine to coarse and from wet to dry—different speeds and gears may need to be used. Usually, spinning the tires is needed since wheel speed is a factor to keep on top of the sand. Lowering air pressure and running wide tires help in the flotation department as well.

Sand dunes can have steep drop-offs and other obstacles, so being alert is extremely important. If you're climbing a sand hill and realize you've run out of engine power, downshift quickly, and floor it without losing momentum. This is where automatic transmissions excel—virtually instant downshifts with no loss of momentum. Shifting a manual truck usually means the momentum is gone before the clutch is ever let back out. Side hilling in the sand or running a bowl is great if you have enough speed and power, but turn downhill as soon as you start to bog down. Point your ride straight down, and if the nose starts to go sideways give it a little gas to straighten it out.

Water Crossings

Driving through water can be as hazardous as any other terrain. The swift current, unknown bottom conditions, and possibility of engine damage can ruin a nice 4x4 outing. Check the depth and bottom conditions before you attempt to drive across a stream. Look to see where others have made it, and imagine what happens if your rig floats or gets washed downstream.

Cross streams and rivers at an angle upstream to prevent the force of the water from pushing the vehicle downstream. This helps you keep going in a more controlled manner without getting moved downstream. Know where your engine air intake is, and be sure that it is not lower than the deepest part of the stream you are crossing. Many new vehicles have the air intake lower than the front bumper or in the fender. If water gets into the cylinders of a running engine it will hydrolock the engine, stopping it cold, and probably damaging the engine. Avoid spinning tires when they are wet, as wet rubber cuts as easily on sharp rocks.

Mud

Different consistencies of mud call for different styles of driving. Some mud responds to fast driving with a lot of wheelspin, while others may do better with a slower gate with just enough spin to clean out the tires.
Like in snow, skinny tires can dig down to the hard stuff, while wide flotation tires can keep you on top of the goo. Regardless of what the mud is like, a steady forward progress is needed. In other words, keep your momentum up. If you get off the gas, you can risk losing the momentum needed to traverse the slop. Be aware that spinning the tires while stopped may get you going, but quite often you'll simply dig down and get stuck to the gills.

It's always easier to extricate your 4x4 from deep mud before it's resting on the framerails. So if the rig's not moving forward as you spin tires, it's probably going down. Don't be afraid to back out of a sticky situation either; the ruts are already there and you may escape without getting stuck.

Appendix F: The Natural Heritage Network Ranking System

Just as ancient artifacts and historic buildings represent our cultural heritage, a diversity of plant and animal species and their habitats represent our "natural heritage." Colorado's natural heritage encompasses a wide variety of ecosystems from tallgrass prairie and shortgrass high plains to alpine cirques and rugged peaks, from canyon lands and sagebrush deserts to dense subalpine spruce-fir forests and wide-open tundra.

These widely diversified habitats are determined by water availability, temperature extremes, altitude, geologic history, and land use history. The species that inhabit each of these ecosystems have adapted to the specific set of conditions found there. Because human influence today touches every part of the Colorado environment, we are responsible for understanding our impacts and carefully planning our actions to ensure our natural heritage persists for future generations.

Some generalist species, like house finches, have flourished over the last century, having adapted to habitats altered by humans. However, many other species are specialized to survive in vulnerable Colorado habitats; among them are Bell's twinpod (a wildflower), the greenback cutthroat trout, and the Pawnee montane skipper (a butterfly). These species have special requirements for survival that may be threatened by incompatible land management practices and competition from non-native species. Many of these species have become imperiled not only in Colorado, but also throughout their range of distribution. Some species exist in less than five populations in the entire world. The decline of these specialized species often indicates disruptions that could permanently alter entire ecosystems. Thus, recognition and protection of rare and imperiled species is crucial to preserving Colorado's diverse natural heritage.

Colorado is inhabited by some 800 vertebrate species and subspecies, and tens of thousands of invertebrate species. In addition, the state has approximately 4,300 species of plants and more than 450 recognized plant communities that represent terrestrial and wetland ecosystems. It is this rich natural heritage that has provided the basis for Colorado's diverse economy. Some components of this heritage have always been rare, while others have become imperiled with human-induced changes in the landscape. This decline in biological diversity is a global trend resulting from human population growth, land development, and subsequent habitat loss. Globally, the loss in species diversity has become so rapid and severe that Wilson (1988) has compared the phenomenon to the great natural catastrophes at the end of the Paleozoic and Mesozoic eras.

The need to address this loss in biological diversity has been recognized for decades in the scientific community. However, many conservation efforts made in this country were not based upon preserving biological diversity; instead, they primarily focused on preserving game animals, striking scenery, and locally favorite open spaces. To address the absence of a methodical, scientifically based approach to preserving biological diversity Dr. Robert Jenkins of The Nature Conservancy pioneered the Natural Heritage Methodology in the early 1970s.

Recognizing that rare and imperiled species are more likely to become extinct than common ones, the Natural Heritage Methodology ranks species according to their rarity or degree of imperilment. The ranking system is scientifically based upon the number of known locations of the species as well as its biology and known threats. By ranking the relative rarity or imperilment of a species, the quality of its populations, and the importance of associated conservation sites, the methodology can facilitate the prioritization of conservation efforts so the most rare and imperiled species may be preserved first. As the scientific community realized that plant communities are equally important as individual species, this methodology has been applied to ranking and preserving rare plant communities, as well as the best examples of common communities.

The Natural Heritage Methodology is used by Natural Heritage Programs throughout North, Central, and South America, forming an international database network. The 85 Natural Heritage Network data centers are located in each of the 50 U.S. states, 11 Canadian provinces and territories, and many countries and territories in Latin America and the Caribbean. This network enables scientists to monitor the status of species from a state, national, and global perspective. Information collected by the Natural Heritage Programs can provide a means to protect species before the need for legal endangerment status arises. It can also enable conservationists and natural resource managers to make informed, objective decisions in prioritizing and focusing conservation efforts.

What is Biological Diversity?

Protecting biological diversity has become an important management issue for many natural resource professionals. Biological diversity at its most basic level includes the full range of species on Earth, from single-celled organisms such as bacteria and protists through the multicellular kingdoms of plants and animals. At finer levels of organization, biological diversity includes the genetic variation within species, both among geographically separated populations and among individuals within a single population. On a wider scale, diversity includes variations in the biological communities in which species live, the ecosystems in which communities exist, and the interactions between these levels. All levels are necessary for the continued survival of species and plant communities, and many are important for the well being of humans.

The biological diversity of an area can be described at four levels:

Genetic Diversity — the genetic variation within a population and among populations of a plant or animal species. The genetic makeup of a species varies between populations within its geographic range. Loss of a population results in a loss of genetic diversity for that species and a reduction of total biological diversity for the region. Once lost, this unique genetic information cannot be reclaimed.

Species Diversity — the total number and abundance of plant and animal species and subspecies in an area.

Community Diversity — the variety of plant communities within an area that represent the range of species relationships and inter-dependence. These communities may be diagnostic of or even restricted to an area.

Landscape Diversity — the type, condition, pattern, and connectedness of natural communities. A landscape consisting of a mosaic of natural communities may contain one multifaceted ecosystem, such as a wetland ecosystem. A landscape also may contain several distinct ecosystems, such as a riparian corridor meandering through shortgrass prairie. Fragmentation of landscapes, loss of connections and migratory corridors, and loss of natural communities all result in a loss of biological diversity for a region.

The conservation of biological diversity should include all levels of diversity: genetic, species, community, and landscape. Each level is dependent on the other levels and inextricably linked. In addition, and all too often omitted, humans and the results of their activities are also closely linked to all levels of this hierarchy and are integral parts of most landscapes. We at the Colorado Natural Heritage Program believe that a healthy natural environment and a healthy human environment go hand in hand, and that recognition of the most imperiled species is an important step in comprehensive conservation planning.

Colorado's Natural Heritage Program

To place this document in context, it is useful to understand the history and functions of the Colorado Natural Heritage Program (CNHP).

CNHP is the state's primary comprehensive biological diversity data center, gathering information and field observations to help develop statewide conservation priorities. After operating in the Colorado Division of Parks and Outdoor Recreation for 14 years, the Program was relocated to the University of Colorado Museum in 1992, and then to the College of Natural Resources at Colorado State University in 1994, where it has operated since.

The multi-disciplinary team of scientists, planners, and information managers at CNHP gathers comprehensive information on the rare, threatened, and endangered species and significant plant communities of Colorado. Life history, status, and locational data are incorporated into a continually updated data system. Sources include published and unpublished literature, museum and herbaria labels, and field surveys conducted by knowledgeable naturalists, experts, agency personnel, and our own staff of botanists, ecologists, and zoologists.

All Natural Heritage Programs house data about imperiled species and are implementing use of the Biodiversity Tracking and Conservation System (BIOTICS) developed by NatureServe. This database includes taxonomic group, global and state rarity ranks, federal and state legal status, observation source, observation date, county, township, range, watershed, and other relevant facts and observations. BIOTICS also has an ArcView based mapping program for digitizing and mapping occurrences of rare plants, animals, and plant communities. These rare species and plant communities are referred to as "elements of natural diversity" or simply "elements."

Concentrating on site-specific data for each element enables CNHP to evaluate the significance of each location for the conservation of biological diversity in Colorado and in the nation. By using species imperilment ranks and quality ratings for each location, priorities can be established to guide conservation action. A continually updated locational database and priority-setting system such as that maintained by CNHP provides an effective, proactive land-planning tool.

To assist in biological diversity conservation efforts, CNHP scientists strive to answer questions like the following:

- What species and ecological communities exist in the area of interest?
- Which are at greatest risk of extinction or are otherwise significant from a conservation perspective?
- What are their biological and ecological characteristics, and where are these priority species or communities found?
- What is the species' condition at these locations, and what processes or activities are sustaining or threatening them?
- Where are the most important sites to protect?
- Who owns or manages those places deemed most important to protect, and what may be threatening the biodiversity at those places?
- What actions are needed for the protection of those sites and the significant elements of biological diversity they contain?
- How can we measure our progress toward conservation goals?

CNHP has effective working relationships with several state and federal agencies, including the Colorado Department of Natural Resources, the Colorado Division of Wildlife, the Bureau of Land Management, and the U.S. Forest Service. Numerous local governments and private entities, such as consulting firms, educators, landowners, county commissioners, and non-profit organizations, also work closely with CNHP. Use of the data by many different individuals and organizations encourages a cooperative and proactive approach to conservation, thereby reducing the potential for conflict.

The Natural Heritage Ranking System

Key to the functioning of Natural Heritage Programs is the concept of setting priorities for gathering information and conducting inventories. The number of possible facts and observations that can be gathered about the natural world is essentially limitless. The financial and human resources available to gather such information are not. Because biological inventories tend to be under-funded, there is a premium on devising systems that are both effective in providing information that meets users' needs and efficient in gathering that information. The cornerstone of Natural Heritage inventories is the use of a ranking system to achieve these twin objectives of effectiveness and efficiency.

Ranking species and ecological communities according to their imperilment status provides guidance for where Natural Heritage Programs should focus their information-gathering activities. For species deemed secure, only general information needs to be maintained by Natural Heritage Programs. Fortunately, the more common and secure species constitute the majority of most groups of organisms. On the other hand, for those species that are by their nature rare, more detailed information is needed. Because of these species' rarity, gathering comprehensive and detailed population data can be less daunting than gathering similarly comprehensive information on more abundant species.

To determine the status of species within Colorado, CNHP gathers information on plants, animals, and plant communities. Each of these elements of natural diversity is assigned a rank that indicates its relative degree of imperilment on a five-point scale (for example, 1 = extremely rare/imperiled, 5 = abundant/secure). The primary criterion for ranking elements is the number of occurrences (in other words, the number of known distinct localities or populations). This factor is weighted more heavily than other factors because an element found in one place is more imperiled than something found in twenty-one places. Also of importance are the size of the geographic range, the number of individuals, the trends in both population and distribution, identifiable threats, and the number of protected occurrences.

Element imperilment ranks are assigned both in terms of the element's degree of imperilment within Colorado (its State-rank or S-rank) and the element's imperilment over its entire range (its Global-rank or G-rank). Taken together, these two ranks indicate the degree of imperilment of an element. For example, the lynx, which is thought to be secure in northern North America but is known from less than five current locations in Colorado, is ranked G5 S1 (globally-secure, but critically imperiled in this state). The Rocky Mountain Columbine, which is known only in Colorado from about 30 locations, is ranked a G3 S3 (vulnerable both in the state and globally, since it only occurs in Colorado and then in small numbers). Further, a tiger beetle that is only known from one location in the world at the Great Sand Dunes National Monument is ranked G1 S1 (critically imperiled both in the state and globally, because it exists in a single location). CNHP actively collects, maps, and electronically processes specific occurrence information for animal and plant species considered extremely imperiled to vulnerable in the state (S1 - S3). Several factors, such as rarity, evolutionary distinctiveness, and endemism (specificity of habitat requirements), contribute to the conservation priority of each species. Certain species are “watchlisted,” meaning that specific occurrence data are collected and periodically analyzed to determine whether more active tracking is warranted. A complete description of each of the Natural Heritage ranks is provided in Table 1.

This single rank system works readily for all species except those that are migratory. Those animals that migrate may spend only a portion of their life cycles within the state. In these cases, it is necessary to distinguish between breeding, non-breeding, and resident species. As noted in Table 1, ranks followed by a "B,” for example S1B, indicate that the rank applies only to the status of breeding occurrences. Similarly, ranks followed by an "N,” for example S4N, refer to non-breeding status, typically during migration and winter. Elements without this notation are believed to be year-round residents within the state.

Table 17. Definition of Natural Heritage Imperilment Ranks

G/S1	Critically imperiled globally/state because of rarity (5 or fewer occurrences in the world/state; or 1,000 or fewer individuals), or because some factor of its biology makes it especially vulnerable to extinction.
G/S2	Imperiled globally/state because of rarity (6 to 20 occurrences, or 1,000 to 3,000 individuals), or because other factors demonstrably make it very vulnerable to extinction throughout its range.
G/S3	Vulnerable through its range or found locally in a restricted range (21 to 100 occurrences, or 3,000 to 10,000 individuals).
G/S4	Apparently secure globally/state, though it may be quite rare in parts of its range, especially at the periphery. Usually more than 100 occurrences and 10,000 individuals.
G/S5	Demonstrably secure globally/state, though it may be quite rare in parts of its range, especially at the periphery.
G/SX	Presumed extinct globally, or extirpated within the state.
G#?	Indicates uncertainty about an assigned global rank.
G/SU	Unable to assign rank due to lack of available information.
GQ	Indicates uncertainty about taxonomic status.
G/SH	Historically known, but usually not verified for an extended period of time.
G#T#	Trinomial rank (T) is used for subspecies or varieties. These taxa are ranked on the same criteria as G1-G5.
S#B	Refers to the breeding season imperilment of elements that are not residents.
S#N	Refers to the non-breeding season imperilment of elements that are not permanent residents. Where no consistent location can be discerned for migrants or non-breeding populations, a rank of SZN is used.
SZ	Migrant whose occurrences are too irregular, transitory, and/or dispersed to be reliably identified, mapped, and protected.
SA	Accidental in the state.
SR	Reported to occur in the state but unverified.
S?	Unranked. Some evidence that species may be imperiled, but awaiting formal rarity ranking.

Note: Where two numbers appear in a state or global rank (for example, S2S3), the actual rank of the element is uncertain, but falls within the stated range.

Legal Designations for Rare Species

Natural Heritage imperilment ranks should not be interpreted as legal designations. Although most species protected under state or federal endangered species laws are extremely rare, not all rare species receive legal protection. Legal status is designated by either the U.S. Fish and Wildlife Service under the Endangered Species Act or by the Colorado Division of Wildlife under Colorado Statutes 33-2-105 Article 2. In addition, the U.S. Forest Service recognizes some species as "Sensitive," as does the Bureau of Land Management. Table 2 defines the special status assigned by these agencies and provides a key to abbreviations used by CNHP.

Table 18. Federal and State Agency Special Designations for Rare Species

Federal Status:	
1. U.S. Fish and Wildlife Service (58 Federal Register 51147, 1993) and (61 Federal Register 7598, 1996)	
LE	Listed Endangered: defined as a species, subspecies, or variety in danger of extinction throughout all or a significant portion of its range.
LT	Listed Threatened: defined as a species, subspecies, or variety likely to become endangered in the foreseeable future throughout all or a significant portion of its range.
P	Proposed: taxa formally proposed for listing as Endangered or Threatened (a proposal has been published in the Federal Register, but not a final rule).
C	Candidate: taxa for which substantial biological information exists on file to support proposals to list them as endangered or threatened, but no proposal has been published yet in the Federal Register.
PDL	Proposed for delisting.
XN	Nonessential experimental population.
2. U.S. Forest Service (Forest Service Manual 2670.5) (noted by the Forest Service as S")	
FS	Sensitive: those plant and animal species identified by the Regional Forester for which population viability is a concern as evidenced by: Significant current or predicted downward trends in population numbers or density. Significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.
3. Bureau of Land Management (BLM Manual 6840.06D) (noted by BLM as "S")	
BLM	Sensitive: those species found on public lands designated by a State Director that could easily become endangered or extinct in a state. The protection provided for sensitive species is the same as that provided for C (candidate) species.
4. State Status:	
The Colorado Division of Wildlife has developed categories of imperilment for non-game species (refer to the Colorado Division of Wildlife's Chapter 10 – Nongame Wildlife of the Wildlife Commission's regulations). The categories being used and the associated CNHP codes are provided below.	
E	Endangered: those species or subspecies of native wildlife whose prospects for survival or recruitment within this state are in jeopardy, as determined by the Commission.
T	Threatened: those species or subspecies of native wildlife which, as determined by the Commission, are not in immediate jeopardy of extinction but are vulnerable because they exist in such small numbers, are so extremely restricted in their range, or are experiencing such low recruitment or survival that they may become extinct.
SC	Special Concern: those species or subspecies of native wildlife that have been removed from the state threatened or endangered list within the last five years; are proposed for federal listing (or are a federal listing "candidate species") and are not already state listed; have experienced, based on the best available data, a downward trend in numbers or distribution lasting at least five years that may lead to an endangered or threatened status; or are otherwise determined to be vulnerable in Colorado.

Element Occurrences and their Ranking

Actual locations of elements, whether they are single organisms, populations, or plant communities, are referred to as element occurrences. The element occurrence is considered the most fundamental unit of conservation interest and is at the heart of the Natural Heritage Methodology. To prioritize element occurrences for a given species, an element occurrence rank (EO-Rank) is assigned according to the ecological quality of the occurrences whenever sufficient information is available. This ranking system is designed to indicate which occurrences are the healthiest and ecologically the most viable, thus focusing conservation efforts where they will be most successful. The EO-Rank is based on three factors:

Size – a measure of the area or abundance of the element's occurrence. Takes into account factors such as area of occupancy, population abundance, population density, population fluctuation, and minimum dynamic area (which is the area needed to ensure survival or re-establishment of an element after natural disturbance). This factor for an occurrence is evaluated relative to other known, and/or presumed viable, examples.

Condition/Quality – an integrated measure of the composition, structure, and biotic interactions that characterize the occurrence. This includes measures such as reproduction, age structure, biological composition (such as the presence of exotic versus native species), structure (for example, canopy, understory, and ground cover in a forest community), and biotic interactions (such as levels of competition, predation, and disease).

Landscape Context – an integrated measure of two factors: the dominant environmental regimes and processes that establish and maintain the element, and connectivity. Dominant environmental regimes and processes include herbivory, hydrologic and water chemistry regimes (surface and groundwater), geomorphic processes, climatic regimes (temperature and precipitation), fire regimes, and many kinds of natural disturbances. Connectivity includes such factors as a species having access to habitats and resources needed for life cycle completion, fragmentation of ecological communities and systems, and the ability of the species to respond to environmental change through dispersal, migration, or re-colonization.

Each of these factors is rated on a scale of A through D, with A representing an excellent rank and D representing a poor rank. These ranks for each factor are then averaged to determine an appropriate EO-Rank for the occurrence. If not enough information is available to rank an element occurrence, an EO-Rank of E is assigned. EO-Ranks and their definitions are summarized in Table 3.

Table 19. Element Occurrence Ranks and their Definitions

A	Excellent viability.
B	Good viability
C	Fair viability.
D	Poor viability.
H	Historic: known from historical record, but not verified for an extended period of time.
X	Extirpated (extinct within the state).
E	Extant: the occurrence does exist but not enough information is available to rank.
F	Failed to find: the occurrence could not be relocated.

Potential Conservation Areas

In order to successfully protect populations or occurrences, it is helpful to delineate Potential Conservation Areas (PCAs). These PCAs focus on capturing the ecological processes that are necessary to support the continued existence of a particular element occurrence of natural heritage significance. Potential Conservation Areas may include a single occurrence of a rare element, or a suite of rare element occurrences or significant features.

The PCA is designed to identify a land area that can provide the habitat and ecological processes upon which a particular element occurrence, or suite of element occurrences, depends for its continued existence. The best available knowledge about each species' life history is used in conjunction with information about topographic, geomorphic, and hydrologic features; vegetative cover; and current and potential land uses. In developing the boundaries of a PCA, CNHP scientists consider a number of factors that include, but are not limited to:

- ecological processes necessary to maintain or improve existing conditions;
- species movement and migration corridors;
- maintenance of surface water quality within the PCA and the surrounding watershed;
- maintenance of the hydrologic integrity of the groundwater;
- land intended to buffer the PCA against future changes in the use of surrounding lands;
- exclusion or control of invasive exotic species;

- land necessary for management or monitoring activities.

The boundaries presented are meant to be used for conservation planning purposes and have no legal status. The proposed boundary does not automatically recommend exclusion of all activity. Rather, the boundaries designate ecologically significant areas in which land managers may wish to consider how specific activities or land use changes within or near the PCA affect the natural heritage resources and sensitive species on which the PCA is based. Please note that these boundaries are based on our best estimate of the primary area supporting the long-term survival of targeted species and plant communities. A thorough analysis of the human context and potential stresses has not been conducted. However, CNHP's conservation planning staff is available to assist with these types of analyses where conservation priority and local interest warrant additional research.

Off-Site Considerations

Frequently, all necessary ecological processes cannot be contained within a PCA of reasonable size. For example, taken to the extreme, the threat of ozone depletion could expand every PCA to include the entire planet. The boundaries described in this report indicate the immediate, and therefore most important, area to be considered for protection. Continued landscape level conservation efforts that may extend far beyond PCA boundaries are necessary as well. This will involve regional efforts in addition to coordination and cooperation with private landowners, neighboring land planners, and state and federal agencies.

Ranking of Potential Conservation Areas

CNHP uses element and element occurrence ranks to assess the overall biological diversity significance of a PCA, which may include one or many element occurrences. Based on these ranks, each PCA is assigned a biological diversity rank (or B-rank). See Table 4 for a summary of these B-ranks.

Table 20. Natural Heritage Program Biological Diversity Ranks and their Definitions

B1	Outstanding Significance (indispensable): only known occurrence of an element A-ranked occurrence of a G1 element (or at least C-ranked if best available occurrence) concentration of A- or B-ranked occurrences of G1 or G2 elements (four or more)
B2	Very High Significance: B- or C-ranked occurrence of a G1 element A- or B-ranked occurrence of a G2 element One of the most outstanding (for example, among the five best) occurrences rangewide (at least A- or B-ranked) of a G3 element. Concentration of A- or B-ranked G3 elements (four or more) Concentration of C-ranked G2 elements (four or more)
B3	High Significance: C-ranked occurrence of a G2 element A- or B-ranked occurrence of a G3 element D-ranked occurrence of a G1 element (if best available occurrence) Up to five of the best occurrences of a G4 or G5 community (at least A- or B-ranked) in an ecoregion (requires consultation with other experts)
B4	Moderate Significance: Other A- or B-ranked occurrences of a G4 or G5 community C-ranked occurrence of a G3 element A- or B-ranked occurrence of a G4 or G5 S1 species (or at least C-ranked if it is the only state, provincial, national, or ecoregional occurrence) Concentration of A- or B-ranked occurrences of G4 or G5 N1-N2, S1-S2 elements (four or more) D-ranked occurrence of a G2 element At least C-ranked occurrence of a disjunct G4 or G5 element Concentration of excellent or good occurrences (A- or B-ranked) of G4 S1 or G5 S1 elements (four or more)
B5	General or State-wide Biological Diversity Significance: good or marginal occurrence of common community types and globally secure S1 or S2 species.

Protection Urgency Ranks

Protection urgency ranks (P-ranks) refer to the timeframe in which it is recommended that conservation protection occur. In most cases, this rank refers to the need for a major change of protective status (for example agency special area designations or ownership). The urgency for protection rating reflects the need to take legal, political, or other administrative measures to protect the area. Table 5 summarizes the P-ranks and their definitions.

Table 21. Natural Heritage Program Protection Urgency Ranks and their Definitions

P1	Protection actions needed immediately. It is estimated that current stresses may reduce the viability of the elements in the PCA within 1 year.
P2	Protection actions may be needed within 5 years. It is estimated that current stresses may reduce the viability of the elements in the PCA within this approximate timeframe.
P3	Protection actions may be needed, but probably not within the next 5 years. It is estimated that current stresses may reduce the viability of the elements in the PCA if protection action is not taken.
P4	No protection actions are needed in the foreseeable future.
P5	Land protection is complete and no protection actions are needed.

A protection action involves increasing the current level of protection accorded one or more tracts within a potential conservation area. It may also include activities such as educational or public relations campaigns, or collaborative planning efforts with public or private entities, to minimize adverse impacts to element occurrences at a site. It does not include management actions. Situations that may require a protection action may include the following

- Forces that threaten the existence of one or more element occurrences at a PCA. For example, development that would destroy, degrade or seriously compromise the long-term viability of an element occurrence; or timber, range, recreational, or hydrologic management that is incompatible with an element occurrence's existence;

- The inability to undertake a management action in the absence of a protection action; for example, obtaining a management agreement;

- In extraordinary circumstances, a prospective change in ownership or management that will make future protection actions more difficult.

Management Urgency Ranks

Management urgency ranks (M-ranks) indicate the timeframe in which it is recommended that a change occur in management of the PCA. This rank refers to the need for management in contrast to protection (for example, increased fire frequency, decreased grazing, weed control, etc.). The urgency for management rating focuses on land use management or land stewardship action required to maintain element occurrences at the potential conservation area.

A management action may include biological management (prescribed burning, removal of exotics, mowing, etc.) or people and site management (building barriers, re-routing trails, patrolling for collectors, hunters, or trespassers, etc.). Management action does not include legal, political, or administrative measures taken to protect a potential conservation area. Table 6 summarizes M-ranks and their definitions.

Table 22. Natural Heritage Program Management Urgency Ranks and their Definitions

M1	Management actions may be required within one year or the element occurrences could be lost or irretrievably degraded.
M2	New management actions may be needed within 5 years to prevent the loss of the element occurrences within the PCA.
M3	New management actions may be needed within 5 years to maintain the current quality of the element occurrences in the PCA.
M4	Current management seems to favor the persistence of the elements in the PCA, but management actions may be needed in the future to maintain the current quality of the element occurrences.
M5	No management needs are known or anticipated in the PCA.

Appendix G: GRSA Contact List

NAME, AGENCY	E-MAIL ADDRESS	PHONE NUMBER	POSITION/SPECIALTY
Andrew Valdez, NPS	andrew_valdez@nps.gov	719.378.6362	Geology
Barbara Erwin, NPS	barb_irwin@nps.gov	719.378.6372	GSDNP Housing Officer
Billy Schweiger, NPS	billy_schweiger@nps.gov	off:970.267.2147 cell:970.213.2677	Ecology, Sample Design
Brent Frakes, NPS	brent_frakes@nps.gov	970.267.2156	Data Management
Bruce Short, USFS	bshort@fs.fed.us	719.852.6225	US Forest Service, BLM
Chris Lea, NPS	chris_lea@nps.gov	303.969.2807	botanist/ecologist, NPS-USGS vegetation mapper
Dan Cogan, USBR	dcogan@do.usbr.gov	303.445.2291	GIS/photo interpreter/ecologist (Denver)
David Pillmore, NPS	david_pillmore@nps.gov	970.586.1398	Data Technician
Doug Stephen, NPS	doug_stephen@nps.gov	303.969.2947 (or maybe 2997)	fire ecology, fire effects monitoring, FIREGIS_
Fred Bunch, NPS	fred_bunch@nps.gov	719.378.6361	NPS, Great Sand Dunes
Hobey Dixon	pixies@amigo.net	719.589.3813	Botanist/Plant Ecologist, GRSA & SLV
Jeff Gossage, TNC		719.378.2904	Medano-Zapata Ranch Manager (TNC)
Jim Erdman, USGS	jerdman@cteko.net	719.256.4177	plant/fire ecology, biogeochem, noxious weeds
Joe Funk		719.378.2141	Zapata Property Owners Association
Joe Steven, CNHP	js@colostate.edu	970.491.7760	Ecology Team Leader, CNHP
Karl Brown, USGS	karl_brown@usgs.gov	303.202.4240	GIS/GPS
Keith Schulz, NatureServe	keith_schulz@natureserve.org	303.541.0356	Regional Vegetation Ecologist
Kelli Stone	kelli_stone@fws.gov	off:719.589.4021ex.226 c:719.588.8469	USFWS, Baca National Wildlife Refuge
Mike Artman, USFWS	mike_artman@fws.gove	303.236.4381	land protection planning/division of refuges
Nate Williamson, NPS	nathan_williamson@nps.gov	970.586.1434	wildlife biologist
Pat Stephen, NPS	pat_stephen@nps.gov	303.817.6201	Fuels Data Development Technician
Paul Robertson, TNC	probertson@tnc.org	719.378.2356	conservation planning/ecosystem ecology
Phyllis Pineda Bovin	phyllis_bovin@nps.gov	719.378.6363	Biology
Rickie White, NatureServe	rickie_white@natureserve.org	703.908.1811	Coordinator for NatureServe's role in the NPS VMP/ plant ecologist
Tim Smith, NPS	tim_smith@nps.gov	303.969.2086	GIS/GPS

Appendix H: Camera and GPS Settings and GPS-Photo Link

Camera Settings

Turn the knob to the SETUP function. On page 2/3, select: C Reset all, and reset. This restores all camera settings to default. From there, check the **Date** on page 1/3 of the SETUP menu. Finally, turn the knob one click counter-clockwise to the icon for Image Quality/ Size. This should be set at **FINE** and **5M**. Check the Date and Image Quality/ Size at the beginning of each session and whenever you change the battery.

GPS Settings

The settings which matter the most are the Location Format and Map Datum. They affect the way we navigate to and record our locations. These can be found under Main Menu (Press the Menu button twice): Setup (arrow down): Location (arrow over). The Location Format should be set to **UTM UPS** and the Map Datum to **WGS 84**.

The second most important settings can be found under Main Menu: Setup: Units. We will be recording our Elevations in **Meters**. As our plots are laid out in meters also, it is helpful to use meters for Distance and Speed, to get in the metric mindset.

The other settings can be changed to suit your needs. Many of the display pages allow you to set up small fields that report things like elevation and distance to the next waypoint. The number and content of these fields can be changed by hitting the Menu button once and selecting Setup Page Layout or Change Data Fields. Play with them. Get to know your GPS!

There are a few shortcuts printed in black next to some of the buttons on the GPS unit. To turn on the magnetic compass, hold the Page button until the “Compass Turned On” message appears. Hold Enter to Mark a Waypoint. Press Nav once to select a point to navigate to. If you hold Nav too long, your GPS thinks that someone has fallen overboard and takes an emergency waypoint called MOB.

GPS-Photo Link

When at a plot:

1. If you are at the first plot of the day/week/photoperiod, snap one of the GPS screen. Be sure to record CREW # on the Daily Log.
2. Take an averaged waypoint at the plot center and name the waypoint the same as the plot number. Be sure to note the accuracy of the GPS before finalizing the waypoint as it will not show up once the point is saved.
3. Take the four photos, in order, N-E-S-W. Use the photo placard to display plot number, date and direction. It is important to take the waypoint first and the pictures quickly thereafter because Photo Link can be used to match the photos to the closest waypoint BEFORE they were taken.
4. Record the photo numbers from the camera and the UTMs from the new waypoint on the data sheet.
5. Any time the camera battery needs to be replaced, check to make sure the time and date is set correctly. Take another picture of the GPS screen and note if there were any adjustments to the date/ time. If there were adjustments, the photos will have to be processed in separate groups.
6. Do not delete any waypoints.

Using GPS–Photo Link:

1. Start GPS–Photo Link.
2. Hook up the GPS and CF card to the computer.
3. Using Windows Explorer, move all non-plot photos to the CREW SHOTS folder.

Select Photos

- Select the Photo Source as Camera Folder on the left of the screen.
- Set the camera folder to the flash card, (something like: E:\DCIM\100K5000).
- The Root Folder should remain as: C:\VegetationMapping\Photos\DONE\SESSION (__).
- The New Folder can remain with the default name of the day's date.

If more than one group is downloading, it will automatically add an extra digit to the end of the name.

- Original Photo Action: Copy photos to output folder.

GPS Data

- GPS data source: Download *Garmin Waypoints* on port *Auto*.
- Datum/ Position Format: UTM , NAD 83 worldwide

Time Sync.

- Use photo of GPS receiver.
- Use GPS position only if within *500* seconds. (not really necessary, play with it)
- Matching: *Match to closest point before photo*.
- Time zone: *(GMT -07:00) Mountain Time (US & Canada)*
- (*check*) Auto-adjust for daylight savings time, if needed.

Time Offset Entry / Photo Edit

- Select the photo of the GPS display by highlighting the photo number in the left column and (*check*) Use this photo for time entry.
- Enter the GPS date and time from the display.
- (*check*) Do not include photo in output.
- Okay.

Watermark

- Font:
  Arial Black
  Halo White
  Size: *Small*
- Placement: *Bottom, Bottom* (*check*) Place outside of photo area.
- Show / Format:
- (*check*) Lat / Lon: whatever
- Grid: 1m
- (no) Elevation
- (*check*) Date:MM/DD/YYYY
- (*check*) Time: HH:MM:SS am
- (*check*) Extra Data (Title, Comment)

Extra Data Entry

- All Photos: Title for all Photos: GRSA.VMP
- Comment: Plot # (space) Direction; examples: 105 N, 105 E, etc.

File Output

- File Output Options: (*check*) ESRI Shape Files
- Specify photo size: *1024 pixels*
- Specify photo quality: *(JPEG) best*

- Rename output files using: *Comment*

Done Processing

Here it should say something like '8 of 8 photos linked to GPS'. You can browse the output folder to make sure the UTMs are correct on the photos, or if they didn't all link you can try processing them again and change the settings on the Time Sync page. To reprocess, hit continue and select the Existing Folder in the Photo Source box. Things like the time offset and photo comments will have remained the same. You can go in to edit, change comments etc. from the same cycle of pages that you went through the first time.

**Downloading photos for later:

1. Place the CF card in the adapter.
2. Make a new folder under

   C:\VegetationMapping\Photos\RAW\3000 (or \4000, or \5000)

   Named with the date of the day of downloading, for example:

   C:\VegetationMapping\Photos\RAW\3000\06-21-2005
3. Copy pictures to the new folder and clear and eject the CF card.
4. Select this folder as the Photo Source / Camera Folder when processing.

Appendix I: National Vegetation Classification Principles and Structure

III

The U.S. National Vegetation Classification

Guiding Principles of the U.S. National Vegetation Classification

The USNVC has been constructed from the efforts of many ecologists whose work preceded that of the Conservancy. It is an attempt to integrate the features of existing systems that best fit the needs of the Conservancy and its partners. Six key decisions were made regarding the issues that were discussed in Section II. The classification

- *is vegetation-based*
- *uses a systematic approach to classifying a continuum*
- *emphasizes natural vegetation*
- *emphasizes existing vegetation*
- *uses a combined physiognomic-floristic hierarchy*
- *identifies vegetation units based on both qualitative and quantitative data at a scale that is practical for conservation*
- *is appropriate for mapping at multiple scales*

These decisions are discussed in greater detail below.

III.A. Base the Classification on Vegetation

A pivotal decision made by Conservancy ecologists was to develop a terrestrial classification system that was based primarily on vegetation. Several factors were key to this decision. First, the mission of the Conservancy is to protect biodiversity. A classification that emphasizes the biotic component of ecological systems was seen as most directly relevant to this mission. Second, vegetation is a readily measured component of ecological systems. Ease of measurement is important to ongoing surveys of the status of biodiversity being conducted on the ground and through analysis of aerial photography and satellite imagery, as well as to monitoring and restoration efforts. Third, building such a system was more practical than building a complex multi-factor system.

A vegetation-based classification is valuable in itself because it describes an important biotic component of ecological systems. The Conservancy has a strong interest in linking its vegetation-based approach to ecological land classifications such as ECOMAP (Avers et al. 1994) and that of Bailey (1995). These classifications provide a series of hypotheses about the ecological variables that structure a system and represent the ecological variability present in a landscape, irrespective of the disturbances to the vegetation (Lapin and Barnes 1995). In addition, vegetation-based descriptions of the landscape will benefit from an integration with assessments of landscape processes (Bourgeron et al. 1994, Chen et al. 1996).

III.B. Use a Systematic Approach to Classifying a Vegetation Continuum

The USNVC recognizes that the underlying pattern of vegetation is more or less that of a continuum. However, continuum theory does not preclude recognizing the degree to which species form repeating groups in ecologically similar habitats. Thus, the USNVC categorizes continuously varying, multi-dimensional species assemblages in a reasoned, systematic, but somewhat arbitrary way. Such categories or types are an important tool for organizing information and communicating the needs of conservation and management (Shimwell 1971, McIntosh 1993).

A plant community type in any classification system can be characterized based on specified criteria for homogeneity, but individual stands can present great variability in species composition and structure. To accommodate some of this variability, the USNVC is ecologically realistic: it does not require too rigid a system of diagnostic species or physiognomic structure. It relies on units that are flexibly designed with respect to concordant species patterns, but which are explicit in their descriptions of the major dominants and characteristic species of the types and the full range of the type's variability.

The USNVC represents a simplification of natural complexity and a consequent loss of information, as does any classification. Thus, the classification will be only one component of efforts to describe and understand the multi-dimensional, continuous pattern of vegetation. However, when a systematic sampling of vegetation is undertaken across a region, the classification of that pattern can be a powerful stimulus to the conservation, management, and restoration of vegetation (Daubenmire 1952, Curtis 1959, Shimwell 1971, Rodwell 1991).

III.C. Apply the Classification to Natural Vegetation

The Conservancy's focus is on the classification of natural vegetation for conservation applications. Whereas the USNVC framework can be used to classify all vegetation, only the more natural types are systematically classified and described by the Conservancy and the Natural Heritage Network. Within the context of the USNVC, "natural vegetation" is broadly defined to include types that occur spontaneously without regular management, maintenance, or planting, and that generally have a strong component of native species. For the purposes of conservation, however, it is useful to further divide these natural and semi-natural types into natural/near natural and semi-natural/altered categories (see Figure 1 on page 16 and Appendix E on page 123). Natural/near natural vegetation refers to plant communities that appear to be unmodified, or only marginally impacted, by human activities. Where anthropogenic impacts are apparent, the resulting physiognomic and floristic patterns have a clear, naturally maintained analogue. For example, a native grassland stand that has been invaded by native shrubs due to fire suppression may be considered a near-natural type when it resembles natural stands where fire was less frequent[3]. Semi-natural/altered vegetation may be defined as plant communities where the species composition or structure of the vegetation has been sufficiently altered by anthropogenic

[3] The effects of human influences on natural/near-natural vegetation can partly be evaluated by the Conservancy using a ranking system that rates the individual stands with respect to their naturalness. The ranking system reduces the need to classify human impacts per se on natural/near-natural vegetation, treating these impacts instead as part of the variability of a type. Only where such impacts cause a considerable departure from the floristic and physiognomic characteristics of the type are the stands classified as semi-natural/altered or planted/cultivated types.

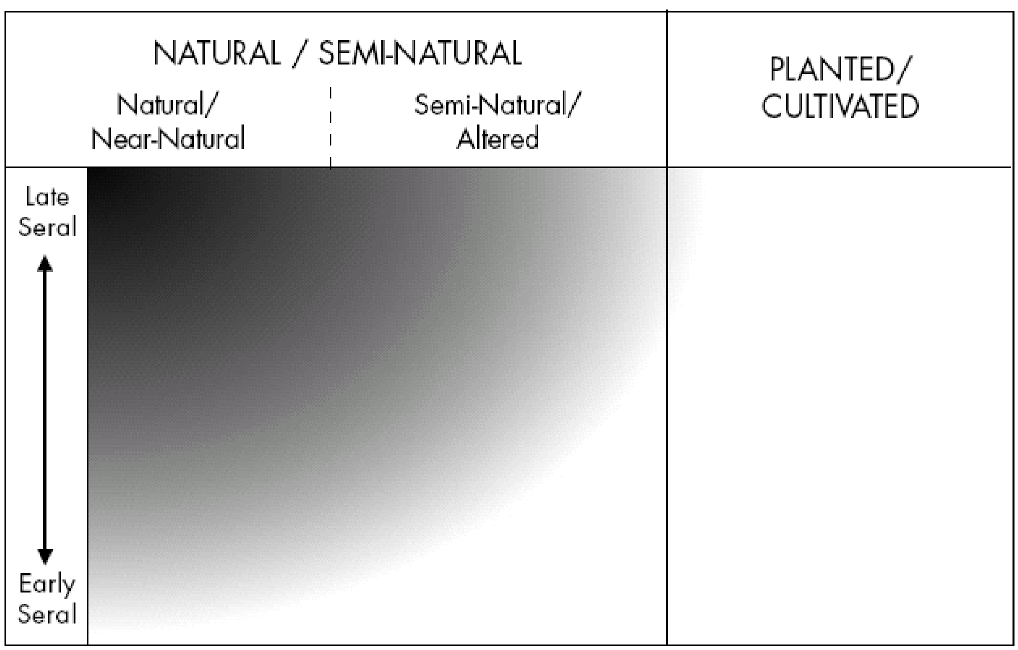
disturbance such that no clear natural analogue is known. This type of vegetation may be dominated by either native or exotic species. One example is an old field community that originated on abandoned farmland and is dominated by native species, but the species assemblage is never found in natural/near-natural stands. A second example is a stand of Melaleuca or cajeput-tree (*Melaleuca quinquenervia*), an aggressive exotic species that occurs without human maintenance or management and has become a major part of the Everglades landscape in south Florida.

Planted/cultivated vegetation includes types such as orchards, pastures, and vineyards. Semi-natural/altered and planted/cultivated vegetation types have not been classified or described to any great extent by the Conservancy, but further development of these types will undoubtedly be useful to, and pursued by, other organizations and agencies.

III.D. Apply the Classification to Existing Vegetation

The focus of the USNVC is on existing, rather than potential, vegetation. In the Conservancy's conservation strategy, it is assumed that effective conservation of all existing natural community types will ensure the conservation of a high percentage of all species, both plant and animal. Therefore, identification of all existing natural types, rather than only those that are late-seral

FIGURE 1. Vegetation Being Classified by the Conservancy and Natural Heritage Programs



Shading illustrates vegetation being classified by the Conservancy and Heritage Programs. All types of vegetation—natural and cultural—may be classified with the USNVC system, but the Conservancy and Heritage Program efforts have been primarily focused on mid- to late-seral, natural/near-natural vegetation. Less natural and earlier seral vegetation are also sometimes classified (typically on an as-needed basis for use in various applications). Often these classifications are at a coarser level of the hierarchy and are less comprehensive than those focused on more natural, late-seral types.

or potential, is a necessary component of the Conservancy's approach to biodiversity conservation. While the USNVC framework is comprehensive with regard to existing vegetation—encompassing the spectrum from natural to cultivated—the Conservancy's efforts have focused on the best existing occurrences of natural types, both naturally disturbed (early- and mid-seral) and naturally *un*disturbed (late-seral) types.

In addition to its usefulness for conservation purposes, the classification of existing, rather than potential, vegetation makes fewer assumptions about process or vegetation dynamics and allows the taxonomy to be grounded in what is directly observable and measurable. When the sampling and description of types includes environmental factors, an emphasis on existing vegetation allows the greatest latitude in subsequent data interpretation. Classification of existing natural vegetation also allows interpretation of vegetation patterns in the context of ecological units and processes at multiple scales. Therefore, the focus on existing vegetation can support a wide number of uses in addition to the identification of conservation sites. These include inventory and monitoring of the current status of vegetation, mapping of the landscape, and development of dynamic ecological models (including models of succession and response to management).

III.E. Use a Physiognomic-Floristic Approach

The USNVC uses both physiognomic and total floristic composition criteria, allowing for most of the advantages of both approaches. The formation concept guides the development of physiognomic types (Whittaker 1962, 1975), and the association concept guides the development of floristic units (Moravec 1993).

The USNVC has a hierarchical taxonomic structure with physiognomic criteria used at the coarsest levels of the hierarchy and floristic criteria used at the finest. This ordered structure allows flexibility in emphasis from essentially physiognomic to essentially floristic descriptions and provides a unifying framework within which to relate national and international physiognomic systems to local and regional floristic systems. Structuring the classification in a hierarchical fashion allows it to be used at different taxonomic scales, depending on the amount of information and resolution needed. This approach also facilitates the organization and tracking of information.

The current USNVC represents an initial attempt at melding floristic and physiognomic approaches; the floristic levels are at least partially *constrained* by the upper levels. Such a statement may imply an overly rigid classification, with floristically very similar stands being artificially separated solely by physiognomic criteria. However, the USNVC accounts for the inherent variability of vegetation by placing the *abstract* floristic type within a single physiognomic class, explicitly noting that individual stands will express physiognomic variation clustering around this average expression.

In certain cases, structurally different stands of very similar species composition are placed in different formations, in recognition that these structural differences have a particular significance. These "variants" may or may not warrant recognition as separate associations based on pure floristics, but such distinctions are both a trade-off for retaining the utility of the physiognomic upper levels and a recognition that structural patterns can have important ecological meaning beyond those indicated by floristics alone. Ongoing review of both the physiognomic and floristic criteria chosen will be needed to ensure maximal value of both these criteria. Because the USNVC has primarily been developed using a "top down" approach (i.e., by partially constraining floristic types to pre-defined physiognomic categories), an overall reexamination of the physiognomic criteria used is especially needed to ensure that they provide the most useful and "unforced" bases for further classification.

III.F. Identify Types Using a Pragmatic Approach

The USNVC was specifically developed for conservation purposes. Conservancy ecologists have used both qualitative and quantitative analysis of existing and newly collected field data to develop a list of vegetation types that could be used to efficiently inform conservation decision making.

III.F.1. Delineating Stands

As stated previously, the process of entitating stands is strongly influenced by the classification approach to be employed. Because the USNVC employs a physiognomic-floristic approach, stands are chosen based on homogeneity of floristics, physiognomy, and habitat.

III.F.2. Identifying Vegetation Types

The finest level of the USNVC, the association, is intended to be the basic unit of inventory for biodiversity assessment. Associations are defined as mutually exclusive, with definite conceptual boundaries. Each association is designed to be clearly recognizable by trained ecologists. Each occurrence or stand of an association is similar enough in composition, structure, and habitat that it can be compared, contrasted and ultimately ranked against other occurrences of its type for conservation purposes. Yet a reasonable range of variation within a type is accepted, so that the number of types does not become so great that types can no longer be effectively described, tracked, and managed.

The status of expert knowledge and existing data dictates that the development of USNVC types be an iterative, qualitative, and quantitative process that will require successive approximation and refinement over time. Thus far, in the absence of complete floristic data sets, many alliances and associations have been defined using a thorough qualitative analysis based on available information on the dominant species, characteristic species (those that are typical or indicative of a habitat or have a particular geographic distribution), and environmental variables. Wherever existing classifications that rely on concepts similar to that of the formation and the association are available, their types are provisionally included in the USNVC. Expert local and regional ecological opinion is widely used to assist in this process.

To date, no explicit quantitative or qualitative formula has been applied in the formal recognition of USNVC associations. The lack of total floristic data in many cases precludes the standard use of an index of similarity or other mathematical measure; in some cases criteria other than floristic composition (e.g., structure) necessarily dictate the preliminary recognition of associations.

Quantitative analysis of stand data collected for vegetation types across their perceived range is increasingly used to define types in the USNVC (see Section V.B.1.d.). As this practice becomes increasingly widespread, objectivity and repeatability in classification will improve. To achieve this long-term goal, the Conservancy has implemented a set of guidelines for standardized vegetation data collection and has provided general guidance on data analysis (see Section V.B.1.). The refinement of the USNVC will depend on further implementation of standard protocols for analysis of original and existing data sets.

III.G. Facilitate Mapping Applications

The use of physiognomic criteria to define the upper levels of the USNVC hierarchy makes it a practical tool for mapping applications. It is often possible to identify a certain level of the vegetation hierarchy that is appropriate to the scale and resolution of mapping for a particular project. However, USNVC classification units are independent of their scale and ability to be mapped.

For a map at any given scale, some vegetation types can be mapped directly. Many other vegetation types will not be mappable due to the resolution of the imagery and the spatial pattern of the vegetation. As such, map units can be constructed for several associations that are unrelated in the hierarchy but occur as repeating units on the ground. For example, a pine barrens community in New Jersey may contain several distinct associations that often occur together. A map unit created for this area may encompass all of these associations, and thus will not have direct correspondence to a single vegetation type. However, the vegetation pattern of the unit can be described by noting the typical associations that occur within each map unit.

The relationship between vegetation classification and mapping is complex. The USNVC, as a standardized classification system, provides consistent objectives for vegetation mapping. Maps attributed with standardized USNVC types can directly contribute to a standardized information base that is needed for regional, national, and international assessments and planning.

IV

The U.S. National Vegetation Classification

The Structure of the U.S. National Vegetation Classification

The fundamental issues and decisions discussed in Sections II and III provide the context for the development of USNVC. This section discusses the overall structure of the classification framework in more detail. This structure is applicable worldwide; however, the focus of this section is on its application to vegetation within the United States.

IV.A. System Level

The top division of the classification hierarchy separates terrestrial vegetated communities (terrestrial system) from those of deep-water habitats (freshwater aquatic and marine systems) and subterranean habitats (subterranean system). The terrestrial system as defined includes all terrestrial vegetation and all wetland and shallow water vegetation with rooted vascular plants. In relation to Cowardin et al. (1979), this system includes the terrestrial system and those portions of the palustrine, lacustrine, riverine, estuarine, and marine systems that have rooted vegetation.

IV.B. Hierarchical Structure of the Terrestrial System

The terrestrial classification system has seven hierarchical levels. This structure allows the classification to be applied at the appropriate level for the amount of information available and the needed resolution. Five levels (formation class, formation subclass, formation group, formation subgroup, and formation) are based on physiognomic characteristics, and two levels (alliance and association) are derived from species composition (floristics) (see Figure 2, below, and Table 1 at the end of this chapter).

IV.B.1. Physiognomic Levels

The upper levels of the classification framework are a modification of the UNESCO World Physiognomic Classification of Vegetation (1973). This system was chosen for the following reasons:

- It is the existing product of an international group of experts. As such, it is more readily acceptable than a new, local, or single-authored system. It is global in scope, and parts or variants of the framework are presently being used by different United States and international agencies.
- It was constructed to be ecologically meaningful.
- It is a hierarchical system that was designed for classification and mapping at multiple scales, though generally at a scale of 1:1,000,000 or coarser.
- The structure of the framework is somewhat flexible and open-ended; units can be added as needed.

FIGURE 2. Hierarchical Vegetation Classification System for the Terrestrial Ecological Communities

SYSTEM: TERRESTRIAL

FORMATION CLASS
FORMATION SUBCLASS
FORMATION GROUP
FORMATION SUBGROUP
FORMATION

physiognomic levels

floristic levels

ALLIANCE
ASSOCIATION

Several limitations of the UNESCO hierarchy were addressed to meet the objectives for the upper physiognomic levels of the USNVC. A more systematic framework, i.e., the more consistent application of criteria to define each level of the hierarchy, was implemented. For example, in the UNESCO system, different criteria are used to distinguish formation subclasses depending on which formation class is being subdivided. In the USNVC, however, predominant leaf phenology is the single criterion used to define formation subclasses in the Forest, Woodland, Shrubland, and Dwarf-Shrubland Formation Classes. In addition, to ensure a more consistent application of the criteria, supporting information was developed to explain the criteria used (see the descriptions of the USNVC physiognomic levels presented below). Finally, the Conservancy adapted the UNESCO formation level, based on modifications suggested by Driscoll et al. (1984), to make the system more practical for finer scale applications. For example, wetland vegetation was included in the UNESCO classification only when it occurred over large areas, such as extensive woodland bogs. Finer-scale wetland vegetation types, such as sedge meadows and seepage fens, were not recognized, though these are typically physiognomically distinct from adjacent wetland and upland vegetation. USNVC formations allow recognition of these types.

Compatibility with other systems was also a consideration in the development of the physiognomic levels. The "subclass level" of UNESCO was modified, and a new formation subgroup was added to support the Federal Geographic Data Committee's need to classify managed and cultural vegetation (FGDC 1997). Hydrological modifiers based on Cowardin et al. (1979) were also added at the formation level, since they have been used extensively to map wetlands across the United States. Each physiognomic level is described in more detail below.

Formation Class

The formation class (hereinafter called "class") is based on the structure of the vegetation. These types are determined by the relative percentage of cover and the height of the dominant, uppermost life forms, whether they are trees, shrubs, dwarf-shrubs, herbaceous plants, or nonvascular plants. This level has seven mutually exclusive classes:

FOREST: Trees with their crowns overlapping (generally forming 60-100% cover).

WOODLAND: Open stands of trees with crowns not usually touching (generally forming 25-60% cover). Canopy tree cover may be less than 25% in cases where it exceeds shrub, dwarf-shrub, herb, and nonvascular cover, respectively.

SHRUBLAND: Shrubs generally greater than 0.5 m tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 25% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover, respectively. Vegetation dominated by woody vines is generally treated in this class.

DWARF-SHRUBLAND: Low-growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and tall shrubs generally less than 25% cover). Dwarf-shrub cover may be less than 25% where it exceeds tree, shrub, herb, and nonvascular cover, respectively

HERBACEOUS: Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 25% cover; trees, shrubs, and dwarf-shrubs generally with less than 25% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover, respectively.

NONVASCULAR: Nonvascular cover (bryophytes, non-crustose lichens, and algae) dominant (generally forming at least 25% cover). Nonvascular cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and herb cover, respectively.

SPARSE VEGETATION: Abiotic substrate features dominant. Vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources (total vegetation cover is typically less than 25% and greater than 0%).

Types within the Nonvascular and Sparse Vegetation Classes have not been well developed. Sparse Vegetation types are primarily based on substrate features, rather than vegetation. As more information is gathered, these types will be increasingly defined by their vegetation characteristics.

Formation Subclass

The formation subclass (hereinafter called "subclass") is based upon growth-form characteristics. Predominant leaf phenology (i.e., evergreen, deciduous, or mixed evergreen-deciduous) is the character that divides the Forest, Woodland, Shrubland, and Dwarf-Shrubland Classes into subclasses. Persistence and growth form (perennial or annual; and graminoid, forb, or hydromorphic) divide the Herbaceous Class into subclasses. The relative dominance of lichens, mosses, and algae divides the Nonvascular Class. Subclasses (and lower hierarchical levels) of the Sparse Vegetation Class are defined primarily by substrate features. To provide more meaningful and readily observable divisions, particle sizes of the substrate (e.g., consolidated rocks, gravel/cobble) divide the Sparse Vegetation Class at the subclass level.

Formation Group

The formation group (hereinafter called "group") defines vegetation units based on leaf characters, such as broad-leaf, needle-leaf, microphyllous, and xeromorphic. These units are identified and named in conjunction with broadly defined macroclimatic types (tropical or subtropical, temperate or subpolar, winter-rain, drought-deciduous, cold-deciduous) to provide a structural-geographic orientation, but the ecological climate terms do not usually define the groups per se. The presence of woody strata is used with climate to separate groups in the Herbaceous and Nonvascular Classes (e.g., herbaceous with a sparse tree layer is separated from herbaceous with a sparse shrub layer). Sparse Vegetation groups are separated by major topographic position types or landforms (e.g., cliffs versus flat pavement, talus versus rock flats).

Formation Subgroup

The formation subgroup (hereinafter called "subgroup") level divides each group into either a Natural/Semi-natural or a Cultural Subgroup, providing a consistent dichotomy between natural vegetation (broadly defined to include natural, semi-natural, and modified vegetation) and cultural or planted/cultivated vegetation. This level does not exist in the UNESCO (1973) classification; it was introduced to the USNVC to facilitate the inventory, classification, and mapping of all vegetation types across the natural and cultural landscape. Its placement at the subgroup level allows for the development of culturally distinct formations (e.g., orchards and vineyards) within the overall hierarchy.

Formation

The formation represents vegetation types that share a definite physiognomy or structure within broadly defined environmental factors, relative landscape positions, or hydrologic regimes. Structural factors such as crown shape and lifeform of the dominant stratum are used in addition to the physiognomic characters already specified at the higher levels. Hydrologic modifiers, adapted from Cowardin et al. (1979), are used for wetlands.

IV.B.2.
Floristic Levels

The lowest two levels of the hierarchy—the alliance and the association—are based on floristics; both levels are developed from the dominant or diagnostic species. In the absence of detailed floristic information, the emphasis is placed solely on dominant species. When floristic tables are available, alliances and associations are still primarily defined by dominant species, but additional diagnostic species may be considered as well (*see* Moravec 1993).

Alliance

Within a formation, the alliance is a physiognomically uniform group of plant associations (*see Association* below) sharing one or more dominant or diagnostic species, which as a rule are found in the uppermost stratum of the vegetation (*see* Mueller-Dombois and Ellenberg 1974).

For forested communities, the alliance is roughly equivalent to the Society of American Foresters' "cover type" (Eyre 1980), which was developed to describe the forest types of North America. However, the alliance is generally finer in detail than these cover types, which are characterized by a dominant tree species that extends over large geographic areas and varied environmental conditions. Alliances also apply to all nonforest vegetation types.

The alliance is also similar to the "series," a concept developed within the habitat type system to group habitat types that share the same dominant species under climax conditions. Alliances, however, are grouped by the dominant or diagnostic species for *all existing* vegetation types, whereas series are generally restricted to vegetation types occurring at the end of succession, with all early- to mid-successional types grouped into the series they presumably become at climax (*see* Pfister and Arno 1980).

Nomenclature for Alliances

The names of dominant and diagnostic species are the foundation of the alliance names. At least one species from the dominant and/or uppermost stratum is included. In rare cases where the combination of species in the upper and lower strata is strongly diagnostic, species from other strata are included in the name. Species occurring in the same stratum are separated by a hyphen (-), and those occurring in a different strata are separated by a slash (/). Species occurring in the uppermost stratum are listed first, followed successively by those in lower strata. In physiognomic types where there is a dominant herbaceous layer with a scattered woody layer, alliance names can be based on species found in the herbaceous layer and/or the woody layer, whichever is more diagnostic of the type.

Species less consistently found in all associations of the alliance may be placed in parentheses, and these parenthetical names are generally listed alphabetically. In cases where a particular genus is dominant or diagnostic, but the presence of individual species of the genus may vary among associations, only the specific epithets are placed in parentheses.

Nomenclature for vascular plant species follows a nationally standardized list (Kartesz 1994), with very few exceptions. Nomenclature for nonvascular plants follows Anderson (1990), Anderson et al. (1990), Egan (1987, 1989, 1990), Esslinger and Egan (1995), and Stotler and Crandall-Stotler (1977).

The lowest possible number of species is used for an alliance name. A maximum of four species is currently allowed.

Alliance names include the class (e.g.,

"Forest," "Woodland," "Herbaceous") in which they are classified, followed by the word "alliance." Use of the word "alliance" in the name distinguishes these types from associations. Exceptions are types within the Sparse Vegetation Class, which are not based on floristics; these do not include the word "alliance" in the name.

For all wetland alliances, the formation hydrologic modifier—which indicates the hydrologic regime in which the alliance is found—is also included in the name (e.g., *Acer saccharinum* Temporarily Flooded Forest Alliance). Alliances may be assumed to be upland types when the name lacks a hydrologic modifier.

Modifiers descriptive of the height of the vegetation or of environmental conditions are used sparingly, primarily in cases where the species composition of the alliance is incompletely understood and the alliance name would not otherwise be unique (e.g., *Picea sitchensis* Giant Forest Alliance, *Quercus alba* Montane Forest Alliance). These modifiers are "placeholders" only; they will eventually be replaced by diagnostic species name(s).

Alliance names generally do not include infraspecific taxa unless such taxa are particularly diagnostic.

A genus name followed by the abbreviation "spp." is used to indicate that the alliance contains numerous mixed species of that genus *or* that the species are unknown.

Examples of alliance names:

Pseudotsuga menziesii Forest Alliance
Fagus grandifolia - Magnolia grandiflora Forest Alliance
Pinus virginiana - Quercus (coccinea, prinus) Forest Alliance
Pinus rigida Woodland Alliance
Juniperus virginiana - (Fraxinus americana, Ostrya virginiana) Woodland Alliance
Pinus palustris / Quercus spp. Woodland Alliance
Artemisia tridentata ssp. *wyomingensis* Shrubland Alliance
Andropogon gerardii - (Calamagrostis canadensis, Panicum virgatum) Herbaceous Alliance
Cobble/Gravel Shore Sparse Vegetation

Association

The association is the finest level of the hierarchy, and the basic unit for vegetation classification in North America. It is defined as "a plant community type of definite floristic composition, uniform habitat conditions, and uniform physiognomy" (see Flahault and Schroter 1910).

Associations may occur at variable spatial scales. The variation is driven by the steepness of the environmental gradients and patterning of disturbance processes across the landscape. For example, many upland eastern forests and western grassland associations occur naturally in patches of thousands or even tens of thousands of acres, whereas some herbaceous associations of seasonally flooded wetlands may occupy a few acres or less. In addition, the same association can occur at different scales under different environmental and disturbance conditions. Uniformity of physiognomy and habitat conditions may include patterned fine-scale heterogeneity (e.g., shrub savanna).[4] "Habitat" refers to the combination of environmental (site) conditions and ecological processes (such as disturbances) influencing the community.

Nomenclature for Associations

As with alliances, the names of dominant and diagnostic species are the foundation of the association names. Species occurring in the same stratum are separated by a hyphen (-), and those occurring in different strata are separated by a slash (/). Species occurring in the uppermost strata are listed first, followed successively by those in lower strata. Within the same stratum,

[4] The association may also consist of a complex of plant communities when those communities co-occur and constitute a functioning ecological unit (e.g., hummock and hollow vegetation in patterned peatland). Such cases are exceptional in the USNVC.

the order of species names generally reflects decreasing levels of dominance, constancy, or indicator value. In physiognomic types where there is a dominant herbaceous layer with a scattered woody layer, association names can be based on species found in the herbaceous layer and/or the woody layer, whichever is more diagnostic of the type.

Species less consistently found in all occurrences of the association are placed in parentheses. In cases where a particular genus is dominant or diagnostic, but individual species of the genus may vary among occurrences, only the specific epithets are placed in parentheses.

Nomenclature for vascular plant species follows the nationally standardized list of Kartesz (1994), with very few exceptions. Nomenclature for nonvascular plants follows Anderson (1990), Anderson et al. (1990), Egan (1987, 1989, 1990), Esslinger and Egan (1995), and Stotler and Crandall-Stotler (1977).

The lowest possible number of species is used in an association name. The use of up to six species may be necessary to define types with very diverse vegetation, relatively even dominance, and variable total composition.

Association names include the class in which they are classified. The word "vegetation" follows "herbaceous" and "nonvascular" for types in those classes.

In cases where diagnostic species are unknown or in question, a more general term is currently allowed as a "placeholder" (e.g., *Pinus banksiana* - (*Quercus ellipsoidalis*) / *Schizachyrium scoparium* - Prairie Forbs Wooded Herbaceous Vegetation). An environmental or geographic term, or one that is descriptive of the height of the vegetation, can also be used as a modifier when such a term is necessary to adequately characterize the association. For

TABLE 1. The USNVC's Physiognomic-floristic Hierarchy for Terrestrial Vegetation

LEVEL	PRIMARY BASIS FOR CLASSIFICATION	EXAMPLE
Class	Growth form and structure of vegetation	Woodland
Subclass	Growth form characteristics, e.g., leaf phenology	Deciduous Woodland
Group	Leaf types, corresponding to climate	Cold-deciduous Woodland
Subgroup	Relative human impact (natural/semi-natural, or cultural)	Natural/Semi-natural
Formation	Additional physiognomic and environmental factors, including hydrology	Temporarily Flooded Cold-deciduous Woodland
Alliance	Dominant/diagnostic species of uppermost or dominant stratum	*Populus deltoides* Temporarily Flooded Woodland Alliance
Association	Additional dominant/diagnostic species from any strata	*Populus deltoides* - (*Salix amygdaloides*) / *Salix exigua* Woodland

Table 1 provides a summary and an example of the terrestrial classification hierarchy.

reasons of standardization and brevity, however, this is kept to a minimum. Examples are: *Quercus alba / Carex pensylvanica - Carex ouachitana* Dwarf Forest, *Cephalanthus occidentalis / Carex* spp. Northern Shrubland.

When confidence in the circumscription of the association is low, especially in cases where the association represents a large, heterogeneous group of stands that is unlikely to remain one association following analysis of additional data, the association name is followed by the term "[Provisional]".

Examples of association names:

Abies lasiocarpa / Vaccinium scoparium Forest
Metopium toxiferum - Eugenia foetida - Krugiodendron ferreum - Swietenia mahagoni/ Capparis flexuosa Forest
Rhododendron carolinianum Shrubland
Quercus macrocarpa - (*Quercus alba - Quercus velutina*) / *Andropogon gerardii* Wooded Herbaceous Vegetation
Schizachyrium scoparium - (*Aristida* spp.) Herbaceous Vegetation

Appendix J: Provisional Map Units and Associations

Map Unit	Association
Agriculture	Crops
Recently Mined or Quarried Areas	Mined/Quarried
Developed	(blank)
Unclassified Barren (Rock and Bare ground)	Barren Rock
Burned	Holodiscus dumosus Shrubland
Chained Pinyon-Juniper Areas	Pinus edulis / Sparse Understory Forest
Dead and Down	Dead and Down
Invasive Annual Grassland	Weedy graminoids
Invasive Forbland	Weedy forbs
Invasive Perennial Grassland	Weedy graminoids
Barren Sand Dune	Barren Sand
Greasewood Dune Shrubland Association	Sarcobatus vermiculatus Dune Shrubland
	Undescribed community formed by mix of Atriplex, Sarcobatus, and Chrysothamnus.
Herbaceous Stabilized Dune	Achnatherum hymenoides - Muhlenbergia pungens Herbaceous Vegetation
	Achnatherum hymenoides - Psoralidium lanceolatum Herbaceous Vegetation
	Hesperostipa comata - Achnatherum hymenoides Herbaceous Vegetation
	Redfieldia flexuosa - (Psoralidium lanceolatum) Herbaceous Vegetation
Inter-Mountain Basins Interdunal Swale	Carex nebrascensis Herbaceous Vegetation
	Carex utriculata Herbaceous Vegetation
	Glyceria grandis - Schoenoplectus acutus Herbaceous Vegetation
	Juncus balticus - Carex rossii Herbaceous Vegetation
	Juncus balticus Herbaceous Vegetation
	Muhlenbergia asperifolia Herbaceous Vegetation
	Pascopyrum smithii Herbaceous Vegetation
	Salicornia rubra Herbaceous Vegetation
	Salix spp shrubland
	Schoenoplectus acutus Herbaceous Vegetation
	Schoenoplectus americanus - Carex spp. Herbaceous Vegetation
	Schoenoplectus americanus - Eleocharis palustris Herbaceous Vegetation
	Schoenoplectus americanus - Eleocharis spp. Herbaceous Vegetation
	Schoenoplectus americanus Western Herbaceous Vegetation
	Schoenoplectus maritimus Herbaceous Vegetation
	Schoenoplectus pungens Herbaceous Vegetation
	Typha domingensis Western Herbaceous Vegetation
	Typha latifolia Western Herbaceous Vegetation
Inter-Mountain Basins Wash	Atriplex canescens - Ericameria nauseosa Wash Shrubland

Map Unit	Association
Narrowleaf Cottonwood Sand Dune Forest Association	Populus angustifolia Sand Dune Forest
Ponderosa Pine / Indian Ricegrass Sparse Vegetation Association	Pinus ponderosa / Achnatherum hymenoides Sparse Vegetation
Sandsheet Rabbitbrush Shrubland and Steppe Alliances	Ericameria nauseosa / Achnatherum hymenoides Sand Deposit Shrubland
	Ericameria nauseosa / Equisetum laevigatum
	Ericameria nauseosa / Muhlenbergia pungens - Achnatherum hymenoides Shrub Herbaceous Vegetation
	Ericameria nauseosa Sand Deposit Sparse Shrubland
	Ericameria nauseosa Shrubland [Provisional]
Barren Playa	Barren Playa
Cattail Herbaceous Alliances	Typha domingensis Western Herbaceous Vegetation
	Typha latifolia Western Herbaceous Vegetation
Greasewood Flat Herbaceous Alliances	Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation
	Distichlis spicata Herbaceous Vegetation
	Eleocharis palustris Herbaceous Vegetation
	Ericameria nauseosa / Distichlis spicata Shrubland
	Puccinellia nuttalliana Herbaceous Vegetation
	Spartina gracilis Herbaceous Vegetation
	Sporobolus airoides - Distichlis spicata Herbaceous Vegetation
	Suaeda calceoliformis Herbaceous Vegetation
Greasewood Flats Shrubland Alliances	Sarcobatus vermiculatus - Ericameria nauseosa Mixed Graminoid Shrubland
	Sarcobatus vermiculatus / Distichlis spicata Shrubland
	Sarcobatus vermiculatus / Halogeton glomeratus Shrubland
	Sarcobatus vermiculatus / Juncus balticus Sparse Vegetation
	Sarcobatus vermiculatus / Sporobolus airoides Sparse Vegetation
	Sarcobatus vermiculatus / Suaeda calceoliformis Shrubland
	Sarcobatus vermiculatus / Suaeda moquinii Shrubland
	Sarcobatus vermiculatus Shrubland
	Sarcobatus vermiculatus/ Pascopyrum smithii Shrubland
Greasewood Playa Alliances	Ericameria nauseosa / Halophytic Herbaceous Vegetation
	Sarcobatus vermiculatus / Distichlis spicata Shrubland
	Sarcobatus vermiculatus / Sporobolus airoides Sparse Vegetation
	Sarcobatus vermiculatus Shrubland
	Suaeda moquinii Shrubland
Inter-Mountain Basins Mesic Meadow	Carex nebrascensis Herbaceous Vegetation
	Carex pellita Herbaceous Vegetation
	Carex praegracilis Herbaceous Vegetation
	Distichlis spicata Herbaceous Vegetation
	Eleocharis acicularis Herbaceous Vegetation
	Eleocharis palustris Herbaceous Vegetation
Inter-Mountain Basins Mesic Meadow	Muhlenbergia asperifolia Herbaceous Vegetation

Map Unit	Association
	Pascopyrum smithii - Juncus balticus Herbaceous Vegetation
	Sporobolus airoides - Distichlis spicata Herbaceous Vegetation
	Sporobolus airoides Monotype Herbaceous Vegetation
North American Arid West Emergent Marsh	Calamagrostis canadensis Western Herbaceous Vegetation
	Carex nebrascensis Herbaceous Vegetation
	Carex pellita Herbaceous Vegetation
	Carex simulata Herbaceous Vegetation
	Carex utriculata Herbaceous Vegetation
	Carex vesicaria Herbaceous Vegetation
	Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation
	Hippuris vulgaris Herbaceous Vegetation
	Juncus balticus Herbaceous Vegetation
	Myriophyllum sibiricum Herbaceous Vegetation
	Nuphar lutea ssp. polysepala Herbaceous Vegetation
	Phalaris arundinacea Western Herbaceous Vegetation
	Polygonum amphibium Permanently Flooded Herbaceous Vegetation [Placeholder]
	Potamogeton diversifolius Herbaceous Vegetation
	Potamogeton foliosus Herbaceous Vegetation
	Potamogeton natans Herbaceous Vegetation
	Ranunculus aquatilis - Callitriche palustris Herbaceous Vegetation
	Rorippa palustris Herbaceous Vegetation
	Schoenoplectus acutus Herbaceous Vegetation
	Schoenoplectus americanus - Eleocharis palustris Herbaceous Vegetation
	Schoenoplectus americanus Western Herbaceous Vegetation
	Schoenoplectus maritimus Herbaceous Vegetation
	Schoenoplectus pungens Herbaceous Vegetation
	Schoenoplectus tabernaemontani Temperate Herbaceous Vegetation
	Sparganium angustifolium Herbaceous Vegetation
	Sparganium eurycarpum Herbaceous Vegetation
	Spartina gracilis Herbaceous Vegetation
	Triglochin maritima Herbaceous Vegetation
Open Water	Water
Playa Herbaceous Alliances	Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation
	Distichlis spicata Herbaceous Vegetation
	Juncus balticus Herbaceous Vegetation
	Salicornia rubra Herbaceous Vegetation
	Salsola tragus - Suaeda calceoliformis Semi-natural Herbaceous
	Spartina gracilis Herbaceous Vegetation
	Sporobolus airoides - Distichlis spicata Herbaceous Vegetation
Playa Herbaceous Alliances	Suaeda calceoliformis Herbaceous Vegetation

Map Unit	Association
Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances	Chrysothamnus viscidiflorus / Poa pratensis Semi-natural Shrub Herbaceous Vegetation
	Ericameria nauseosa - Chrysothamnus greenii / Bouteloua gracilis Shrubland
	Ericameria nauseosa - Sarcobatus vermiculatus Shrubland
	Ericameria nauseosa / Achnatherum hymenoides
	Ericameria nauseosa / Bouteloua gracilis Shrubland [Provisional]
	Ericameria nauseosa / Bromus tectorum Semi-natural Shrubland
	Ericameria nauseosa / Juncus balticus Shrubland
	Ericameria nauseosa / Mixed Graminoid Shrubland
	Ericameria nauseosa / Sporobolus airoides Shrubland [Provisional]
	Ericameria nauseosa Shrubland [Provisional]
	Ericameria parryi Shrubland [Provisional]
	Undescribed community formed by combinations of Atriplex, Sarcobatus, and Chrysothamnus.
Fourwing Saltbush Shrubland Alliance	Atriplex canescens Shrubland
Montane Mahogany Shrubland Alliance	Cercocarpus montanus / Muhlenbergia montana Shrubland
Piedmont Semi-Desert Grassland Alliances	Hesperostipa comata - Achnatherum hymenoides Herbaceous Vegetation
	Muhlenbergia asperifolia Herbaceous Vegetation
	Pascopyrum smithii Herbaceous Vegetation
	Sporobolus airoides Monotype Herbaceous Vegetation
Pinyon Pine / Rockland Woodland Association	Pinus edulis / Rockland Woodland
Pinyon Pine Forest Alliances	Pinus edulis - Juniperus scopulorum Sparse Understory
	Pinus edulis / Sparse Understory Forest
Southern Rocky Mountain Pinyon-Juniper Woodland with Shrub Understory	Pinus edulis - Juniperus scopulorum / Holodiscus dumosus
	Pinus edulis - Juniperus spp. / Cercocarpus montanus Woodland
	Pinus edulis / Fallugia paradoxa Woodland
Southern Rocky Mountain Pinyon-Juniper Woodland with Herbaceous Understory	Pinus edulis - (Juniperus monosperma) / Bouteloua gracilis Woodland
	Pinus edulis / Artemisia dracunculus Woodland
	Pinus edulis / Bouteloua gracilis Woodland
	Pinus edulis / Poa fendleriana Woodland
Winterfat Dwarf-shrubland Alliance	Krascheninnikovia lanata Shrubland
Aspen - Douglas-fir Forest Alliance	Populus tremuloides - Pseudotsuga menziesii / Amelanchier alnifolia Forest
	Populus tremuloides - Pseudotsuga menziesii / Juniperus communis Forest
	Populus tremuloides - Pseudotsuga menziesii / Symphoricarpos oreophilus Forest
Ponderosa Pine - Aspen Forest Alliance	Populus tremuloides - Pinus ponderosa Rocky Mountain Forest
Ponderosa Pine / Rockland Woodland Association	Pinus ponderosa / Rockland Woodland

Map Unit	Association
Rocky Mountain Cliff, Canyon and Massive Bedrock.Treed	Abies concolor / Holodiscus dumosus Scree Woodland
	Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland
Rocky Mountain Lower Montane-Foothill Shrubland	Acer glabrum Shrubland
	Ericameria nauseosa Shrubland [Provisional]
	Rhus trilobata Rocky Mountain Shrub Herbaceous Vegetation
	Symphoricarpos oreophilus - Chrysothamnus viscidiflorus Shrubland
Southern Rocky Mountain Montane-Subalpine Grassland	Deschampsia caespitosa Herbaceous Vegetation
	Festuca arizonica - Muhlenbergia montana Herbaceous Vegetation
	Festuca thurberi Subalpine Grassland Herbaceous Vegetation
	Hesperostipa comata - Bouteloua gracilis Colorado Front Range Herbaceous Vegetation
	Hesperostipa comata Herbaceous Vegetation
	Muhlenbergia filiculmis Herbaceous Vegetation
	Pascopyrum smithii - Bouteloua gracilis Herbaceous Vegetation
Southern Rocky Mountain Ponderosa Pine Woodland with Herbaceous Understory	Pinus ponderosa / Bouteloua gracilis Woodland
	Pinus ponderosa / Carex inops ssp. heliophila Woodland
	Pinus ponderosa / Festuca arizonica Woodland
	Pinus ponderosa / Muhlenbergia montana Woodland
Southern Rocky Mountain Ponderosa Pine Woodland with Shrub Understory	Pinus ponderosa - Pseudotsuga menziesii / Cercocarpus montanus Woodland
	Pinus ponderosa / Arctostaphylos uva-ursi Woodland
	Pinus ponderosa / Cercocarpus montanus Woodland
	Pinus ponderosa / Ericameria nauseosa Woodland
	Pinus ponderosa / Juniperus scopulorum Woodland
White Fir - Aspen Forest Alliance	Populus tremuloides - Abies concolor / Acer glabrum Forest
	Populus tremuloides - Abies concolor / Physocarpus monogynus Forest
	Populus tremuloides - Abies concolor / Symphoricarpos oreophilus Forest
White Fir Forest and Woodland Alliances	Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest
	Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest
	Abies concolor - Pseudotsuga menziesii / Betula occidentalis Woodland
	Abies concolor - Pseudotsuga menziesii / Erigeron eximius Forest
White Fir Forest and Woodland Alliances	Abies concolor - Pseudotsuga menziesii / Festuca arizonica
	Abies concolor - Pseudotsuga menziesii / Holodiscus dumosus Forest
	Abies concolor - Pseudotsuga menziesii / Jamesia americana Avalanche Vegetation

Map Unit	Association
	Abies concolor - Pseudotsuga menziesii / Vaccinium myrtillus Forest
	Abies concolor / Galium triflorum Woodland
	Abies concolor / Holodiscus dumosus Scree Woodland
	Abies concolor / Ribes leptanthum Forest
	Abies concolor / Symphoricarpos oreophilus Forest
	Pseudotsuga menziesii - Abies concolor / Juniperus scopulorum Woodland
Aspen Flooded Forest Alliances	Populus tremuloides / Acer glabrum Forest
	Populus tremuloides / Alnus incana - Salix spp. Forest
	Populus tremuloides / Calamagrostis canadensis Forest
	Populus tremuloides / Ribes montigenum Forest
	Populus tremuloides / Salix drummondiana Forest
	Populus tremuloides / Salix eriocephala Woodland
	Populus tremuloides / Salix scouleriana Woodland
	Populus tremuloides / Senecio bigelovii var. bigelovii Forest
Aspen Forest Alliance	Populus tremuloides / Acer glabrum Forest
	Populus tremuloides / Carex siccata Forest
	Populus tremuloides / Festuca thurberi Forest
	Populus tremuloides / Juniperus communis Forest
	Populus tremuloides / Lonicera involucrata Forest
	Populus tremuloides / Physocarpus monogynus
	Populus tremuloides / Pteridium aquilinum Forest
	Populus tremuloides / Rosa woodsii Woodland
	Populus tremuloides / Sambucus racemosa Forest
	Populus tremuloides / Shepherdia canadensis Forest
	Populus tremuloides / Symphoricarpos oreophilus / Thalictrum fendleri Forest
	Populus tremuloides / Symphoricarpos oreophilus Forest
	Populus tremuloides / Vaccinium myrtillus Forest
Aspen mixed conifer Forest Alliances	Populus tremuloides - Picea pungens Forest
	Populus tremuloides - Pinus aristata Woodland
	Populus tremuloides - Pinus flexilis Forest
Coyote Willow Temporarily Flooded Shrubland Alliances	Crataegus rivularis Shrubland
	Salix exigua - Salix ligulifolia Shrubland
	Salix exigua - Salix lucida ssp. caudata Shrubland
	Salix exigua / Agrostis stolonifera Shrubland
	Salix exigua / Elymus X pseudorepens Shrubland
	Salix exigua / Mesic Forbs Shrubland
	Salix exigua / Mesic Graminoids Shrubland
	Salix exigua Temporarily Flooded Shrubland
	Salix geyeriana / Mesic Graminoids Shrubland
	Salix irrorata Shrubland
Douglas-fir Forest and Woodland Alliances	Picea engelmannii - Pinus aristata / Juniperus communis Woodland

Map Unit	Association
	Pseudotsuga menziesii - Festuca arizonica Forest
	Pseudotsuga menziesii - Pinus flexilis / Mixed Shrub Woodland
	Pseudotsuga menziesii / Bromus ciliatus Forest
	Pseudotsuga menziesii / Cercocarpus montanus Woodland
	Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland
	Pseudotsuga menziesii / Holodiscus dumosus Woodland
	Pseudotsuga menziesii / Jamesia americana Forest
	Pseudotsuga menziesii / Mahonia repens Forest
	Pseudotsuga menziesii / Symphoricarpos oreophilus Forest
Hillside Oceanspray Shrubland Alliance	Holodiscus dumosus - Symphoricarpos oreophilus Shrubland
	Holodiscus dumosus Shrubland
Montane-subalpine Wetland Alliances	Calamagrostis canadensis - Carex scopulorum - Mertensia ciliata Herbaceous Vegetation
	Calamagrostis canadensis - Senecio triangularis Herbaceous Vegetation
	Calamagrostis canadensis Western Herbaceous Vegetation
	Calamagrostis stricta Herbaceous Vegetation [Provisional]
	Caltha leptosepala - Deschampsia caespitosa Herbaceous Vegetation
	Cardamine cordifolia - Caltha leptosepala Herbaceous Vegetation
	Carex aquatilis - Carex utriculata Herbaceous Vegetation
	Carex aquatilis - Pedicularis groenlandica Herbaceous Vegetation
	Carex aquatilis Herbaceous Vegetation
	Carex microptera Herbaceous Vegetation
	Carex nebrascensis - Catabrosa aquatica Herbaceous Vegetation
	Carex nebrascensis Herbaceous Vegetation
	Carex pellita Herbaceous Vegetation
	Carex utriculata Herbaceous Vegetation
	Dasiphora fruticosa ssp. floribunda Shrubland [Provisional]
	Deschampsia caespitosa Herbaceous Vegetation
	Eleocharis acicularis Herbaceous Vegetation
	Eleocharis palustris Herbaceous Vegetation
	Eleocharis quinqueflora Herbaceous Vegetation
	Juncus balticus Herbaceous Vegetation
	Mertensia ciliata Herbaceous Vegetation
	Phippsia algida Herbaceous Vegetation
Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance	Populus angustifolia - Abies concolor Woodland
	Populus angustifolia - Juniperus scopulorum Woodland
Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance	Populus angustifolia - Picea pungens / Alnus incana Woodland
	Populus angustifolia - Picea pungens Woodland
	Populus angustifolia - Populus tremuloides - Abies concolor Woodland

Map Unit	Association
	Populus angustifolia - Pseudotsuga menziesii Woodland
	Populus angustifolia / Alnus incana Woodland
	Populus angustifolia / Betula occidentalis Woodland
	Populus angustifolia / Crataegus rivularis Woodland
	Populus angustifolia / Ericameria nauseosa Woodland
	Populus angustifolia / Rhus trilobata Dune Forest
	Populus angustifolia / Rhus trilobata Woodland
	Populus angustifolia / Ribes aureum Woodland
	Populus angustifolia / Salix (monticola, drummondiana, lucida) Woodland
	Populus angustifolia / Salix drummondiana - Acer glabrum Woodland
	Populus angustifolia / Salix exigua Woodland
	Populus angustifolia Riparian Forest
Rocky Mountain Subalpine Mesic Meadow	Carex aquatilis Herbaceous Vegetation
	Chamerion angustifolium Rocky Mountain Herbaceous Vegetation [Provisional]
	Geum rossii - Sibbaldia procumbens Herbaceous Vegetation
	Senecio atratus Herbaceous Rockland
	Trifolium dasyphyllum Herbaceous Vegetation
Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland	Pinus aristata - Picea engelmannii / Juniperus communis
	Pinus aristata / Festuca arizonica Woodland
	Pinus aristata / Ribes montigenum Woodland
	Pinus aristata / Symphoricarpos oreophilus woodland
	Pinus aristata / Vaccinium myrtillus Woodland
	Pinus flexilis / Arctostaphylos uva-ursi Woodland
	Pinus flexilis / Festuca arizonica
	Pinus flexilis / Juniperus communis Woodland
	Pinus flexilis / Rockland Woodland
Rocky Mountain Subalpine-Montane Riparian Forest	Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest
	Abies lasiocarpa / Mertensia ciliata Forest
	Abies lasiocarpa / Salix drummondiana Forest
	Picea engelmannii / Heracleum maximum Forest
	Picea pungens / Cornus sericea Woodland
	Populus tremuloides - Abies concolor / Acer glabrum Forest
	Populus tremuloides - Picea engelmannii Mesic Forbs
Rocky Mountain Subalpine-Montane Riparian Shrubland	Alnus incana - Betula occidentalis Shrubland
	Alnus incana - Salix (monticola, lucida, ligulifolia) Shrubland
	Alnus incana - Salix drummondiana Shrubland
	Alnus incana / Mesic Forbs Shrubland
	Alnus incana / Mesic Graminoids Shrubland
Rocky Mountain Subalpine-Montane Riparian Shrubland	Alnus incana ssp. tenuifolia - Salix irrorata Shrubland
	Salix boothii / Mesic Forbs Shrubland

Map Unit	Association
	Salix boothii / Mesic Graminoids Shrubland
	Salix brachycarpa / Carex aquatilis Shrubland
	Salix brachycarpa / Mesic Forbs Shrubland
	Salix drummondiana / Calamagrostis canadensis Shrubland
	Salix drummondiana / Carex utriculata Shrubland
	Salix drummondiana / Mesic Forbs Shrubland
	Salix geyeriana / Calamagrostis canadensis Shrubland
	Salix geyeriana / Carex aquatilis Shrubland
	Salix geyeriana / Carex utriculata Shrubland
	Salix geyeriana / Deschampsia caespitosa Shrubland
	Salix geyeriana / Mesic Forbs Shrubland
	Salix geyeriana / Mesic Graminoids Shrubland
	Salix ligulifolia / Carex utriculata Shrubland [Provisional]
	Salix ligulifolia Shrubland
	Salix lucida ssp. caudata / Rosa woodsii Shrubland
	Salix lucida ssp. caudata Shrubland [Provisional]
	Salix lutea / Calamagrostis canadensis Shrubland
	Salix lutea / Carex utriculata Shrubland
	Salix lutea / Mesic Forbs Shrubland
	Salix monticola / Calamagrostis canadensis Shrubland
	Salix monticola / Carex aquatilis Shrubland
	Salix monticola / Carex utriculata Shrubland
	Salix monticola / Mesic Forbs Shrubland
	Salix monticola / Mesic Graminoids Shrubland
	Salix monticola Thicket Shrubland
	Salix planifolia / Calamagrostis canadensis Shrubland
	Salix planifolia / Caltha leptosepala Shrubland
	Salix planifolia / Carex aquatilis Shrubland
	Salix planifolia / Carex scopulorum Shrubland
	Salix planifolia / Deschampsia caespitosa Shrubland
	Salix planifolia / Mesic Forbs Shrubland
	Salix planifolia Shrubland
	Salix wolfii / Carex aquatilis Shrubland
	Salix wolfii / Carex utriculata Shrubland
	Salix wolfii / Deschampsia caespitosa Shrubland
	Salix wolfii / Mesic Forbs Shrubland
Subalpine Fir - Aspen Forest Alliance	Populus tremuloides - Abies lasiocarpa / Carex geyeri Forest
	Populus tremuloides - Abies lasiocarpa / Carex rossii Forest
	Populus tremuloides - Abies lasiocarpa / Juniperus communis Forest
	Populus tremuloides - Abies lasiocarpa / Shepherdia canadensis Forest
	Populus tremuloides - Abies lasiocarpa / Symphoricarpos oreophilus / Tall Forbs Forest
	Populus tremuloides - Abies lasiocarpa / Tall Forbs Forest
Subalpine Fir - Aspen Forest Alliance	Populus tremuloides - Picea engelmannii / Salix scouleriana

Map Unit	Association
	Woodland
Alpine Wetland Alliances	Caltha leptosepala - Polygonum bistortoides Herbaceous Vegetation
	Caltha leptosepala - Rhodiola rhodantha Herbaceous Vegetation
	Caltha leptosepala Herbaceous Vegetation
	Carex aquatilis - Pedicularis groenlandica Herbaceous Vegetation
	Carex scopulorum - Caltha leptosepala Herbaceous Vegetation
	Carex scopulorum - Elymus trachycaulus Herbaceous Vegetation
	Carex scopulorum Herbaceous Vegetation
	Carex simulata Herbaceous Vegetation
	Carex vesicaria Herbaceous Vegetation
	Deschampsia caespitosa - Geum rossii Herbaceous Vegetation
	Geum rossii - Polygonum bistortoides Herbaceous Vegetation
Rocky Mountain Alpine Bedrock and Scree	Aquilegia caerulea - Cirsium scopulorum Scree Herbaceous Vegetation
	Cirsium scopulorum - Polemonium viscosum Herbaceous Vegetation
	Saxifraga bronchialis Scree Slope Sparse Vegetation
Rocky Mountain Alpine Fell-Field	Carex elynoides Herbaceous Vegetation
	Geum rossii Herbaceous Vegetation
	Minuartia obtusiloba Herbaceous Vegetation
	Paronychia pulvinata - Silene acaulis Dwarf-shrubland
	Sibbaldia procumbens - Polygonum bistortoides Herbaceous Vegetation
	Silene acaulis Herbaceous Vegetation
Rocky Mountain Dry Tundra	Carex elynoides - Geum rossii Herbaceous Vegetation
	Carex elynoides Herbaceous Vegetation
	Carex rupestris - Geum rossii Herbaceous Vegetation
	Carex spp. - Geum rossii Herbaceous Vegetation
	Dasiphora floribunda / Festuca thurberi Subalpine Shrubland
	Dasiphora floribunda Subalpine Vegetation
	Dryas octopetala Dwarf-shrub Herbaceous Vegetation
	Festuca brachyphylla - Geum rossii var. turbinatum Herbaceous Vegetation
	Festuca thurberi Subalpine Grassland Herbaceous Vegetation
	Kobresia myosuroides - Geum rossii Herbaceous Vegetation
	Minuartia obtusiloba Herbaceous Vegetation
	Salix arctica - Salix nivalis Dwarf-shrubland
	Salix nivalis Herbaceous Vegetation
	Sibbaldia procumbens - Polygonum bistortoides Herbaceous Vegetation
	Trifolium dasyphyllum Herbaceous Vegetation
Rocky Mountain Dry Tundra	Vaccinium caespitosum Dwarf Shrubland

Map Unit	Association
Rocky Mountain Subalpine Spruce-Fir Forest and Woodland	Abies lasiocarpa / Acer glabrum Forest
	Abies lasiocarpa / Erigeron eximius Forest
	Abies lasiocarpa / Juniperus communis Woodland
	Abies lasiocarpa / Moss Forest
	Abies lasiocarpa / Ribes (montigenum, lacustre, inerme) Forest
	Abies lasiocarpa / Vaccinium myrtillus Forest
	Abies lasiocarpa / Vaccinium scoparium Forest
	Picea engelmannii - Pinus aristata Avalanche Woodland
	Picea engelmannii / Festuca thurberi
	Picea engelmannii / Moss Forest
	Picea engelmannii / Vaccinium myrtillus Forest
Subalpine Fir - Engelmann Spruce – Bristlecone Pine - Limber Pine Krummholz Shrubland Alliance	Abies lasiocarpa / Salix brachycarpa Shrubland
	Abies lasiocarpa Krummholz Shrubland

Appendix G: Biophysical Modeling and Image Interpretation

Biophysical Modeling

NAIP Image Processing

True-color NAIP imagery was the source data for delineating and coarsely attributing polygons based on computer-assisted biophysical modeling. A Principal Components Analysis (PCA) was performed on the NAIP data to create a more interpretable dataset. The resulting PCA dataset was used both to identify common spectral characteristics and define a tree density layer.

Trees were identified in the project imagery based on observable spectral thresholds. These thresholds were used to create a data file of ones and zeros using Model Maker in ERDAS Imagine software. A 15- x 15-pixel neighborhood function was used to sum pixel values for each moving center. If every pixel in a 15- x 15- pixel neighborhood had a value of one, for example, then the center pixel of that group would be a sum of the values, that is, 225. The output thus resulted in pixel values ranging from 0 to 225, or areas with no trees to areas with a closed canopy of trees. Model Maker was used again to break the new values into percentages (i.e., 0-9 percent, 10-15 percent, 25-60 percent, and 61-100 percent) as specified by the Northern Colorado Plateau Network (NCPN).

A slope layer was created from the 10-meter Digital Elevation Model (DEM) data using Erdas Imagine software. This dataset, along with PCA band 1 and the tree density layer, were the primary working datasets for the modeling.

Alluvial, sandsheet, and upland areas were delineated from the NAIP imagery and slope datasets and processed as three separate layers. The image analysts also used field data (plot and observation points) and field reconnaissance notes as aids to interpret patterns of color, texture, and landscape position for distinguishing between the different physiognomic types.

Sandsheet map classes were modeled using PCA band 1, the tree density layer, and slope thresholds to delineate eight separate types: 1) Emergent Marsh; 2) Mesic Meadow; 3) Greasewood Flat Herbaceous; 4) Sandsheet Rabbitbrush and Steppe; 5) Rabbitbrush, Interdunal Swales, or Herbaceous Stabilized Dunes; 6) Grass or Herbaceous Stabilized Dunes; 7) Greasewood Playa or Greasewood Dunes; and 8) Greasewood Flat Shrubland.

The alluvial area was modeled, employing the same datasets as those used for the sandsheet mapping, to define six vegetation categories: Sandsheet/Alluvial rabbitbrush; Piedmont/Grass/Herbaceous Dunes, and Pinon/Ponderosa/Cottonwood Rockland, 10-25% trees, 25 – 60% trees, and >60% trees (conifer, cottonwood, or aspen).

Three additional vegetation types were delineated in the same way for upland vegetation: Smooth High Canopy, Green Low Cover, and Rocky.

Each of the above 15 mapping types was placed into its own image file. A model was run extracting summation thresholds to yield files with the values of one or zero. The value one would indicate the presence of the vegetation type and a value of zero would be everything else. The quality of the upland dataset was not acceptable due to the poor quality of the NAIP imagery for effectively differentiating these land cover types. These classes were dropped from further analysis and subsequently redefined using Quickbird imagery. The next modeling sequence defined individual polygons though clumping and sieving procedures. All the individual map classes were then incorporated into a single layer with coarse attributes for each.

A neighborhood majority filter was run to eliminate small patches of isolated pixels and to smooth the edges of the polygons. The final step in the process eliminated any polygons of 0.25 hectares or less. Normally, the minimum mapping unit is 0.5 hectares for the final products, but in this early stage, it was felt that important small classes could be missed if the eliminate procedure was run too early in the process.

Quickbird Image Processing:

Quickbird imagery for the higher elevation portions of the study area were acquired by the USGS to augment the dataset that was derived from the NAIP imagery. Similar processing techniques were used to essentially segment the imagery into fairly homogeneous groupings. Unique signatures on the ground were differentiated using modeling routines in Erdas Imagine software along with the Quickbird imagery, tree density, and slope datasets. The resulting six groups could be broadly defined as: 1) >= 25% trees with an infrared signature in the medium to low range 2) <= 25% trees with an infrared signature in the medium to low range, 3) <= 25% trees with high gray tones, 4) trees >= 75% trees with an infrared signature in the high infrared range, 5) trees >= 75%, and 6) undifferentiated non-forested areas.

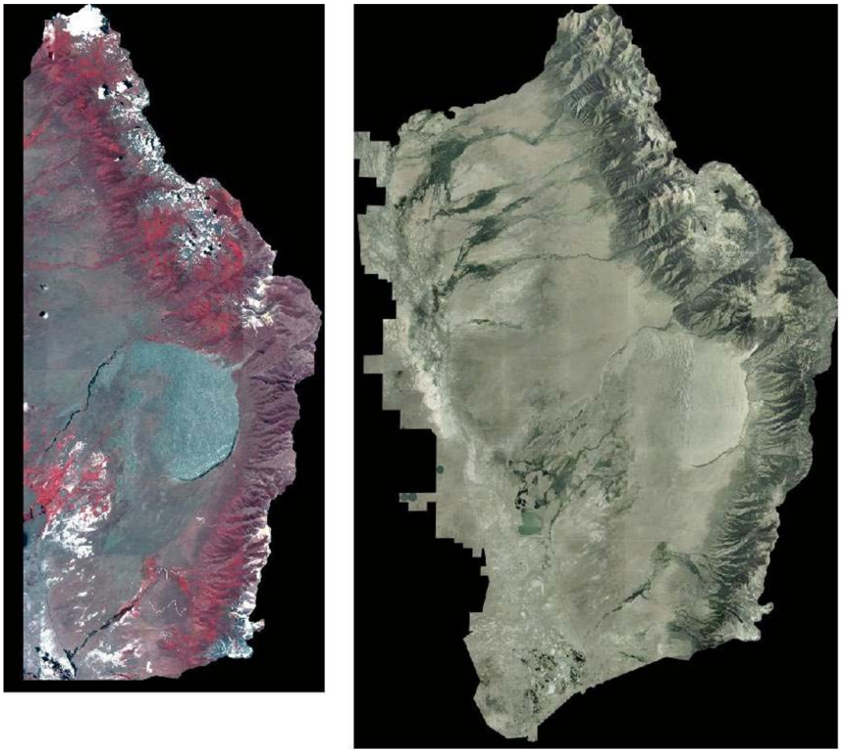
Quickbird Imagery Acquisition

Panchromatic and multispectral Quickbird data were acquired by the USGS for the higher elevation portions of the study area (fig. 1). The raw dataset consisted of three images in a tiff format collected on October 23, 2007.

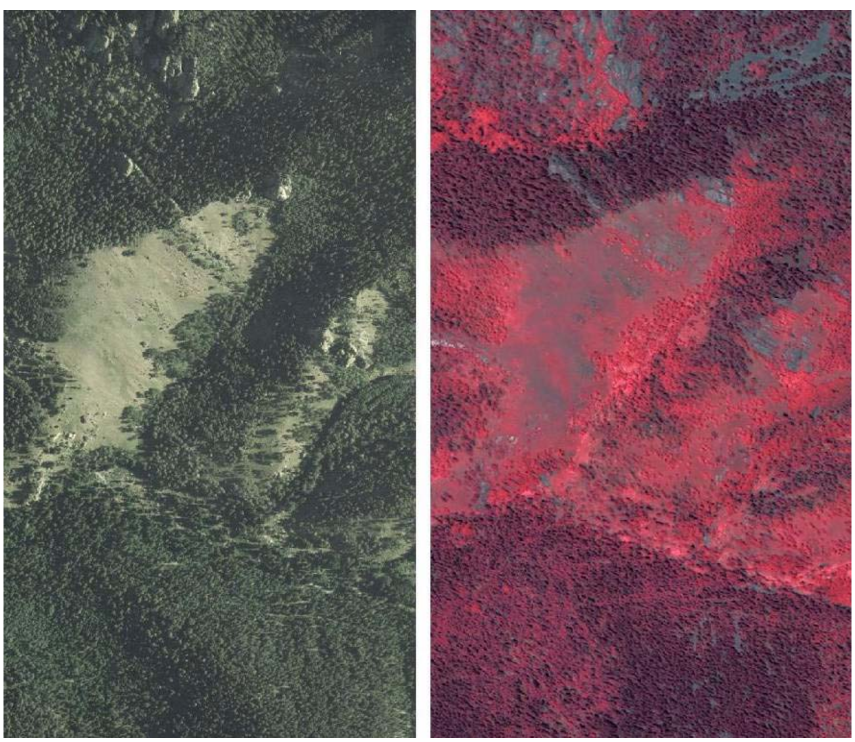
A fall collection date was selected to capture aspen foliage in a leaf-on condition. A high-resolution multi-band image was also warranted to help image interpretation of the complex shrubland, woodland, and forest vegetation (fig. 2).

ERDAS Imagine 9.2 software was used for a multiresolution image fusion to sharpen the multispectral data with the panchromatic data layer. The pan band was resampled from 0.6m to 1 meter to assist processing of the large dataset. Principal Component was the method selected to merge the high resolution and multispectral files. This is a statistical method for partitioning multispectral data among higher-resolution data cells. The image was resampled using the cubic convolution option and output to an unsigned 8-bit file (fig. 3). The final image was projected from geographic to UTM Zone 13, NAD93 datum.

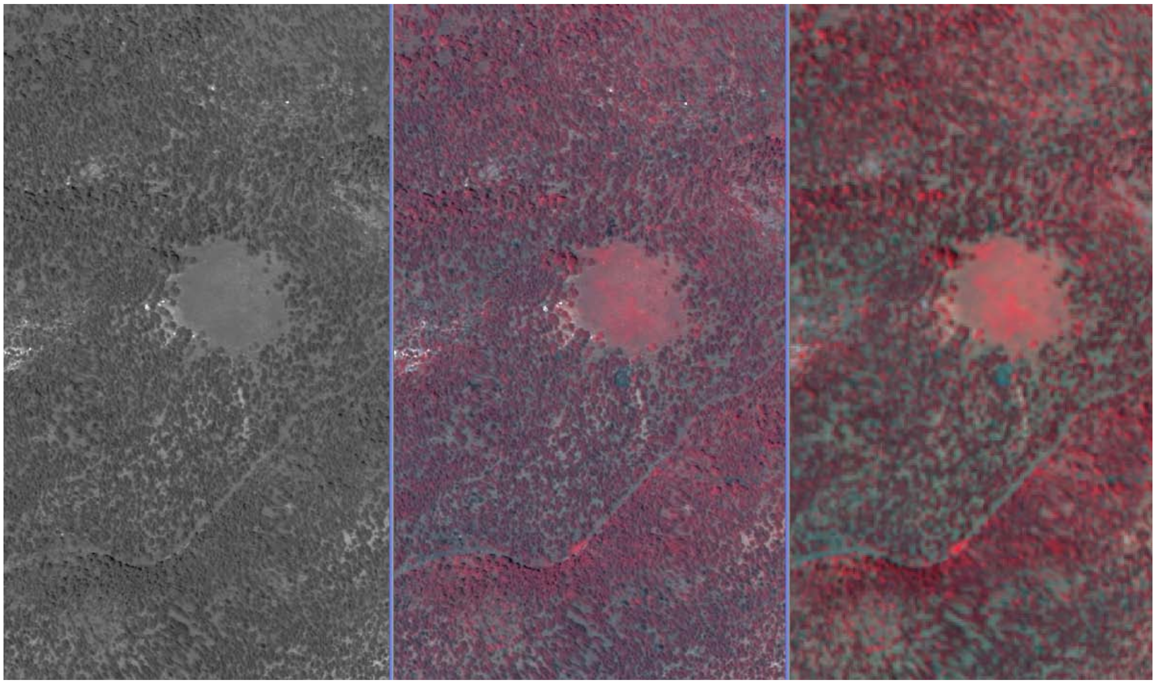
Because of licensing restrictions, the Quickbird imagery can only be provided to state, local, and foreign governments or inter-governmental organizations, non-government (NGOs) and other non-profit organizations (see nextview.txt for additional information).



The right image shows the study area extent, while the left image shows the portion covered by the Quickbird image acquisition.



The left image shows the NAIP true-color image and the right image shows the same area with the Quickbird data.



The left image shows a portion of the panchromatic image, the right the same area in the multispectral image, and the center image shows the same location for the pan-sharpened image file.

Image Interpretation

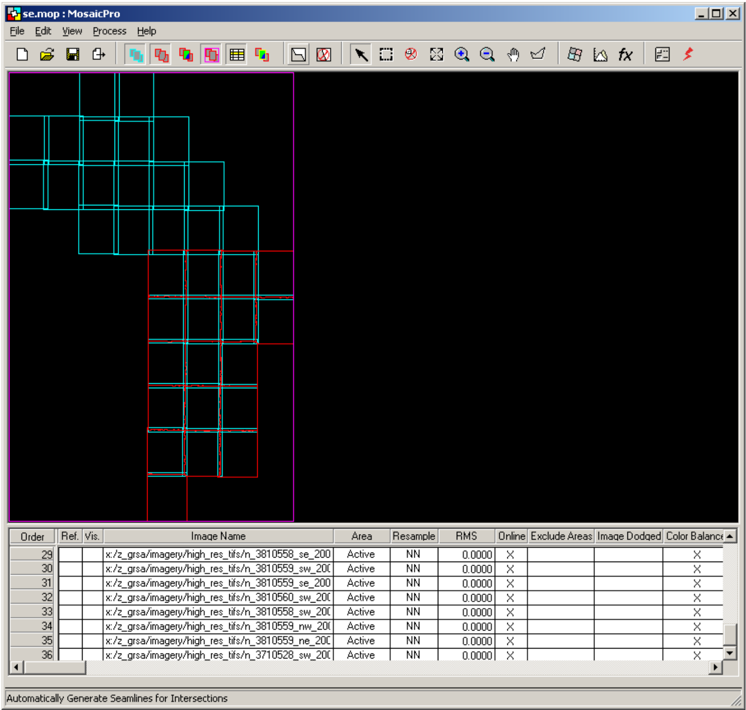
The image interpretation for GRSA involved a series of steps as described or illustrated below. Menus are shown to illustrate an example of the selections used for the processing steps and generally are not explained further. A few notes are included, however, to provide comments or additional detail.

Mosaic and subset NAIP imagery

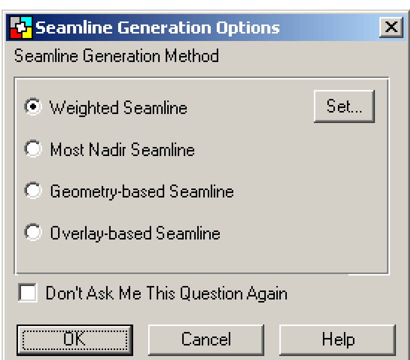
Sixty-six tiff images were mosaiced together, color balanced, and subset to the project boundary.

Mosaic Pro

> Add 2005 NAIP natural color quarter-quad .tif images
>
> * Can not add more than approximately 15 quarter quads per mosaic



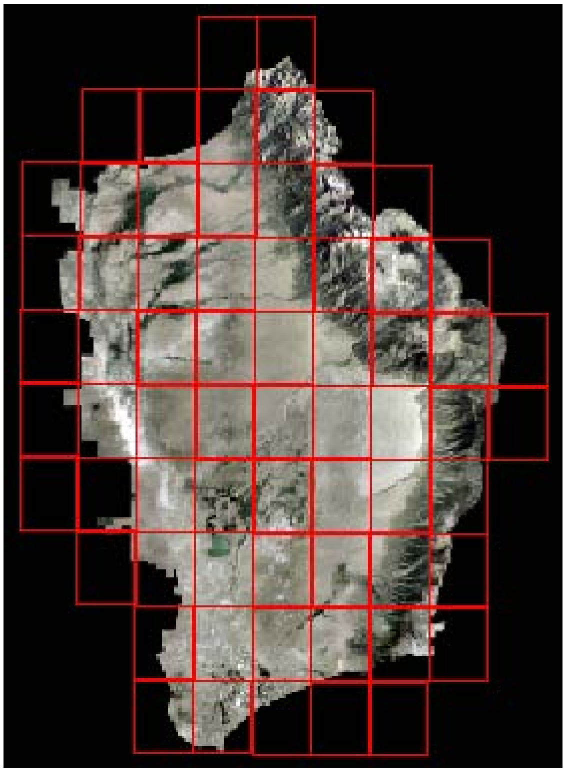
> Automatically Generate Seamlines



> Weighted Seamlines - (about 30 minutes per 10qq)
> Can add to mosaic without undoing previous seamlines

> Color Correction
> > Color Balancing

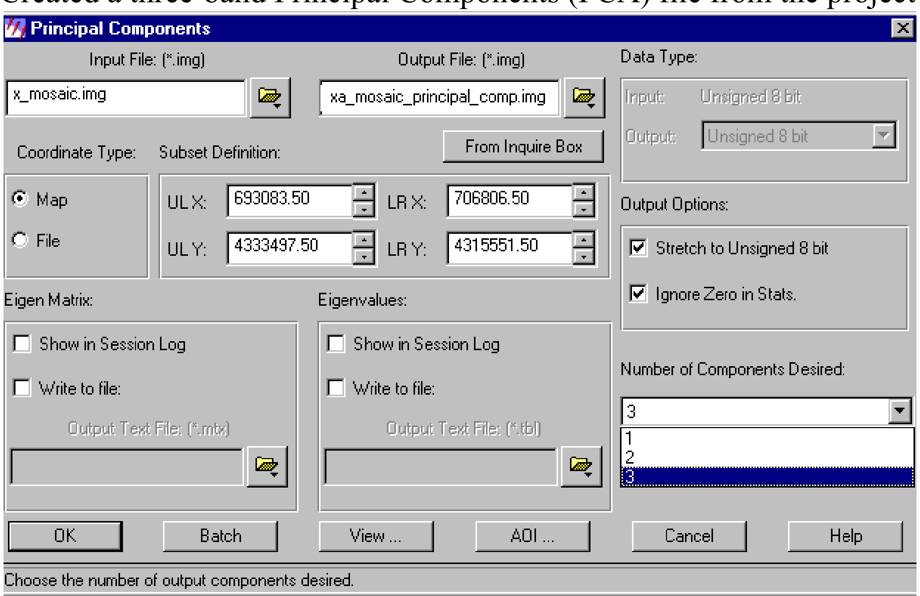
> Process
> > Run Mosaic
> > > New Filename.img



Study area showing individual tiff footprints and the final NAIP mosaic

Create PCA image

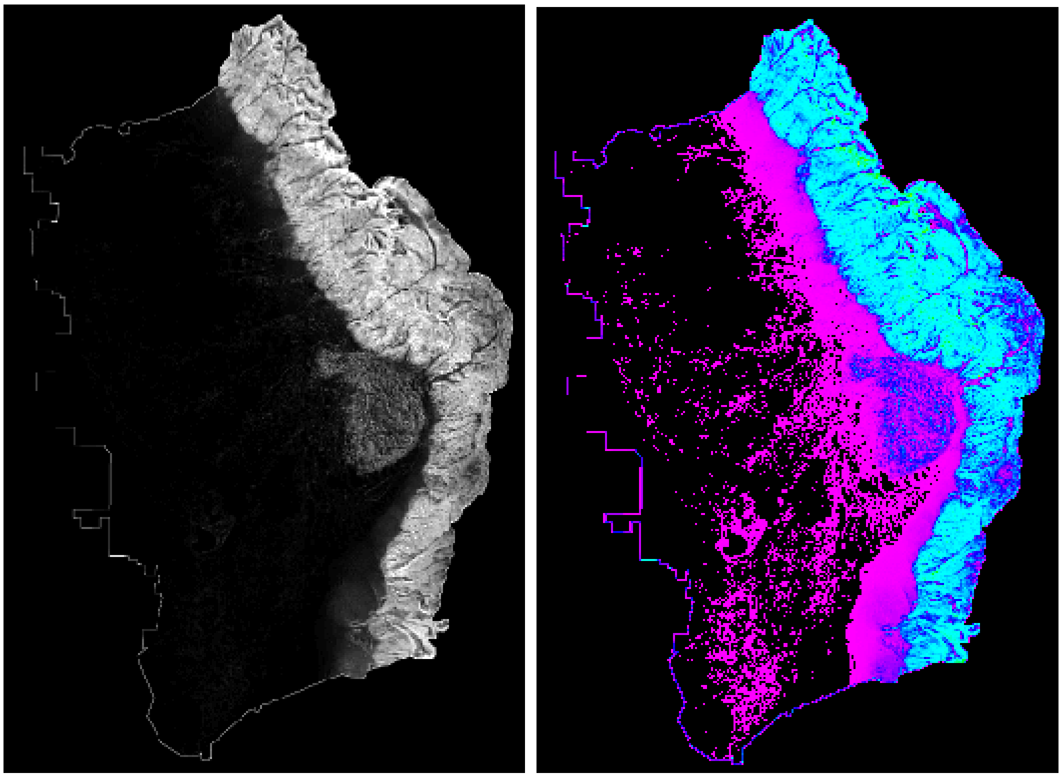
Created a three-band Principal Components (PCA) file from the project imagery.



ERDAS menu to create a 3-band principal components file

Create slope layer

A slope layer in degrees was created from the 10-meter Digital Elevation Model (DEM) data using ERDAS Imagine software.

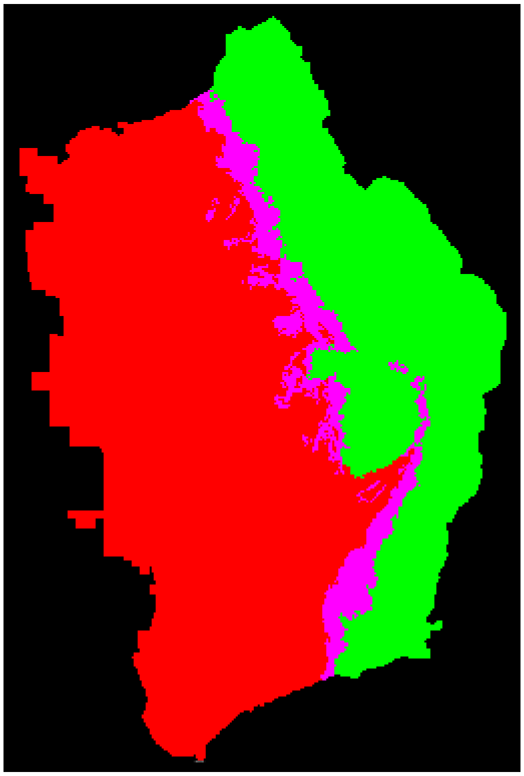


Slope layer of study area (black and white and color version shown here)

Determine three zones for mapping

Three separate mapping zones were created based on slope. These zones roughly corresponded to the alluvial, sandsheet, and upland areas and were processed separately.

```
1) CONDITIONAL
        ($n5_slope_10m<=2) 2,
        ($n5_slope_10m>=3 AND $n5_slope_10m<=10) 3,
        ($n5_slope_10m>=11) 4
```



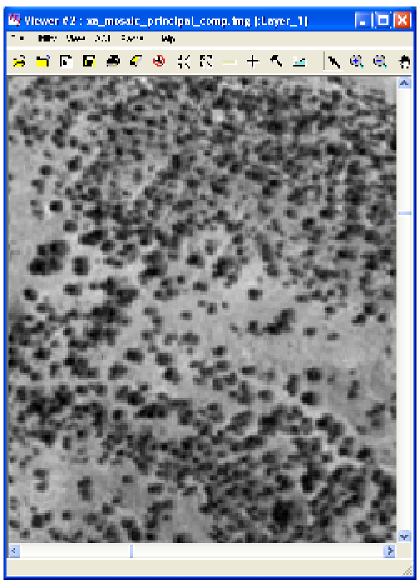
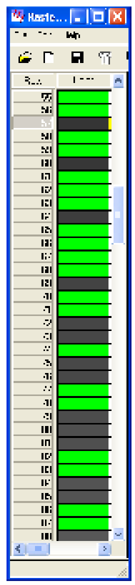
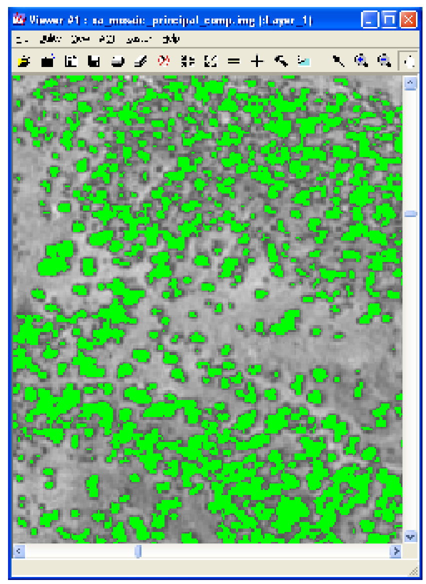
Three zones used for modeling. From left to right: sandsheet (red), alluvial (pink), and upland (green) areas.

Created model to extract trees

Trees were identified and modeled in ERDAS Model Maker using slope, aspect, and spectral thresholds from PCA band 1.

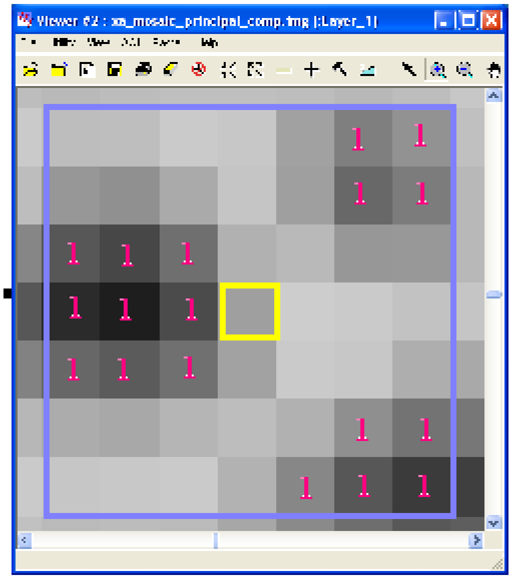
```
CONDITIONAL {
        ($n5_pca(1)>=0 AND $n5_pca(1)<=68 AND $n7_slope_2_10_100==2) 1

        ($n5_pca(1)>=0 AND $n5_pca(1)<=98 AND $n7_slope_2_10_100==3) 1

        # north
        ($n5_pca(1)>=0 AND $n5_pca(1)<=98 AND $n7_slope_2_10_100==4
        AND $n9_aspect_10m>=1 AND $n9_aspect_10m<=68 AND
            $n8_dem_10m_clipped<=3530 ) 1,

        ($n5_pca(1)>=0 AND $n5_pca(1)<=98 AND $n7_slope_2_10_100==4

        AND $n9_aspect_10m>=294 AND $n9_aspect_10m<=360 AND
            $n8_dem_10m_clipped<=3530 ) 1,

        # south
        ($n5_pca(1)>=0 AND $n5_pca(1)<=98 AND $n7_slope_2_10_100==4
```

```
AND $n9_aspect_10m>=114 AND $n9_aspect_10m<=248 AND
        $n8_dem_10m_clipped<=3630 ) 1,
# east
($n5_pca(1)>=0 AND $n5_pca(1)<=98 AND $n7_slope_2_10_100==4
AND $n9_aspect_10m>=70 AND $n9_aspect_10m<=113 AND
        $n8_dem_10m_clipped<=3630 ) 1,

# west
($n5_pca(1)>=0 AND $n5_pca(1)<=98 AND $n7_slope_2_10_100==4
AND $n9_aspect_10m>=249 AND $n9_aspect_10m<=293 AND
        $n8_dem_10m_clipped<=3630 ) 1,

# remaining
($n5_pca(1)>=0 AND $n5_pca(1)<=98 AND $n7_slope_2_10_100==4
AND $n8_dem_10m_clipped<=3530 ) 1
```

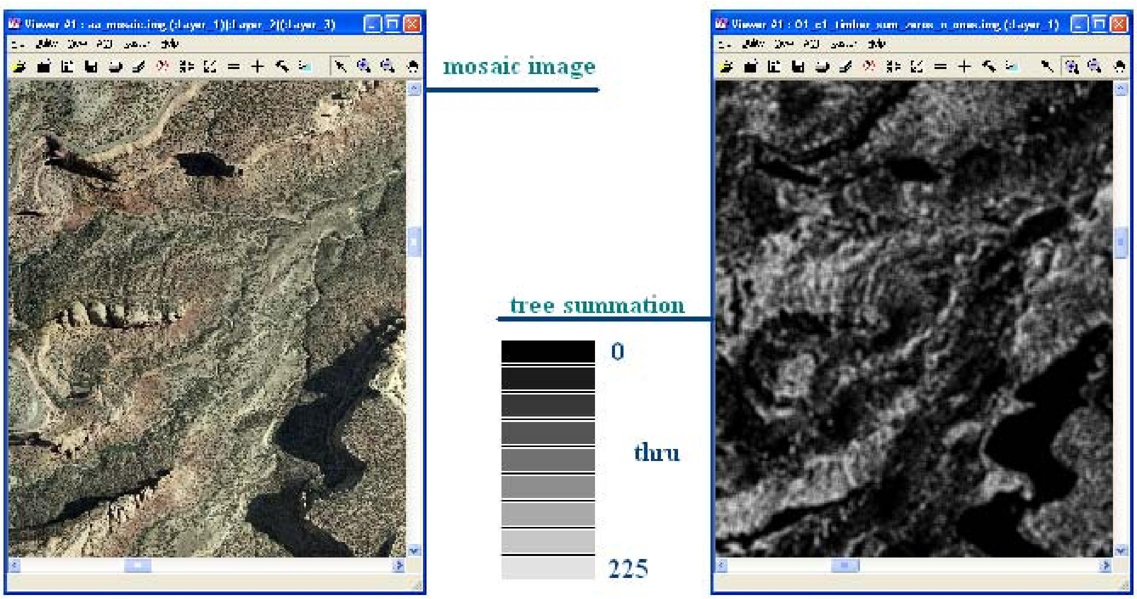




Spectral thresholding to extract trees

A15- x 15-pixel neighborhood analysis function was run to return the sum of the pixels in the focal window around each pixel. Values ranged from 0 to 225, or areas with no trees to areas with a closed canopy of trees, which were converted to percentages from 0 – 100%.
FOCAL SUM
15 x 15 matrix



In the example above, the numeric value of the center pixel will be replaced with the sum of the 1s using a 7- x 7-pixel window. The resulting value is 18 or 37% tree cover. (Note: a 15- x 15-pixel matrix was used for the GRSA tree analysis.)



Tree density percentages based on the summation values

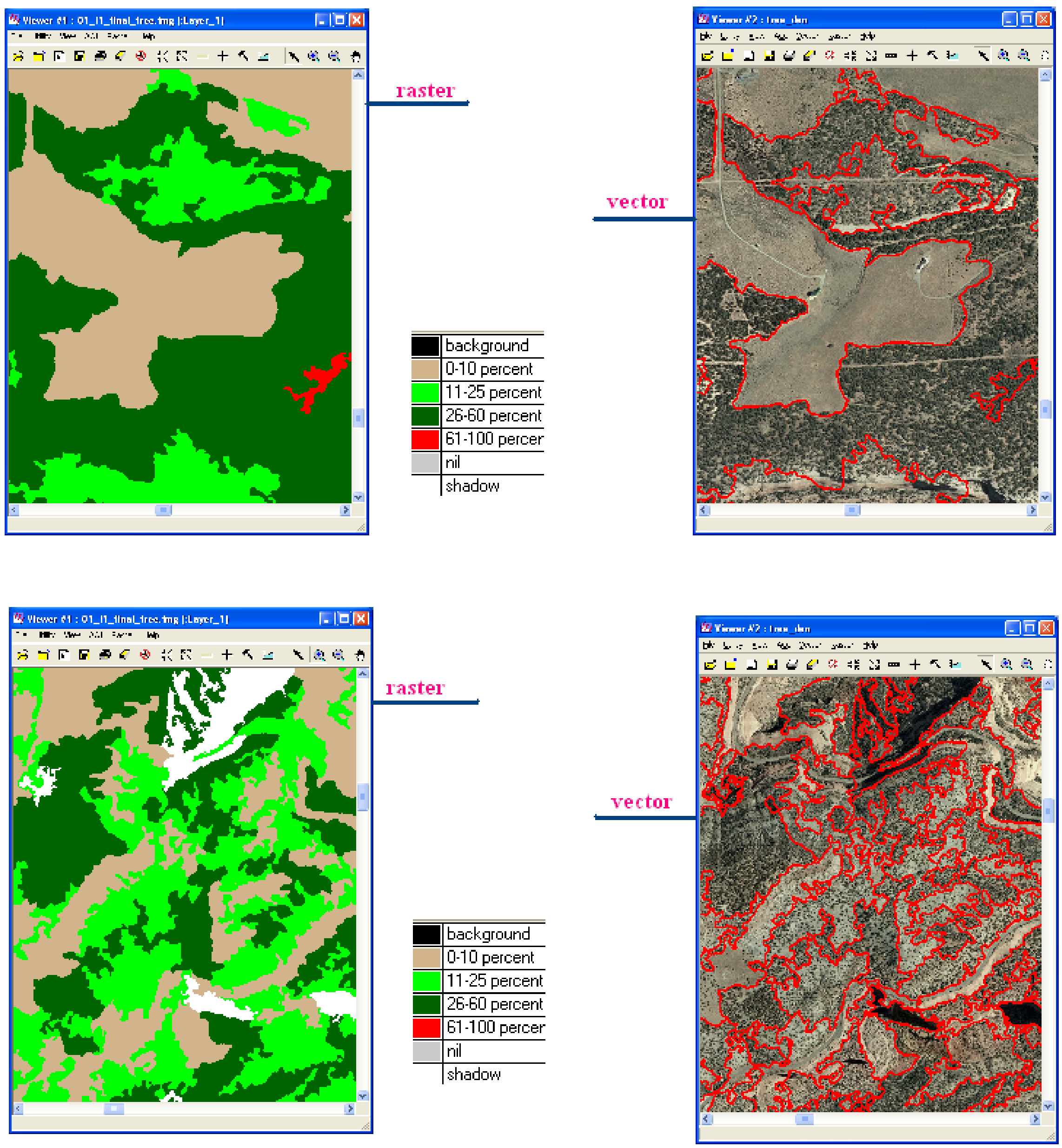
3) CONDITIONAL {
($n10_03_combo_trees<=1) 0,
($n10_03_combo_trees<=2) 1,
($n10_03_combo_trees<=5) 2,
($n10_03_combo_trees<=7) 3,
($n10_03_combo_trees<=9) 4,
($n10_03_combo_trees<=11) 5,

```
($n10_03_combo_trees<=14) 6,
($n10_03_combo_trees<=16) 7,
($n10_03_combo_trees<=18) 8,
($n10_03_combo_trees<=20) 9,
($n10_03_combo_trees<=23) 10,
($n10_03_combo_trees<=25) 11,
($n10_03_combo_trees<=27) 12,
($n10_03_combo_trees<=29) 13,
($n10_03_combo_trees<=32) 14,
($n10_03_combo_trees<=34) 15,
($n10_03_combo_trees<=36) 16,
($n10_03_combo_trees<=38) 17,
($n10_03_combo_trees<=41) 18,
($n10_03_combo_trees<=43) 19,
($n10_03_combo_trees<=45) 20,
($n10_03_combo_trees<=47) 21,
($n10_03_combo_trees<=50) 22,
($n10_03_combo_trees<=52) 23,
($n10_03_combo_trees<=54) 24,
($n10_03_combo_trees<=56) 25,
($n10_03_combo_trees<=59) 26,
($n10_03_combo_trees<=61) 27,
($n10_03_combo_trees<=63) 28,
($n10_03_combo_trees<=65) 29,
($n10_03_combo_trees<=67) 30,
($n10_03_combo_trees<=70) 31,
($n10_03_combo_trees<=72) 32,
($n10_03_combo_trees<=74) 33,
($n10_03_combo_trees<=76) 34,
($n10_03_combo_trees<=79) 35,
($n10_03_combo_trees<=81) 36,
($n10_03_combo_trees<=83) 37,
($n10_03_combo_trees<=85) 38,
($n10_03_combo_trees<=88) 39,
($n10_03_combo_trees<=90) 40,
($n10_03_combo_trees<=92) 41,
($n10_03_combo_trees<=94) 42,
($n10_03_combo_trees<=97) 43,
($n10_03_combo_trees<=99) 44,
($n10_03_combo_trees<=101) 45,
($n10_03_combo_trees<=103) 46,
($n10_03_combo_trees<=106) 47,
($n10_03_combo_trees<=108) 48,
($n10_03_combo_trees<=110) 49,
($n10_03_combo_trees<=113) 50,
($n10_03_combo_trees<=115) 51,
($n10_03_combo_trees<=117) 52,
($n10_03_combo_trees<=119) 53,
($n10_03_combo_trees<=122) 54,
($n10_03_combo_trees<=124) 55,
```

```
($n10_03_combo_trees<=126) 56,
($n10_03_combo_trees<=128) 57,
($n10_03_combo_trees<=131) 58,
($n10_03_combo_trees<=133) 59,
($n10_03_combo_trees<=135) 60,
($n10_03_combo_trees<=137) 61,
($n10_03_combo_trees<=140) 62,
($n10_03_combo_trees<=142) 63,
($n10_03_combo_trees<=144) 64,
($n10_03_combo_trees<=146) 65,
($n10_03_combo_trees<=149) 66,
($n10_03_combo_trees<=151) 67,
($n10_03_combo_trees<=153) 68,
($n10_03_combo_trees<=155) 69,
($n10_03_combo_trees<=158) 70,
($n10_03_combo_trees<=160) 71,
($n10_03_combo_trees<=162) 72,
($n10_03_combo_trees<=164) 73,
($n10_03_combo_trees<=167) 74,
($n10_03_combo_trees<=169) 75,
($n10_03_combo_trees<=171) 76,
($n10_03_combo_trees<=173) 77,
($n10_03_combo_trees<=176) 78,
($n10_03_combo_trees<=178) 79,
($n10_03_combo_trees<=180) 80,
($n10_03_combo_trees<=182) 81,
($n10_03_combo_trees<=185) 82,
($n10_03_combo_trees<=187) 83,
($n10_03_combo_trees<=189) 84,
($n10_03_combo_trees<=191) 85,
($n10_03_combo_trees<=194) 86,
($n10_03_combo_trees<=196) 87,
($n10_03_combo_trees<=198) 88,
($n10_03_combo_trees<=200) 89,
($n10_03_combo_trees<=203) 90,
($n10_03_combo_trees<=205) 91,
($n10_03_combo_trees<=207) 92,
($n10_03_combo_trees<=209) 93,
($n10_03_combo_trees<=212) 94,
($n10_03_combo_trees<=214) 95,
($n10_03_combo_trees<=216) 96,
($n10_03_combo_trees<=218) 97,
($n10_03_combo_trees<=221) 98,
($n10_03_combo_trees<=223) 99,
($n10_03_combo_trees<=225) 100
```

Model Maker was used again to group the new values into percent categories (i.e., 0-9 percent, 10-15 percent, 25-60 percent, and 61-100 percent). Aspect was used in addition for the steeper slopes.

4) CONDITIONAL {
($n12_04_trees_0_100_percent>=60) 4,
($n12_04_trees_0_100_percent>=25) 3,
($n12_04_trees_0_100_percent>=10) 2,
($n12_04_trees_0_100_percent>=1) 1



Examples of the final tree density categories

Model individual classes

PCA thresholds were identified based on interpretation and plot and observation data. The image analysts also used field data and reconnaissance notes as aids to interpret patterns of color, texture, and landscape position for distinguishing the different physiognomic types.

Example of imagery displayed in ArcGIS along with field notes, labels, and observation point data.

Sandsheet

Sandsheet map classes were modeled using PCA band 1 and slope thresholds to delineate eight separate types: 1) Emergent Marsh; 2) Mesic Meadow; 3) Greasewood Flat Herbaceous; 4) Sandsheet Rabbitbrush and Steppe; 5) Rabbitbrush, Interdunal Swales, or Herbaceous Stabilized Dunes; 6) Grass or Herbaceous Stabilized Dunes; 7) Greasewood Playa or Greasewood Dunes; and 8) Greasewood Flat Shrubland.

<u>Emergent Marsh</u>
CONDITIONAL
($n5_pca(1)>=0 AND $n5_pca(1)<=68 AND $n7_slope_2_10_100==2) 1

<u>Mesic Meadow</u>
($n5_pca(1)>=68 AND $n5_pca(1)<=99 AND $n7_slope_2_10_100==2) 1

<u>Greasewood Flat Herbaceous</u>
($n5_pca(1)>=100 AND $n5_pca(1)<=116 AND $n7_slope_2_10_100==2) 1

<u>Sandsheet Rabbitbrush and Steppe</u>
($n5_pca(1)>=117 AND $n5_pca(1)<=139 AND $n7_slope_2_10_100==2) 1

<u>Rabbitbrush, Interdunal Swales, or Herbaceous Stabilized Dunes</u>
($n5_pca(1)>=139 AND $n5_pca(1)<=155 AND $n7_slope_2_10_100==2) 1

Grass or Herbaceous Stabilized Dunes

($n5_pca(1)>=155 AND $n5_pca(1)<=176 AND $n7_slope_2_10_100==2) 1

Greasewood Playa or Greasewood Dunes

($n5_pca(1)>=176 AND $n7_slope_2_10_100==2) 1

Greasewood Flat Shrubland

Remaining

Alluvial

The alluvial area was modeled, using the same datasets as those for the sandsheet mapping, to define four vegetation categories: 1) Sandsheet/Alluvial Rabbitbrush, 2) Piedmont/Grass/Herbaceous Dunes, 3) Greasewood and 4) Pinon/Ponderosa/Cottonwood Rockland.

Sandsheet/Alluvial Rabbitbrush

($n5_pca(1)>=116 AND $n5_pca(1)<=160 AND $n7_slope_2_10_100==3) 1

Piedmont/Grass/Herbaceous Dunes

($n5_pca(1)>=161 AND $n5_pca(1)<=176 AND $n7_slope_2_10_100==3) 1

Greasewood

($n5_pca(1)>=99 AND $n5_pca(1)<=116 AND $n7_slope_2_10_100==3) 1

Pinon/Pondersoa/Cottonwood Rockland

($n5_pca(1)>=176 AND $n7_slope_2_10_100==3) 1

Upland

Three additional vegetation types were delineated in the same way for upland vegetation: 1) Smooth High Canopy, 2) Green Low Cover, and 3) Rocky.

Smooth High Canopy

($n5_pca(1)>=98 AND $n5_pca(1)<=135 AND $n7_slope_2_10_100>=4) 1

Green Low Cover

($n5_pca(1)>=135 AND $n5_pca(1)<=166 AND $n7_slope_2_10_100>=4) 1

Rocky

($n5_pca(1)>=166 AND $n7_slope_2_10_100>=4) 1

Model summation on each class

Each of the mapping types was placed into its own image file and a summation process was run on them separately

2) FOCAL SUM
   15 x 15 Matrix

Model to extract summation thresholds

A model was run extracting summation thresholds to yield files with the values of one or zero. The value one would indicate the presence of the vegetation type and a value of zero would be everything else.

Sandsheet

CONDITIONAL {

Emergent Marsh

($n5_em>=68) 1

Mesic Meadow

($n5_mm>=68) 1

Greasewood Flat Herbaceous

($n5_gfh>=68) 1

Sandsheet Rabbitbrush and Steppe

($n5_srs>=112) 1

Rabbitbrush, Interdunal Swales, or Herbaceous Stabilized Dunes

($n5_rsd>=112) 1

Grass or Herbaceous Stabilized Dunes

($n5_ghsd>=68) 1

Greasewood Playa or Greasewood Dunes

($n5_gpgd>=112) 1

Alluvial

Sandsheet/Alluvial Rabbitbrush

($n5_pca(1)>=112) 1

Piedmont/Grass/Herbaceous Dunes

($n5_pca(1)>=112) 1

Greasewood

($n5_pca(1)>=68) 1

Pinon/Pondersoa/Cottonwood Rockland

($n5_pca(1)>=112) 1

Upland

Smooth High Canopy

($n5_pca(1)>=90) 1

Green Low Cover

($n5_pca(1)>=68) 1

Rocky

($n5_pca(1)>=50) 1

Model to define individual polygons

The next modeling sequence defined individual polygons though clumping and sieving procedures.

4) CLUMP ($n33_a, 8)

Model to limit polygon size

SIEVETABLE

Sandsheet

Emergent Marsh
(2500, HISTOGRAM ($n10_b))
Mesic Meadow
(2500, HISTOGRAM ($n10_b))
Greasewood Flat Herbaceous
(2500, HISTOGRAM ($n10_b))
Sandsheet Rabbitbrush and Steppe
(2500, HISTOGRAM ($n10_b))
Rabbitbrush, Interdunal Swales, or Herbaceous Stabilized Dunes
(2500, HISTOGRAM ($n10_b))
Grass or Herbaceous Stabilized Dunes
(2500, HISTOGRAM ($n10_b))
Greasewood Playa or Greasewood Dunes
(2500, HISTOGRAM ($n10_b))

Alluvial

Sandsheet/Alluvial Rabbitbrush
(2500, HISTOGRAM ($n10_b))
Piedmont/Grass/Herbaceous Dunes
(2500, HISTOGRAM ($n10_b))
Greasewood
(2500, HISTOGRAM ($n10_b))
Pinon/Pondersoa/Cottonwood Rockland
(2500, HISTOGRAM ($n10_b))

Upland

Smooth High Canopy (Tree or Tall Shrub)
(2500, HISTOGRAM ($n10_b))
Green Low Cover (Low Shrub)
(2500, HISTOGRAM ($n10_b))
Rocky
(2500, HISTOGRAM ($n10_b))

Model to incorporate layers

All the individual map classes were incorporated into a single layer with coarse attributes for each.

Sandsheet

1) CONDITIONAL {
($n1_03_Emergent Marsh==1) 8,
($n2_03_Mesic Meadow==1) 9,
($n3_03_Greasewood Flat Herbaceous==1) 3,

($n4_03_Sandsheet Rabbitbrush and Steppe==1) 4,
($n5_03_Rabbitbrush, Interdunal Swales, or Herbaceous Stabilized Dunes==1) 5,
($n6_03_Grass or Herbaceous Stabilized Dunes==1)6,
($n7_03_Greasewood Playa or Greasewood Dunes==1) 1,
($n8_03_Greasewood Flat Shrubland==1) 7,

Alluvial

1) CONDITIONAL {
($n5_09_Alluvial_Greasewood==1) 3,
($n6_10_Alluvial_Rabbitbrush==1) 13,
($n7_11_Alluvial_ Grass==1) 14,
($n8_12_Alluvial_Rockland==1) 15

Upland

The quality of this dataset was not acceptable due to the poor quality of the NAIP imagery for effectively differentiating the upland land cover types. These classes were dropped from further analysis and subsequently redefined using Quickbird imagery.

Additional categories

The three classes below came from the tree density layer for nps categories:
($n1_05_nps_percent==1) 2,
($n1_05_nps_percent==2) 10,
($n1_05_nps_percent==3) 11,
($n1_05_nps_percent==4) 12,

Row	Histogram	Class Names	Color
0	0	Background	
1	37871830	Greasewood Playa or Greasewood Dunes	
2	2399816	Greater than 9 Percent Trees	
3	115809107	Greasewood Flat Herbaceous	
4	241067402	Sandsheet Rabbitbrush and Steppe	
5	223575981	Rabbitbrush, Interdunal Swales, or Herbaceous Stabilized Dunes	
6	73051663	Grass or Herbaceous Stabilized Dunes	
7	218645637	Greasewood Flat Shrubland	
8	26902962	Emergent Marsh	
9	60643235	Mesic Meadow	
10	11093164	10_25 Percent Trees	
11	28349897	25_60 Percent Trees	
12	2831903	60 Percent Trees or Cottonwood/Aspen	
13	64876174	Alluvial Rabbitbrush	
14	11306992	Alluvial Grass or Herbaceous Dunes	
15	6029850	Pinon/Ponderosa/Cottonwood Rockland	

Raster attributes for the modeled vegetation groups

Majority Neighborhood

A 15 x 15 majority neighborhood filter was run to eliminate small patches of isolated pixels and to smooth the edges of the polygons.

Clump Majority Neighborhood

Eliminate

The final step in the process eliminated any polygons of 0.25 hectares or less. Normally, the minimum mapping unit is 0.5 hectares for the final products, but in this early stage, it was felt that important small classes could be missed if the eliminate procedure was run too early in the process.

Quickbird Image Processing

Quickbird imagery for the higher elevation portions of the study area were acquired by the USGS to augment the dataset that was derived from the NAIP imagery. Similar processing techniques were used essentially to segment the imagery into fairly homogeneous groupings. Unique signatures on the ground were differentiated using modeling routines in ERDAS Imagine software along with the Quickbird imagery, tree density, and slope datasets. The resulting six groups could be broadly defined as: 1) >= 25% trees with an infrared signature in the medium to low range 2) <= 25% trees with an infrared signature in the medium to low range, 3) <= 25% trees with high gray tones, 4) trees >= 75% trees with an infrared signature in the high infrared range, 5) trees >= 75%, and 6) undifferentiated non-forested areas.

Appendix H:
Keys to the Vegetation Types and Map Classes

Dichotomous Key to the Plant Associations of Great Sand Dunes National Park and Preserve

Association List

Association Name	Related Map Classes
Abies concolor - (Picea pungens) - Populus angustifolia / Acer glabrum Forest	27, 53
Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest	11
Abies concolor - Pseudotsuga menziesii / Jamesia americana Avalanche Chute Shrubland	56
Abies concolor / Betula occidentalis Woodland	11
Abies concolor / Festuca arizonica Woodland	11
Abies concolor / Holodiscus dumosus Scree Woodland	11
Abies concolor / Symphoricarpos oreophilus Forest	11
Abies lasiocarpa - Picea engelmannii / Juniperus communis Woodland	56
Abies lasiocarpa - Picea engelmannii / Mertensia ciliata Forest	41, 43
Abies lasiocarpa - Picea engelmannii / Moss Forest	41
Abies lasiocarpa - Picea engelmannii / Salix (brachycarpa, glauca) Krummholz Shrubland	51
Abies lasiocarpa - Picea engelmannii / Salix drummondiana Forest	43
Abies lasiocarpa - Picea engelmannii / Sparse Understory Forest	41
Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus Forest	41
Abies lasiocarpa - Picea engelmannii Krummholz Shrubland	51
Abies lasiocarpa - Populus tremuloides Forest Alliance	43,50
Abies lasiocarpa / Erigeron eximius Forest	41
Achnatherum hymenoides - Psoralidium lanceolatum Herbaceous Vegetation	17
Alnus incana - Betula occidentalis Shrubland	65
Alnus incana - Salix drummondiana Shrubland	65
Aquilegia caerulea - Cirsium scopulorum Scree Sparse Vegetation	35
Atriplex canescens / Achnatherum hymenoides Shrubland	23
Barren	5, 37
Bouteloua gracilis Herbaceous Vegetation	46
Cardamine cordifolia - Caltha leptosepala Herbaceous Vegetation	64
Cardamine cordifolia - Mertensia ciliata - Senecio triangularis Herbaceous Vegetation	64
Carex aquatilis - Pedicularis groenlandica Herbaceous Vegetation	64
Carex aquatilis Herbaceous Vegetation	64
Carex elynoides - Geum rossii Herbaceous Vegetation	38
Carex elynoides Herbaceous Vegetation	38
Carex nebrascensis Herbaceous Vegetation	21, 28
Carex pellita Herbaceous Vegetation	21, 28

Association Name	Related Map Classes
Carex praegracilis Herbaceous Vegetation	21
Carex rupestris - Geum rossii Herbaceous Vegetation	38
Carex scopulorum - Caltha leptosepala Herbaceous Vegetation	64
Carex scopulorum Herbaceous Vegetation	38, 64
Carex siccata - Geum rossii Herbaceous Vegetation	38
Carex simulata Herbaceous Vegetation	28
Carex utriculata Herbaceous Vegetation	28
Carex utriculata Perched Wetland Herbaceous Vegetation	24
Cercocarpus montanus / Muhlenbergia montana Shrubland	25
Cirsium scopulorum - Polemonium viscosum Herbaceous Vegetation	35
Danthonia parryi Herbaceous Vegetation	46
Dasiphora floribunda / Festuca thurberi Subalpine Shrubland	38, 46
Dasiphora fruticosa ssp. floribunda Subalpine Shrubland	38
Deschampsia caespitosa - Caltha leptosepala Herbaceous Vegetation	44
Deschampsia caespitosa - Carex microptera Herbaceous Vegetation	64
Deschampsia caespitosa - Geum rossii Herbaceous Vegetation	64
Deschampsia caespitosa Herbaceous Vegetation	64
Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation	14, 22
Distichlis spicata Herbaceous Vegetation	14, 21, 22
Dryas octopetala - Carex rupestris Dwarf-shrub Herbaceous Vegetation	38
Dryas octopetala - Carex spp. Dwarf-shrub Herbaceous Vegetation	38
Eleocharis acicularis Herbaceous Vegetation	28
Eleocharis palustris Herbaceous Vegetation	21, 28
Ericameria nauseosa / Bouteloua gracilis Shrub Herbaceous Vegetation	28
Ericameria nauseosa / Distichlis spicata Shrubland	45, 61
Ericameria nauseosa / Equisetum laevigatum Shrubland	15, 45
Ericameria nauseosa / Muhlenbergia pungens - Achnatherum hymenoides Shrub Herbaceous Vegetation	45
Ericameria nauseosa / Sporobolus airoides Shrubland	45
Ericameria nauseosa Sand Deposit Sparse Shrubland	45
Ericameria parryi / Achnatherum hymenoides Shrubland	45
Festuca arizonica - Muhlenbergia montana Herbaceous Vegetation	61
Festuca brachyphylla - Trisetum spicatum Herbaceous Vegetation	46
Festuca brachyphylla Herbaceous Vegetation	38
Festuca thurberi Subalpine Grassland Herbaceous Vegetation	38
Geum rossii - Polygonum bistortoides Herbaceous Vegetation	46
Geum rossii - Sibbaldia procumbens Herbaceous Vegetation	38, 64
Geum rossii Herbaceous Vegetation	64
Glyceria grandis - Schoenoplectus acutus Herbaceous Vegetation	38,64
Halogeton glomeratus Herbaceous Vegetation	38, 64

Association Name	Related Map Classes
Hesperostipa comata - Achnatherum hymenoides Herbaceous Vegetation	20
Hippuris vulgaris Herbaceous Vegetation	22
Holodiscus dumosus / Muhlenbergia montana Shrubland	17, 30, 39, 45, 46
Holodiscus dumosus Rock Outcrop Sparse Vegetation	28
Hordeum jubatum Herbaceous Vegetation	18
Juncus balticus - Pascopyrum smithii Herbaceous Vegetation	18, 37
Juncus balticus (Iris missouriensis) Mixed Herbaceous Vegetation	21
Juncus balticus Herbaceous Vegetation	21
Kobresia myosuroides - Geum rossii Herbaceous Vegetation	21
Krascheninnikovia lanata / Achnatherum hymenoides Dwarf-shrubland	14, 20, 21, 22, 24, 28, 45
Minuartia obtusiloba Mixed Cushion Plant Herbaceous Vegetation	38
Mixed Conifer - Aspen Avalanche Chute Shrubland	56
Muhlenbergia asperifolia Herbaceous Vegetation	36, 38
Muhlenbergia montana Herbaceous Vegetation	56
Muhlenbergia pungens Herbaceous Vegetation	20, 21
Myriophyllum sibiricum Herbaceous Vegetation	46
Paronychia pulvinata - Silene acaulis Dwarf-shrubland	30
Pascopyrum smithii - Scirpus nevadensis Herbaceous Vegetation	28
Pascopyrum smithii Herbaceous Vegetation	36
Phragmites australis Western North America Temperate Semi-natural Herbaceous Vegetation	20
Picea engelmannii / Ribes montigenum Forest	21, 30
Picea engelmannii / Vaccinium myrtillus Forest	15
Picea pungens / Festuca thurberi Sparse Woodland	41
Pinus aristata - (Picea engelmannii) / Juniperus communis Woodland	41, 51
Pinus aristata / Festuca arizonica Woodland	11
Pinus aristata / Festuca thurberi Woodland	11, 42
Pinus aristata / Ribes montigenum Woodland	42
Pinus aristata / Vaccinium myrtillus Woodland	42
Pinus aristata Krummholz Shrubland	42
Pinus edulis - (Juniperus monosperma) / Bouteloua gracilis Woodland	41, 42
Pinus edulis - Juniperus scopulorum / Holodiscus dumosus Woodland	51
Pinus edulis - Juniperus spp. / Cercocarpus montanus - Mixed Shrubs Woodland	31, 47
Pinus edulis / Rockland Woodland	60
Pinus edulis / Sparse Understory Forest	25, 49, 60
Pinus flexilis / Arctostaphylos uva-ursi Woodland	31, 32, 60
Pinus flexilis / Festuca arizonica - Muhlenbergia montana Woodland	32
Pinus flexilis / Juniperus communis Woodland	8
Pinus ponderosa / Ericameria nauseosa / Achnatherum hymenoides - Hesperostipa comata Woodland	31
Pinus ponderosa / Festuca arizonica Woodland	42

Association Name	Related Map Classes
Pinus ponderosa / Juniperus scopulorum Woodland	42, 47
Pinus ponderosa / Muhlenbergia montana Woodland	42
Polygonum amphibium Permanently Flooded Herbaceous Vegetation [Placeholder]	34
Populus angustifolia - Abies concolor / Betula occidentalis Woodland	48
Populus angustifolia - Abies concolor / Juniperus scopulorum Woodland	49
Populus angustifolia - Juniperus scopulorum Woodland	42, 48
Populus angustifolia / Alnus incana Woodland	28
Populus angustifolia / Betula occidentalis Woodland	53
Populus angustifolia / Ericameria nauseosa Sandsheet Woodland	27
Populus angustifolia / Rhus trilobata Woodland	27
Populus angustifolia / Ribes aureum Woodland	27
Populus angustifolia / Salix (monticola, drummondiana, lucida) Woodland	27
Populus angustifolia / Salix drummondiana - Acer glabrum Woodland	27
Populus angustifolia / Salix exigua Woodland	26, 27
Populus angustifolia Sand Dune Forest	27
Populus tremuloides - Abies concolor / Acer glabrum Forest	27
Populus tremuloides - Abies concolor / Alnus incana Forest	2, 27
Populus tremuloides - Abies concolor / Physocarpus monogynus Forest	27
Populus tremuloides - Abies lasiocarpa (Picea engelmannii) / Vaccinium myrtillus	26, 27
Populus tremuloides - Abies lasiocarpa / Juniperus communis Forest	2, 45, 53, 63
Populus tremuloides - Abies lasiocarpa / Shepherdia canadensis Forest	53
Populus tremuloides - Pinus flexilis Forest	53
Populus tremuloides - Pinus ponderosa Rocky Mountain Forest	63
Populus tremuloides - Pseudotsuga menziesii / Juniperus communis Forest	50
Populus tremuloides / Acer glabrum Forest	50
Populus tremuloides / Alnus incana Forest	50
Populus tremuloides / Arctostaphylos uva-ursi Woodland	3
Populus tremuloides / Bromus ciliatus - (Thermopsis spp.) Forest	33
Populus tremuloides / Calamagrostis canadensis Forest	63
Populus tremuloides / Carex siccata Forest	2
Populus tremuloides / Cornus sericea Forest	2, 43
Populus tremuloides / Festuca thurberi Forest	2
Populus tremuloides / Hesperostipa comata Forest	2
Populus tremuloides / Juniperus communis Forest	2
Populus tremuloides / Physocarpus monogynus Forest	2
Populus tremuloides / Ribes montigenum Forest	2
Populus tremuloides / Rosa woodsii Forest	2
Populus tremuloides / Salix drummondiana Forest	2
Populus tremuloides / Salix scouleriana Forest	2
Populus tremuloides / Sambucus racemosa Forest	2

Association Name	Related Map Classes
Populus tremuloides / Shepherdia canadensis Forest	2
Populus tremuloides / Symphoricarpos spp. Forest	2
Populus tremuloides / Thalictrum fendleri Forest	2
Populus tremuloides / Vaccinium myrtillus Forest	2
Populus tremuloides Scree Woodland	2
Potamogeton foliosus Herbaceous Vegetation	2
Prunus virginiana - (Prunus americana) Shrubland	2
Pseudotsuga menziesii / Bromus ciliatus Forest	2
Pseudotsuga menziesii / Cercocarpus montanus Woodland	2
Pseudotsuga menziesii / Festuca arizonica Forest	2
Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland	28
Pseudotsuga menziesii / Jamesia americana Forest	39
Pseudotsuga menziesii / Juniperus communis Forest	11
Pseudotsuga menziesii / Symphoricarpos oreophilus Forest	11
Puccinellia nuttalliana Herbaceous Vegetation	11
Ranunculus aquatilis - Callitriche palustris Herbaceous Vegetation	11
Redfieldia flexuosa - (Psoralidium lanceolatum) Herbaceous Vegetation	11
Rhus trilobata Dune Shrubland	11, 63
Rhus trilobata Rocky Mountain Shrub Herbaceous Vegetation	11
Rorippa palustris Herbaceous Vegetation	14, 21
Salicornia rubra Herbaceous Vegetation	28
Salix brachycarpa / Mesic Forbs Shrubland	17
Salix drummondiana / Mesic Forbs Shrubland	45
Salix exigua - Salix ligulifolia Shrubland	39, 45
Salix exigua - Salix lucida ssp. caudata Shrubland	28
Salix exigua Dune Shrubland	22
Salix exigua Temporarily Flooded Shrubland	44, 57
Salix monticola / Mesic Forbs Shrubland	65
Salix nivalis / Geum rossii Dwarf-shrubland	9
Salix planifolia / Calamagrostis canadensis Shrubland	9
Salix planifolia / Carex aquatilis Shrubland	20
Salix planifolia / Carex scopulorum Shrubland	9
Salix planifolia / Carex utriculata Shrubland	65
Salix planifolia / Deschampsia caespitosa Shrubland	38
Salix planifolia / Mesic Forbs Shrubland	44
Salsola spp. Herbaceous Vegetation [Provisional]	44
Sarcobatus vermiculatus / Distichlis spicata Shrubland	44
Sarcobatus vermiculatus / Ericameria nauseosa Shrubland	44
Sarcobatus vermiculatus / Juncus balticus Sparse Vegetation	44
Sarcobatus vermiculatus / Leymus triticoides Shrubland	44

Association Name	Related Map Classes
Sarcobatus vermiculatus / Sporobolus airoides Shrubland	59
Sarcobatus vermiculatus Disturbed Shrubland	13, 14, 15
Sarcobatus vermiculatus Dune Shrubland	13, 14, 15, 45
Saxifraga bronchialis Scree Slope Sparse Vegetation	15
Schoenoplectus acutus Herbaceous Vegetation	15
Schoenoplectus americanus - Carex spp. Herbaceous Vegetation	15
Schoenoplectus americanus - Eleocharis palustris Herbaceous Vegetation	15
Schoenoplectus americanus Western Herbaceous Vegetation	13, 45
Schoenoplectus maritimus Herbaceous Vegetation	35
Senecio atratus - Cirsium scopulorum Herbaceous Rockland	28
Sibbaldia procumbens - Polygonum bistortoides Herbaceous Vegetation	20, 21
Sparganium eurycarpum Herbaceous Vegetation	20, 28
Spartina gracilis Herbaceous Vegetation	20, 28
Sporobolus airoides - Distichlis spicata Herbaceous Vegetation	28
Sporobolus airoides Monotype Herbaceous Vegetation	35, 38, 56
Suaeda calceoliformis Herbaceous Vegetation	64
Suaeda moquinii Shrubland	28
Symphoricarpos spp. Shrubland	39
Trifolium nanum Herbaceous Vegetation	36
Typha (latifolia, angustifolia) Western Herbaceous Vegetation	7
Typha domingensis Western Herbaceous Vegetation	7
Vaccinium (caespitosum, scoparium) Dwarf-shrubland	38

Key to Associations

Key A: Alpine Life Zone..303

This key includes associations generally found at high elevations above tree line. Stunted Krummholz tree assocociations and subalpine shrublands are addressed here, but subalpine woodlands and forests are not. Krummholz consists of dense islands of shrub forms (usually less than 2 m tall) of *Abies lasiocarpa, Picea engelmannii* and occasionally *Pinus aristata* forming the upper timberline, in a mosaic with alpine tundra or fellfields. This key also includes alpine tundra, fell-field, sparse vegetation and alpine wetland associations.

Note: *Many alpine associations tend to occur in small patches and mosaics which vary over a small scale. Where plants grow is often influenced by subtleties in microclimate, such as shade from a large boulder or water flow from a melting snowfield. A plot the size of a minimum mapping unit (0.5hA) will often contain multiple associations.*

Key B: Valley Floor and Alluvial Fan Life Zones..309

This key includes associations found on the floor of the San Luis Valley and reaching to the edge of the lower "treeline" along the base of the mountains. Geographically, it covers the basin floor, dunefield, sand ramp and alluvial fan up to the edge of the pinyon-juniper woodlands.Woodlands of cottonwood or ponderosa pine located on the valley floor, the sand ramp, or the alluvial fan are not included here, but are found in Key C.

Key C: Montane to Subalpine Life Zones..317

This key includes associations found between the low montane to subalpine including all forest and woodland associations and the montane grasslands and shrublands which occur within them. It also includes cliff and canyon sparse vegetation found at montane elevations.

Key A: Alpine Life Zone

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1a. Vegetation absent; rock outcrops, barren talus and scree fields, or lakes. 2
1b. Vegetation present, sometimes with sparse cover (2-10 %) in talus and scree fields. 3

2a. Alpine lakes and ponds. .... **Open water**
2b. Rock ....(<2% total plant cover) **Geology type/Barren**

Sparse talus and scree vegetation
3a. Typically sparsely vegetated (2-10% total vegetation cover) talus or scree fields (vascular and non-vascular vegetation may occur in scattered clumps between rocks) 4
3b. Not as above...7

4a. *Saxifraga bronchialis* dominant in the sparse forb layer. ....***Saxifraga bronchialis* Scree Slope Sparse Vegetation**
4b. *Cirsium scopulorum* present to dominant, often with *Aquilegia caerulea*, *Polemonium viscosum* or *Senecio atratus*. 5

5a. *Senecio atratus* present to strongly dominant, and usually visually dominant. This association exists as both a sparse alpine type and extends to lower elevations along avalanche chutes. At lower elevations, the stands can have high covers of subalpine plants from surrounding stands of trees and may have up to 40% cover of *Senecio atratus*. .... ***Senecio atratus – Cirsium scopulorum* Herbaceous Rockland**
5b. Not as above...6

6a. *Aquilegia caerulea* with higher cover than *Polemonium viscosum*. ....***Aquilegia caerulea – Cirsium scopulorum* Scree Sparse Vegetation**
6b. *Polemonium viscosum* present to codominant, with equal to higher cover than *Aquilegia caerulea*...................***Cirsium scopulorum – Polemonium viscosum* Herbaceous Vegetation**

Krummholz and alpine/subalpine willows

7a. Krummholz or short shrublands of *Picea engelmannii*, *Abies lasiocarpa*, *Pinus aristata*, *Salix brachycarpa* or *Salix planifolia* or Willow dominated *Salix brachycarpa* or *Salix planifolia* shrublands 8
7b. Not composed of the above species; shrublands or herbaceous associations. 17

8a. Krummholz shrubland composed of stunted conifers (may be codominated by *Salix brachycarpa*. 9
8b. Willow dominated *Salix brachycarpa* or *Salix planifolia* shrublands. 11

9a. *Pinus aristata* with greater cover than *Abies lasiocarpa* and *Picea engelmannii*....................... .... ***Pinus aristata* Krummholz Shrubland**
9b. *Abies lasiocarpa* or *Picea engelmannii* dominant or codominant with *Salix brachycarpa* or *Salix planifolia* 10

10a. Deciduous short shrubs *Salix brachycarpa* and/or *Salix planifolia* with less than 25% relative cover in the shrub layers. .... ***Abies lasiocarpa – Picea engelmannii* Krummholz Shrubland**
10b. Deciduous short shrubs *Salix brachycarpa* and/or *Salix planifolia* with at least 25% relative cover in the shrub layers. .... ***Abies lasiocarpa-Picea engelmannii / Salix* (*brachycarpa, glauca*) Krummholz Shrubland**

11a. *Salix brachycarpa* with greater cover than *Salix planifolia*; generally upland stands surrounded by alpine tundra; may contain small inclusions of *Salix planifolia* and wetland herbaceous plants .... ***Salix brachycarpa* / Mesic Forbs**
11b. *Salix planifolia* with greater cover than *Salix brachycarpa*; generally riparian wetlands that fill the bottom of broad alpine valleys or side drainages; may contain small inclusions of *Salix brachycarpa* 12

12a. Herbaceous layer composed mainly of mesic forbs, such as: *Senecio triangularis*, *Mertensia ciliata*, *Caltha leptosepala*, or *Cardamine cordifolia*. ....***Salix planifolia* / Mesic Forbs Shrubland**
12b. Herbaceous layer composed mainly of graminoid species. 13

13a. *Carex* species dominate the understory..14
13b. Grasses dominate the understory. 16

14a. *Carex utriculata* is the most prevalent graminoid. Stands may occur around the edges of *Carex utriculata* dominated wetlands............. .***Salix planifolia* / *Carex utriculata* Shrubland**
14b. Not as above...15

15a. *Carex aquatilis* is the most prevalent graminoid, and may form hummocks beneath a sparse *Salix planifolia* short shrub layer. .... ***Salix planifolia* / *Carex aquatilis* Shrubland**
15b. *Carex scopulorum* is the most prevalent graminoid in what can be a varied herbaceous layer. Willows form a moderate to dense short shrub layer and may be denser adjacent to stream edges. .... ***Salix planifolia* / *Carex scopulorum* Shrubland**

16a. *Deschampsia caespitosa* is the most prevalent graminoid. Sites can be more upland, located along snowmelt channels, and include dry turf species in the herbaceous layer...***Salix planifolia* / *Deschampsia caespitosa* Shrubland**
16b. *Calamagrostis canadensis* is the most prevalent graminoid. Sites can be located along braided stream channels and extend down into the subalpine zone...***Salix planifolia* / *Calamagrostis canadensis* Shrubland**

Alpine herbaceous wetlands

17a. Alpine wetlands; usually located in small depressions, seeps or along streams; often including species such as *Carex scopulorum*, *Carex aquatilis*, *Deschampsia caespitosa*, *Mertensia ciliata*, *Caltha leptosepala* or *Cardamine cordifolia*..18
17b. Upland areas including dry tundra, grasslands and fell fields; may have small wetland inclusions or appear wet during snowmelt and after storms..27

18a. Graminoid or mixed forb – graminoid wetlands..19
18b. Forb dominated wetlands..26

19a. *Deschampsia caespitosa* dominant or codominant...20
19b. Sedges *Carex scopulorum* or *Carex aquatilis* dominant or codominant..............................23

20a. *Deschampsia caespitosa* strongly dominant...***Deschampsia caespitosa* Herbaceous Vegetation**
20b. *Deschampsia caespitosa* codominant with another species...19

21a. *Carex microptera* codominant with *Deschampsia caespitosa*..***Deschampsia caespitosa – Carex microptera* Herbaceous Vegetation**
21b. Not as above...22

22a. *Caltha leptosepala* codominant with *Deschampsia caespitosa*.. ***Deschampsia caespitosa – Caltha leptosepala* Herbaceous Vegetation**
22b. *Geum rossii* codominant with *Deschampsia caespitosa*...***Deschampsia caespitosa – Geum rossii* Herbaceous Vegetation**

23a. *Carex scopulorum* dominant or codominant..24
23b. *Carex aquatilis* dominant or codominant 25

24a. *Carex scopulorum* strongly dominant................ ***Carex scopulorum* Herbaceous Vegetation**
24b. *Caltha leptosepala* codominant with *Carex scopulorum*...***Carex scopulorum – Caltha leptosepala* Herbaceous Vegetation**

25a. *Carex aquatilis* strongly dominant..........................***Carex aquatilis* Herbaceous Vegetation**
25b. *Pedicularis groenlandica* codominant with *Carex aquatilis*...***Carex aquatilis – Pedicularis groenlandica* Herbaceous Vegetation**

26a. *Caltha leptosepala* dominant to codominant with *Cardamine cordifolia* .... ***Cardamine cordifolia* – *Caltha leptosepala* Herbaceous Vegetaion**
26b. Stand a combination of the mesic forbs: *Mertensia ciliata*, *Senecio triangularis* or *Cardamine cordifolia*.. .... ***Cardamine cordifolia* – *Mertensia ciliata* – *Senecio triangularis* Herbaceous Vegetation**

27a. Alpine fell fields characterized by low, matted vegetation, and including the species *Paronychia pulvinata*, *Salix nivalis*, *Silene acaulis*, *Minuartia obtusiloba* or *Trifolium nanum*; often located on exposed, wind-swept ridges and saddles and have a high cover of rocks...........28
27b. Not as above; alpine turf, grasslands and shrublands. 31

Alpine fell fields

28a. Dwarf shrublands dominated by *Paronychia pulvinata* or *Salix nivalis*...............................29
28b. Cushion plant or other herbaceous dominated vegetation 30

29a. *Paronychia pulvinata* dominant; *Silene acaulis* usually present .... ***Paronychia pulvinata* – *Silene acaulis* Dwarf-shrubland**
29b. *Salix nivalis* dominant or codominant... .... ***Salix nivalis* / *Geum rossii* Dwarf-shrubland**

30a. *Trifolium nanum* dominant.................................. ***Trifolium nanum* Herbaceous Vegetation**
30b. *Minuartia obtusiloba* and *Silene acaulis* present and codominant .... ***Minuartia obtusiloba* Mixed Cushion Plant Herbaceous Vegetation**

Alpine Turf

31a. Subalpine and alpine grasslands or shrublands with a graminoid layer dominated by *Festuca thurberi* 32
31b. Not as above...33

32a. *Dasiphora floribunda* with 10 % or more cover .... ***Dasiphora floribunda* / *Festuca thurberi* Subalpine Shrubland**
32b. *Dasiphora floribunda* absent or with less than 10 % cover ....***Festuca thurberi* Subalpine Grassland Herbaceous Vegetation**

33a. Dwarf to short shrublands dominated by *Dasiphora floribunda* with the herbaceous layer composed of dry turf species including: *Carex elynoides*, *Carex rupestris* or *Geum rossii* var. *turbinatum*; *Festuca thurberi* trace to absent.. .... ***Dasiphora fruticosa* ssp. *floribunda* Subalpine Shrubland**
33b. Not as above...34

34a. Dwarf shrubland associations of *Dryas octopetala, Vaccinium* spp., or *Salix nivalis.*..........35
34b. Herbaceous associations 38

35a. *Vaccinium caespitosum* or *Vaccinium scoparium* with at least 15% cover .... ***Vaccinium* (*caespitosum, scoparium*) Dwarf Shrubland**

35b. Not as above..36

36a. *Salix nivalis* dominant or codominant...
.... ***Salix nivalis* / *Geum rossii* Dwarf-shrubland**
36b. *Dryas octopetala* dominant and dwarf *Salix* species not strongly represented. 37

37a. *Carex rupestris* dominant in the graminoid stratum ....
.............................***Dryas octopetala* – *Carex rupestris* Dwarf-shrub Herbaceous Vegetation**
37b. *Carex elynoides* or another *Carex* species with the highest cover in the graminoid stratum ....
...................................***Dryas octopetala* – *Carex* spp. Dwarf-shrub Herbaceous Vegetation**

38a. Stands codominated by graminoids; sites tend to be dry turf 43
38b. Stands dominated by *Geum rossii* or codominated by forbs; sites tend to be more mesic turf or located in snowmelt areas...39

39a. *Geum rossii* strongly dominant, forming a thick turf or patches between rocks; sites are usually diverse and may contain species from the other *Geum rossii* associations.....................
....***Geum rossii* Herbaceous Vegetation**
39b. Not as above..40

40a. *Kobresia myosuroides* dominant to codominant with *Geum rossii* ....
....***Kobresia myosuroides* – *Geum rossii* Herbaceous Vegetation**
40b. Not as above..41

41a. *Carex rupestris* dominant to codominant with *Geum rossii* ....
.... ***Carex rupestris* – *Geum rossii* Herbaceous Vegetation**
41b. Not as above..42

42a. *Carex elynoides* codominant with *Geum rossii* ....
....***Carex elynoides* – *Geum rossii* Herbaceous Vegetation**
42b. *Carex siccata* (*C. foenea*) is the most prevalent graminoid; stands may be codominated by *Geum rossii* ....***Carex siccata* – *Geum rossii* Herbaceous Vegetation**

43a. *Polygonum bistortoides* codominant with *Geum rossii* ....
....***Geum rossii* – *Polygonum bistortoides* Herbaceous Vegetation**
43b. *Sibbaldia procumbens* present, *Geum rossii* absent or present; *Carex elynoides, Festuca brachyphylla, Trisetum spicatum, Polygonum bistortoides , Artemisia scopulorum* and *Juncus drummondii* may be present or have high cover...44

44a. *Sibbaldia procumbens* codominant with *Geum rossii*; *Artemisia scopulorum* may have high cover.......................................***Geum rossii* – *Sibbaldia procumbens* Herbaceous Vegetation**
44b. Not as above..45

45a. *Sibbaldia procumbens* present with at least 15% cover; sites located in mesic turf, snowmelt areas or wet depressions; *Geum rossii* absent or present with up to 5% cover; *Juncus drummondii* may be present to dominant...

.... ***Sibbaldia procumbens – Polygonum bistortoides* Herbaceous Vegetation**
45b. Not as above...46

46a. *Carex elynoides* strongly dominant.........................***Carex elynoides* Herbaceous Vegetation**
46b. *Festuca brachyphylla* dominant or codominant 46

46a. *Festuca brachyphylla* strongly dominant...... ***Festuca brachyphylla* Herbaceous Vegetation**
46b. *Trisetum spicatum* codominant with *Festuca brachyphylla* ....
.... ***Festuca brachyphylla – Trisetum spicatum* Herbaceous Vegetation**

Key B: Valley Floor and Alluvial Fan Life Zones

This key includes associations found on the floor of the San Luis Valley and reaching to the edge of the lower "treeline" along the base of the mountains. Geographically, it covers the basin floor, dunefield, sand ramp, and alluvial fan up to the lower edge of the pinyon-juniper and ponderosa pine woodlands. Riparian areas with cottonwoods on the valley floor and woodlands of ponderosa pine on the sand ramp and alluvial fan are included in Key C.

1a. Vegetation absent or with less than 2% cover. 2
1b. Vegetation with greater than 2% cover, including submerged aquatic vegetation. 3

2a. Playa lakes; unvegetated salt flats or open water. ....**Barren Playa**
2b. Barren sand dunes .... **Barren Sand Dunes**

3a. Herbaceous vegetation of active and stabilized dunes, characterized by *Redfieldia flexuosa*, *Achnatherum hymenoides* and *Psoralidium lanceolatum*; may contain significant cover of annual species *Helianthus petiolaris*, *Ambrosia psilostachya* and *Salsola* spp. 4
3b. Not as above; not located on dunes or having a shrub layer. 5

4a. *Redfieldia flexuosa* is the most prevalent graminoid; *Psoralidium lanceolatum* can be absent to strongly dominant; sites are typically early seral and occupy the most active vegetated dunes ....***Redfieldia flexuosa* – (*Psoralidium lanceolatum*) Herbaceous Vegetation**
4b. *Achnatherum hymenoides* has higher cover than *Redfieldia flexuosa* ....***Achnatherum hymenoides* – *Psoralidium lanceolatum* Herbaceous Vegetation**

5a. Shrublands (>15% cover of shrubs) and shrub-steppe (sparse shrublands with a strong grassland component, but with the shrub stratum exceeding the herbaceous stratum) 6
5b. Herbaceous associations; may have 10% cover of shrubs if the herbaceous layer is strongly dominant 28

Shrublands and Shrub-steppe

6a. *Sarcobatus vermiculatus*, *Ericameria nauseosa*, and *Atriplex canescens* all present, none strongly dominant .... ***Atriplex canescens* - *Ericameria nauseosa* - *Sarcobatus vemiculatus* Shrubland**
6b. Not as above, *Atriplex canescens,* if present, is not codominant with *Sarcobatus vermiculatus* or *Ericameria nauseosa* 7

7a.*Sarcobatus vermiculatus* present to dominant; may be codominant with *Ericameria nauseosa*8
7b. Not as above; shrublands without *Sarcobatus vermiculatus*. 14

8a. *Ericameria nauseosa* codominant with *Sarcobatus vermiculatus* .... ***Sarcobatus vermiculatus* / *Ericameria nauseosa* Shrubland**
8b. *Sarcobatus vermiculatus* strongly dominant...9

9a. Stands located on active or stabilized dunes dominated by loose sandy soils; sand and bare soil dominate groundcover. *Sarcobatus vermiculatus* makes up 20-80% of other cover; *Atriplex canescens, Chrysothamnus greenei, Ericameria nauseosa,* and *Krascheninnikovia lanata* have cover ranging from 0-10%; and *Kochia americana, Achnatherum hymenoides, Artimisia frigida, Chenopodium leptophyllum,* and *Opuntia polyacantha have cover ranging* from 5-10%.

.... ***Sarcobatus vermiculatus* Dune Shrubland**
9b. Not as above; sites located on alluvial flats 10

10a. Herbaceous layer dominated by *Distichlis spicata* ....
.... ***Sarcobatus vermiculatus / Distichlis spicata* Shrubland**
10b. Not as above 11

11a. Herbaceous layer dominated by *Sporobolus airoides*, other graminoids may be present in smaller amounts .... ***Sarcobatus vermiculatus / Sporobolus airoides* Shrubland**
11b. Not as above 12

12a. Herbaceous layer dominated by *Leymus triticoides*, other graminoids may be present in smaller amounts .... ***Sarcobatus vermiculatus / Leymus triticoides* Shrubland**
12b. Not as above 13

13a. Herbaceous layer strongly dominated by *Juncus balticus*, other species present in only small amounts .... ***Sarcobatus vermiculatus / Juncus balticus* Sparse Vegetation**
13b. Understory with sparse vegetation (<5-35%) of weedy and/or exotic species such as *Halogeton glomeratus*, but which may also include native species such as *Distichlis spicata* and *Suaeda calceoliformis*. .... ***Sarcobatus vermiculatus* Disturbed Shrubland**

14a. Shrublands of alluvial fans, dominated by *Krascheninnikovia lanata* or *Ericameria parryi* ....
.... 15
14b. Not as above, shrublands dominated by other species 16

15a. Shrublands dominated by *Krascheninnikovia lanata* ....
.... ***Krascheninnikovia lanata / Achnatherum hymenoides* Dwarf-shrubland**
15b. Shrublands dominated by *Ericameria parryi* ....
.... ***Ericameria parryi / Achnatherum hymenoides* Shrubland**

16a. *Ericameria nauseosa* shrubland and shrub steppe associations; *Ericameria nauseosa* cover greater than 15% OR greater than total herbaceous cover 17
16b. Not as above; shrublands without *Ericameria nauseosa* 22

17a. Dune or sandsheet shrublands with sparse understory ....
.... ***Ericameria nauseosa* Sand Deposit Sparse Shrubland**
17b. Not as above; herbaceous stratum present 18

18a. *Muhlenbergia pungens* and *Achnatherum hymenoides* present to codominant in the herbaceous layer ....

.... ***Ericameria nauseosa / Muhlenbergia pungens – Achnatherum hymenoides* Shrub Herbaceous Vegetation**
18b. Not as above..19

19a. *Bouteloua gracilis* is the dominant graminoid; *Opuntia polyacantha* my be present with high cover............***Ericameria nauseosa / Bouteloua gracilis* Shrub Herbaceous Vegetation**
19b. Not as above..20

20a. *Equisetum laevigatum* dominant in the understory ....***Ericameria nauseosa / Equisetum laevigatum* Shrubland**
20b. Alkaline grasses *Distichlis spicata* or *Sporobolus airoides* dominant in the understory 21

21a. *Distichlis spicata*.................................***Ericameria nauseosa / Distichlis spicata* Shrubland**
21b. *Sporobolus airoides* .... ***Ericameria nauseosa / Sporobolus airoides* Shrubland**

22a. *Salix* sp. shrublands...23
22b. Other shrublands 26

23a. *Salix exigua* dominated shrublands...24
23b. *Salix exigua* codominant with another willow species 25

24a. Shrublands located on active dunes or near swales ....***Salix exigua* Dune Shrubland**
24b. Riparian shrublands .... ***Salix exigua* Temporarily Flooded Shrubland**

25a. *Salix lucida* ssp. *caudata*.......................***Salix exigua – Salix lucida* ssp. *caudata* Shrubland**
25b. *Salix ligulifolia*...***Salix exigua – Salix ligulifolia* Shrubland**

26a. *Rhus trilobata* dune shrublands...***Rhus trilobata* Dune Shrubland**
26b. Other shrublands 27

27a. *Atriplex canescens* shrublands ....***Atriplex canescens / Achnatherum hymenoides* Shrubland**
27b. Suaeda moquinii alluvial flat shrublands..................................***Suaeda moquinii* Shrubland**

Herbaceous associations

28a. Wetlands with saturated soils and often with standing water 29
28b. Mesic meadows, playas, alluvial flats and sandsheet herbaceous vegetation........................50

29a. Aquatic vegetation or vegetation of drying lakebeds..30
29b. Not as above; emergent herbaceous wetlands along streams or the edges of lakes 35

30a. Ponds with aquatic vegetation dominated by *Myriophyllum sibiricum* ....***Myriophyllum sibiricum* Herbaceous Vegetation**
30b. Not as above..31

31a. Permanently flooded areas dominated or codominated by *Polygonum amphibium* .... ***Polygonum amphibium* Permanently Flooded Herbaceous Vegetation**
31b. Not as above...32

32a. Vegetation of ponds or slow moving water, dominated by *Ranunculus aquatilis*.................... ....***Ranunculus aquatilis – Callitriche palustris* Herbaceous Vegetation**
32b. Not as above...33

33a. Permanently flooded areas dominated by *Potamogeton foliosus* ....***Potamogeton foliosus* Herbaceous Vegetation**
33b. Not as above...34

34a. Flooded or mucky areas dominated by *Hippuris vulgaris* ....***Hippuris vulgaris* Herbaceous Vegetation**
34b. Mucky soil of drying lakebed dominated by *Rorippa palustris* .... ***Rorippa palustris* Herbaceous Vegetation**

35a. *Schoenoplectus* sp. dominated or codominated stands 36
35b. Stands dominated by other graminoids..41

36a. *Schoenoplectus acutus* dominant 37
36b. Other *Schoenoplectus* spp. dominant...38

37a. Emergent vegetation dominated by *Schoenoplectus acutus* .... ***Schoenoplectus acutus* Herbaceous Vegetation**
37b. Wet swales codominated by *Schoenoplectus acutus* and *Glyceria grandis* ....***Glyceria grandis – Schoenoplectus acutus* Herbaceous Vegetation**

38a. Stands often with open water, vegetation somewhat sparse and dominated by *Schoenoplectus maritimus* .... ***Schoenoplectus maritimus* Herbaceous Vegetation**
38b. *Schoenoplectus americanus* dominant or codominant..39

39a. Marshy swales dominated by *Schoenoplectus americanus* .... ***Schoenoplectus americanus* Western Herbaceous Vegetation**
39b. *Schoenoplectus americanus* codominant with another graminoid..40

40a. *Schoenoplectus americanus* codominant with one or more *Carex* spp.................................... ....***Schoenoplectus americanus – Carex* spp. Herbaceous Vegetation**
40b. *Schoenoplectus americanus* codominant with *Eleocharis palustris*... ....***Schoenoplectus americanus – Eleocharis palustris* Herbaceous Vegetation**

41a. *Carex* sp. dominated stands...42
41b. Stands dominated by other graminoids..45

42a. Wet depressions, swales, or saturated stream edges dominated by *Carex pellita*. A variety of other graminoids may be present..............................***Carex pellita* Herbaceous Vegetation**

42b. Not as above..43

43a. Stands of wet areas dominated by *Carex utriculata* ....
....***Carex utriculata* Herbaceous Vegetation**
43b. Not as above..44

44a. Wet depressions, swales, or saturated stream edges dominated by *Carex nebrascensis*. A variety of other graminoids may be present........***Carex nebrascensis* Herbaceous Vegetation**
44b. Saturated creek-side areas dominated by *Carex simulata* ....
....***Carex simulata* Herbaceous Vegetation**

45a. *Typha* sp. wetlands..46
45b. Other herbaceous wetlands 47

46a. Stands dominated by *Typha latifolia*..
....***Typha* (*latifolia, angustifolia*) Western Herbaceous Vegetation**
46b. Stands dominated by *Typha domingensis* ....
.... ***Typha domingensis* Western Herbaceous Vegetation**

47a. Saturated stream-side areas dominated by *Sparganium eurycarpum* ....
.... ***Sparganium eurycarpum* Herbaceous Vegetation**
47b. Not as above..48

48a. Stands on a variety of soils, *Juncus balticus* dominant...
....***Juncus balticus* Herbaceous Vegetation**
48b. Stands dominated by *Eleocharis* sp. 49

49a. Stands dominted by *Eleocharis acicularis*, few other species present ....
....***Eleocharis acicularis* Herbaceous Vegetation**
49b. Stands dominted by *Eleocharis palustris* ....***Eleocharis palustris* Herbaceous Vegetation**

50a. Sandsheet grasslands..51
50b. Mesic meadows, playas, or alluvial flats characterized by a mix of forbs and graminoids, any of which can be dominant over small areas and may form bands around the edges of the meadows. Graminoids include: *Juncus balticus*, *Distichlis spicata*, *Muhlenbergia wrightii*, *Muhlenbergia asperifolia*, *Puccinellia nuttalliana*, *Carex praegracilis* and *Hordeum jubatum*. Stands often have a significant forb component..53

51a. Open grasslands dominated by *Hesperostipa comata*, usually in combination with *Achnatherum hymneoides* and *Bouteloua gracilis*...
..........................***Hesperostipa comata – Achnatherum hymenoides* Herbaceous Vegetation**
51b. Not as above..52

52a. Grasslands dominated by *Muhlenbergia pungens* ....
.... ***Muhlenbergia pungens* Herbaceous Vegetation**

52b. *Bouteloua gracilis* dominant, other grasses also present can include: *Festuca arizonica, Hesperostipa comata* and others...
....***Bouteloua gracilis* Herbaceous Vegetation**

53a. Short, sparsely vegetated flats dominated by *Puccinellia nuttalliana* ....
....***Puccinellia nuttalliana* Herbaceous Vegetation**
53b. Not as above..54

54a. Mesic meadows strongly dominated by *Carex praegracilis*..
.... ***Carex praegracilis* Herbaceous Vegetation**
54b. Not as above..55

55a. Interdunal swales and mesic meadows dominated by *Muhlenbergia asperifolia*.....................
....***Muhlenbergia asperifolia* Herbaceous Vegetation**
55b. Not as above..56

56b. Stands strongly dominated by *Hordeum jubatum*...
.... ***Hordeum jubatum* Herbaceous Vegetation**
56b. Not as above..57

57a. Stands codominated by a number of the species listed in couplet 50 ....
.... ***Juncus balticus* – (*Iris missouriensis*) Mixed Herbaceous Vegetation**
57b. Not as above..58

58a. *Distichlis spicata* dominant to codominant...59
58b. Not as above..62

59a. *Distichlis spicata* dominant..................................***Distichlis spicata* Herbaceous Vegetation**
59b. *Distichlis spicata* codominant with another graminoid 60

60a. *Juncus balticus* codominant with *Distichlis spicata*; mesic meadow stands with significant forb component which usually includes *Iris missouriensis* and *Pyrrocoma lanceolata*; *Distichlis spicata* may be dominant in small patches or around the edges of the mesic meadow .... ***Juncus balticus* – (*Iris missouriensis*) Mixed Herbaceous Vegetation**
60b. Not as above..61

61a. *Distichlis spicata* codominant with *Scirpus nevadensis*; stands can be an even mix of the two species, or strongly dominated by *Scirpus nevadensis* ....
....***Distichlis spicata* – (*Scirpus nevadensis*) Herbaceous Vegetation**
61b. *Distichlis spicata* codominant with *Sporobolus airoides* ....
....***Sporobolus airoides* – *Distichlis spicata* Herbaceous Vegetation**

62a. *Sporobolus airoides* forms a near monoculture in low areas and slight depressions; mature grasses tend to form hummocks and the ground between hummocks can be either sandy or cemented ....***Sporobolus airoides* Monotype Herbaceous Vegetation**
62b. Not as above..63

63a. *Spartina gracilis* is the predominant grass; stands can be sparse to dense .... ***Spartina gracilis* Herbaceous Vegetation**
63b. Not as above...64

64a. *Salicornia rubra* growing along playa edges; this is known from one location around the Blanca Wetlands .... ***Salicornia rubra* Herbaceous Vegetation**
64b. Not as above...65

65a. *Eleocharis palustris* dominant; stands occur along streams, lake edges and in low wet areas.. ....***Eleocharis palustris* Herbaceous Vegetation**
65b. Not as above...66

66a. *Scirpus nevadensis* strongly dominates the herbaceous layer; stands can be located in alluvial flats or in narrow bands around drying playa lakes; *Distichlis spicata* is present to codominant........................***Distichlis spicata* – (*Scirpus nevadensis*) Herbaceous Vegetation**
66b. Not as above...67

67a. *Pascopyrum smithii* dominant or codominant...68
67b. Not as above...70

68a. *Pascopyrum smithii* strongly dominant............***Pascopyrum smithii* Herbaceous Vegetation**
68b. *Pascopyrum smithii* codominant with other graminoids 69

69a. *Scirpus nevadensis* codominant with *Pascopyrum smithii*; found in interdunal swales and possibly other habitats.....***Pascopyrum smithii* – *Scirpus nevadensis* Herbaceous Vegetation**
69b. *Juncus balticus* codominant with *Pascopyrum smithii* ....***Juncus balticus* – *Pascopyrum smithii* Herbaceous Vegetation**

70a. *Phragmites australis* dominates the stand, forming a large clonal thicket .... ***Phragmites australis* Western North America Temperate Semi-natural Herbaceous Vegetation**
70b. Not as above...71

71a. Dry playas with *Halogeton glomeratus* and not much else ....***Halogeton glomeratus* Herbaceous Vegetation**
71b. Dry playas or alluvial flats dominated by *Suaeda calceoliformis* or *Salsola* spp..................72

72a. *Suaeda calceoliformis* dominates or codominates with *Salsola* spp... .... ***Suaeda calceoliformis* Herbaceous Vegetation**
72b. *Salsola* spp dominant. ....***Salsola* spp. Herbaceous Vegetation [Provisional**]

Key C: Montane to Subalpine Life Zones

This key includes associations found between the low montane to subalpine including all forest and woodland associations and the montane grasslands and shrublands which occur within them. It begins at the lower edge of the pinyon-juniper and ponderosa pine woodlands on the alluvial fan and sand ramp and extends onto the valley floor in those areas where riparian woodlands of cottonwood occur. The upper elevational limit occurs at treeline and includes all of the krummholz forest types. It also includes cliff and canyon sparse vegetation found at montane elevations.

1a. Vegetation absent or with less than 2% cover 2
1b. Vegetation with greater than 2% cover...4

2a. Bedrock outcrops, cliffs and talus slopes (may include sparse vegetation and non-vascular vegetation type 3
2b. Lakes .... **Open Water**

3a. High elevation avalanche chutes sparsely vegetated with short-stature *Picea engelmannii, Abies lasiocarpa* and *Populus tremuloides*... ....**Mixed Conifer - Aspen Avalanche Chute Shrubland**
3b. Other barren, rocky areas, unclassified..........................**Cliff, Canyon and Massive Bedrock**

4a. Grasslands, wet meadows and shrublands, trees generally absent...5
4b. Woodlands and forests. Trees species present with at least 25% canopy cover; canopy cover can be as low as 10% in some stands of *Pinus ponderosa*, and as low as 2-10% in Cliff and Canyon sparse woodlands...6

5a. Wet meadow, dominated by *Carex utriculata* ....***Carex utriculata* Perched Wetland Herbaceous Vegetation**
5b. Grasslands and Shrublands .... **Subkey 1: Montane and Subalpine Grasslands and Shrublands**

6a. Canopy cover of deciduous trees (*Populus angustifolia* and *Populus tremuloides*) accounts for at least 25% of the total canopy cover in the stand (25% relative cover). Coniferous trees may be absent to codominant...7
6b. Coniferous trees with at least 75% relative canopy cover. Deciduous tree species may be present with less than 25% relative canopy cover. 8

7a. *Populus angustifolia* present in the canopy layers with at least 5% cover (usually >10% relative cover) and representing more than one individual. *P. tremuloides* and conifers absent to codominant... ....**Subkey 2: *Populus angustifolia* and *P. angustifolia-Mixed* Conifer Associations**
7b. *Populus tremuloides* present in the canopy layers. Conifers absent to codominant. (<25% relative cover) If present *Populus angulstifolia* has low cover <5%, and is accidental and not scattered throughout stand. .... **Subkey 3: *Populus tremuloides* and *P. tremuloides-Mixed* Conifer Associations**

8a. *Pinus ponderosa* characteristic and typically dominant with at least 10% canopy cover. Stands may also include *Pinus edulis*, *Pseudotsuga menziesii*, and *Pinus flexilis*. .... **Subkey 4: *Pinus ponderosa* Associations**
8b. Not as above...9

9a. *Pinus edulis* dominant or sometimes codominant with *Juniperus scopulorum*. *Pinus aristata* may be present .... **Subkey 5: *Pinus edulis* Associations**
9b. Not as above...10

10a. *Pinus flexilis* or *Pinus aristata* dominant or codominant. Stands may include *Pseudotsuga menziesii*, *Pinus ponderosa*, and *Picea engelmannii*. .... **Subkey 6: *Pinus flexilis* and *Pinus aristata* Associations**
10b. Not as above...11

11a. *Pseudotsuga menziesii* or *Abies concolor* dominant or codominant.. **Subkey 7: *Pseudotsuga menziesii* and *Abies concolor* Associations**
11b. Not as above...12

12a. *Picea engelmannii* or *Abies lasiocarpa* dominant or codominant. .... **Subkey 8: *Picea engelmannii* and *Abies lasiocarpa* Associations**
12b. *Picea pungens* dominant.................... ***Picea pungens / Festuca thurberi* Sparse Woodland**

Subkey 1: Montane and Subalpine Grasslands and Shrublands

1a. Tall shrublands composed of *Salix* spp., *Alnus incana*, or *Betula occidentalis*; usually exist as linear patches associated with riparian wetlands. 2
1b. Grasslands or shrublands composed of dwarf or short shrubs..5

2b. Tall shrublands composed of *Alnus incana* and *Betula occidentalis*.. .... ***Alnus incana - Betula occidentalis* Shrubland**
2a. Not as above; tall shrublands composed of *Salix* spp., may include *Alnus incana*....................3

3a. *Salix drummondiana* dominant or co-dominant..4
3b. *Salix monticola* dominant .... ***Salix monticola* / Mesic Forbs Shrubland**

4a. *Salix drummondiana* co-dominant with *Alnus incana* ....***Alnus incana - Salix drummondiana* Shrubland**
4b. *Salix drummondiana* dominant.................... ***Salix drummondiana* / Mesic Forbs Shrubland**

5a. Short shrublands typically with greater than 15%* total short shrub cover, but may include stands with 10% shrub cover if not strongly dominated by herbaceous layer (shrub steppe).

Shrub heights may vary between stands with some "short shrub" species ranging from 0.3m to over 2m 6
5b. Grasslands with a minimal shrub layer (<10% cover). 13
* In many montane meadows, it is difficult to draw the line between grassland and shrubland. In general, select whichever is the dominant stratum and try keying both ways.

6a. Subalpine shrublands dominated by *Dasiphora floribunda*...Key A30
6b. Not as above...7

7a. *Holodiscus dumosus* cover greater than 10%; may include small amounts of other mixed shrubs 8
7b. *Holodiscus dumosus* not a significant component 9

8a. Rocky talus slopes and scree, with sparse to open canopy of *Holodiscus dumosus* ....***Holodiscus dumosus* Rock Outcrop Sparse Vegetation**
8b. Less rocky, soils more developed, with an understory of *Muhlenbergia montana* ....***Holodiscus dumosus / Muhlenbergia montana* Shrubland**

9a. *Rhus trilobata* with greater than 10% cover and with the largest relative cover of the short shrub stratum; other associated shrub species include: *Symphoricarpos* spp., *Chrysothanmus viscidiflorus*, *Prunus virginiana*, and *Cercocarpus montanus*.. ....***Rhus trilobata* Rocky Mountain Shrub Herbaceous Vegetation**
9b. Not as above...10

10a. *Prunus virginiana* dominant in the short shrub layer with greater than 25% cover. ....***Prunus virginiana - (Prunus americana)* Shrubland**
10b. Not as above..11

11a. *Cercocarpus montanus* dominant in the short shrub layer; *Muhlenbergia montana* in the herbaceous layer.......................***Cercocarpus montanus / Muhlenbergia montana* Shrubland**
11b. *Symphoricarpos* spp. dominant in the short shrub layer.. ....***Symphoricarpos oreophilus* Shrubland**

12a. *Hesperostipa comata* and *Achnatherum hymenoides* codominant; lower elevation grasslands usually with sandy soils; *Ericameria nauseosa* sometimes present. ....***Hesperostipa comata - Achnatherum hymenoides* Herbaceous Vegetation**
12b. Higher elevation grasslands with *Festuca arizonica*, *Festuca thurberi*, *Muhlenbergia montana* or *Danthonia parryi*. 13

13a. *Festuca thurberi* dominant; subalpine to alpine... ....***Festuca thurberi* Subalpine Grassland Herbaceous Vegetation**
13b. *Festuca thurberi* not dominant...14

14a. *Bouteloua gracilis* dominant, other grasses also present can include: *Festuca arizonica*, *Hesperostipa comata* and others.. ....***Bouteloua gracilis* Herbaceous Vegetation**

14b. Grassland a combination of *Festuca arizonica*, *Muhlenbergia montana* and *Danthonia parryi*...15

15a. *Danthonia parryi* with higher cover than *Festuca arizonica*...**_Danthonia parryi_ Herbaceous Vegetation**
15b. *Festuca arizonica* dominant to codominant with *Muhlenbergia montana*..............................**_Festuca arizonica - Muhlenbergia montana_ Herbaceous Vegetation**

Subkey 2: _Populus angustifolia_ and _P. angustifolia_-Mixed Conifer Associations

1a. *Populus angustifolia* typically dominant with greater than 75% relative cover of deciduous trees in the canopy layers; may be codominated by *Populus tremuloides*. 2
1b. Not as above; *Populus angustifolia* codominant with at least one conifer tree species. Both deciduous and coniferous trees have 25-75% relative cover 11

2a. Woodlands located on active and stabilized dunes. 3
2b. Woodlands and forests with short or tall shrub layers; may be located on the sand sheet, but not on the main dune mass. 4

3a. Stands with sparse to absent herbaceous and shrub strata. Trace species tend to include *Redfieldia flexuosa*, *Achnatherum hymenoides*, *Psoralidium lanceolatum*, and *Ericameria nauseosa*...**_Populus angustifolia_ Sand Dune Forest**
3b. *Rhus trilobata* dominant in understory or present with at least 5% cover..**_Populus angustifolia / Rhus trilobata_ Woodland**

4a. Stands with a tall shrub stratum of *Juniperus scopulorum*, *Betula occidentalis*, *Alnus incana*, *Salix drummondiana* or *Acer glabrum*..5
4b. Stands with a shrub statum of *Salix exigua*, *Ribes aureum*, or *Ericameria nauseosa*..............9

5a *Juniperus scopulorum* dominant in tall shrub or subcanopy layers...**_Populus angustifolia - Juniperus scopulorum_ Woodland**
5b. Stands dominated by deciduous tall shrubs. 6

6a. Stands dominated by *Alnus incana* or *Betula occidentalis* 7
6b. Stands dominated by *Salix* spp. and/or *Acer glabrum* 8

7a. *Betula occidentalis* dominant in the tall shrub stratum..**_Populus angustifolia / Betula occidentalis_ Woodland**
7b. *Alnus incana* dominant in the tall shrub stratum. ....**_Populus angustifolia / Alnus incana_ Woodland**

8a. *Salix drummondiana* and *Acer glabrum* codominant in the tall shrub stratum; stands of lower to middle montane riparian areas...**_Populus angustifolia / Salix drummondiana - Acer glabrum_ Woodland**

8b. Salix lucida and other willows dominant in the tall shrub stratum...
.........................***Populus angustifolia / Salix (monticola, drummondiana, lucida)*** **Woodland**

9a. *Salix exigua* dominant in the short or tall shrub stratum...
....***Populus angustifolia / Salix exigua*** **Woodland**
9b. Not as above...10

10a. *Ribes aureum* dominant in the short shrub stratum...
.... ***Populus angustifolia / Ribes aureum*** **Woodland**
10b. *Ericameria nauseosa* dominant in the short shrub stratum. ....
....***Populus angustifolia / Ericameria nauseosa*** **Sandsheet Woodland**

11a. *Abies concolor* codominant with *Populus angustifolia*; *Picea pungens* and *Populus tremuloides* may also be present. *Juniperus scopulorum* dominant in the tall shrub or subcanopy .... ***Populus angustifolia - Abies concolor / Juniperus scopulorum*** **Woodland**
11b. *Abies concolor* codominant with *Populus angustifolia*; *Picea pungens* and *Populus tremuloides* may also be present. Subcanopy not dominated by *Juniperus scopulorum*.........12

12a. *Betula occidentalis* dominant in the tall shrub stratum...
.................................***Populus angustifolia - Abies concolor / Betula occidentalis*** **Woodland**
12b. *Acer glabrum* dominant in the tall shrub stratum. ....
.... ***Abies concolor - (Picea pungens) - Populus angustifolia / Acer glabrum*** **Forest**

Subkey 3: *Populus tremuloides* and *P. tremuloides*-Mixed Conifer Associations

1a. *Populus tremuloides* typically dominant with greater than 75% relative cover in the canopy layers..2
1b. Not as above; *Populus tremuloides* codominant with at least one other conifer tree species. Both deciduous and conifer trees have 25-75% relative cover 23

2a. Stands located on partially stabilized scree; sparse shrub and herbaceous layers. ....
....***Populus tremuloides*** **Scree Woodland**
2b. Not as above...3

3a. Shrub layers present. 4
3b. Shrub layers absent; herbaceous understory. 18

4a. Tall shrub layer present..5
4b. Tall shrub layer absent; short or dwarf shrub understory. 9

Tall Shrubs

5a. *Salix* spp. dominant in the tall shrub layer. 6
5b. *Acer glabrum*, *Alnus incana* or *Jamesia americana* dominant in the tall shrub layer. 7

6a. *Salix drummondiana* dominant; riparian stands...
....***Populus tremuloides / Salix drummondiana*** **Forest**

6b. *Salix scouleriana* dominant; upland stands....***Populus tremuloides / Salix scouleriana*** **Forest**

7a. *Acer glabrum* dominant in the tall shrub layer; mixed short shrubs. ....
....***Populus tremuloides / Acer glabrum*** **Forest**
7b. Not as above...8

8a. *Alnus incana* dominant; riparian stands. ....***Populus tremuloides / Alnus incana*** **Forest**
8b. *Jamesia americana* dominant; upland stands. ....
....***Populus tremuloides / Jamesia americana*** **Woodland**

Short and Dwarf Shrubs
9a. Short shrub layer present...10
9b. Short shrub layer sparse or absent; dwarf shrub layer present with *Arctostaphylos uva-ursi* or *Vaccinium myrtillus*. 17

10a. *Cornus sericea* dominant. ....***Populus tremuloides / Cornus sericea*** **Forest**
10b. Not as above...11

11a. *Sambucus racemosa* dominant...............***Populus tremuloides / Sambucus racemosa*** **Forest**
11b. Not as above...12

12a. *Physocarpos monogynus* dominant. ***Populus tremuloides / Physocarpus monogynus*** **Forest**
12b. Not as above...13

13a. *Ribes montigenum* dominant.....................***Populus tremuloides / Ribes montigenum*** **Forest**
13b. Not as above...14

14a. *Symphoricarpos* spp. dominant... ***Populus tremuloides / Symphoricarpos oreophilus*** **Forest**
14b. Not as above...15

15a. *Rosa woodsii* dominant. ....***Populus tremuloides / Rosa woodsii*** **Forest**
15b. Not as above...16

16a. *Shepherdia canadensis* dominant........***Populus tremuloides / Shepherdia canadensis*** **Forest**
16b. *Juniperus communis* dominant. ....***Populus tremuloides / Juniperus communis*** **Forest**

17a. *Arctostaphylos uva-ursi* dominant. ....
....***Populus tremuloides / Arctostaphylos uva-ursi*** **Woodland**
17b. *Vaccinium myrtillus* dominant. ....***Populus tremuloides / Vaccinium myrtillus*** **Forest**

Herbaceous
18a. Forbs dominate herbaceous layer; *Thalictrum fendleri* present to abundant. ....
....***Populus tremuloides / Thalictrum fendleri*** **Forest**
18b. Graminoids dominate herbaceous layer..19

19a. *Hesperostipa comata*.............................***Populus tremuloides / Hesperostipa comata*** **Forest**

19b. Not as above..20

20a. *Carex siccata* dominant..................................... ***Populus tremuloides / Carex siccata* Forest**
20b. Not as above..21

21a. *Festuca thurberi* dominant...........................***Populus tremuloides / Festuca thurberi* Forest**
21b. Not a above. 22

22a. *Bromus ciliatus* dominant; *Thermopsis* spp absent to codominant. ....
....***Populus tremuloides / Bromus ciliatus* - (*Thermopsis* spp.) Forest**
22b. *Calamagrostis canadensis* dominant. ....
....***Populus tremuloides / Calamagrostis canadensis* Forest**

Mixed Aspen - Conifer
23a. *Abies concolor* or *Pseudotsuga menziesii* codominant with *Populus tremuloides.* 24
23b. Other conifers codominant with *Populus tremuloides*...28

24a. *Abies concolor* present in the canopy layers; *Pseudotsuga menziesii* absent to codominant. ...
....25
24b. *Abies concolor* absent; *Juniperus communis* dominant in the short shrub layer. ....
.... ***Populus tremuloides - Pseudotsuga menziesii / Juniperus communis* Forest**

25a. Stands with a tall shrub layer with *Acer glabrum*. ....
....***Populus tremuloides - Abies concolor / Acer glabrum* Forest**
25b. Not as above..26

26a. Stands with a tall shrub layer of *Juniperus scopulorum* ....
....***Populus tremuloides - Abies concolor / Juniperus scopulorum* Forest**
26b. Not as above..27

27a. Stands with a tall shrub layer of *Alnus incana*. ....
....***Populus tremuloides - Abies concolor / Alnus incana* Forest**
27b. Tall shrubs lacking; *Physocarpos monogynus* dominant in the short shrub layer. ....
.... ***Populus tremuloides - Abies concolor / Physocarpus monogynus* Forest**

28a. Canopy layers codominated by *Pinus* spp. 29
28b. Canopy layers codominated by *Populus tremuloid* and either *Abies lasiocarpa* or *Picea engelmannii*. 30

29a. *Pinus ponderosa* codominant with *Populus tremuloides*. Other tree species may be present in lesser amounts.....................***Populus tremuloides - Pinus ponderosa* Rocky Mountain Forest**
29b. *Pinus flexilis* codominant with *Populus tremuloides*. ....
....***Populus tremuloides - Pinus flexilis* Forest**

30a. *Abies lasiocarpa* may be absent. *Picea engelmannii* codominant with *Populus tremuloides* ...
....***Picea engelmannii - Populus tremuloides* Forest Alliance**

30b. *Abies lasiocarpa* present in the canopy layers. 31

31a. *Shepherdia canadensis* dominant in the short shrub layer. ....
.... ***Populus tremuloides - Abies lasiocarpa / Shepherdia canadensis* Forest**
31b. Not as above. 32

32a. *Juniperus communis* dominant in the short or dwarf shrub layer. ....
.... ***Populus tremuloides - Abies lasiocarpa / Juniperus communis* Forest**
32b. *Vaccinium myrtillus* dominant and with at least 2X the cover of *Juniperus communis* ....
.... ***Populus tremuloides - Abies lasiocarpa (Picea engelmannii) / Vaccinium myrtillus* Forest**

Subkey 4: *Pinus ponderosa* Associations

1a. *Pinus ponderosa* dominant, *Pinus flexilis* or *Pinus edulis* may be present...............................2
1b. *Pinus ponderosa* codominant with *Pseudotsuga menziesii*, understory of Cercocarpus montanus ... ***Pinus ponderosa - Pseudotsuga menziesii / Cercocarupus montanus* Woodland**

2a. *Juniperus scopulorum* dominant in the tall shrub layer and with at least 10% cover.................
.... ***Pinus ponderosa / Juniperus scopulorum* Woodland**
2b. Not as above. 3

3a. Open stands of sandy soils with a sparse but fairly diverse understory usually containing *Ericameria nauseosa*, *Achnatherum hymenoides* and *Hesperostipa comata* ....
***Pinus ponderosa / Ericameria nauseosa / Achnatherum hymenoides - Hesperostipa comata* Woodland**
3b. Stands with grass dominated understory, shrub understory generally absent. 4

4a. Stands with an understory dominated by *Muhlenbergia montana*...
.... ***Pinus ponderosa / Muhlenbergia montana* Woodland**
4b. Stands with an understory dominated by *Festuca arizonica*. ....
.... ***Pinus ponderosa / Festuca arizonica* Woodland**

Subkey 5: *Pinus edulis* Associations

1a. Open woodlands with sparse understory vegetation. 2
1b. Woodlands with shrub or herbaceous understory layers. 3

2a. Bedrock, rock and gravel with greater than 50% ground cover; plots located on colluvial slopes or bedrock outcrops above the alluvial fan. .... ***Pinus edulis* / Rockland Woodland**
2b. Stands located on the alluvial fan; high ground cover of bare soil and cobble. ....
.... ***Pinus edulis* / Sparse Understory Forest**

3a. Stands with a short shrub layer. 4
3b. Short shrub layer lacking; herbaceous understory present. 5

4a. Moderately dense canopy of *Pinus edulis* and *Juniperus scopulorum* with a short or tall shrub stratum with 10 – 20% cover dominated by *Cercocarpus montanus*. Scattered individuals of *Pinus ponderosa*, *Pseudotsuga menziesii,* and *Pinus flexilis* may be present in the canopy or as emergent trees. *Artemisia frigida*, *Opuntia polyacantha*, *Muhlenbergia montana* and *Eriogonum jamesii* may be present in understory. ***Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrubs Woodland**
4b. *Holodiscus dumosus* dominant in the short shrub layer, often with *Symphoricarpos* spp. ....***Pinus edulis - Juniperus scopulorum / Holodiscus dumosus* Woodland**

5a. *Bouteloua gracilis* is the dominant graminoid, may codominate the herbaceous layer with *Opuntia polycantha*.***Pinus edulis - (Juniperus monosperma) / Bouteloua gracilis* Woodland**
5b. Other graminoids dominant; *Pinus edulis* and *Juniperus scopulorum* form an open canopy with 20 – 30% cover. The understory is sparse and forms no distinct layers. Understory may include *Ribes cereum, Bouteloua gracilis, Festuca arizonica, Elymus elymoides, Heterotheca villosa* and *Opuntia polyacantha*. ....***Pinus edulis* / Sparse Understory Forest**

Subkey 6: *Pinus flexilis* and *Pinus aristata* Associations

1a. *Pinus flexilis* with greater cover than *Pinus aristata* 2
1b. *Pinus aristata* with equal to or greater cover than *Pinus flexilis* 4

2a. Dwarf-shrub layer of *Arctostaphylos uva-ursi* present ....***Pinus flexilis / Arctostaphylos uva-ursi* Woodland**
2b. Gramminoid or *Juniperus communis* dominated understory..3

3a. *Juniperus communis*....................................***Pinus flexilis / Juniperus communis* Woodland**
3b. *Festuca arizonica* and *Muhlenbergia montana*. ....***Pinus flexilis / Festuca arizonica - Muhlenbergia montana* Woodland**

4a. Short shrub or dwarf-shrub layer present..5
4b. Shrubs lacking; graminoid understory 7

5a. *Picea engelmannii* absent to codominant with *Pinus aristata*; *Juniperus communis* short or dwarf-shrub layer ....***Pinus aristata - (Picea engelmannii) / Juniperus communis* Woodland**
5b. Not as above..6

6a. *Vaccinium myrtillus* forming a dwarf-shrub layer ....***Pinus aristata / Vaccinium myrtillus* Woodland**
6b. Shrub layer dominated by *Ribes montigenum* .***Pinus aristata / Ribes montigenum* Woodland**

7a. *Festuca arizonica* dominant; lower elevation ...***Pinus aristata / Festuca arizonica* Woodland**
7b. *Festuca thurberi* dominant; higher elevation......***Pinus aristata / Festuca thurberi* Woodland**

Subkey 7: *Pseudotsuga menziesii* and *Abies concolor* Associations

1a. *Abies concolor* present with >10% cover; *Pseudotsuga menziesii* absent to dominant............2
1b. *Abies concolor* not present; *Pseudotsuga menziesii* dominant. 8

2a. Stands located on scree slopes; *Holodiscus dumosus* present..
....***Abies concolor / Holodiscus dumosus* Scree Woodland**
2b. Not as above...3

3a. Stands located in avalanche paths; trees shorter than surrounding forests; *Jamesia americana* *present*...
***Abies concolor - Pseudotsuga menziesii / Jamesia americana* Avalanche Chute Shrubland**
3b. Not as above...4

4a. Stands with a tall shrub layer. 5
4b. Tall shrubs lacking; short shrub or herbaceous layers dominant..7

5a. *Acer glabrum* dominant.........***Abies concolor - Pseudotsuga menziesii / Acer glabrum* Forest**
5b. Not as above...6

6a. *Betula occidentalis* dominant........................***Abies concolor / Betula occidentalis* Woodland**
6b. *Juniperus scopulorum* dominant...
.... ***Abies concolor - Pseudotsuga menziesii / Juniperus scopulorum* Woodland**

7a. Stands with a short shrub layer, *Symphoricarpos* spp. dominant ....
....***Abies concolor / Symphoricarpos oreophilus* Forest**
7b. Short shrubs lacking; herbaceous layer dominated by *Festuca arizonica*..................................
....***Abies concolor / Festuca arizonica* Woodland**

8a. *Pseudotsuga menziesii* with 20-40% canopy cover. Shrub layer is dominated by *Holodiscus dumosus* (5-30% cover), but includes many other species such as *Acer glabrum, Jamesia americana, Physocarpus monogynus, Ribes* spp., *Rosa woodsii*, and *Symphoricarpos oreophilus*. Occasionally significant cover of grasses such as *Festuca arizonica* or *Poa fendleriana* in herbaceous layer.
....***Pseudotsuga menziesii / Holodiscus dumosus* Scree Woodland**
8b. Not as above...9

9a. Stands with tall or short shrub layers. 10
9b. Shrubs lacking; herbaceous layers dominant. 13

10a. *Jamesia americana* dominant. ....***Pseudotsuga menziesii / Jamesia americana* Forest**
10b. Not as above...11

11a. *Juniperus communis* dominant...........***Pseudotsuga menziesii / Juniperus communis* Forest**
11b. Not as above...12

12a. *Symphoricarpos* spp. dominant.***Pseudotsuga menziesii / Symphoricarpos oreophilus* Forest**
12b. *Cercocarpus montanus* dominant. .... ***Pseudotsuga menziesii / Cercocarpus montanus* Woodland**

13a. *Festuca arizonica* dominant.....................***Pseudotsuga menziesii / Festuca arizonica* Forest**
13b. *Bromus ciliatus* dominant. .... ***Pseudotsuga menziesii / Bromus ciliatus* Forest**

Subkey 8: *Picea engelmannii* and *Abies lasiocarpa* Associations
1a. *Abies lasiocarpa* present. 2
1b. *Abies lasiocarpa* asbsent...8

2a. Understory sparse, no significant shrub or herbaceous layers; non-vascular cover may be significant..3
2b. Shrub or herbaceous layers present..4

3a. Moss with greater than 20% cover......... ***Abies lasiocarpa - Picea engelmannii* / Moss Forest**
3b. No significant moss or understory layers.. ***Abies lasiocarpa - Picea engelmannii* / Sparse Understory Forest**

4a. *Salix drummondiana* dominant in the tall shrub layer; riparian.. ***Abies lasiocarpa - Picea engelmannii / Salix drummondiana* Forest**
4b. Not as above..5

5a. *Juniperus communis* dominant in the short or dwarf shrub layers with cover greater than or equal to *Vaccinium myrtillus*. .... ***Abies lasiocarpa - Picea engelmannii / Juniperus communis* Woodland**
5b. Not as above..6

6a. *Vaccinium myrtillus* dominant in the dwarf shrub stratum. *Juniperus communis* may be present but has significantly less cover than *Vaccinium myrtillus* .... ***Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus* Forest**
6b. Not as above; no shrub layers. 7

7a. Mesic sites, *Mertensia ciliata*, *Senecio triangularis*, or *Cardamine cordifolia* dominant in understory .... ***Abies lasiocarpa - Picea engelmannii / Mertensia ciliata* Forest**
7b. Generally not as moist as above, *Erigeron eximius* dominant in understory... ***Abies lasiocarpa / Erigeron eximius* Forest**

8a. Understory dominated by *Festuca thurberi*, no significant shrub layers... ***Picea engelmannii - (Abies lasiocarpa) / Festuca thurberi* Woodland**
8b. Not as above..9

9a. *Vaccinium myrtillus* dominantes the dwarf shrub stratum.. ***Picea engelmannii / Vaccinium myrtillus* Forest**

9b. *Ribes montigenum* dominantes the short shrub stratum...
....***Picea engelmannii / Ribes montigenum* Forest**

Field Key to Map Classes of Great Sand Dunes National Park and Preserve

NatureServe
Terrestrial Ecology Department
Nov 3, 2009

Contacts:
Keith Schulz, Regional Vegetation Ecologist, 303.541.0356, keith_schulz@natureserve.org
Joe Stevens, Ecologist, Colorado Natural Heritage Program, 970.491.7760 joe.stevens@colostate.edu
Marion Reid, Senior Regional Ecologist, 303.541.0342, marion_reid@natureserve.org

TABLE OF CONTENTS

Introduction 330
KEY A. Landuse, Agriculture, and Disturbed Land Cover Map Classes 334
KEY B. Dune and Sandsheet Map Classes 335
KEY C Alluvial Flats Map Classes 336
KEY D Foothill and Alluvial Fan Map Classes 338
KEY E Montane and Subalpine Map Classes 342
KEY F Alpine Map Classes 346

Introduction

These keys are to the map classes in the legend for Great Sand Dunes National Park Vegetation Mapping Project map. The project area includes the Great Sand Dunes National Park and Preserve, Baca National Wildlife Refuge, TNC Medeno-Zapata Ranch, Blanca Wetlands, other state and private lands and adjacent lands managed by the Rio Grande National Forest and Bureau of Land Management.

The keys are organized by major life zone with map classes listed in more then one zone where appropriate. The keys are "dichotomous", which means the user follows the order of the 'couplets' and makes a choice between the 2 options represented in the couplet. The ordering of the couplets in each key does matter, and the user should choose the option in each couplet that best fits the data or field situation. A choice leads the user to the next couplet to be utilized in the keying process, via a number at the far right, or else leads to a final result (map class).

If the choices the user makes leads to a "result", then a map class is named and represents a NVC association, alliance or group of alliances, or a landcover or landuse type such as Cliff, Canyon and Massive Bedrock or Farmland. These NVC-based map classes are recognizable because "alliance" or "association" is in the name, although some of the landcover types may be described using NVC alliances. The logic of the key is to first the user determines life zone, then map class. Keys are generally based on dominance within vegetation strata, with tree cover generally considered first, then shrubs, and finally the herbaceous component. Co-dominant species within a given strata may be important as well, in some cases an association or alliances will have 2 or more codominant species, which may or may not be present in all stands.

Some terminology is commonly employed throughout the keys that distinguish general spatial characteristics of the vegetation or environmental setting. For example 'matrix' types of vegetation are dominant across the majority of a given landscape, while 'large patch' types tend to occur as distinctive patches within the larger 'matrix.' Elevation-based life zones are commonly employed, with reference to 'alpine,' 'subalpine,' 'montane,' or 'foothill' zones. These zones vary significantly in actual elevational thresholds with aspect and special environmental conditions such as "frost pockets" where cold air acculmulates and extends a zone below a typical threashold. More precise definition of these elevation breaks by map zone could be accomplished with additional research. Plant names are almost always in Latin and follow the nomenclature of Kartesz (1999).

A summery of map classes by life zone for Great Sand Dunes NP vegetation mapping project area is presented in Table 1.

Table 1. Map Classes for Great Sand Dunes NP

MC type/Life zone	Map Class Name *indicates map class is in multiple life zones in key	MC#
Landuse type	Chained Pinyon-Juniper Areas	8
Landuse type	Farmlands	67
Landuse type	Invasive Forbland	59
Landuse type	Other	71
Landuse type	Roads	69
Landuse type	Urban Residentual	68
Landuse type	Urban Semi-industrial	66
Landuse type	Water*	70
Dune/sandsheet	Barren Sand Dune	5
Dune/sandsheet	Coyote Willow Temporarily Flooded Shrubland Alliances*	9
Dune/sandsheet	Greasewood Sand Deposit Shrubland and Steppe Alliances	13
Dune/sandsheet	Herbaceous Stabilized Dune and Sandsheet Alliances	17
Dune/sandsheet	Interdunal Swale Wetland Alliances	20
Dune/sandsheet	Narrowleaf Cottonwood Sand Dune Woodland Association	26
Dune/sandsheet	Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance*	27
Dune/sandsheet	Ponderosa Pine Sand Ramp Woodland *	34
Dune/sandsheet	Sandsheet Rabbitbrush Shrubland and Steppe Alliances	45
Dune/sandsheet	Wash*	23
Dune/sandsheet	Water*	70
Alluvial flats	Alluvial Flat Herbaceous Alliances	14
Alluvial flats	Cattail Herbaceous Alliances	7
Alluvial flats	Emergent Marsh Alliances	28
Alluvial flats	Fourwing Saltbush Shrubland Alliance	12
Alluvial flats	Greasewood Flat Shrubland and Steppe Alliances	15
Alluvial flats	Playa Alliances	22
Alluvial flats	San Luis Valley Mesic Meadow Alliances	21
Alluvial flats	Wash*	23
Alluvial flats	Water*	70
Foothill/Alluvial fan	Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances	61
Foothill/Alluvial fan	Aspen – Douglas-fir (White Fir) Upland Forest Alliance*	63
Foothill/Alluvial fan	Aspen Forest Alliances*	2
Foothill/Alluvial fan	Aspen - Limber Pine Forest Alliance*	3
Foothill/Alluvial fan	Cliff, Canyon and Massive Bedrock*	37
Foothill/Alluvial fan	Coyote Willow Temporarily Flooded Shrubland Alliances*	9
Foothill/Alluvial fan	Fourwing Saltbush Shrubland Alliance*	12
Foothill/Alluvial fan	Montane-Foothill Dry-Mesic Shrubland Alliances*	18
Foothill/Alluvial fan	Montane Riparian Shrubland Alliances	65
Foothill/Alluvial fan	Mountain Mahogany Shrubland Alliance	25
Foothill/Alluvial fan	Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance*	27
Foothill/Alluvial fan	Piedmont Semi-Desert Grassland Alliances	30
Foothill/Alluvial fan	Pinyon Pine / Rockland Woodland Association	31

MC type/Life zone	Map Class Name *indicates map class is in multiple life zones in key	MC#
Foothill/Alluvial fan	Pinyon Pine Woodland with Herbaceous or Sparse Understory*	32
Foothill/Alluvial fan	Pinyon-Juniper Woodland with Shrub Understory	60
Foothill/Alluvial fan	Ponderosa Pine - Aspen Forest Alliance*	33
Foothill/Alluvial fan	Ponderosa Pine Sand Ramp Woodland *	34
Foothill/Alluvial fan	Ponderosa Pine Woodland with Herbaceous Understory*	49
Foothill/Alluvial fan	Ponderosa Pine Woodland with Shrub Understory*	48
Foothill/Alluvial fan	Wash*	23
Foothill/Alluvial fan	White Fir – Mixed Deciduous Lowland Forest Alliances *	53
Foothill/Alluvial fan	Winterfat Dwarf-shrubland Alliance	55
Montane-Subalpine	Alpine - Upper Subalpine Herbaceous Wetland Alliances*	64
Montane-Subalpine	Aspen – Douglas-fir (White Fir) Upland Forest Alliances*	63
Montane-Subalpine	Aspen Forest Alliances*	2
Montane-Subalpine	Aspen - Limber Pine Forest Alliance*	3
Montane-Subalpine	Avalanche Chute Shrubland	56
Montane-Subalpine	Cliff, Canyon and Massive Bedrock*	37
Montane-Subalpine	Coyote Willow Temporarily Flooded Shrubland Alliances*	9
Montane-Subalpine	White Fir - Douglas-fir Forest and Woodland Alliances*	11
Montane-Subalpine	Mountain Mahogany Shrubland Alliance	25
Montane-Subalpine	Montane-Foothill Dry-Mesic Shrubland Alliances*	18
Montane-Subalpine	Montane Riparian Shrubland Alliances	65
Montane-Subalpine	Montane - Subalpine Grassland Alliances	46
Montane-Subalpine	Montane - Lower Subalpine Wetland Alliances	24
Montane-Subalpine	Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance*	27
Montane-Subalpine	Pinyon Pine / Rockland Woodland Association*	31
Montane-Subalpine	Pinyon Pine Woodland with Herbaceous or Sparse Understory*	32
Montane-Subalpine	Pinyon-Juniper Woodland with Shrub Understory*	60
Montane-Subalpine	Ponderosa Pine - Aspen Forest Alliance*	33
Montane-Subalpine	Ponderosa Pine Woodland with Herbaceous Understory*	49
Montane-Subalpine	Ponderosa Pine Woodland with Shrub Understory*	48
Montane-Subalpine	Subalpine Fir (Engelmann Spruce) - Aspen Forest Alliance	50
Montane-Subalpine	Subalpine Spruce-Fir Forest and Woodland Alliances	41
Montane-Subalpine	Subalpine - Montane Limber-Bristlecone Pine Woodland Alliances	42
Montane-Subalpine	Subalpine Riparian Forest Alliances	43
Montane-Subalpine	Subalpine - Alpine Riparian Shrubland	44
Montane-Subalpine	Water*	70
Montane-Subalpine	White Fir - Mixed Deciduous Lowland Forest Alliances*	53
Alpine	Alpine Bedrock and Scree	35
Alpine	Alpine Fell - Field Alliances	36
Alpine	Alpine Turf Alliances	38
Alpine	Alpine - Upper Subalpine Herbaceous Wetland Alliances	64
Alpine	Alpine Willow (Spruce) Shrubland Alliances	57
Alpine	Montane - Lower Subalpine Wetland Alliances	24
Alpine	Montane - Subalpine Grassland Alliances	46

MC type/Life zone	Map Class Name *indicates map class is in multiple life zones in key	MC#
Alpine	Subalpine - Alpine Riparian Shrubland	44
Alpine	Subalpine Fir - Engelmann Spruce - Bristlecone Pine - Limber Pine Krummholz Shrubland Alliance	51
Alpine	Water*	70

Field Key to Great Sand Dunes NP and Preserve Map Classes

This key is intended for identifying map classes found in the Great Sand Dunes NP and Preserve, Baca NWR, Medano-Zapata Ranch and adjacent National Forest, state and other included private lands.

1a. Landcover is natural or semi-natural **2**
1b. Landcover is agricultural, disturbed, dominated by introduced species or otherwised altered .... **GO TO KEY A (Land use types)**

2a. Site is on valley floor and sand ramp (eolian sand deposits on alluvial fan from near Point of No Return to Sand Creek). Can be wetland or upland **3**
2b. Site is on alluvial fan, foothills in mountains. Can be wetland or upland **4**

3a. Site is typically a nearly continuous matrix of relatively deep (>15 cm), loose, eolian sand forming the sand sheet or dunes on valley floor or or alluvial fan (sand ramp). Small deflation areas that expose alluvial flat (in depressions) with clay pan or sabkha substrate may be present (usually <1/3 ground cover). Does Not form a mosaic of alluvial flats with vegetated sand lens (small usually coppice dunes) .... **GO TO KEY B: Dune and Sandsheet**
3b. Site is on alluvial flat, playa, sub-irrigated wetland or mesic meadow. Soil on alluvial flat is typically sabkha (evaporate cemented sand), sandy to clayey soil or organic muck, and may include small, loose sand areas (usually <2/3 ground cover) of coppice dunes (shallow sand lens trapped within shrubs) or low dunes that form a mosaic of with alluvial flats or depressions. Salt crusts are often present. .... **GO TO KEY C: Alluvial Flats and Wet Meadow**
4a. Site is on alluvial fan and foothill or lower montane zones (Pinyon-Juniper woodland). Can be wetland or upland .... **GO TO KEY D: Alluvial Fan or Foothills Zone**
4b. Site is in mountains, montane to alpine zones. Can be wetland or upland **5**

5a. Site is characterized by montane or subalpine vegetation .... **GO TO KEY E: Montane and Subalpine Zones**
5b. Site is characterized by alpine vegetation including krummholz and barren alpine slopes. May extend into upper subalpine zone .... **GO TO KEY F: Alpine Zone**

KEY A. Landuse, Agriculture, and Disturbed Land Cover Map Classes

Sites often occur near development and roads

1a. Site is permanently or semi-permanently flooded such as a lake or reservoir .... **Water #70**
1b. Site is not flooded or only seasonally flooded **2**

2a. Site is maintained road. .... **Roads #69**
2b. Site is not a maintained road **3**

3a. Land use is cropland either rowcrop or forage such as barley, potatoes or alfalfa that is irrigated with sprinklers or otherwise intensively managed for agriculture (crop circles) .... **Farmlands #67**
3b. Land use is not intensively managed for agriculture; wildlife and livestock grazing may occur on sites **4**

4a. Site is urban.developement **5**
4b. Site not as above **6**

5a. Site is residential development .... **Urban Residentual #68**
5b. Site is not residential development such as quarries area. .... **Urban Semi-industrial #66**

6a. Site is former Pinyon-Juniper Woodland that has evidence of being chained. Current vegetation is dependant on previous community and time since chaining...**Chained Pinyon-Juniper Areas #8**
6b. Site does not have evidence of being chained **7**

7a. Site is mostly barren of vegetation because of recent human caused disturbance. .... **Other #71**
7b. Site is not barren, or if barren then occurs naturally such as a playa center (Key C) or active dune (Key B)........... **8**

8a. Land cover is more or less natural vegetation in areas with high water tables. Naturally high water tables may have been modified by ditching and water spreading historically to produce forage, but irrigation is largely abandoned, or used to maintain historically high water tables. Vegetation is primarily native ....**Key C, Alluvial Flats**
8b. Herbaceous cover typically dominated by introduced forbs (including *Cenntarea* spp.*, Cirsium arvense, Euphorbia esula, Lepidium latifolium, Melilotus* spp.*,Halogeton glomeratus, Kochia scoparium, Lepidium latifolia, L. perfoliatum, Salsola tragus,* etc.). May also include areas dominated by introduced grasses (including *Agropyron cristatum, Agrostis gigantea, Bromus inermis, B. japonicus, B. tectorum, Dactylis glomerata, Poa pratensis, Phleum pratense, Thinopyrum intermedium,* and other introduced forage species. If desired an Alliance can be named for the dominant species. Note: introduced graminoid forage species (*Poa pratensis* and *Bromus inermis*) may dominate some stands of the Montane - Subalpine Grassland Alliances.............................. **Invasive Forbland #59**

KEY B. Dune and Sandsheet Map Classes

Sites occur on eolian sand sheet, sand ramp or dunes

1a. Site is permanently or semi-permanently flooded such as a pond, lake or reservoir ....**Water #70**
1b. Site is not flooded or only seasonally flooded... **2**

2a. Land cover is restricted to drainages, stream terraces, depressions, semi-riparian flats, springs or seeps and areas with high water tables (wetland, wet meadow, riparian vegation) **3**
2b. Land cover is barren upland or vegetation without seeps and springs or areas with high water tables (upland vegetation) **7**

3a. Site occurs along intermittent or perennial stream channels on sand sheet or dune systems.................................... **4**
3b. Site occurs in interdunal swale at least 200 meters away from intermittent or perennial stream channels. These wetlands have shallow water table and may hold open water during part or the year. Dominant species frequently include *Carex* spp., *Juncus balticus, Muhlenbergia asperifolia, Schoenoplectus americanus, S. pungens***Interdunal Swale Wetland Alliances #20**

4a. Open woodlands associated with drainages, stream terraces, semi-riparian flats with high water table and springs on the sandsheet... **5**
4b. Non-wooded stream channels or narrow washes on sandsheet. **6**

5a. Lower montane – foothill woodlands restricted to drainages, stream terraces, and semi-riparian flats that may extend out from alluvial fan on to the sandsheet for a short distance. Streambed is cobbly or gravelly alluvium. Stands are dominated or codominated by *Populus angustifolia.* Other trees such as *Abies concolor, Picea pungens, Populus tremuloides, Pseudotsuga menziesii, Juniperus scopulorum* may codominate. Small patch (inclusions below MMU) aspen stands may be may be present in this map unit. Mesic shrubs such as *Alnus incana, Betula occidentalis, Salix* spp. are often present ....**Narrowleaf Cottonwood Temporarily Flooded Woodland Alliances #27**
5b. Open woodlands associated with drainages, stream terraces, semi-riparian flats with high water table and springs on the sandsheet. Streambed is mostly sand. Narrowleaf cottonwood (*Populus angustifolia*) is codominant to dominant in tree canopy. The understory is generally sparse with *Rhus trilobata, Ericameria nauseousa* or less commonly *Salix* spp. Herbaceous wetland and dune endemic species may be present. Aeolian processes dominate or are major influence. Some stands form coppice dunes in response to sand burial ...**Narrowleaf Cottonwood Sand Dune Forest Association #26**

6a. Riparian shrublands restricted to drainages and semi-riparian flats that are typical of the alluvial fan, but may extend out on valley floor. Generally dominated by *Salix exigua*, but may have inclusions of other communities such as *Crataegus rivularis* and *Salix irrorata*, or rarely *Salix drummondiana*..**Coyote Willow Temporarily Flooded Shrubland Alliances #9**
6b. Broad braided ephemeral stream channels (Medano and Sand creeks) to narrow washes on sandsheet. Stream channel is often barren, but may sparsely vegetated with shrubs, grasses or forbs. Vegetation may be continuous or discontinuous (patchy) along drainage, often composed of upland species *Ericameria nauseousa*, or scattered riparian species. Many of these drainages are narrow and occur below MMU. ....**Wash #23**

7a. Unvegetated dunes and sandsheets (usually < 10% total vegetation cover. Includes active dunes and large "blowout" or deflation areas within vegetated areas (above MMU) ....**Barren Sand Dune #5**
7b. Vegetated dunes and sandsheets characterized by trees, shrubs, or grasses.. **8**

8a. Very open sandsheet woodlands characterized by ponderosa pine (*Pinus ponderosa*) that extends up on alluvial fan where sandsheet is encroaching because of climbing dunes (sand ramp near point of no return). Some stands may have scattered trees with understory dominated by grasses (*Achnatherum hymenoides, Hesperostipa comata,* and/or *Muhlenbergia pungens*) or shrubs (especially *Ericameria nauseousa*) .... **Ponderosa Pine Sand Ramp Woodland #34**
8b. Open sandsheet vegetation not characterized by trees (shrubs, grasses or barren).. **9**

9a. Vegetated dunes and sandsheets characterized by shrubs generally with >10% cover. If total vegetation cover is between 10-20% then shrub cover is between 5-20% cover **10**
9b. Vegetated dunes and sandsheets characterized by herbaceous vegetation (typically *Psoralidium lanceolatum* and/or *Redfieldia flexuosa* sometimes with *Achnatherum hymenoides* (early seral),or *Achnatherum hymenoides, Hesperostipa comata* (mid seral), and/or *Muhlenbergia pungens* (late seral). Scattered shrubs may be present with low cover (generally <5% cover) .... **Herbaceous Stabilized Dune and Sandsheet Alliances #17**

10a. Vegetated sandsheet or dune characterized by having over 15% relative cover of Greaswood (*Sarcobatus vermiculatus*). Stands may extend up on alluvial fan where deep sandsheet has moved (sand ramp). Note stands may have a shrub layer dominated by rubber rabbitbrush as long as *Sarcobatus vermiculatus* is present with significant cover (>15% relative cover is diagnostic)...**Greasewood Sand Deposit Shrubland and Steppe Alliances #13**
10b. Vegetated sandsheet, dunes or sand ramp characterized by an open to closed shrub layer dominated by rubber rabbitbrush (*Ericameria nauseousa*) with sparse to dense herbaceous layer dominated by *Achnatherum hymenoides, Hesperostipa comata* or *Muhlenbergia pungens.* Greasewood (*Sarcobatus vermiculatus*) is typically absent or has low cover (<15% relative cover). May contain inclusions of skunkbush (*Rhus trilobata*) dominated shrublands. .... **Sandsheet Rabbitbrush Shrubland and Steppe Alliances #45**

KEY C Alluvial Flats Map Classes

Sites occur on alluvial flats, mesic meadows, wetlands and playas on valley floor

Depending on scale being considered, this whole portion of the valley floor could be considered an alluvial flat complex that includes a series of inter-connected, intermittently flooded basins (playas), greasewood flats, ephemeral and perennial wetlands, and mesic, sub-irrigated mesic meadows. These "playas" are not typically rain-water fed, but instead mostly receive water from ephemeral, snow-melt fed streams that discharge into this Closed Basin. Historically, the amount of snow determined the number of interconnected basins that fill, although local precipitation events have some inpact. Current management of the Closed Basin Project and water diversion for irrigation impacts when playas fill. Large (>0.5 ha) distinctive playas will be identified and mapped separately from alluvial flats even though hydrologically they may be functionally connected. Substrates include clayey, silty, fine sandy loam, or sabkha (carbonate cemented sand).

1a. Site occurs in a large, distinctive intermittently flooded basin (playa). Landcover may be barren with salt deposits or characterized by shrubs, grasses or open water in wet years or after rain storms **2**

1b. Site occurs in uplands or lowlands, but does not occur in a large, distinctive intermittently flooded playa. May include a thin layer (<15 cm) of loose sand over sabkha (cemented sand) layer or form a mosaic of thin to thick loose sand deposits (coppice dunes) (<2/3 ground cover) and barren depressional areas with sabkha or clayey substrate on flats. Sand is being transported across flats toward dune field **3**

2a. Playa vegetation characterized by an herbaceous layer sometime with scatter shrubs. Dominant species include *Distichilis spicata*, *Eleocharis* spp., *Juncus balticus*, *Salicornia rubra* or *Schoenplectus* spp. that often forms concentric rings of vegetation based on salinity and hydrology. Scattered greasewood (*Sarcobatus vermiculatus*) and less commonly rubber rabbitbrush (*Ericameria nauseousa*) or seepweed (*Suaeda* spp) may be present. Depending on time of year being sampled, this type may include small areas of barren salt deposits or shallow water in center of playas. If dominated by *Halogeton glomeratus* or *Salsola tragus* or other introduced species, then keys to Invasive Forbland ....**Playa Alliances #22**

2b. Playa site open water that is permanent or semi-permanent... **Water #70**

3a. Site occurs along intermittent, perennial or semi-perennial stream channels, lake shore, wetlands or is open water **4**

3b. Site not a wetland or wash... **7**

4a. Site has larger patches (>MMU) of open water that is permanent or semi-permanent and often adjacent to Emergent Marsh... **Water #70**

4b. Site may have small inclusions of open water that is permanent or semi-permanent. **5**

5a. Non-wooded ephemeral stream channels or washes on alluvial fan. Stands are dominated by shrubs, grasses or sparsely vegetated to barren. If present on alluvial fan, stands will be narrow and mostly occurring below MMU. Vegetation may include intermittent bands of *Atriplex canescens, Sarcobatus vermiculatus* or *Ericameria nauseousa.* Not sampled yet on alluvial flats.. **Wash #23**

5b. Site Not an intermittently flooded wash (ephemeral)... **6**

6a. Small patch herbaceous wetlands dominated by cattails (*Typha* spp.) sometimes found below seeps and springs .... **Cattail Herbaceous Alliances #7**

6b. Small patch herbaceous wetlands (alluvial fan to valley floor) dominated by a variety of wet sedges and rushes, but not cattails (separate map unit). Common species may include *Carex nebrascensis, Carex pellita, Carex simulata, Carex utriculata, Eleocharis acicularis, Juncus balticus, Polygonum* spp.*, Potamogeton foliosus, Schoenoplectus acutus.* There is often standing water for much of the growing season and small inclusions (<MMU) of open water ....**Emergent Marsh Alliances #28**

7a. Site is characterized by graminoid or forbs **8**

7b. Site is characterized by shrubs **9**

8a. Lower elevation grasslands found on sub-irrigated valley bottom between the main active dune active complex and alluvial flats. It is best characterized as a native, short to medium tall, mesic grassland. These areas with naturally high water tables have been augmented by ditching and water spreading historically to increase area for forage production. Irrigation is manage less intensively now and used to maintain historically high water tables. Vegetation is variable but mesic species usually dominate or codominate. Mesic graminoids include *Carex pellita, Carex praegracilis, Hordeum jubatum, Juncus balticus, Leymus triticoides, Muhlenbergia asperifolia, Muhlenbergia wrightii, Pascopyrum smithii, Poa fendleriana, Puccinellia nuttalliana, Sporobolus airoides,* and forbs *Argentina anserina, Cleome multicaulis, Iris missouriensis,* and *Potentilla hippiana.* Lush saltgrass (*Distichlis spicata*) may dominate with mesic indicator species on dryer portions of these meadows. Scattered greasewood (*Sarcobatus vermiculatus*), rabbitbrush or other shrubs may be present. Wetland species such as *Carex nebrascensis, Eleocharis palustris, Schoenoplectus* spp., may be present, but only dominate in small wetland inclusions below MMU. Much of this system has been historically managed as hay meadow or pasture and grazed by cattle, and more recently bison and elk, but has maintained its native composition. If vegetation is dominated by introduced species, then key to Invasive Forbland #59. .... **San Luis Valley Mesic Meadow #21**

8b. Lower elevation dry grasslands found on alluvial flat. Vegetation is typically dominated or codominated by *Distichlis spicata* or other herbaceous species such as *Achnatherum hymenoides, Bouteloua gracilis, Hesperostipa comata, Pleuraphis jamesii*, *Spartina gracilis, Sporobolus airoides* or *Suaeda calceoliformis* and may include scatter shrubs (especially *Sarcobatus vermiculatus*), dwarf-shrubs and cacti. Typically found on Sabkha or alluvial flats ....**Alluvial Flat Herbaceous Alliances #14**

9a. Open to moderately dense shrublands dominated by fourwing saltbush (*Atriplex canescens*). Winterfat (*Krascheninnikovia lanata*) may be present, but not dominant. Greasewood (*Sarcobatus vermiculatus*) is absent or has low cover. Typical of saline basins, alluvial slopes and flats across the Intermountain western U.S and extending into the Great Plains, but minor type at Great Sand Dunes. ....**Fourwing Saltbush Shrubland Alliance #12**

9b. Open to moderately dense shrublands dominated or codominated by greasewood (*Sarcobatus vermiculatus*) that are found on sabkha or alluvial flats in the San Luis Valley. *Atriplex canescens, Ericameria nauseosa, Krascheninnikovia lanata* or *Suaeda* spp. may be present to codominant with small patches of *Distichlis spicata* or other grasslands. Commonly occurs on Sabkha (cement sand), saline/alkaline plains and basins, sometimes encircling playas, on stream terraces or alluvial flats .... **Greasewood Flat Shrubland Alliances #15**

KEY D Foothill and Alluvial Fan Map Classes

Sites occur on alluvial fan and into pinyon-juniper foothills elevation zone

Alluvial fans extend below the mountain slopes of the Sangre de Cristo Range and coalesce to form a cobbly-gravelly bajada from the outwash. The surface boundary between the fan and the sand sheet can be most readily seen if one follows a rocky wash down the fan to where it disappears in the sandsheet where eolian process dominate the surface. The lower alluvial fan substrates may be sandy, but not deep sand. Several key species such as Indian ricegrass, needleandthread and rabbitbrush may occur in both settings, so it is important to compare related map units.

1a. Site occurs along intermittent or perennial stream channel, or stream terrace. **2**
1b. Site is upland, generally above stream terraces and mesic lower slopes **7**

2a. Non-forested ephemeral stream channels or washes on alluvial fan. Stands are dominated by shrubs, grasses or sparsely vegetated to barren. If present on alluvial fan stands will be narrow and mostly occurring below MMU. Vegetation likely includes often intermittent bands of *Atriplex canescens* or *Ericameria nauseousa.* ...... **Wash #23**
2b. Riparian shrubland or forest vegetation that occurs along perennial or semi-perennial stream **3**

3a. Montane to foothill shrublands restricted to drainages, semi-riparian flats and spring or seep fed slopes. **4**
3b. Montane to foothill woodlands restricted to drainages, semi-riparian flats and spring or seep fed slope **5**

4a. Foothill to lower montane shrublands restricted to drainages, semi-riparian flats and spring or seep fed slopes. Typically dominated or codominated by *Salix exigua*, but may have inclusions of other communities such as *Crataegus rivularis* and *Salix irrorata*. ....**Coyote Willow Temporarily Flooded Shrubland Alliances #9**
4b. Montane to lower subalpine shrublands restricted to drainages, stream terraces, semi-riparian flats and spring or seep fed slopes. These shrublands occurring as narrow bands of shrubs lining streambanks and alluvial terraces in narrow mountain valley bottoms and often occurs as a mosaic of multiple communities that are shrub- and herb-dominated. The dominant shrubs reflect the large elevation gradient with *Alnus incana, Betula occidentalis, Prunus virginiana, Salix bebbiana, S. drummondiana, S. monticola* at lower elevations and tall *Salix planifolia* at higher elevations. *Salix exigua* is typically absent, but be present with very low cover..... **Montane Riparian Shrubland Alliances #65**

5a. Mixed conifer-broadleaf forests and woodlands co-dominated by deciduous trees (*Populus angustifolia* and/or *Populus tremuloides*) and conifers (*Abies concolor, Picea pungens* and *Pseudotsuga menziesii)* with 25-75% relative tree canopy of each canopy type. Tyically found on stream terraces and toe slopes of hillsides. **White Fir – Mixed Deciduous Lowland Forest Alliances #53**

5b. Broadleaf riparian forests and woodlands. **6**

6a. Lower montane – foothill woodlands restricted to drainages, stream terraces, semi-riparian flats and spring or seep fed slope. Stands are dominated or codominated by *Populus angustifolia.* Other trees such as *Abies concolor, Picea pungens, Populus tremuloides, Pseudotsuga menziesii, Juniperus scopulorum* may be present. *Populus tremuloides* is especially common in montane stands transitioning to Aspen Forest. Small patch (inclusions below MMU) aspen stands may be may be present in this map unit. Mesic shrubs such as *Alnus incana, Betula occidentalis, Salix* spp. are often present .... **Narrowleaf Cottonwood Temporarily Flooded Woodland Alliances #27**

6b. Lower montane – foothill woodlands restricted to drainages, stream terraces, semi-riparian flats and spring or seep fed slope. Stands are dominated by *Populus tremuloides*...................................... **Aspen Forest Alliances #2**

7a. Site is characterized by steep, (>15% slope) rock outcrop, talus and scree. Vegetation is barren to relatively sparse. Scattered *Pinus ponderosa, Pinus flexilis, Pinus edulis* and *Juniperus scopulorum* trees or shrubs such as *Cercocarpus montanus, Holidiscus dumosus,* or *Ribes* spp. may be present. At higher elevations and open tree canopies dominated by *Abies concolor or Pseudotsuga menziesii* on scree may occur **8**

7b. Site may be rocky or not, but is <u>not</u> characterized by steep, rocky sparsely vegetated to wooded scree **9**

8a. Site is characterized by relatively steep hillsides (>15% slope) of rock outcrop, talus and scree. Vegetation is sparse to moderately dense shrubland and often characterized by *Holidiscus dumosus, Rhus trilobata,*or *Ribes cereum*. *Cercocarpus montanus* is generally absent or sparse. .... **Montane-Foothill Dry-Mesic Shrubland Alliances #18**

8b. Site is characterized by steep, (often >30 degree slope) rock outcrop, talus and scree. Vegetation is barren or generally sparse. Scattered individuals or clumps of *Pinus ponderosa, Pinus flexilis, Pinus edulis,*and *Juniperus scopulorum* trees or shrubs such as *Cercocarpus montanus, Holidiscus dumosus,* or *Ribes* spp. may be present. At higher elevations and open tree canopy woodlands dominated by *Abies concolor or Pseudotsuga menziesii* on scree may occur. .... **Cliff, Canyon and Massive Bedrock #37**

9a. Site is characterized by woody vegetation on alluvial fan to foothill and lower montane slopes............................ **10**

9b. Site is characterized by herbaceous vegetation on sandy or gravelly alluvial fans and extends up dry rocky piedmont slopes. Stands are typically dominated by dry, perennial graminoids such as *Hesperostipa comata, Achnatherum hymenoides, Bouteloua gracilis, Elymus elymoides, Pleuraphis jamesii,* and *Pascopyrum smithii.* Moderate cover of Opuntia spp., Gutierrezia sarothrae, and scattered shrub may be present. This type does not occur on the sandsheet or valley floor. More plot data is needed to clarify this minor map unit. **Piedmont Semi-Desert Grassland Alliances #30**

10a. Site is characterized by shrubs or dwarf-shrubs. **11**

10b. Site is characterized by trees. **15**

11a. Low shrubland or shrub steppe strongly dominated by winterfat (*Krascheninnikovia lanata*). Other shrubs may be present such as *Chrysothamnus viscidiflorus, C. greenei, Ericameria nauseosa* and/or *Ericameria parryi.* This widespread type is common throughout the intermountain western US and well as foothills around the San Luis Valley. .... **Winterfat Dwarf-shrubland Alliance #55**

11b. Low shrubland or shrub steppe dominated or co-dominated by other shrubs and dwarf0shrubs. *Krascheninnikovia lanata* may be present, but not dominant.. **12**

12a. Low shrubland or shrub steppe dominated by *Atriplex canescens* or co-dominated with *Ericameria nauseosa*. Often found on stream terraces and saline basins. .... **Fourwing Saltbush Shrubland Alliance #12**

12b. Low shrubland or shrub steppe Not dominated or co-dominated by *Atriplex canescens*. **13**

13a. Low shrubland or shrub steppe dominated or co-dominated by rabbitbrush species (*Chrysothamnus viscidiflorus, Ericameria greenei, Ericameria nauseosa* and/or *Ericameria parryi*). *Krascheninnikovia lanata* may be present, but not dominant. This widespread type is common in the foothills and on alluvial fans around the San Luis Valley. .... **Alluvial Fan Rabbitbrush Shrubland and Steppe Alliances #61**

13b. Foothill or lower montane shrubland. **14**

14a. Shrubland or shrub steppe of lower montane and foothill elevations that is strongly dominated to co-dominated by mountain mahogany (*Cercocarpus montanus*). Other shrub present may include *Rhus trilobata, Ribes cereum, Symphoricarpos oreophilus, S. rotundifolia* and/or *Yucca glauca.* ....**Mountain Mahogany Shrubland Alliance #25**

14b. Shrubland or shrub steppe of lower montane and foothill elevations. Shrub layer is dominated or co-dominated by *Acer glabrum, Amelanchier utahensis, Chrysothamnus parryii, Prunus virginiana, Purshia stansburiana, Purshia tridentata, Rhus trilobata, Ribes cereum, Symphoricarpos oreophilus, S. rotundifolia* and/or *Yucca glauca. Cercocarpus montanus* dominated shrublands are not included in this map unit (mapped separately). .....**Montane-Foothill Dry-Mesic Shrubland Alliances #18**

15a. Conifer forests and woodlands (deciduous trees may make up less than 25% cover of the total tree canopy). Tree canopy is generally >25% cover, but may include open woodland stands with 10-25% tree cover (if lacking a strong perennial herbaceous layer i.e. savanna). **20**

15b. Broadleaf forests and woodlands or mixed conifer-aspen forests and woodlands (deciduous trees make up 25-100% of the tree canopy). **16**

16a. Broadleaf forest or woodland typically dominated by *Populus tremuloides* (and possible inclusions of other broadleaf tree species) with less than 25% total tree canopy cover of conifers ....**Aspen Forest Alliances #2**

16b. Mixed conifer-broadleaf forests and woodlands co-dominated by *Populus tremuloides* and a conifer trees with 25-75% relative tree canopy of each canopy type.. **17**

17a. Mixed conifer-broadleaf forests and woodlands co-dominated by aspen (*Populus tremuloides*) and ponderosa pine (*Pinus ponderosa*) trees with 25-75% relative tree canopy of each canopy type. Other conifer tree species such as limber pine *(Pinus flexilis)* and Douglas-fir *(Pseudotsuga menziesii)* may be present to codominate as long as ponderosa pine is the dominant conifer. Tyically found on or near stream terraces and in areas with past canopy disturbance..**Ponderosa Pine - Aspen Forest Alliance #33**

17b. Mixed conifer-broadleaf forests and woodlands co-dominated by *Populus tremuloides* and conifers, but *Pinus ponderosa* does not dominate conifers **18**

18a. Mixed conifer-broadleaf forests and woodlands co-dominated by aspen (*Populus tremuloides*) and limber pine (*Pinus flexilis*) with 25-75% relative tree canopy of each canopy type. Other conifers may be present such as *Pinus aristata, Pinus ponderosa,* or *Pseudotsuga menziesii,* but with less cover than *Pinus flexilis*. Tyically found on or near stream terraces and in areas with past canopy disturbance. ....**Aspen - Limber Pine Forest Alliance #3**

18b. Mixed conifer-broadleaf forests and woodlands co-dominated by *Populus tremuloides* and conifers, but *Pinus flexilis* does not dominate conifers.. **19**

19a. Mixed conifer-broadleaf forests and woodlands co-dominated by deciduous trees (*Populus angustifolia* and/or *Populus tremuloides*) and conifers (*Abies concolor, Picea pungens* and *Pseudotsuga menziesii)* with 25-75% relative tree canopy of each canopy type. Tyically found on or near stream terraces and adjacent toe slopes of hillsides. .... **White Fir – Mixed Deciduous Lowland Forest Alliances #53**

19a. Mixed conifer-broadleaf forests and woodlands co-dominated by aspen (*Populus tremuloides*) and conifers, typically Douglas-fir (*Pseudotsuga menziesii*) trees with 25-75% relative tree canopy of each canopy type. Other conifer trees may be present such as *Abies concolor* and montane pines (*Pinus aristata, P. flexilis, P. ponderosa*), but do not dominate the conifer portion of the canopy. Tyically found in upland areas with past canopy disturbance ....**Aspen – Douglas-fir (White Fir) Upland Forest Alliances #63**

20a. Foothill conifer woodlands dominated by *Pinus edulis* and/or *Juniperus* spp. If *Pinus ponderosa* or *Abies concolor* is present, then cover is low and trees are restricted to mesic microsites (inclusions).. **21**

20b. Foothill conifer woodlands dominated *Pinus ponderosa* or other montane tree. *Pinus edulis* and/or *Juniperus* spp. are sometimes codominant. **24**

21a. Open woodlands to dense forest dominated by *Pinus edulis* or codominated by *Juniperus scopulorum.* Understory is absent or sparse (<5% cover) **22**
21b. Open to dense woodland dominated by *Pinus edulis* or codominated by *Juniperus scopulorum.* Herbaceous or shrub understory is present **23**

22a. Open woodlands dominated by *Pinus edulis* or codominated by *Juniperus scopulorum* on a rocky substrates (colluvium and bedrock) on colluvial slopes and ridges. Understory is absent or sparse (<5% cover) and does not form a shrub or herbaceous layers because the rocky substrate restricts understory plant growth........ **Pinyon Pine / Rockland Woodland Association #31**
22b. Open to moderately-dense woodland dominated by *Pinus edulis* or codominated by *Juniperus scopulorum* known from upper alluvial fan on southern portion of project area. Substrate is small and large alluvial rock and may form uniform layer of cobbles fluvial deposition or mixed sizes indicating mass wasting. Understory is absent or sparse (<5% cover) and does not form distinct shrub or herbaceous layers. Ground surface often cover by pine needles. .... **Pinyon Pine Woodland with Herbaceous or Sparse Understory #32**

23a. Open to moderately dense woodlands dominated by *Pinus edulis* or codominated by *Juniperus scopulorum.* Understory is characterized by shrubs with or without an herbaceous layer. Substrate may be rocky or not **Pinyon-Juniper Woodland with Shrub Understory #60**
23b. Open to moderately dense woodlands dominated by *Pinus edulis* or codominated by *Juniperus scopulorum.* Understory is characterized by an herbaceous layer often dominated by perennial graminoids such as *Bouteloua gracilis*. Scattered shrubs may be present, but do not form a layer .... **Pinyon Pine Woodland with Herbaceous or Sparse Understory #32**

24a. Conifer forests and woodlands dominated by *Abies concolor, Picea pungens,* or *Pseudotsuga menziesii,* and sometime co-dominated by *Pinus ponderosa. Populus tremuloides* may be present, but is generally <25% of tree canopy .... **Go to Key E**
24b Open to moderately dense woodlands dominated by *Pinus ponderosa,* sometime with *Pinus edulis* or *Juniperus scopulorum* present to codominant. **25**

25a. Very open woodlands characterized by ponderosa pine (*Pinus ponderosa*) that occur on alluvial fan where climbing dunes extend sandsheet (sand ramp). Substrates are deep sand over rocky alluvial fan. Stands may have scattered trees with understory dominated by grasses (*Achnatherum hymenoides, Hesperostipa comata,* and/or *Muhlenbergia pungens*) or shrubs (especially *Ericameria nauseousa*) .... **Ponderosa Pine Sand Ramp Woodland #34**
25b. Open to moderately dense woodlands dominated by ponderosa pine (*Pinus ponderosa*) growing on rocky substrates. If soil is sandy then not deep sand that occurs on sand ramp.......... **26**

26b. Open to moderately dense woodlands dominated by *Pinus ponderosa* sometime with *Pinus edulis* or *Juniperus scopulorum* codominant. Understory is characterized by shrubs with or with an herbaceous layer. Substrate may be rocky or not.......... **Ponderosa Pine Woodland with Shrub Understory #48**
26b Open to moderately dense woodlands dominated by *Pinus ponderosa* sometime with *Pinus edulis* or *Juniperus scopulorum* codominant. Understory is characterized by an herbaceous layer. Scattered shrubs may be present, but do not form a layer.......... **Ponderosa Pine Woodland with Herbaceous Understory #49**

KEY E Montane and Subalpine Map Classes

Sites occur on mountain slopes between montane and subalpine zones

Montane and subalpine mountain slopes and valleys of the Sangre de Cristo Range (above PJ woodland zone and below alpine). Elevations typically range between 2660-3660 m (8,725-12, 000 feet), but may extend below in cold air drainage area and above on southern aspects.

1a. Site is permanently or semi-permanently flooded such as a pond, lake or reservoir ....**Water #70**
1b. Site is not flooded or only seasonally flooded.. **2**

2a. Site occurs along intermittent or perennial stream channel, mesic stream terrace or wetland.................................. **3**
2b. Site is upland... **12**

3a. Herbaceous dominated wetlands. Scattered trees and shrubs may be present but do not form a layer. **4**
3b. Riparian shrubland or forest vegetation that occurs along perennial or semi-perennial stream **5**

4a. Vegetation dominated by herbaceous species that occur on montane to lower subalpine wetland sites with very low-velocity surface and subsurface flows. Stands occur mostly small meadows in montane and lower subalpine valleys and as narrow wetland bands along streams and lakes. One large patch example occurs at Willow Creek Park. Soils are typically highly organic. Characteristic wetland species include *Calamagrostis canadensis, Caltha leptosepala, Carex utriculata, Deschampsia caespitosa, Eleocharis quinqueflora, Juncus balticus, Ranuculus* spp.*, Senecio triangularis* and *Veratrum tenuipetalum.* Shrubs such as *Dasiphora floribunda* or *Salix* spp. may be present in some stands. Disturbed stands may be dominated by introduced forage species such as *Poa pratensis* and *Bromus inermis.* This map unit includes subirrigated wet meadows dominated by mesic species with wetland indicator species. ....**Montane - Lower Subalpine Wetland Alliances #24**
4b. Vegetation dominated by herbaceous species that occur on alpine and upper subalpine wetland sites with very low-velocity surface and subsurface flows. Stands occur at and above treeline as small to medium wet meadows in alpine valleys, as narrow wetland bands along streams and alpine lakes, depressions or gentle slope below snowfields or seeps. Soils are typically highly organic muck. It is characterized by alpine and some subalpine wetland and mesic species such as *Calamagrostis stricta, Caltha leptosepala, Cardamine cordifolia, Carex illota, Carex microptera, Carex nigricans, Carex scopulorum, Carex vernacula, Deschampsia caespitosa, Eleocharis quinqueflora, Geum rossii, Juncus drummondii, Phippsia algida, Polygonum bistortoides, Rorippa alpina, Trifolium parryi, and Trollius laxus*. Stands may be seasonally flooded during spring runoff, but dry out during the growing season. Stands occur as large meadows in alpine valleys.......... **Alpine - Upper Subalpine Herbaceous Wetland Alliances #64**

5a. Lower montane to subalpine shrublands restricted to drainages, stream terraces, semi-riparian flats and spring or seep fed slopes. **6**
5b. Lower montane to subalpine woodlands restricted to drainages, stream terrace, semi-riparian flats and spring or seep fed slopes... **8**

6a. Foothill to lower montane shrublands that are restricted to drainages, semi-riparian flats and spring or seep fed slopes. Typically dominated or codominated by *Salix exigua*, but may have inclusions of other communities such as *Crataegus rivularis* and *Salix irrorata*. ....**Coyote Willow Temporarily Flooded Shrubland Alliances #9**
6b. Montane to subalpine shrubland woodlands restricted to drainages, semi-riparian flats and spring or seep fed slope. **7**

7a. Short willow shrublands restricted to drainages and stream terraces and in upper subalpine and alpine zones that are dominated by *Salix planifolia* or *S. brachycarpa.* Short *Picea engelmannii* trees may be present in some stands. . **Subalpine - Alpine Riparian Shrubland #44**
7b. Tall shrublands restricted to drainages, stream terraces, semi-riparian flats and elevations and spring or seep fed slopes in montane to lower subalpine zones. These shrublands occurring as narrow bands of shrubs lining streambanks and alluvial terraces in narrow, mountain valley bottoms and often occurs as a mosaic of multiple

communities that are shrub- and herb-dominated. Dominant species include *Alnus incana, Betula occidentalis, Prunus virginiana, Salix bebbiana, S. drummondiana, S. monticola* and tall *Salix planifolia* (in upper montane and lower subalpine). *Salix exigua* is typically absent, but may be present with very low cover .... **Montane Riparian Shrubland #65**

8a. Lowland and upland mixed conifer forests and woodlands of the montane zone dominated or codominated by *Pseudotsuga menziesi* and/or *Abies concolor* in canopy. *Picea pungens* may dominate or codominate small patch inclusions. Other conifers such as may be present. In transition areas to subalpine, *Abies lasiocarpa* and/or *Picea engelmannii* may be present with less than a third of the canopy cover. Deciduous trees, *Populus angustifolia* or *P. tremuloides* may be present, but with generally <25% of tree canopy. .... **White Fir - Douglas-fir Forest and Woodland Alliances #11**

8b. Conifer forests and woodlands Not dominated by *Pseudotsuga menziesii, Abies concolor* and/or *Picea pungens* although this species may be present **9**

9a. Conifer woodlands restricted to drainages, steam terraces, semi-riparian flats and spring or seep fed slopes in subalpine zone. Dominant species include *Abies lasiocarpa* and *Picea engelmannii* sometime with scattered *Pseudotsuga menziesii* or *Populus tremuloides.* .... **Subalpine Riparian Forest Alliances #43**

9b. Broadleaf or mixed conifer-broadleaf riparian forests and woodlands. **10**

10a. Mixed conifer-broadleaf forests and woodlands co-dominated by deciduous trees (*Populus angustifolia* and/or *Populus tremuloides*) and conifers (*Abies concolor, Picea pungens* and *Pseudotsuga menziesii)* with 25-75% relative tree canopy of each canopy type. Tyically found on stream terraces and adjacent toe slopes of hillsides.**White Fir – Mixed Deciduous Lowland Forest Alliances #53**

10b. Broadleaf riparian forests and woodlands. **11**

11a Lower montane woodlands restricted to drainages, stream terraces, semi-riparian flats and spring or seep fed slope. Stands are characterized and typically dominated by *Populus angustifolia,* the diagnostic species. The significant presence of this species (>5% cove) in this deciduous forest is diagnostic of this map unit. Other trees such as *Abies concolor, Picea pungens, Populus tremuloides, Pseudotsuga menziesii, Juniperus scopulorum* may be present. *Populus tremuloides* is especially common in montane stands transitioning to Aspen Forest and may codominate. Small patch (inclusions below MMU) aspen stands may be may be present in this map unit. Mesic shrubs such as *Alnus incana, Betula occidentalis, Salix* spp. are often present .... **Narrowleaf Cottonwood Temporarily Flooded Woodland Alliance #27**

11b. Broadleaf forest or woodland typically dominated by *Populus tremuloides* with less than 25% total tree canopy cover of conifers ....**Aspen Forest Alliances #2**

12a. Tall shrubland of stunted trees and shrubs that occurs in avalanche areas. Common species are stunted/damaged tree species such as Populus tremuloides, Abies lasiocarpa and Picea engelmannii, and Pseudotsuga menziesii .... **Avalanche Chute Shrubland #56**

12b. Not as above (site not avalanche chute). **13**
...

13a. Site is characterized by steep (often >30 degree slope), rock outcrop, talus an scree. Vegetation is barren to relatively sparse. Scattered *Pinus ponderosa, P. flexilis, P. edulis* and *Juniperus scopulorum* trees or shrubs such as *Cercocarpus montanus, Holidiscus dumosus,* or *Ribes* spp. may be present. At higher elevations open tree canopy woodlands dominated by *Abies concolor or Pseudotsuga menziesii* on scree may occur. If shrubs form an open to moderately dense layer, then go to couplet #15.. .... **Cliff, Canyon and Massive Bedrock #37**

13b. Site may be rocky or not, but is Not characterized by steep, rocky sparsely vegetated or wooded scree **14**

14a. Montane – subalpine grasslands found between 2200-3000 m elevation on dry flat to rolling plains or lower side slopes , but may extend up to 3350 m on warm aspects. Vegetation is often dominated by bunch grasses such as *Danthonia* parryi, *Festuca arizonica, F. therberi, Muhlenbergia filiculmis*, or *M. montana.* However, heavily grazed and disturbed stands may be dominated by *Bouteloua gracilis* or other dry shortgrass with montane bunchgrass species only present. ....**Montane - Subalpine Grassland #46**

14b. Site is characterized by woody vegetation on lower montane to upper subalpine slopes..................................... **15**

15a. Site is characterized by shrubs... **16**
15b. Site is characterized by trees. **18**

16a. Gennerally dry shrubland or shrub steppe of montane and foothill elevations that is strongly dominated to co-dominated by mountain mahogany (*Cercocarpus montanus*). Low cover of other shrub may be present including *Rhus trilobata, Ribes cereum, Symphoricarpos oreophilus, S. rotundifolia* and/or *Yucca glauca*. ....**Mountain Mahogany Shrubland Alliance #25**
16b. Shrubland may occur on dry or mesic sites, but mountain mahogany (*Cercocarpus montanus*) is absent or has low cover.

17ba. Site is characterized by relatively steep hillsides (>15% slope) of rock outcrop, talus and scree. Vegetation is sparse to moderately dense shrubland and often characterized by *Holidiscus dumosus, Rhus trilobata,*or *Ribes cereum*. *Cercocarpus montanus* is generally absent or sparse... ....**Montane-Foothill Dry-Mesic Shrubland Alliances (dry phase) #18**
17b Relatively mesic shrubland or shrub steppe extending into upper montane zone. Shrub layer is dominated or co-dominated by *Acer glabrum, Amelanchier utahensis, Chrysothamnus parryii, Holidiscus dumosus, Prunus virginiana, Purshia stansburiana, P. tridentata, Rhus trilobata, Ribes cereum, Symphoricarpos oreophilus, S. rotundifolia* and/or *Yucca glauca. Cercocarpus montanus* may be present but not dominant in this shrubland ....**Montane-Foothill Dry-Mesic Shrubland Alliances (mesic phase) #18**

18a. Broadleaf forests and woodlands or mixed conifer-aspen forests and woodlands (deciduous trees make up 25-100% of the tree canopy). **19**
18b. Conifer forests and woodlands (deciduous trees may make up less than 25% cover of the total tree canopy). Tree canopy is generally >25% cover, but may include open woodland stands with 15-25% tree cover (if lacking a strong perennial herbaceous layer i.e. savanna). **23**

19a. Broadleaf forest or woodland typically dominated by *Populus tremuloides* (and possible inclusions of other broadleaf tree species) with less than 25% total tree canopy cover of conifers... ....**Aspen Forest Alliances #2**
19b. Mixed conifer-broadleaf forests and woodlands co-dominated by *Populus tremuloides* and a conifer trees with 25-75% relative tree canopy of each canopy type.. **20**

20a. Mixed conifer-broadleaf forests and woodlands co-dominated by *Populus tremuloides* and *Pinus ponderosa* trees with 25-75% relative tree canopy of each canopy type. Other conifer tree species such as limber pine *(Pinus flexilis)* and Douglas-fir *(Pseudotsuga menziesii)* may be present to codominate as long as ponderosa pine is the dominant conifer. Tyically found on or near stream terraces and in areas with past canopy disturbance Tyically found on or near stream terraces and in areas with past canopy disturbance. ....
. ...**Ponderosa Pine - Aspen Forest Alliance #33**
20b. Mixed conifer-broadleaf forests and woodlands co-dominated by *Populus tremuloides* and conifers, but *Pinus ponderosa* does not dominate conifers **21**

21a. Mixed conifer-broadleaf forests and woodlands co-dominated by aspen (*Populus tremuloides*) and limber pine (*Pinus flexilis*) with 25-75% relative tree canopy of each canopy type. Other conifers may be present such as *Pinus aristata, Pinus ponderosa,* or *Pseudotsuga menziesii,* but with less cover than *Pinus flexilis*. Engelmann spruce (*Picea engelmannii*) and/or subalpine fir (*Abies lasiocarpa*) trees have <1/3 cover of conifer tree canonpy. Rarely, *Pinus aristata* may dominate conifer tree canopy (please note if so). Tyically found on or near stream terraces and in areas with past canopy disturbance.. ....**Aspen - Limber Pine Forest Alliance #3**
21b. Mixed conifer-broadleaf forests and woodlands co-dominated by *Populus tremuloides* and conifers, but *Pinus flexilis* does not dominate conifers or *Picea engelmannii* and/or *Abies lasiocarpa* trees have >1/3 conifer tree canopy **22**

22a. Mixed conifer-broadleaf forests and woodlands co-dominated by aspen (*Populus tremuloides*) and conifers, typically Douglas-fir (*Pseudotsuga menziesii*) trees with 25-75% relative tree canopy of each canopy type. Other conifer trees may be present such as *Abies concolor* and montane pines (*Pinus aristata, P. flexilis, P. ponderosa*), but do not dominate the conifer portion of the canopy. *Picea engelmannii* and/or *Abies lasiocarpa* trees have <1/3 conifer tree canopy Tyically found on or near stream terraces and in areas with past canopy disturbance.... **Aspen – Douglas-fir (White Fir) Upland Forest Alliance #63**

22b. Mixed conifer-broadleaf forests and woodlands co-dominated by aspen (*Populus tremuloides*) and conifers with 25-75% relative tree canopy of each canopy type. Engelmann spruce (*Picea engelmannii*) and/or subalpine fir (*Abies lasiocarpa*) trees dominate or codominate the conifer portion of this mixed type. Other conifer trees may be present such as Douglas-fir (*Pseudosuga menziesii*) and montane pines (*Pinus aristata, P. flexilis, P. ponderosa*), but do not dominate the conifer portion of the canopy. Tyically found on or near stream terraces and in areas with past canopy disturbance.. ....**Subalpine Fir (Engelmann Spruce) - Aspen Forest Alliance #50**

23a. Open to moderately dense woodlands dominated or codominated by *Pinus ponderosa* sometime with *Pinus edulis* or *Juniperus scopulorum* codominant. Pinus ponderosa has >5% cover (not accidental) in these mixed stands. If present, other trees have minor cover **24**

23b Open to moderately dense conifier woodlands dominated by other trees. **25**

24a. Open to moderately dense woodlands dominated by *Pinus ponderosa* sometime with *Pinus edulis* or *Juniperus scopulorum* codominant. Understory is characterized by shrubs with or with an herbaceous layer. Substrate may be rocky or not... **Ponderosa Pine Woodland with Shrub Understory #48**

24b Open to moderately dense woodlands dominated by *Pinus ponderosa* sometime with *Pinus edulis* or *Juniperus scopulorum* codominant. Understory is characterized by an herbaceous layer. Scattered shrubs may be present, but do not form a layer...**Ponderosa Pine Woodland with Herbaceous Understory #49**

25a. Conifer woodlands dominated by *Pinus edulis* and/or *Juniperus scopulorum* that are typically restricted to warmer southly aspects in montane zone. If *Pinus ponderosa, Pseudotsuga menziesii* or *Abies concolor* is present, then cover is low (<5% cover). **26**

25b. Montane or subalpine conifer forest or woodlands dominated by *Pseudotsuga menziesii*, *Abies concolor, Pinus aristata, P. flexilis, P. ponderosa*. *Pinus edulis* and/or *Juniperus* spp. may be present but not dominant.............. **28**

26a. Open woodlands dominated by *Pinus edulis* or codominated by *Juniperus scopulorum* on a rocky substrates (colluvium and bedrock) on colluvial slopes and ridges. Understory is absent or sparse (<5% cover) and does not form a shrub or herbaceous layers because the rocky substrate restricts understory plant growth........ **Pinyon Pine / Rockland Woodland Association #31**

26b. Open to dense woodland dominated by *Pinus edulis* or codominated by *Juniperus scopulorum.* Herbaceous or shrub understory is present **27**

27a. Open to moderately dense woodlands dominated by *Pinus edulis* or codominated by *Juniperus scopulorum.* Understory is characterized by shrubs (>5% civer) with or without an herbaceous layer. Substrate may be rocky or not... **Pinyon-Juniper Woodland with Shrub Understory #60**

27b. Open to moderately dense woodlands dominated by *Pinus edulis* or codominated by *Juniperus scopulorum.* Understory is characterized by an herbaceous layer but may be sparse. Sparse scattered shrubs (<5% cover) may be present, but do not form a layer .... **Pinyon Pine Woodland with Herbaceous or Sparse Understory #32**

28a. Conifer forests and woodlands dominated by *Pinus aristata* and/or *Pinus flexilis.* Stands typically occur on dry, exposed, rocky sites such as ridge lines and southly aspect slopes. Other trees species my be present but combined comprise less than half of the tree canopy. *Pinus aristata* dominated stands are more common on upper subalpine slopes and ridges and may be codominated by *Picea engelmannii*, whereas *Pinus flexilis* dominated stands are more common in montane and lower subalpine zones. .... **Limber-Bristlecone Pine Woodland Alliances #42**

28b. Conifer forests and woodlands NOT dominated by *Pinus aristata* and/or *Pinus flexilis* although these species may be present in stand **29**

29a. Matrix lowland and upland mixed conifer forests and woodlands of the montane zone. The tree canopy is dominated or codominated by *Pseudotsuga menziesi* and/or *Abies concolor* in canopy. *Pinus aristata, P. flexilis,* or *P. ponderosa* may be present to codominant forming a montane mixed conifer stand. In transition areas to subalpine, *Abies lasiocarpa* and/or *Picea engelmannii* may be present with less than a third of the canopy cover. *Populus tremuloides* may be present, but is generally <25% of tree canopy. *Picea pungens* may be occasionally present to dominant in tree canopy, especially in lowland stands.. .... **White Fir - Douglas-fir Forest and Woodland Alliances #11**

29b. Matrix forests and woodland of the subalpine zone. The tree canopy is dominated or codominated by *Picea engelmannii* and/or *Abies lasiocarpa* with at least a third of the tree canopy If *Pinus aristata* codominates with *Picea engelmannii*, then go to to couplet #28. *Pinus flexilis* and/or *Pseudotsuga menziesii* may be present in the tree canopy in canopy in lower elevation stands. The understory is variable and may be sparse or dominated by *Festuca thurberi, Juniperus communis, Mertensia ciliata, Populus tremuloides* may be present, but is generally <25% of tree canopy.. **Subalpine Spruce-Fir Forest and Woodland Alliances #41**

KEY F Alpine Map Classes

Sites occur in alpine and subalpine-alpine transition zones

This region extends from ~ 3355m (11,000 feet) (depending on aspect) to over 4270 m (14,000 feet) and includes subalping grassland, krummholz, alpine turf and wet meadows, and alpine scree and rock fields.

1a. Site is permanently or semi-permanently flooded such as an alpine lake...**Water #70**
1b. Site is not flooded or only seasonally flooded.. **2**

2a. Site is a wetland or riparian shrubland that occurs in depressions or along stream channels. **3**
2b. Site is upland. May be wet or dry, but not associated with major stream channels. **5**

3a. Herbaceous dominated wetlands. Scattered trees and shrubs may be present but do not form a layer. **4**
3b. Shrublands restricted to drainages and stream terraces and are dominated be alpine willow species *Salix planifolia* or *S.. brachycarpa.* Short *Picea engelmannii* trees may be present in some stands. .... **Subalpine - Alpine Riparian Shrubland #44**

4a. Vegetation dominated by herbaceous species that occur on montane to lower subalpine wetland sites with very low-velocity surface and subsurface flows. Stands occur mostly small meadows in montane and lower subalpine valleys and as narrow wetland bands along streams and lakes. Soils are typically highly organic. Characteristic wetland species include *Calamagrostis canadensis, Caltha leptosepala, Carex utriculata, Deschampsia caespitosa, Eleocharis quinqueflora,* and *Senecio triangularis.* Shrubs such as *Dasiphora floribunda or Salix species* may be present in some stands .... **Montane - Lower Subalpine Wetland Alliances #24**

4b. Vegetation dominated by herbaceous species that occur on alpine and upper subalpine wetland sites with very low-velocity surface and subsurface flows. Stands occur at and above treeline as small to medium wet meadows in alpine valleys, as narrow wetland bands along streams and alpine lakes, depressions or gentle slope below snowfields or seeps. Soils are typically highly organic muck. It is characterized by alpine and some subalpine wetland and mesic species such as *Calamagrostis stricta, Caltha leptosepala, Cardamine cordifolia, Carex illota, Carex microptera, Carex nigricans, Carex scopulorum, Carex vernacula, Deschampsia caespitosa, Eleocharis quinqueflora, Geum rossii, Juncus drummondii, Phippsia algida, Polygonum bistortoides, Rorippa alpina, Trifolium parryi, and Trollius laxus*. Stands may be seasonally flooded during spring runoff, but dry out during the growing season. Stands occur as large meadows in mountain valleys .... **Alpine - Upper Subalpine Herbaceous Wetland Alliances #64**

5a. Upland site is barren or sparsely vegetated by vascular species (typically <15% cover). May have higher cover of non-vascular species. **6**
5b. Upland site is moderate to densely vegetated by vascular species **7**

6a. Site is barren or sparsely vegetated alpine bedrock, talus, scree or boulder fields. Landforms include colluvial slopes, cliffs, ridges. Elevation ranges from 3434-3888 m. There is typically low cover of herbaceous vegetation that is often diverse. Common species *Aquilegia caerulea, Artemisia arctica, Cirsium scopulorum, Festuca brachyphylla, Geum rossii, Minuartia obtusiloba, Polemonium viscosum, Saxifraga bronchialis, Senecio atratus, Silene acaulis, Trisetum spicatum* and many other alpine cushion and turf plants.. **Alpine Bedrock and Scree #35**

6b. Site is found on windswept upper slopes, saddles, ridges at elevations ranging from 3476-4076 m. Gravel and bare ground typically have moderate to high cover. Vegetation is characterized by sparse to sometime moderate cover of herbaceous vegetation dominated by cushion plants. Common species are *Androsace chamaejasme, Arenaria fendleri, Artemisia scopulorum, Erigeron pinnatisectus, Erigeron simplex, Festuca brachyphylla, Geum rossii, Luzula spicata, Minuartia obtusiloba, Oreoxis alpina, Paronychia pulvinata, Phlox condensata, Potentilla pulcherrima, Saxifraga rhomboidea, Selaginella densa, Silene acaulis, Tetraneuris acaulis, Tonestus pygmaeus, Trifolium dasyphyllum and Trisetum spicatum.* Cover of graminoids such as *Carex elynoides* and *Carex rupestris var. drummondiana* is sparse and does not form a turf.. **Alpine Fell-Field Alliances #36**

7a. Herbaceous dominated upland. Scattered trees and shrubs may be present but do not form a layer........................ **8**

7b. Shrub dominated upland.. **10**

8a. Stands dominated by subalpine grasses such as *Festuca thurberi.* These subalpine grasslands may extend up to 3350 m on warm southerly aspects..**Montane - Subalpine Grassland Alliances #46**

8b. Stands dominated by alpine species **9**

9a. Alpine herbaceous vegetation dominated or codominated by graminoids with low cover of rock. Found between 3200 and 4500 m in elevation on gentle to moderate slopes, flat ridges, valleys, and basins. Dominant species include *Artemisia arctica*, *Carex* spp., *Deschampsia cespitosa, Festuca brachyphylla, Geum rossii, obresia myosuroides*, and *Trifolium dasyphyllum*. Cover of cushion plants is generally lower than graminoides ....
....**Alpine Turf Alliances #38**

9b. Site is found on windswept upper slopes, saddles, ridges at elevations ranging from 3476-4076 m. Gravel and bare ground typically have moderate to high cover. Vegetation is characterized by sparse to sometime moderate cover of herbaceous vegetation dominated by cushion plants. Common species are *Androsace chamaejasme, Arenaria fendleri, Artemisia scopulorum, Erigeron pinnatisectus, Erigeron simplex, Festuca brachyphylla, Geum rossii, Luzula spicata, Minuartia obtusiloba, Oreoxis alpina, Paronychia pulvinata, Phlox condensata, Potentilla pulcherrima, Saxifraga rhomboidea, Selaginella densa, Silene acaulis, Tetraneuris acaulis, Tonestus pygmaeus, Trifolium dasyphyllum and Trisetum spicatum.* Cover of graminoids such as *Carex elynoides* and *C. rupestris var. drummondiana* is sparse and does not form a turf...
.... **Alpine Fell-Field Alliances #36**

10a. Minor shrubland type at GRSA. This shrubland occurs near upper tree line and is composed of dwarf wind-shaped trees. Elevations range from 3527-3750 m on harsh, windswept sites. Sites are nearly level to steeply sloping. The woody canopy is dominated by stunted *Abies lasiocarpa, Picea engelmannii* and/or *Pinus aristata*. Other woody species include shrubs and dwarf-shrubs, such as *Ribes montigenum, Salix brachycarpa, Salix glauca, Salix planifolia, Vaccinium membranaceum, and Vaccinium scoparium* that may be present to codominant. Stands strongly dominated by alpine willows (Salix brachycarpa, S. planifolia) should be mapped as alpine willow (spruce) map unit. Rock outcrop is common. Stands form a mosaic of dense patches of dwarfed evergreen conifer trees (usually less than 2 m tall), alpine turf meadow or fellfields. ....
....**Subalpine Fir - Engelmann Spruce – Bristlecone Pine - Limber Pine Krummholz Shrubland Alliance #51**

10b. Alpine willow dominated shrublands (*Salix planifolia* and *S. brachycarpa*) found in mesic upland sites such as seep areas below snow fields, alpine basins, terraces and occasionally ridges (3355-3700 m elevation). Landforms are variable and include minor drainage channels, colluvial slopes, and ridges. Sites are often below areas of snow acculmulation. Occurs in upper watersheds and is typically not associated with a distinct riparian zone. Similar to krummholz and subalpine riparian shrubland, but does not occur on wind-blasted ridges codominated by windshaped conifers or associated with main stream channels. Short *Picea engelmannii* trees may be present in some stands. .... **Alpine Willow (Spruce) Shrubland Alliances #57**

Appendix I:
Plant Association Descriptions for Great Sand Dunes National Park and Preserve

NATIONAL VEGETATION CLASSIFICATION

Vegetation Associations of Great Sand Dunes National Park and Preserve

29 October 2009

by
Colorado Natural Heritage Program,

Colorado State University
254 General Services Bldg.
Fort Collins, Colorado 80523

and

NatureServe

1101 Wilson Blvd., 15th floor
Arlington, VA 22209

4001 Discovery, Suite 270
Boulder, CO 80303

This subset of the International Ecological Classification Standard covers vegetation associations of Great Sand Dunes National Park and Preserve. This classification has been developed in consultation with many individuals and agencies and incorporates information from a variety of publications and other classifications. Comments and suggestions regarding the contents of this subset should be directed to Mary J. Russo, Central Ecology Data Manager, Durham, NC mary_russo@natureserve.org, and/or Keith Schulz, Vegetation Ecologist, Boulder, CO <keith_schulz@natureserve.org>.

Citations:

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NatureServe
1101 Wilson Blvd, 15th floor
Arlington, VA 22209

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[1] NatureServe is an international organization including NatureServe regional offices, a NatureServe central office, U.S. State Natural Heritage Programs, and Conservation Data Centres (CDC) in Canada and Latin America and the Caribbean. Ecologists from the following organizations have contributed the development of the ecological systems classification

United States
Central NatureServe Office, Arlington, VA; Eastern Regional Office, Boston, MA; Midwestern Regional Office, Minneapolis, MN; Southeastern Regional Office, Durham, NC; Western Regional Office, Boulder, CO; Alabama Natural Heritage Program, Montgomery AL; Alaska Natural Heritage Program, Anchorage, AK; Arizona Heritage Data Management Center, Phoenix AZ; Arkansas Natural Heritage Commission Little Rock, AR; Blue Ridge Parkway, Asheville, NC; California Natural Heritage Program, Sacramento, CA; Colorado Natural Heritage Program, Fort Collins, CO; Connecticut Natural Diversity Database, Hartford, CT; Delaware Natural Heritage Program, Smyrna, DE; District of Columbia Natural Heritage Program/National Capital Region Conservation Data Center, Washington DC; Florida Natural Areas Inventory, Tallahassee, FL; Georgia Natural Heritage Program, Social Circle, GA; Great Smoky Mountains National Park, Gatlinburg, TN; Gulf Islands National Seashore, Gulf Breeze, FL; Hawaii Natural Heritage Program, Honolulu, Hawaii; Idaho Conservation Data Center, Boise, ID; Illinois Natural Heritage Division/Illinois Natural Heritage Database Program, Springfield, IL; Indiana Natural Heritage Data Center, Indianapolis, IN; Iowa Natural Areas Inventory, Des Moines, IA; Kansas Natural Heritage Inventory, Lawrence, KS; Kentucky Natural Heritage Program, Frankfort, KY; Louisiana Natural Heritage Program, Baton Rouge, LA; Maine Natural Areas Program, Augusta, ME; Mammoth Cave National Park, Mammoth Cave, KY; Maryland Wildlife & Heritage Division, Annapolis, MD; Massachusetts Natural Heritage & Endangered Species Program, Westborough, MA; Michigan Natural Features Inventory, Lansing, MI; Minnesota Natural Heritage & Nongame Research and Minnesota County Biological Survey, St. Paul, MN; Mississippi Natural Heritage Program, Jackson, MI; Missouri Natural Heritage Database, Jefferson City, MO; Montana Natural Heritage Program, Helena, MT; National Forest in North Carolina, Asheville, NC; National Forests in Florida, Tallahassee, FL; National Park Service, Southeastern Regional Office, Atlanta, GA; Navajo Natural Heritage Program, Window Rock, AZ; Nebraska Natural Heritage Program, Lincoln, NE; Nevada Natural Heritage Program, Carson City, NV; New Hampshire Natural Heritage Inventory, Concord, NH; New Jersey Natural Heritage Program, Trenton, NJ; New Mexico Natural Heritage Program, Albuquerque , NM; New York Natural Heritage Program, Latham, NY; North Carolina Natural Heritage Program, Raleigh, NC; North Dakota Natural Heritage Inventory, Bismarck, ND; Ohio Natural Heritage Database, Columbus, OH; Oklahoma Natural Heritage Inventory, Norman, OK; Oregon Natural Heritage Program, Portland, OR; Pennsylvania Natural Diversity Inventory, PA; Rhode Island Natural Heritage Program, Providence, RI; South Carolina Heritage Trust, Columbia, SC; South Dakota Natural Heritage Data Base, Pierre, SD; Tennessee Division of Natural Heritage, Nashville, TN; Tennessee Valley Authority Heritage Program, Norris, TN; Texas Conservation Data Center, San Antonio, TX; Utah Natural Heritage Program, Salt Lake City, UT; Vermont Nongame & Natural Heritage Program, Waterbury, VT; Virginia Division of Natural Heritage, Richmond, VA; Washington Natural Heritage Program, Olympia, WA; West Virginia Natural Heritage Program, Elkins, WV; Wisconsin Natural Heritage Program, Madison, WI; Wyoming Natural Diversity Database, Laramie, WY

Canada
Alberta Natural Heritage Information Centre, Edmonton, AB, Canada; Atlantic Canada Conservation Data Centre, Sackville, New Brunswick, Canada; British Columbia Conservation Data Centre, Victoria, BC, Canada; Manitoba Conservation Data Centre. Winnipeg, MB, Canada; Ontario Natural Heritage Information Centre, Peterborough, ON, Canada; Quebec Conservation Data Centre, Quebec, QC, Canada; Saskatchewan Conservation Data Centre, Regina, SK, Canada; Yukon Conservation Data Centre, Yukon, Canada

Latin American and Caribbean
Centro de Datos para la Conservacion de Bolivia, La Paz , Bolivia; Centro de Datos para la Conservacion de Colombia, Cali,Valle, Columbia; Centro de Datos para la Conservacion de Ecuador, Quito, Ecuador; Centro de Datos para la Conservacion de Guatemala, Ciudad de Guatemala , Guatemala; Centro de Datos para la Conservacion de Panama, Querry Heights , Panama; Centro de Datos para la Conservacion de Paraguay, San Lorenzo , Paraguay; Centro de Datos para la Conservacion de Peru, Lima, Peru; Centro de Datos para la Conservacion de Sonora, Hermosillo, Sonora , Mexico; Netherlands Antilles Natural Heritage Program, Curacao , Netherlands Antilles; Puerto Rico-Departmento De Recursos Naturales Y Ambientales, Puerto Rico; Virgin Islands Conservation Data Center, St. Thomas, Virgin Islands.

NatureServe also has partnered with many International and United States Federal and State organizations, which have also contributed significantly to the development of the International Classification. Partners include the following The Nature Conservancy; Provincial Forest Ecosystem Classification Groups in Canada; Canadian Forest Service; Parks Canada; United States Forest Service; National GAP Analysis Program; United States National Park Service; United States Fish and Wildlife Service; United States Geological Survey; United States Department of Defense; Ecological Society of America; Environmental Protection Agency; Natural Resource Conservation Services; United States Department of Energy; and the Tennessee Valley Authority. Many individual state organizations and people from academic institutions have also contributed to the development of this classification.

TABLE OF CONTENTS

I. Forest ... 357
Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest ... 357
Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest ... 358
Abies concolor / Symphoricarpos oreophilus Forest ... 359
Abies lasiocarpa - Picea engelmannii / Moss Forest ... 360
Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus Forest ... 361
Abies lasiocarpa / Erigeron eximius Forest ... 362
Populus tremuloides - Abies lasiocarpa / Juniperus communis Forest ... 363
Populus tremuloides - Abies lasiocarpa / Shepherdia canadensis Forest ... 364
Abies lasiocarpa - Picea engelmannii / Salix drummondiana Forest ... 365
Abies lasiocarpa - Picea engelmannii / Mertensia ciliata Forest ... 366
Picea engelmannii / Ribes montigenum Forest ... 367
Picea engelmannii / Vaccinium myrtillus Forest ... 368
Pinus edulis / Sparse Understory Forest ... 369
Populus tremuloides - Pinus flexilis Forest ... 370
Populus tremuloides - Pinus ponderosa Rocky Mountain Forest ... 371
Populus angustifolia Sand Dune Forest ... 372
Populus tremuloides - Pseudotsuga menziesii / Juniperus communis Forest ... 373
Populus tremuloides / Acer glabrum Forest ... 374
Populus tremuloides / Carex siccata Forest ... 375
Populus tremuloides / Festuca thurberi Forest ... 376
Populus tremuloides / Hesperostipa comata Forest ... 377
Populus tremuloides / Juniperus communis Forest ... 378
Populus tremuloides / Physocarpus monogynus Forest ... 379
Populus tremuloides / Salix scouleriana Forest ... 380
Populus tremuloides / Sambucus racemosa Forest ... 381
Populus tremuloides / Shepherdia canadensis Forest ... 382
Populus tremuloides / Symphoricarpos oreophilus Forest ... 383
Populus tremuloides / Thalictrum fendleri Forest ... 384
Populus tremuloides / Vaccinium myrtillus Forest ... 385
Populus tremuloides / Calamagrostis canadensis Forest ... 386
Populus tremuloides / Alnus incana Forest ... 387
Populus tremuloides / Cornus sericea Forest ... 388
Populus tremuloides / Ribes montigenum Forest ... 389
Populus tremuloides / Rosa woodsii Forest ... 390
Populus tremuloides / Salix drummondiana Forest ... 391
Pseudotsuga menziesii / Bromus ciliatus Forest ... 392
Pseudotsuga menziesii / Festuca arizonica Forest ... 393
Pseudotsuga menziesii / Jamesia americana Forest ... 394
Pseudotsuga menziesii / Juniperus communis Forest ... 395
Pseudotsuga menziesii / Symphoricarpos oreophilus Forest ... 396
II. Woodland ... 398

Abies concolor - (Pseudotsuga menziesii) / Jamesia americana - Holodiscus dumosus Scree Woodland 398
Abies concolor / Festuca arizonica Woodland 399
Abies lasiocarpa - Picea engelmannii / Juniperus communis Woodland 400
Pinus aristata / Festuca arizonica Woodland 401
Pinus aristata / Festuca thurberi Woodland 402
Pinus aristata / Ribes montigenum Woodland 403
Pinus aristata / Vaccinium myrtillus Woodland 404
Pinus edulis - (Juniperus monosperma) / Bouteloua gracilis Woodland 405
Pinus edulis - Juniperus spp. / *Cercocarpus montanus* - Mixed Shrubs Woodland 406
Pinus edulis / Rockland Woodland 407
Pinus flexilis / Festuca arizonica - Muhlenbergia montana Woodland 408
Pinus flexilis / Juniperus communis Woodland 409
Pinus ponderosa / (Ericameria nauseosa) /Achnatherum hymenoides Woodland 411
Pinus ponderosa / Festuca arizonica Woodland 412
Pinus ponderosa / Juniperus scopulorum Woodland 413
Pinus ponderosa / Muhlenbergia montana Woodland 414
Populus angustifolia - Juniperus scopulorum Woodland 415
Populus angustifolia / Alnus incana Woodland 416
Populus angustifolia / Betula occidentalis Woodland 417
Populus angustifolia / Rhus trilobata Woodland 418
Populus angustifolia / Salix (monticola, drummondiana, lucida) Woodland 419
Populus angustifolia / Salix drummondiana - Acer glabrum Woodland 420
Populus angustifolia / Salix exigua Woodland 421
Pseudotsuga menziesii / Cercocarpus montanus Woodland 422
Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland 423
III. Shrubland 425
Abies concolor - Pseudotsuga menziesii / Jamesia americana Avalanche Chute Shrubland [Park Special] 425
Abies lasiocarpa - Picea engelmannii / Salix (brachycarpa, glauca) Krummholz Shrubland 426
Abies lasiocarpa - Picea engelmannii Krummholz Shrubland 427
Alnus incana - Betula occidentalis Shrubland 428
Alnus incana - Salix drummondiana Shrubland 429
Atriplex canescens / Achnatherum hymenoides Shrubland 430
Cercocarpus montanus / Muhlenbergia montana Shrubland 431
Dasiphora fruticosa ssp. floribunda Subalpine Shrubland 432
Ericameria nauseosa / Sporobolus airoides Shrubland 433
Ericameria nauseosa Sand Deposit Sparse Shrubland 434
Ericameria parryi / Achnatherum hymenoides Shrubland 435
Pinus aristata Krummholz Shrubland 436
Prunus virginiana - (Prunus americana) Shrubland 437
Salix exigua - Salix ligulifolia Shrubland 438
Salix exigua - Salix lucida ssp. caudata Shrubland 439
Salix exigua Temporarily Flooded Shrubland 440
Salix brachycarpa / Mesic Forbs Shrubland 441

Salix drummondiana / Mesic Forbs Shrubland 443
Salix monticola / Mesic Forbs Shrubland 444
Salix planifolia / Carex aquatilis Shrubland 445
Salix planifolia / Carex scopulorum Shrubland 446
Salix planifolia / Carex utriculata Shrubland 447
Salix planifolia / Mesic Forbs Shrubland 448
Salix planifolia / Calamagrostis canadensis Shrubland 449
Salix planifolia / Deschampsia caespitosa Shrubland 450
Sarcobatus vermiculatus / Distichlis spicata Shrubland 451
Sarcobatus vermiculatus / Ericameria nauseosa Shrubland 453
Sarcobatus vermiculatus / Sporobolus airoides Shrubland 454
Sarcobatus vermiculatus Disturbed Shrubland 455
Sarcobatus vermiculatus Dune Shrubland 456
Suaeda moquinii Shrubland 457
Symphoricarpos oreophilus Shrubland 458
IV. Dwarf-shrubland 460
Krascheninnikovia lanata / Achnatherum hymenoides Dwarf-shrubland 460
Paronychia pulvinata - Silene acaulis Dwarf-shrubland 461
Salix nivalis / Geum rossii Dwarf-shrubland 462
Vaccinium (caespitosum, scoparium) Dwarf-shrubland 463
V. Herbaceous Vegetation 465
Achnatherum hymenoides - Psoralidium lanceolatum Herbaceous Vegetation 465
Bouteloua gracilis Herbaceous Vegetation 466
Cardamine cordifolia - Caltha leptosepala Herbaceous Vegetation 467
Cardamine cordifolia - Mertensia ciliata - Senecio triangularis Herbaceous Vegetation . 468
Carex utriculata Herbaceous Vegetation 469
Carex utriculata Perched Wetland Herbaceous Vegetation 470
Carex aquatilis - Pedicularis groenlandica Herbaceous Vegetation 471
Carex aquatilis Herbaceous Vegetation 472
Carex elynoides - Geum rossii Herbaceous Vegetation 473
Carex elynoides Herbaceous Vegetation 474
Carex nebrascensis Herbaceous Vegetation 475
Carex pellita Herbaceous Vegetation 476
Carex praegracilis Herbaceous Vegetation 477
Carex rupestris - Geum rossii Herbaceous Vegetation 478
Carex scopulorum - Caltha leptosepala Herbaceous Vegetation 479
Carex scopulorum Herbaceous Vegetation 480
Carex siccata - Geum rossii Herbaceous Vegetation 481
Carex simulata Herbaceous Vegetation 482
Cirsium scopulorum - Polemonium viscosum Herbaceous Vegetation 483
Danthonia parryi Herbaceous Vegetation 484
Deschampsia caespitosa - Caltha leptosepala Herbaceous Vegetation 485
Deschampsia caespitosa - Carex microptera Herbaceous Vegetation 486
Deschampsia caespitosa Herbaceous Vegetation 487
Deschampsia caespitosa - Geum rossii Herbaceous Vegetation 489
Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation 490

Distichlis spicata Herbaceous Vegetation ... 491
Dryas octopetala - Carex rupestris Dwarf-shrub Herbaceous Vegetation ... 492
Dryas octopetala - Carex spp. Dwarf-shrub Herbaceous Vegetation ... 493
Eleocharis palustris Herbaceous Vegetation... 494
Eleocharis acicularis Herbaceous Vegetation... 495
Ericameria nauseosa / Bouteloua gracilis Shrub Herbaceous Vegetation ... 496
Ericameria nauseosa / Muhlenbergia pungens - Achnatherum hymenoides Shrub Herbaceous Vegetation ... 497
Festuca arizonica - Muhlenbergia montana Herbaceous Vegetation ... 498
Festuca brachyphylla - Trisetum spicatum Herbaceous Vegetation ... 499
Festuca brachyphylla Herbaceous Vegetation ... 500
Festuca thurberi Subalpine Grassland Herbaceous Vegetation ... 501
Geum rossii - Polygonum bistortoides Herbaceous Vegetation ... 502
Geum rossii - Sibbaldia procumbens Herbaceous Vegetation ... 503
Geum rossii Herbaceous Vegetation ... 504
Hesperostipa comata - Achnatherum hymenoides Herbaceous Vegetation ... 505
Hippuris vulgaris Herbaceous Vegetation... 507
Hordeum jubatum Herbaceous Vegetation... 508
Juncus balticus Herbaceous Vegetation ... 509
Kobresia myosuroides - Geum rossii Herbaceous Vegetation ... 510
Minuartia obtusiloba Herbaceous Vegetation... 511
Muhlenbergia asperifolia Herbaceous Vegetation ... 512
Muhlenbergia montana Herbaceous Vegetation ... 513
Muhlenbergia pungens Herbaceous Vegetation... 514
Myriophyllum sibiricum Herbaceous Vegetation ... 515
Pascopyrum smithii Herbaceous Vegetation ... 516
Phragmites australis Western North America Temperate Semi-natural Herbaceous Vegetation... 517
Polygonum amphibium Permanently Flooded Herbaceous Vegetation [Placeholder]... 518
Potamogeton foliosus Herbaceous Vegetation ... 519
Puccinellia nuttalliana Herbaceous Vegetation ... 520
Ranunculus aquatilis - Callitriche palustris Herbaceous Vegetation ... 521
Redfieldia flexuosa - (Psoralidium lanceolatum) Herbaceous Vegetation... 521
Rhus trilobata Rocky Mountain Shrub Herbaceous Vegetation ... 522
Salicornia rubra Herbaceous Vegetation ... 523
Schoenoplectus acutus Herbaceous Vegetation... 524
Schoenoplectus americanus - Carex spp. Herbaceous Vegetation... 525
Schoenoplectus americanus - Eleocharis palustris Herbaceous Vegetation... 526
Schoenoplectus americanus Western Herbaceous Vegetation ... 527
Schoenoplectus maritimus Herbaceous Vegetation... 528
Sibbaldia procumbens - Polygonum bistortoides Herbaceous Vegetation... 529
Sparganium eurycarpum Herbaceous Vegetation ... 530
Spartina gracilis Herbaceous Vegetation... 531
Sporobolus airoides Monotype Herbaceous Vegetation ... 531
Sporobolus airoides - Distichlis spicata Herbaceous Vegetation ... 532
Suaeda calceoliformis Herbaceous Vegetation ... 533

Trifolium nanum Herbaceous Vegetation 534
Typha (latifolia, angustifolia) Western Herbaceous Vegetation 535
Typha domingensis Western Herbaceous Vegetation........ 536
VII. Sparse Vegetation........ 538
Aquilegia caerulea - Cirsium scopulorum Scree Sparse Vegetation........ 538
Holodiscus dumosus Rock Outcrop Sparse Vegetation........ 539
Sarcobatus vermiculatus / Juncus balticus Sparse Vegetation........ 540
Saxifraga bronchialis Scree Slope Sparse Vegetation 541
VIII. Hierarchy Placement Undetermined 541
Abies concolor / Betula occidentalis Forest [Park Special]........ 541
Abies lasiocarpa – Picea engelmannii / Sparse Understory Forest [Park Special]........ 542
Dasiphora floribunda / Festuca thurberi Subalpine Shrubland [Park Special] 543
Glyceria grandis - Schoenoplectus acutus Herbaceous Vegetation [Park Special] 544
Halogeton glomeratus Semi-Natural Herbaceous Vegetation [Park Special]........ 545
Juncus balticus - Pascopyrum smithii Herbaceous Vegetation [Park Special] 546
Juncus balticus (Iris missouriensis) Mixed Herbaceous Vegetation [Park Special]........ 547
Pinus aristata - (*Picea engelmannii*) / *Juniperus communis* Woodland [Park Special] 548
Pinus edulis – Juniperus scopulorum / *Holodiscus dumosus* Woodland [Park Special] 549
Populus angustifolia - Abies concolor / Betula occidentalis Woodland [Park Special] 550
Local Description Authors:*Populus angustifolia / Ribes aureum* Woodland [Park Special] 551
Populus tremuloides - Abies concolor / Acer glabrum Forest [ParkSpecial 552
Populus tremuloides - Abies concolor / Physocarpus monogynus Forest [Park Special] ... 553
Populus tremuloides / Bromus ciliatus - (Thermopsis spp.) Forest [Park Special]........ 554
Populus tremuloides Scree Woodland [Park Special] 555
Rhus trilobata Dune Shrubland [ParkSpecial] 556
Rorippa palustris Herbaceous Vegetation [Park Special] 557
Salix exigua Dune Shrubland [Park Special]........ 557
Sarcobatus vermiculatus / Leymus triticoides Shrubland [ParkSpecial]........ 558
Salsola spp. Herbaceous Vegetation [Provisional] 559
Senecio atratus - Cirsium scopulorum Herbaceous Rockland [ParkSpecial] 560

I. Forest

Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest

White Fir - Blue Spruce - Narrowleaf Cottonwood / Rocky Mountain Maple Forest
Identifier: CEGL000255

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: These coniferous forests are found in drainage channels, streambeds, and valley floors at elevations from 2605 to 2810 m. Slopes are gently inclined, ranging from 2-18 degrees. Hydrology ranges from semipermanently to intermittently flooded. Soils are variable and include moderately well-drained sandy loam or loamy sand, somewhat poorly drained loamy sand, poorly drained loam, or rapidly drained loamy sand. Surveyed stands have rocky cover ranging from 5-35%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a mixed canopy of coniferous and deciduous trees and a sparse herbaceous understory. The canopy typically includes *Populus angustifolia, Picea engelmannii*, and *Abies concolor* with total cover ranging from 15-75%. *Pseudotsuga menziesii, Populus tremuloides*, and *Juniperus scopulorum* may also be present, but with lower percent cover. Common understory species include *Acer glabrum, Alnus incana, Rosa woodsii*, and *Ribes* spp. Shrub and herbaceous cover is sparse with ground cover generally dominated by rock and litter.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Abies concolor*, *Picea engelmannii*
Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Populus angustifolia - Picea pungens / Alnus incana* Woodland (CEGL000934)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the following drainages: Sand Creek, Cold Creek, Medano Creek, Mosca Creek, and near Zapata Falls.
Global Range: This association appears to be restricted to a region of southern Colorado, and possibly northern New Mexico, with abundant precipitation at relatively low elevations.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 3075, 4114, 4073, 4052, 135, 538.
Local Description Authors: K.E. Sabo, mod. K. Decker

Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest
White Fir - Douglas-fir / Rocky Mountain Maple Forest
Identifier: CEGL000240

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This forested association occurs in valley floors and ravines between 2770 and 2820 m elevation. Slopes are variable, ranging from nearly flat to steep (2-35 degrees). Soils are moderately well-drained sandy loams and clay loams. Soil surfaces are rocky and may have significant amounts of litter or dead wood accumulation.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Pseudotsuga menziesii* and *Abies concolor* are generally codominant species in this association, although the two sampled stands tended towards domination by *Pseudotsuga*. Total canopy cover of the two dominants ranges from 25-55%. Subcanopy and shrub layers are present and may include *Populus tremuloides, Acer glabrum, Juniperus scopulorum, Symphoricarpos rotundifolius, Physocarpus monogynus*, and *Ribes montigenum*. Herbaceous vegetation is sparse with only trace amounts of cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Abies concolor*, *Pseudotsuga menziesii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Acer glabrum*, *Populus tremuloides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Abies concolor - (Pseudotsuga menziesii) / Jamesia americana - Holodiscus dumosus* Scree Woodland (CEGL000890)
- *Abies concolor - Pseudotsuga menziesii / Erigeron eximius* Forest (CEGL000247)
- *Pseudotsuga menziesii / Acer glabrum* Forest (CEGL000418)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek drainage and Morris Gulch.
Global Range: This montane forest is common in the southern portion of the southern Rocky Mountains and ranges from central and southern Utah and southern Colorado to northern New Mexico and central Arizona.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 254, 5049.
Local Description Authors: K.E. Sabo, mod. K. Decker

Abies concolor / Symphoricarpos oreophilus **Forest**
White Fir / Mountain Snowberry Forest
Identifier: CEGL000263

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This forest association is found on moderate to steep midslopes in drainage channels, colluvial slopes, alluvial fans, stream terraces and valley floors at 2655-2940 m elevation. Aspects are variable but generally westerly. Soils are generally moderately well-drained sandy loams. Ground cover is dominated by downed wood, litter, and duff.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Stands have a moderately dense canopy of *Abies concolor* and *Pseudotsuga menziesii* as codominant species. This association can have a complex canopy strata, with subcanopy, tall-shrub, and short-shrub layers that include *Juniperus scopulorum, Symphoricarpos* spp., *Rosa woodsii*, and *Holodiscus dumosus*. The herbaceous layer is sparse, ranging from 1-45% cover. Commonly occurring species include *Koeleria macrantha, Poa fendleriana*, and *Artemisia dracunculus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Abies concolor*, *Pseudotsuga menziesii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Koeleria macrantha*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Abies concolor - Pseudotsuga menziesii / Erigeron eximius* Forest (CEGL000247)
- *Abies concolor / Juniperus communis* Forest (CEGL000249)--*Abies concolor, Pinus ponderosa*, and to some degree *Populus tremuloides* also dominate the canopy of this dry, mixed-conifer association; however, *Juniperus communis* dominates the shrub layer.
- *Abies concolor / Mahonia repens* Forest (CEGL000251)--has a similar canopy composition; however, it has an extremely sparse to nonexistent shrub layer. *Mahonia repens* is the dominant dwarf-shrub.
- *Pinus ponderosa / Symphoricarpos oreophilus* Forest (CEGL000205)
- *Pseudotsuga menziesii / Symphoricarpos oreophilus* Forest (CEGL000462)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Cold Creek drainage, Horse Canyon, Castle Creek drainage, Sawmill Canyon, and near Zapata Creek drainage.
Global Range: This coniferous forest association has been reported from mountains and high plateaus in New Mexico, Colorado, Utah, and in Arizona along the Mogollon Rim.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3272, 675, 5085, 3098, 458, 426, 3099.
Local Description Authors: K.E. Sabo, mod. K. Decker

Abies lasiocarpa - Picea engelmannii / Moss Forest

Subalpine Fir - Engelmann Spruce / Moss Forest
Identifier: CEGL000321

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from north-facing subalpine colluvial slopes between 2160 and 3585 m in elevation. Stands have a range of slope from 15-40 degrees and can occupy topographic positions from low slopes through high slopes. Mosses make up 20-30% of the ground cover. Needle litter contributes 25-40%, and large rocks can have up to 30% ground cover. Surficial geology is generally granitic, and soils include loams to sandy loams.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Picea engelmannii* and *Abies lasiocarpa* form a dense canopy with 50-70% cover (up to 85% including subcanopy). Within this, *Picea engelmannii* contributes 75-85% relative tree cover. The understory is characterized by a lack of vascular plant species, and 20-30% moss cover on the ground. Trace understory species can include *Oreochrysum parryi, Arnica cordifolia, Erigeron eximius, Artemisia franserioides*, and *Polemonium pulcherrimum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Abies lasiocarpa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Picea engelmannii* / Moss Forest (CEGL000371)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association was sampled in the Little Sand Creek, Sand Creek and South Zapata Creek drainages.
Global Range: This dry, cold spruce forest occurs in the southern Rocky Mountains from northern Arizona and New Mexico to southern Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5050, 3059, 3248.
Local Description Authors: K. Forrest, mod. K. Decker

Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus Forest

Subalpine Fir - Engelmann Spruce / Whortleberry Forest
Identifier: CEGL000343

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is found on middle to high colluvial slopes between 3335 and 3585 m in elevation. Soils are moderately well-drained to well-drained loam, sandy loam and silt loam. Three of the four stands sampled had east to northeast aspects, and one site is located on a west-facing slope. Litter and duff cover 70-90% of the ground, and mosses may have up to 20% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This *Picea engelmannii - Abies lasiocarpa* forest is characterized by a green carpet of *Vaccinium myrtillus*. Tree canopy covers range from 20-40%, with *Picea engelmannii* usually being the most prevalent tree species. *Abies lasiocarpa* is always present, sometimes only in trace amounts. Scattered *Pinus aristata* individuals may also be present. *Vaccinium myrtillus* forms a dwarf-shrub layer with between 15 and 40% cover. The herbaceous layer may include *Oreochrysum parryi, Polemonium pulcherrimum, Arnica cordifolia, Linnaea borealis, Senecio amplectens*, and *Erigeron eximius*, among others. Mosses can make up 20% of the ground cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*
Herb (field)	Dwarf-shrub	*Vaccinium myrtillus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Abies lasiocarpa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments: This association is similar to *Picea engelmannii / Vaccinium myrtillus* Forest (CEGL000379) and can be distinguished by the presence of *Abies lasiocarpa* in the stand.
Global Similar Associations:

- *Abies lasiocarpa - Picea engelmannii / Vaccinium scoparium / Thalictrum occidentale* Forest (CEGL005919)
- *Abies lasiocarpa - Picea engelmannii / Vaccinium scoparium / Xerophyllum tenax* Forest (CEGL005914)
- *Abies lasiocarpa - Picea engelmannii / Vaccinium scoparium* Forest (CEGL000344)
- *Picea engelmannii / Vaccinium myrtillus* Forest (CEGL000379)
- *Pinus contorta / Vaccinium scoparium / Calamagrostis rubescens* Forest (CEGL000174)
- *Populus tremuloides / Vaccinium myrtillus* Forest (CEGL000620)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This common association is found between the Sand Creek and Medano Creek drainages, and likely exists throughout the upper subalpine.

Global Range: This subalpine forest association is found in the high mountains of northern and southwestern New Mexico, southeastern and eastern Arizona (Pinaleno and White mountains), southeastern Utah (La Sal Mountains), and Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 431, 319, 3262, 344.
Local Description Authors: K. Forrest

Abies lasiocarpa / Erigeron eximius Forest

Subalpine Fir / Spruce-fir Fleabane Forest
Identifier: CEGL000310

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one plot at 3190 m in elevation. It is located along a north-facing stream terrace with a slope of 22 degrees. The ground is somewhat poorly drained and intermittently flooded, with 60% litter and duff, 10% each of mosses, water and large rocks, and the remainder of ground cover in wood, basal area and small rocks.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This plant association is found along narrow riparian bands within *Picea engelmannii - Abies lasiocarpa* forests. Total canopy cover of the one plot sampled is 60%. *Erigeron eximius* is the most prevalent forb within the herbaceous layer, with 30% cover. Other species can include *Thalictrum fendleri, Mertensia ciliata, Oreochrysum parryi* (which looks like many *Erigeron* species vegetatively), *Polemonium pulcherrimum, Arnica cordifolia, Artemisia franserioides, Orthilia secunda, Senecio atratus*, and *Saxifraga odontoloma*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*
Herb (field)	Forb	*Erigeron eximius*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Abies lasiocarpa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Exotic/Invasive: *Bromus tectorum* (invasive/exotic, High)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Abies lasiocarpa - Picea engelmannii / Acer glabrum* Forest (CEGL000294)
- *Abies lasiocarpa / Lathyrus lanszwertii var. leucanthus* Forest (CEGL000313)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association was documented at one location adjacent to Smith Creek.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5051
Local Description Authors: K. Forrest

Populus tremuloides - Abies lasiocarpa / Juniperus communis Forest

Quaking Aspen - Subalpine Fir / Common Juniper Forest
Identifier: CEGL000527

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on low benches and colluvial slopes. Elevation ranges from 3000 to 3255 m with either flat or steep slopes. Soils are generally moderately well-drained sandy loams. Ground cover is variable with 40-88% litter and duff, 1-25% wood, and 2-9% rock.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Sampled stands of this forested association are characterized by a mixed canopy of *Populus tremuloides* (that is being replaced by *Picea engelmannii*) and *Abies* spp., which dominate the subcanopy, and are present in shrub layers as well. The shrub layer is variable, averaging 20-30% cover, and may include both taller species, such as *Jamesia americana, Acer glabrum*, and *Shepherdia canadensis*, and short shrub species, such as *Juniperus communis, Vaccinium myrtillus var. oreophilum* and *Arctostaphylos uva-ursi*, with up to 10% cover. The herbaceous layer is sparse to moderate with cover ranging from trace to 30%, and generally more forbs than graminoids Common species of this layer include *Oreochrysum parryi, Fragaria virginiana, Erigeron* spp., *Bromus ciliatus*, and *Carex* spp.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juniperus communis* var. *montana*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Abies lasiocarpa - Picea engelmannii / Juniperus communis* Woodland (CEGL000919)
- *Populus tremuloides / Juniperus communis* Forest (CEGL000587)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Spanish Creek, Little Sand Creek, Cleveland Gulch, and North Arrastre Creek drainages.
Global Range: This association is known from Utah and Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4222, 3061, 3063, 4289, 5055.
Local Description Authors: K.E. Sabo

Populus tremuloides - Abies lasiocarpa / Shepherdia canadensis Forest

Quaking Aspen - Subalpine Fir / Russet Buffaloberry Forest
Identifier: CEGL000529

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a stream terrace at 3098 m elevation. Terrain is gently sloping with north-facing slopes. Soils are somewhat poorly drained sandy loams. Ground cover is dominated by litter and duff, but can have significant cover of wood.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This forested association is dominated by a moderately open canopy of *Populus tremuloides* and *Picea engelmannii*, with scattered *Pseudotsuga menziesii*. Conifers are also present in the shrub layer, which is dominated by *Shepherdia canadensis* (30%). The dwarf-shrub layer is dominated by *Vaccinium myrtillus var. oreophilum* with 60% cover. Forbs and graminoids are present in only trace amounts.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Herb (field)	Dwarf-shrub	*Vaccinium myrtillus* var. *oreophilum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Populus tremuloides / Shepherdia canadensis* Forest (CEGL000606)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Middle Zapata Creek drainage.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5079.
Local Description Authors: K.E. Sabo

Abies lasiocarpa - Picea engelmannii / Salix drummondiana Forest
Subalpine Fir - Engelmann Spruce / Drummond's Willow Forest
Identifier: CEGL000327

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs along permanently to intermittently flooded streams between 3130 and 3315 m in elevation. Surficial geology is alluvial, and the upland soils are sandy loams. Slopes are gentle to moderate (3-18 degrees), and aspects sampled include 150 and 350 degrees.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This plant association occurs as a linear riparian community in the spruce-fir zone. It is characterized by a tall-shrub layer of *Salix drummondiana* beneath an open *Abies lasiocarpa* and *Picea engelmannii* canopy. The tree canopy is sparse, with 15 to 30% combined cover in all tree layers. *Salix drummondiana* has between 5 and 60% cover. *Salix planifolia, Lonicera involucrata*, and other short shrubs may be present. Riparian forbs may form a layer along the streambanks, including *Mertensia ciliata, Cardamine cordifolia, Saxifraga odontoloma*, and *Senecio triangularis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Salix drummondiana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Abies lasiocarpa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Abies lasiocarpa - Picea engelmannii / Alnus incana* Forest (CEGL000296)

- *Picea engelmannii / Salix drummondiana* Woodland (CEGL005843)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Two sites were sampled in the Sand Creek drainage.

Global Range: This spruce-fir riparian association is currently only known from upper montane zones of Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 3047, 5045.

Local Description Authors: K. Forrest

Abies lasiocarpa - Picea engelmannii / Mertensia ciliata Forest

Subalpine Fir - Engelmann Spruce / Mountain Bluebells Forest

Identifier: CEGL002663

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from colluvial slopes and stream terraces between 3395 and 3530 m in elevation. It occurs along seeps and streams in the subalpine zone with any aspect and with slopes between 8 and 15 degrees. Litter generally accounts for at least half of the ground cover beneath the lush riparian vegetation. Along active stream channels, there can be significant cover of water and rocks. Vegetation basal area is usually around 10%. Surficial geology includes granite and conglomerate, and soils range from moderately well-drained loams and sandy loams to somewhat poorly drained silty loams.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Picea engelmannii* and *Abies lasiocarpa* are both present to codominant in the tree canopy. A dense understory of mesic forbs is characteristic of this community. *Mertensia ciliata* is the most consistently present forb species among a suite of mesic forbs found in this community, although it is sometimes absent. Other characteristic forbs include *Senecio triangularis, Cardamine cordifolia, Caltha leptosepala ssp. leptosepala, Aconitum columbianum, Saxifraga odontoloma*, and *Oxypolis fendleri*. Mosses can form a layer with up to 30% cover. This association often occurs in mesic areas within a drier matrix of *Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus* Forest (CEGL000343). *Vaccinium myrtillus* is present with 10-30% cover in all plots sampled, and it is noted to occur on dry hummocks and around the bases of large trees.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Abies lasiocarpa*, *Picea engelmannii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Caltha leptosepala* ssp. *leptosepala*, *Cardamine cordifolia*, *Mertensia ciliata*, *Senecio triangularis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Great Sand Dunes National Park and Preserve Comments: This association often occurs in mesic areas within a drier matrix of *Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus* Forest (CEGL000343).

Global Similar Associations:

- *Abies lasiocarpa - Picea engelmannii / Streptopus amplexifolius* Forest (CEGL000336)
- *Picea engelmannii / Senecio triangularis* Forest (CEGL000376)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association was sampled in the San Isabel, Sand Creek and Little Sand Creek drainages. It is likely more widespread throughout the spruce-fir zone.

Global Range: This association is found from northern Colorado down to northern New Mexico. It may also occur in Montana, Utah (Padgett et al. 1989), and Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 920, 984, 5040, 664.

Local Description Authors: K. Forrest

Picea engelmannii / Ribes montigenum Forest

Engelmann Spruce / Western Prickly Gooseberry Forest
Identifier: CEGL000374

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one location at 3152 m in elevation with a slope of 10 degrees and aspect of 210 degrees. The stand is located on the low slope in a drainage bottom, and sampling took place on a bench away from the main stream channel. The ground cover is 71% litter broken up by piles of large rocks (possibly indicating an old stream channel or mass-wasting event) and small patches of moss and bare soil. The soil is well-drained loamy sand.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Picea engelmannii* forms a canopy of 50% cover with scattered *Pseudotsuga menziesii* and *Populus tremuloides*. *Ribes montigenum* is the dominant shrub in an otherwise sparse understory with 15-30% cover. *Acer glabrum*, typical of drainage channels, is present in the tall-shrub layer. Short shrubs include *Sambucus racemosa* and *Symphoricarpos* sp. *Oreochrysum parryi*, *Fragaria vesca* and *Carex* sp. are the most abundant plants in the herbaceous layer.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*
Short shrub/sapling	Broad-leaved deciduous shrub	*Ribes montigenum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Oreochrysum parryi*, *Sambucus racemosa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from one plot in the Little Medano Creek drainage, although it could potentially be found in the subalpine zone, including cold-air drainages, low slopes, and stream terraces throughout the park.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4215.
Local Description Authors: K. Forrest

Picea engelmannii / Vaccinium myrtillus Forest
Engelmann Spruce / Whortleberry Forest
Identifier: CEGL000379

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from the subalpine zone between 3270 and 3605 m in elevation. Known sites are located on mid to high colluvial slopes, with the slope ranging from 0-50 degrees. Aspect of sampled sites is generally northeast. Needle litter is the predominant ground cover, with cover between 54 and 83%. Mosses and lichens can be present with up to 20% ground cover. Bare soil and rocks may be present with up to 10% cover. Soils are variable and include sandy clay loam, silty loam and sandy loam.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Picea engelmannii* forms a canopy of between 40 and 65% cover and usually also occurs in the subcanopy. *Pseudotsuga menziesii* may be present with scattered individuals, but *Abies lasiocarpa* is absent. The understory is characterized by a dwarf-shrub stratum of *Vaccinium myrtillus*. This species occurs with 10-40% cover, and exceeds any cover of *Juniperus communis*. The herbaceous layer is generally sparse, and the composition varies widely with elevation and other environmental gradients. Most species are common to the subalpine forests, but floristics can be influenced by proximity to alpine turf. Possible forb species include *Arnica cordifolia, Linnaea borealis, Erigeron peregrinus, Polemonium pulcherrimum, Pyrola* sp., and *Fragaria virginiana*. Mosses and lichens can have significant ground cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*
Herb (field)	Dwarf-shrub	*Vaccinium myrtillus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Arnica cordifolia*, *Linnaea borealis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Exotic/Invasive: *Bromus tectorum* (invasive/exotic, High)

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments: This association is similar to *Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus* Forest (CEGL000343) and can be differentiated by the absence of *Abies lasiocarpa* in the tree canopy.
Global Similar Associations:

- *Abies lasiocarpa - Picea engelmannii / Polemonium pulcherrimum* Forest (CEGL000373)
- *Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus* Forest (CEGL000343)
- *Populus tremuloides / Vaccinium myrtillus* Forest (CEGL000620)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This common association is known from the subalpine zone in the Sand Creek and Medano Creek drainages, and likely exists at high elevations throughout the project area.
Global Range: This subalpine forest association occurs in the southern Rocky Mountains from the high mountains and plateaus of central and southwestern New Mexico to north-central Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 92, 494, 239, 600.
Local Description Authors: K. Forrest

Pinus edulis / Sparse Understory Forest

Two-needle Pinyon / Sparse Understory Forest
Identifier: CEGL000795

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This woodland is known from low slopes on the alluvial fan between 2470 and 2725 m in elevation. Large rocks, small rocks and bare soil make up 60 to 95% of the ground cover. Litter can cover up to 40% of the ground, often concentrated as needlefall beneath the trees. Rocks can be of uniform size and form a pavement of cobble, indicating flowing water, or of mixed sizes indicating mass-wasting events. Shallow dry channels may also be present. Understory vegetation is sparse, either due to disturbance or excessively drained and rocky substrates.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Pinus edulis* and *Juniperus scopulorum* form an open canopy with 20-30% cover. The understory is sparse and forms no distinct layers. Characteristic understory species include *Ribes cereum, Bouteloua gracilis, Elymus elymoides, Heterotheca villosa*, and *Opuntia polyacantha*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus edulis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Bouteloua gracilis*, *Juniperus scopulorum*, *Opuntia polyacantha*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments: *Pinus edulis* / Rockland Woodland (CEGL000794) is a related association that occurs on higher elevation colluvial slopes and rocky ridges.
Global Similar Associations:

- *Pinus edulis* / Rockland Woodland (CEGL000794)--is a related association that occurs on higher elevation colluvial slopes and rocky ridges.

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from five plots along the alluvial fan from Deadman Creek south to the flanks of Mount Blanca.
Global Range: These forests and woodlands occur in foothills, mesas, plateaus and mountains of New Mexico, Arizona, Colorado and Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5031, 5018, 41, 5087, 5061.
Local Description Authors: K. Forrest

Populus tremuloides - Pinus flexilis Forest

Quaking Aspen - Limber Pine Forest
Identifier: CEGL000540

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from two plots on colluvial slopes and ridgetops at 3018 and 3028 m elevation. Slopes range from gentle to steep and are generally southwest-facing. Soils are well-drained sandy loam or moderately well-drained silt. Ground cover is 30-65% litter and duff, 2-8% wood, 15-30% bare soil, 0-10% gravel, and 0-25% rock.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Sampled stands of this forested association are characterized by an open canopy of *Pinus flexilis* (25-30% cover) with interspersed decadent *Populus tremuloides* . Shrub species diversity is low and includes *Juniperus communis, Symphoricarpos* spp., and *Physocarpus monogynus* with 10-30% total cover. Herbaceous cover may be sparse or moderately dense, ranging from 0-65% cover, and is graminoid-dominated. Prominent species in the stand with significant herbaceous cover include *Festuca arizonica* (30%), *Muhlenbergia montana* (20%), and *Elymus trachycaulus* (10%).

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus flexilis*
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur near Big South Canyon and Mosca Creek drainage.
Global Range: The geographic range is estimated to encompass 186,480 square km (72,000 square miles), primarily on the Colorado Plateau and in the Great Basin, from the Gros Ventre Mountains of northwestern Wyoming south to the Paunsaugunt Plateau of southern Utah, and west to the Snake Mountains of eastern Nevada. This is the area over which Mueggler (1988) documented his cover type.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5025, 5262.
Local Description Authors: K.E. Sabo

Populus tremuloides - Pinus ponderosa Rocky Mountain Forest
Quaking Aspen - Ponderosa Pine Rocky Mountain Forest
Identifier: CEGL000541

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in drainage channels, colluvial slopes, and ridges at 2545 to 3030 m elevation. Stands are found on broad gentle slopes with well-drained loamy sand, loam, or sandy loam soils. Ground cover is variable, with 35-70% litter and duff and 5-45% bare soil.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open stand of mixed *Pinus ponderosa* and *Populus tremuloides*, with *Pinus ponderosa* slightly more prevalent. Other coniferous species that may be present include *Pinus flexilis, Pinus aristata*, and *Abies lasiocarpa*. The shrub layer is sparse and includes *Juniperus communis* and *Symphoricarpos* spp. The understory is generally graminoid-dominated, with total cover of 20-60%. Dominant species include *Festuca* spp. and *Muhlenbergia montana*. Forbs are moderately diverse but present with very low cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Festuca arizonica*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Populus tremuloides / Corylus cornuta* Forest (CEGL000583)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Deadman Creek, Medano Creek, and Mosca Creek drainages.
Global Range: This minor forest association is described from lower montane slopes and plateaus in the southern Rocky Mountains in Colorado west to the Markagunt Plateaus and Uinta Mountains in Utah and may extend into Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5259, 5094, 324.
Local Description Authors: K.E. Sabo

Populus angustifolia Sand Dune Forest
Narrowleaf Cottonwood Sand Dune Forest
Identifier: CEGL002643

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on sandsheets, sand ramps, dune fields, and valley floors. Elevation ranges from 2320 to 2790 m on flat to moderately steep terrain that is variable due to the fluctuating dunes. Soils are generally rapidly drained loamy sands, often with a high percentage of bare soil, but occasionally with significant amounts of litter on the surface.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: These forest stands may include several age classes of *Populus angustifolia*, which can be present in the overstory and shrub layers with cover of 30-40%. Additional cover is sparse and consists largely of sandsheet species such as *Ericameria nauseosa, Senecio spartioides, Rhus trilobata, Artemisia* spp., *Achnatherum hymenoides, Psoralidium lanceolatum, Pascopyrum smithii*, and *Redfieldia flexuosa*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Achnatherum hymenoides*, *Ericameria nauseosa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek and Little Medano Creek drainages.
Global Range: Geomorphic conditions exist in Colorado only in the San Luis Valley in south-central Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4011, 3051, 185, 4103, 4101, 4220, 4286.
Local Description Authors: K.E. Sabo

Populus tremuloides - Pseudotsuga menziesii / Juniperus communis Forest

Quaking Aspen - Douglas-fir / Common Juniper Forest
Identifier: CEGL000545

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in drainage channels and colluvial slopes between 3010 and 3180 m elevation. Slopes are steep and generally northeast-facing. Soils are well-drained sandy loams or loamy sands. Ground cover is dominated by litter and duff, and there can be a large component of rock (20%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a fairly dense canopy of *Populus tremuloides* and *Pseudotsuga menziesii*, that may also include *Pinus flexilis* and *Picea engelmannii* The shrub layer includes short- and dwarf-shrub species such as *Jamesia americana, Juniperus communis*, and *Vaccinium myrtillus var. oreophilum*, with less than 30% total cover. The herbaceous layer is sparse with under 5% cover and forb-dominated. Common species include *Artemisia franserioides, Fragaria vesca, Oreochrysum parryi*, and *Bromus ciliatus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juniperus communis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Populus tremuloides / Juniperus communis* Forest (CEGL000587)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Deadman Creek drainage, Little Spring Gulch, and near Big South Canyon.
Global Range: This minor, seral, mixed aspen-conifer forest association occurs in the Uinta Mountains and Paunsaugunt Plateau in Utah, Snake Range in eastern Nevada, and the Colorado Front Range.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2255, 238, 247.
Local Description Authors: K.E. Sabo

Populus tremuloides / Acer glabrum Forest
Quaking Aspen / Rocky Mountain Maple Forest
Identifier: CEGL000563

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association was sampled in ravines, colluvial slopes and stream terraces at 2700 to 2970 m elevation. Slopes are moderate to steep and are east- or southwest-facing. Soils are moderately drained or well-drained loamy sandy, sandy loams, or loams. Stands have a large percentage of rock (5-20%) and wood (5-30%) on the soil surface.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a canopy dominated by 30-40% *Populus tremuloides*. Occasional individuals of coniferous tree species such as *Pinus flexilis* or *Pseudotsuga menziesii* may also be present in the canopy. *Acer glabrum* forms a tall subcanopy with 20-30% cover. Other tall-shrub species may include *Amelanchier alnifolia, Jamesia americana*, and *Juniperus scopulorum*. *Rosa woodsii* is the dominant short shrub with 10% cover, but other shrub species present include *Holodiscus dumosus, Juniperus communis, Physocarpus monogynus, Ribes* spp., *Shepherdia canadensis*, and *Symphoricarpos oreophilus*. A variety of grass and forb species are present in very small amounts.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Acer glabrum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Rosa woodsii*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Pseudotsuga menziesii / Acer glabrum* Forest (CEGL000418)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the following drainages: Deadman Creek, Pole Creek, Sand Creek, and Cold Creek.
Global Range: This type is only recorded from the Rocky Mountains in Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5202, 4067, 3091, 3110.
Local Description Authors: K.E. Sabo

Populus tremuloides / Carex siccata Forest

Quaking Aspen / Dry-spike Sedge Forest
Identifier: CEGL000578

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from two plots in stream terraces at 2998 and 3079 m elevation. Terrain is gently sloping to steep with warmer southeast to west-facing aspects. Soils are moderately well- to well-drained sandy loams derived from fluvial deposition. Ground cover is dominated by litter and duff, but there is a significant amount of large rock cover (15%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: These are moderately open thickets with 30-40% cover of *Populus tremuloides* and occasional *Picea engelmannii*. The short-shrub layer is dominated by *Rosa woodsii* and *Juniperus communis*. The herbaceous layer is dominated by *Carex siccata* with 10-30% cover. *Thermopsis montana* and *Fragaria virginiana* are the dominant forbs with 10-30% cover although forb cover may be diverse.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Herb (field)	Forb	*Fragaria virginiana*, *Thermopsis montana*
Herb (field)	Graminoid	*Carex siccata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak

Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Populus tremuloides* / Tall Forbs Forest (CEGL000618)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known on stream terraces in South Isabel Creek, Jones Creek, and Cold Creek drainages.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3093, 5035, 4062.
Local Description Authors: K.E. Sabo, mod. by K.A. Schulz

Populus tremuloides / Festuca thurberi Forest
Quaking Aspen / Thurber's Fescue Forest
Identifier: CEGL000585

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This forest association occurs on moderate to steep colluvial slopes at 3205 to 3555 m elevation. Sites are generally south-facing and are derived from either colluvial, granitic, or igneous parent material. Soils are well-drained loams or sandy loams. Ground cover is variable and may be quite rocky.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a moderately open canopy of *Populus tremuloides* (30-40%), with occasional included conifers such as *Pinus aristata, Pinus flexilis, Abies lasiocarpa*, and *Picea engelmannii*. Shrub cover is sparse but may include *Arctostaphylos uva-ursi, Juniperus communis, Ribes montigenum, Rosa woodsii*, or *Symphoricarpos rotundifolius*. The understory is generally grassy and dominated by *Festuca thurberi* and *Bromus ciliatus* with 20-30% cover each. A variety of forb species may be present in very small amounts.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Herb (field)	Graminoid	*Bromus ciliatus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Festuca thurberi*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Deadman Creek, Hudson Branch, and Garden Creek drainages.
Global Range: This high-elevation forest association is present in southern and western Colorado and Wyoming and occurs on both sides of the Continental Divide in the Colorado Rocky Mountains. It is also known to occur within the Valles Caldera National Preserve and Bandelier National Monument in north-central New Mexico, as well as on the Aquarius and Fish Lake plateaus in Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5204, 4279, 4025.
Local Description Authors: K.E. Sabo

Populus tremuloides / Hesperostipa comata Forest
Quaking Aspen / Needle-and-Thread Forest
Identifier: CEGL000608

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one location on a flat sand ramp at 2606 m elevation. Soils are moderately drained loamy sands. Ground surface cover is dominated by 70% litter and duff.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open, homogenous stand of *Populus tremuloides* (20-25%), which is present in both the tree and shrub layers. The sparse short-shrub layer includes *Rosa woodsii* and *Symphoricarpos* spp. The herbaceous layer is grassy, with *Hesperostipa comata* as the dominant species (30% cover). Forb cover is moderate and dominated by *Artemisia dracunculus* and *Heterotheca villosa* with 10% cover each.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Herb (field)	Graminoid	*Hesperostipa comata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Artemisia dracunculus*, *Heterotheca villosa*, *Rosa woodsii*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Little Medano Creek drainage.

Global Range: The association is reported as ranging from the Centennial Mountains in northeastern Idaho to the Markagunt Plateau in southern Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4104.
Local Description Authors: K.E. Sabo

Populus tremuloides / Juniperus communis Forest

Quaking Aspen / Common Juniper Forest
Identifier: CEGL000587

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This forest association was sampled on moderate to steep colluvial slopes with elevation ranging from 2995 to 3280 m. Soils are generally moderately well-drained sandy loam, sandy clay loam or loam. Ground cover is dominated by litter and duff, but some stands have significant amounts of rock and gravel cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Stands in general are dominated by *Populus tremuloides* with cover ranging from 10-50%. *Abies concolor, Pinus aristata, Pinus flexilis, Pseudotsuga menziesii*, and *Picea engelmannii* may be present in the canopy or subcanopy. The shrub layer is dominated by *Juniperus communis* (20-30%) with other shrub species including *Arctostaphylos uva-ursi, Jamesia americana, Rosa woodsii*, and *Shepherdia canadensis*. The herbaceous layer is generally sparse. Common graminoid species include *Bromus ciliatus, Festuca* spp., and *Poa* spp. Typical forbs include *Fragaria virginiana, Maianthemum stellatum, Oreochrysum parryi, Pseudocymopterus montanus*, and *Packera fendleri (= Senecio fendleri).*

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Festuca thurberi*, *Juniperus communis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3); **Exotic/Invasive**: *Poa pratensis* (invasive, Medium)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Populus tremuloides - Abies lasiocarpa / Juniperus communis* Forest (CEGL000527)
- *Populus tremuloides - Pinus contorta / Juniperus communis* Forest (CEGL000537)
- *Populus tremuloides - Pseudotsuga menziesii / Juniperus communis* Forest (CEGL000545)
- *Populus tremuloides / Juniperus communis / Carex geyeri* Forest (CEGL000588)
- *Populus tremuloides / Juniperus communis / Lupinus argenteus* Forest (CEGL000589)

- *Populus tremuloides / Shepherdia canadensis* Forest (CEGL000606)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Deadman Creek, Sand Creek, Hudson Branch, North Arrastre Creek, and North Zapata Creek drainages.
Global Range: This association is known from the mountains and high plateaus of Utah, Colorado, Wyoming and Montana.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 644, 5203, 3233, 5010, 3218.
Local Description Authors: K.E. Sabo

Populus tremuloides / Physocarpus monogynus Forest
Quaking Aspen / Mountain Ninebark Forest
Identifier: CEGL005932

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This forested association occurs in drainage channels and stream terraces at 2800 and 2830 m elevation. Slopes are gentle and are southwest-facing. Soils range from somewhat poorly drained loams to well-drained loamy sands. Ground cover is dominated by litter and duff with large amounts of downed wood.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This forested association is characterized by a canopy of 40-60% cover of *Populus tremuloides*. The shrub layer is dominated by a dense layer of *Physocarpus monogynus* with 40-60% cover. *Rosa woodsii* is also found in all sampled stands with 10% cover, and other shrub species, such as *Acer glabrum, Arctostaphylos uva-ursi, Juniperus communis, Jamesia americana*, and *Prunus virginiana*, may be present. The herbaceous layer is sparse, with less than 15% cover, and may include *Bromus ciliatus, Fragaria vesca, Oreochrysum parryi, Thalictrum fendleri*, and other species.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Physocarpus monogynus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Rosa woodsii*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Spanish Creek and Arrastre Creek drainages.
Global Range: This association occurs in the southern Rocky Mountains and is reported from Rocky Mountain National Park and Great Sand Dunes National Park and Preserve.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3113, 4111.
Local Description Authors: K.E. Sabo

***Populus tremuloides / Salix scouleriana* Forest**

Quaking Aspen / Scouler's Willow Forest
Identifier: CEGL000604

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This forested association occurs on steep mid colluvial slopes. Elevation ranges from 2960 to 3065 m. Soils are well-drained sandy loams or moderately well-drained loams. Litter and duff are the dominant ground cover, but rock cover ranges from 20-30%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association has a canopy dominated by *Populus tremuloides* with 40-80% cover. A sparse tall-shrub layer includes *Salix scouleriana* and *Jamesia americana*, both with cover of 10-20%. The short-shrub layer is generally sparse and may include *Rosa woodsii* with 10-30% cover, as well as small amounts of species such as *Ribes montigenum, Shepherdia canadensis*, or conifer saplings. Herbaceous cover is sparse and forb-dominated, with species such as *Oreochrysum parryi* and *Artemisia franserioides*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Jamesia americana*, *Salix scouleriana*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Alpine Creek and McKenney Creek drainages.
Global Range: This association occurs in the mountains of eastern Oregon, Nevada, Utah, Idaho, Wyoming and Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5089, 4069.
Local Description Authors: K.E. Sabo

Populus tremuloides / Sambucus racemosa Forest
Quaking Aspen / European Red Elder Forest
Identifier: CEGL000605

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one plot found on a moderately steep toeslope at 3106 m elevation. The surveyed stand is southeast-facing. Soils are somewhat poorly drained loams. Litter and duff are the dominant ground cover, but wood has significant cover with 20%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand appears to be early-successional. *Populus tremuloides* is present with >60% cover in a multi-layered canopy with heights ranging from 5-20 m tall. The short-shrub layer is dominated by *Sambucus racemosa* with 20% cover. The herbaceous layer has 5-15% graminoid cover and 25-35% forb cover. Dominant graminoid species include *Carex siccata (= Carex foenea var. foenea)* and *Calamagrostis canadensis*. Dominant forb species include *Chamerion angustifolium, Thalictrum fendleri*, and *Maianthemum stellatum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Short shrub/sapling	Broad-leaved deciduous shrub	*Sambucus racemosa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Chamerion angustifolium*, *Thalictrum fendleri*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Medano Creek drainage.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5027.
Local Description Authors: K.E. Sabo

Populus tremuloides / Shepherdia canadensis Forest
Quaking Aspen / Russet Buffaloberry Forest
Identifier: CEGL000606

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on colluvial slopes, ridges, and stream terraces. Slopes are variable, ranging from gentle to steep, and occur on all aspects. Elevation ranges from 3045 to 3290 m. Soils are generally well-drained sandy clay loam, sandy loam, or silt loam. Litter and duff are the dominant ground cover, but rock can have significant cover (up to 20%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by *Populus tremuloides* (30-70% cover) but may include scattered conifers such as *Abies concolor, Abies lasiocarpa, Pinus aristata, Pinus flexilis*, and *Pseudotsuga menziesii*. The shrub layer is dominated by *Shepherdia canadensis* (10-30%). Other commonly occurring shrub species are *Arctostaphylos uva-ursi, Juniperus communis, Rosa woodsii*, and *Vaccinium myrtillus*. The herbaceous understory is sparse with a mixture of graminoids and forbs. *Oreochrysum parryi* is the only herbaceous species common to all surveyed stands and has an average cover of 10%. Other species that may be present with significant cover include *Chamerion angustifolium, Bromus ciliatus*, and *Artemisia franserioides*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Oreochrysum parryi*, *Shepherdia canadensis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Populus tremuloides - Abies lasiocarpa / Shepherdia canadensis* Forest (CEGL000529)--comprises a later successional stage following fir establishment.
- *Populus tremuloides / Juniperus communis* Forest (CEGL000587)--has similar species composition, but shrub layer is dominated by *Juniperus communis*.

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association was sampled in the San Isabel Creek, North Fork Creek, and Lake Fork drainages, and near Raspberry Canyon.
Global Range: This association is known from eastern Idaho, western Wyoming, and central Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 4059, 4042, 4015, 5034.
Local Description Authors: K.E. Sabo

Populus tremuloides / Symphoricarpos oreophilus **Forest**
Quaking Aspen / Mountain Snowberry Forest
Identifier: CEGL000610

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This forest association occurs on toeslopes, valley floors, and sand ramps at 2505 to 2970 m elevation. Terrain has gently rolling northwest-facing slopes. Soils are well-drained sandy loams or loamy sands. Each stand surveyed experiences either heavy grazing by elk or fire that created dense stands of *Populus tremuloides* regeneration.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Sampled stands have open to moderately dense canopies dominated by *Populus tremuloides* (20-60%), which occurs in both the tree and tall-shrub layers. *Symphoricarpos* spp. dominate the short-shrub layer with 20% cover. The herbaceous layer is graminoid-dominated and typically includes *Carex inops, Poa pratensis, Hesperostipa comata, Festuca arizonica*, and *Koeleria macrantha*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Hesperostipa comata*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Exotic/Invasive: *Poa pratensis* (invasive/exotic, Medium)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Bromus carinatus* Forest (CEGL000566)
- *Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Calamagrostis rubescens* Forest (CEGL000567)
- *Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus* / Tall Forbs Forest (CEGL000568)
- *Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Thalictrum fendleri* Forest (CEGL000569)
- *Populus tremuloides / Quercus gambelii / Symphoricarpos oreophilus* Forest (CEGL000598)
- *Populus tremuloides / Symphoricarpos oreophilus / Bromus carinatus* Forest (CEGL000611)
- *Populus tremuloides / Symphoricarpos oreophilus / Calamagrostis rubescens* Forest (CEGL000612)

- *Populus tremuloides / Symphoricarpos oreophilus / Carex rossii* Forest (CEGL000613)
- *Populus tremuloides / Symphoricarpos oreophilus / Festuca thurberi* Forest (CEGL000614)
- *Populus tremuloides / Symphoricarpos oreophilus* / Tall Forbs Forest (CEGL000615)
- *Populus tremuloides / Symphoricarpos oreophilus / Thalictrum fendleri* Forest (CEGL000616)
- *Populus tremuloides / Symphoricarpos oreophilus / Wyethia amplexicaulis* Forest (CEGL000617)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Cold Creek drainage, Medano Creek drainage, and Morris Gulch.
Global Range: This aspen forest association occurs throughout the Rocky Mountain region and in mountains in the interior western U.S. and possibly Trans-Pecos Texas.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 938, 5014, 57.
Local Description Authors: K.E. Sabo

Populus tremuloides / Thalictrum fendleri Forest

Quaking Aspen / Fendler's Meadowrue Forest
Identifier: CEGL000619

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association was sampled at 3070 m elevation on a mid colluvial slope. The terrain is gently sloping (16 degrees) and south-facing, with two small streams running through the surveyed stand. The soil is rapidly drained silty clay loam. Ground cover is dominated by 91% litter and duff.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Populus tremuloides* forms a dense homogeneous canopy with 70% cover. The herbaceous layer is sparse with no dominant species. Species with more than trace cover include *Geranium richardsonii, Thalictrum fendleri, Bromus porteri, Carex canescens*, and *Fragaria virginiana*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur along Cottonwood Creek drainage.
Global Range: This in an infrequent forest association known from Idaho, western Wyoming, Utah, north-central New Mexico, and Colorado, and possibly California.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 6002
Local Description Authors: K.E. Sabo

Populus tremuloides / Vaccinium myrtillus Forest
Quaking Aspen / Whortleberry Forest
Identifier: CEGL000620

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This forest association was sampled on high colluvial slopes, ridges and toeslopes at 3220 to 3375 m elevation with west-facing moderately steep slopes. Soils are moderately well-drained loam, sandy clay loam, or sandy loam. Ground cover is dominated by litter and duff, but there can be a significant amounts of rock (2-13%) and gravel (0-7%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a moderately dense overstory of *Populus tremuloides* (30-40%), with occasional individuals of *Picea engelmannii*. The understory consists of a moderately dense dwarf-shrub layer dominated by *Vaccinium myrtillus var. oreophilum* (30-40%), interspersed with a few short shrubs and sparse herbaceous cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Herb (field)	Dwarf-shrub	*Vaccinium myrtillus* var. *oreophilum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Picea engelmannii*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Abies concolor - Pseudotsuga menziesii / Vaccinium myrtillus* Forest (CEGL000265)
- *Abies lasiocarpa - Picea engelmannii / Vaccinium myrtillus* Forest (CEGL000343)
- *Picea engelmannii / Vaccinium myrtillus* Forest (CEGL000379)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Middle Fork North Crestone Creek drainage, Little Sand Creek drainage, and near Raspberry Canyon.
Global Range: This association is known to occur in Colorado from the northern mountains of the Park Range to the southern mountains of the Sangre de Cristo Range.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3060, 4016, 4041.
Local Description Authors: K.E. Sabo

Populus tremuloides / Calamagrostis canadensis **Forest**

Quaking Aspen / Bluejoint Forest
Identifier: CEGL000574

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a stream terrace at 2967 m elevation. Terrain is gently sloping and west-facing. The soil is well-drained loamy sand with litter and duff as the largest component of the ground cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand has a moderately dense homogeneous canopy of *Populus tremuloides* and a sparse shrub layer that includes *Acer glabrum* and *Rosa woodsii*. Herbaceous cover is sparse and dominated by *Calamagrostis canadensis* and *Carex siccata (= Carex foenea var. foenea)*, together with a variety of forbs.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Calamagrostis canadensis*, *Carex siccata*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Abies lasiocarpa - Picea engelmannii / Calamagrostis canadensis* Forest (CEGL000300)
- *Pinus contorta / Calamagrostis canadensis* Forest (CEGL000138)
- *Populus balsamifera ssp. trichocarpa - Populus tremuloides* - Conifer / *Calamagrostis canadensis* Forest (CEGL005909)
- *Populus balsamifera ssp. trichocarpa / Calamagrostis canadensis* Forest [Provisional] (CEGL005845)

- *Populus tremuloides / Carex aquatilis var. aquatilis* Forest (CEGL003442)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Cold Creek drainage.
Global Range: This association occurs in the mountains of eastern Washington and Oregon, Montana, Idaho, Colorado, and possibly Wyoming. It also is found in southern Alberta, Canada.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3092.
Local Description Authors: K.E. Sabo

Populus tremuloides / Alnus incana Forest
Quaking Aspen / Gray Alder Forest
Identifier: CEGL001150

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This riparian association is found in terraces and valley floors at 1775 to 2905 m elevation. Stands can be permanently or temporarily flooded. Soils are poorly drained or somewhat poorly drained loams. Ground cover is variable with 50-65% litter and duff, 5-10% wood, and 0-15% moss.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The relatively closed (~70% cover), multi-storied canopy is dominated by *Populus tremuloides* and subcanopy (or tall shrub layer)dominated by *Alnus incana*. Conifer tree species can be present, but at lower cover values (<10%cover), and include *Abies concolor* and *Picea engelmannii*. In some stands a tall-shrub layer that includes *Salix drummondiana* and *Acer glabrum* is present. The herbaceous layer is variable, ranging from sparse to dense (15-85% cover). Dominant herbaceous species, each with cover ranging from 10-20%, include *Bromus ciliatus, Calamagrostis canadensis, Osmorhiza depauperata, Epilobium hornemannii*, and *Heracleum maximum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Alnus incana*, *Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Calamagrostis canadensis*, *Salix drummondiana*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Medano Creek and Sand Creek drainages.

Global Range: This plant association has not been described in any previous literature or been documented outside of Colorado. However, it is expected to occur in other Rocky Mountain States.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 3269, 4071, 4275, 4276.

Local Description Authors: K.E. Sabo,mod by K.A. Schulz

Populus tremuloides / Cornus sericea **Forest**

Quaking Aspen / Red-osier Dogwood Forest

Identifier: CEGL000582

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This palustrine association occurs in channels at 2675 and 2790 m elevation. Slopes are gentle and west-facing. Stands are either semipermanently flooded or seasonally flooded. Soils are very poorly drained or somewhat poorly drained loams. Ground cover is dominated by litter and duff and can have significant cover of wood.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a multi-storied canopy dominated by *Populus tremuloides* (20-40%) with up to 10% *Abies concolor, Picea pungens*, or *Pseudotsuga menziesii*. The shrub layer is dominated by *Cornus sericea* (40-70%), and may include significant amounts of other shrubs such as *Rosa woodsii, Ribes leptanthum*, or *Salix* spp. Other commonly occurring shrub species include *Salix monticola, Acer glabrum*, and *Salix drummondiana*. The herbaceous layer is sparse with no dominant species. Common species include *Bromus ciliatus, Geum macrophyllum*, and *Maianthemum stellatum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Cornus sericea*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

Great Sand Dunes National Park and Preserve Comments:

Global Similar Associations:

- *Picea engelmannii / Cornus sericea* Woodland (CEGL002677)
- *Populus balsamifera ssp. trichocarpa / Cornus sericea* Forest (CEGL000672)

- *Pseudotsuga menziesii / Cornus sericea* Woodland (CEGL000899)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Horse Canyon and Castle Creek drainage.
Global Range: This association occurs in Colorado, Montana, Utah, Idaho, Oregon, Washington, Alberta, and possibly California.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5257, 3274.
Local Description Authors: K.E. Sabo

Populus tremuloides / Ribes montigenum Forest

Quaking Aspen / Western Prickly Gooseberry Forest
Identifier: CEGL000600

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is found on moderately steep colluvial and toeslopes. Elevation ranges from 3195 to 3545 m. Soils are moderately drained or well-drained loams. Ground cover is variable across surveyed stands. Litter and duff range in cover from 25-74%, rock from 15-55%, and vegetation basal cover from 4-10%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This forested association dominated by *Populus tremuloides* (40-70% cover) is characterized by a moderately dense tree canopy and short-shrub layer, but has low species richness and simple canopy structure. *Ribes montigenum* is the dominant shrub species with 10-30% cover. The only other shrub species present is *Rosa woodsii*. The herbaceous layer is sparse, ranging in cover from 5-35% cover. Species present in both sampled stands include *Calamagrostis canadensis, Thalictrum fendleri*, and *Geranium richardsonii*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Shrub/sapling (tall & short)	Broad-leaved deciduous shrub	*Ribes montigenum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the North Fork Creek and Deadman Creek drainages.

Global Range: This minor riparian forest association is found east of the Continental Divide in a mountainous region of south-central Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5208, 4058.
Local Description Authors: K.E. Sabo

Populus tremuloides / Rosa woodsii **Forest**
Quaking Aspen / Woods' Rose Forest
Identifier: CEGL003149

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in valley floors, drainage channels, colluvial slopes, and stream terraces. Terrain is variable, ranging from low to steep west-facing slopes with elevation ranging from 2595 to 3265 m. Surveyed stands can be intermittently flooded with loam or sandy loam soils. Ground cover is dominated by litter and duff, but there can be a significant amounts of wood (4-15%) present.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This forested association is dominated by a moderately dense canopy of *Populus tremuloides* (40-60%), with occasional presence of coniferous species such as *Pinus ponderosa, Pseudotsuga menziesii, Pinus flexilis, Pinus aristata*, and *Picea engelmannii*. *Juniperus scopulorum* is frequently present as a tall shrub. The short-shrub layer is generally dominated by *Rosa woodsii* (5-40%), but may also include *Ericameria nauseosa, Ribes inerme, Symphoricarpos rotundifolius*, and other species. Herbaceous cover is variable, ranging from 1-55%. No species are constant across all sampled stands, but common components include the graminoids *Bromus ciliatus, Calamagrostis canadensis*, and *Poa* spp., and forbs such as *Artemisia* spp., *Carex siccata (= Carex foenea var. foenea), Chamerion angustifolium, Equisetum arvense, Maianthemum stellatum, Oreochrysum parryi*, and *Thalictrum fendleri*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Rosa woodsii*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3); **Exotic/Invasive**: *Poa pratensis* (invasive/exotic, Medium)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Deadman Creek, Little Medano Creek, Medano Creek, Mosca Creek, North Arrastre Creek, and South Zapata Creek drainages.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3011, 3201, 4078, 3230, 4093, 150, 5092.
Local Description Authors: K.E. Sabo

Populus tremuloides / Salix drummondiana **Forest**
Quaking Aspen / Drummond's Willow Forest
Identifier: CEGL002902

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in streambeds and drainage channels at 2710 to 3150 m elevation. Terrain is flat to gently sloping and southwest-facing. This palustrine type ranges from seasonally flooded to permanently flooded with moderately drained sandy loam soils. Litter and duff dominate the ground cover with a significant portion of wood and rock.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This forested association is dominated by *Populus tremuloides* in the canopy and subcanopy layers with cover ranging from 30-50%. The tall-shrub layer is dominated by *Salix drummondiana* with 10-20% cover. Other shrub species that may be present include *Acer glabrum, Lonicera involucrata, Rosa woodsii, Ribes* spp., *Rubus idaeus*, and *Sambucus racemosa*. The herbaceous layer is sparse and generally includes both graminoids, such as *Calamagrostis canadensis* and *Carex* spp., and forbs, such as *Actaea rubra, Artemisia franserioides, Fragaria virginiana, Geranium richardsonii, Heracleum maximum, Oreochrysum parryi*, and *Thalictrum fendleri*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Salix drummondiana*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the San Isabel Creek, North Fork Creek, and Pole Creek drainages.

Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4053, 3111, 5042, 5036.
Local Description Authors: K.E. Sabo

Pseudotsuga menziesii / Bromus ciliatus Forest

Douglas-fir / Fringed Brome Forest
Identifier: CEGL000428

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one location, occurring on a mountain flank at 3030 m elevation. Slopes are moderately steep (18 degrees) and northeast-facing. Soils are well-drained sandy loam.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The single sample of this association is characterized by a homogeneous dense canopy of *Pseudotsuga menziesii* (55-65%). The herbaceous understory is sparse, with 15-25% total cover, and includes *Bromus ciliatus, Trisetum spicatum*, and *Piptatherum micranthum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Bromus ciliatus*, *Piptatherum micranthum*, *Trisetum spicatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Little Medano Creek.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5239.
Local Description Authors: K.E. Sabo, mod. K. Decker

Pseudotsuga menziesii / Festuca arizonica Forest
Douglas-fir / Arizona Fescue Forest
Identifier: CEGL000433

ENVIRONMENTAL DESCRIPTION
Great Sand Dunes National Park and Preserve Environment: This association is known from one location found on a moderately steep low shoulder slope at 2878 m elevation. Soils are moderately drained loams. Live vegetation basal area dominates the soil surface, along with moderate amounts of litter and bare soil.

VEGETATION DESCRIPTION
Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open low-statured canopy of *Pseudotsuga menziesii* (10%). The herbaceous layer ranges from 25-35% cover with *Muhlenbergia montana, Festuca arizonica*, and *Danthonia parryi* as dominant species.

MOST ABUNDANT SPECIES
Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*

CHARACTERISTIC SPECIES
Great Sand Dunes National Park and Preserve: *Danthonia parryi*, *Festuca arizonica*, *Muhlenbergia montana*

OTHER NOTEWORTHY SPECIES
Great Sand Dunes National Park and Preserve:

CLASSIFICATION
Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Pseudotsuga menziesii / Muhlenbergia montana* Forest (CEGL000443)
- *Pseudotsuga menziesii / Poa fendleriana* Woodland (CEGL002809)
- *Pseudotsuga menziesii / Quercus gambelii* Forest (CEGL000452)

ELEMENT DISTRIBUTION
Great Sand Dunes National Park and Preserve Range: This association is known to occur near Axtel Canyon.
Global Range: Data not available

ELEMENT SOURCES
Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4051
Local Description Authors: K.E. Sabo, mod. K. Decker

Pseudotsuga menziesii / Jamesia americana Forest
Douglas-fir / Five-petal Cliffbush Forest
Identifier: CEGL000438

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on midslopes of colluvial origin and in drainage channels from 2795 and 2890 m elevation. Slopes may be gentle to very steep. Soils are rapidly drained loamy sands or moderately well-drained sandy loams. Stands can be very rocky or dominated by litter and duff.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a moderately dense canopy of *Pseudotsuga menziesii*. Other tree species may be present with very low cover, including *Abies concolor, Juniperus scopulorum, Picea engelmannii, Pinus flexilis*, or *Populus angustifolia*. *Jamesia americana* forms a tall-shrub layer with 15-25% cover. Other shrubs may include *Acer glabrum, Holodiscus dumosus, Ribes* spp., and *Rosa woodsii*. The herbaceous layer is sparse with 1-5% cover and there is no dominant species.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Jamesia americana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Jamesia americana*, *Pseudotsuga menziesii*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments: This association can be distinguished from other similar associations by the presence of *Jamesia americana* and the absence of significant amounts of other coniferous species.
Global Similar Associations:
- *Abies concolor - (Pseudotsuga menziesii) / Jamesia americana - Holodiscus dumosus* Scree Woodland (CEGL000890)
- *Pseudotsuga menziesii / Physocarpus monogynus* Forest (CEGL000449)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Cleavland Gulch and Buck Creek drainage.
Global Range: This montane forest association occurs in the southern Rocky Mountains of Colorado and into Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5032, 5052.
Local Description Authors: K.E. Sabo, mod. K. Decker

Pseudotsuga menziesii / Juniperus communis Forest
Douglas-fir / Common Juniper Forest
Identifier: CEGL000439

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on very steep colluvial slopes at 2970-3005 m elevation. Soils are well-drained sandy loam, sandy clay loam, or loamy sand. Stands are generally rocky (2-12% cover) with litter and duff covering the largest percentage of the ground.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This forest association is characterized by a moderately dense canopy of *Pseudotsuga menziesii* (33-40%). Other tree species are present but not dominant, with up to 10% cover, and include a mix of evergreen needle-leaved and deciduous trees such as *Abies concolor*, *Pinus flexilis*, *Picea engelmannii*, and *Populus tremuloides* . The short-shrub layer is dominated by *Juniperus communis* (10-20%), but may also include smaller amounts of species such as *Arctostaphylos uva-ursi, Holodiscus dumosus, Jamesia americana, Rosa woodsii*, and *Shepherdia canadensis*. The herbaceous layer is sparse and includes both forb and graminoid species.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*
Short shrub/sapling	Needle-leaved shrub	*Juniperus communis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Picea engelmannii*, *Populus tremuloides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Picea engelmannii / Juniperus communis* Forest (CEGL005925)
- *Picea pungens / Juniperus communis* Forest (CEGL000392)
- *Pinus albicaulis / Juniperus communis* Woodland (CEGL000756)
- *Pinus contorta / Juniperus communis* Woodland (CEGL000764)
- *Pinus flexilis / Juniperus communis* Woodland (CEGL000807)
- *Pseudotsuga menziesii / Arctostaphylos uva-ursi* Forest (CEGL000424)
- *Pseudotsuga menziesii / Mahonia repens* Forest (CEGL000442)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Willow Creek drainage, Sand Creek drainage, Cleavland Gulch, and Mosca Creek drainage.
Global Range: This forested association occurs from northwestern Montana south into central and eastern Idaho, western Wyoming and northern Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4070, 3208, 158, 5224.
Local Description Authors: K.E. Sabo, mod. K. Decker

Pseudotsuga menziesii / Symphoricarpos oreophilus Forest

Douglas-fir / Mountain Snowberry Forest
Identifier: CEGL000462

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one location on a steep north-facing ridge at 2930 m elevation. Soils are well-drained sandy loams with the majority of the ground surface covered with litter and duff.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The single sample of this association has a sparse tree canopy dominated by *Pseudotsuga menziesii*. *Juniperus scopulorum* and *Pinus edulis* are also present. The shrub layer is dominated by *Symphoricarpos oreophilus* (10%), but small amounts of other shrub species such as *Juniperus communis* and *Ribes* spp. are also present. The grassy herbaceous layer ranges in cover from 25-35% and is dominated by *Festuca arizonica* (10%), *Festuca thurberi* (10%), and *Danthonia parryi* (3%).

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Festuca arizonica*, *Festuca thurberi*, *Juniperus scopulorum*, *Symphoricarpos oreophilus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Abies concolor / Symphoricarpos oreophilus* Forest (CEGL000263)
- *Pinus ponderosa / Symphoricarpos oreophilus* Forest (CEGL000205)
- *Populus tremuloides - Pseudotsuga menziesii / Symphoricarpos oreophilus* Forest (CEGL000546)
- *Pseudotsuga menziesii / Cercocarpus montanus* Woodland (CEGL000898)
- *Pseudotsuga menziesii / Mahonia repens* Forest (CEGL000442)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the South Zapata Falls drainage.

Global Range: This widespread montane forest association occurs in foothills, mountains and plateaus from southwestern Montana through Wyoming and Colorado to Trans-Pecos Texas, west to Arizona, Utah, and into eastern Oregon and Washington.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5023.
Local Description Authors: K.E. Sabo, mod. K. Decker

II. Woodland

Abies concolor - (Pseudotsuga menziesii) / Jamesia americana - Holodiscus dumosus Scree Woodland

White Fir - (Douglas-fir) / Five-petal Cliffbush - Glandular Oceanspray Scree Woodland
Identifier: CEGL000890

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from two plots located in ravines and drainage channels at 2798 and 2801 m elevation. Terrain is very steep. Soils can be saturated and range from somewhat poorly drained loam to rapidly drained clay loam. Ground cover includes 15-30% litter and duff, 10-15% wood, 0-15% gravel, 37-40% rock, and 15-25% moss.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open canopy of *Pseudotsuga menziesii* and *Abies concolor* with a total of 5-25% cover. The shrub layer ranges in cover from 35-55% with *Holodiscus dumosus* (30%), *Symphoricarpos* spp. (10%), and *Ribes leptanthum* (3%) as common species. The herbaceous understory is sparse, with less than 20% cover and low species diversity. Common species include graminoids *Bromus ciliatus, Koeleria macrantha*, and *Piptatherum micranthum*, and the forb *Saxifraga bronchialis ssp. austromontana*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Abies concolor*, *Pseudotsuga menziesii*
Short shrub/sapling	Broad-leaved deciduous shrub	*Holodiscus dumosus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Abies concolor*, *Holodiscus dumosus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Abies concolor - Pseudotsuga menziesii / Acer glabrum* Forest (CEGL000240)
- *Pseudotsuga menziesii / Holodiscus dumosus* Scree Woodland (CEGL000902)
- *Pseudotsuga menziesii / Jamesia americana* Forest (CEGL000438)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur near Zapata Creek.
Global Range: This association occurs in the southern Rocky Mountains in southern Colorado, New Mexico and Arizona.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5086, 4116.
Local Description Authors: K.E. Sabo

Abies concolor / Festuca arizonica Woodland

White Fir / Arizona Fescue Woodland
Identifier: CEGL000887

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on colluvial slopes and sand ramps with elevation ranging from 2635 to 2950 m. Slopes are gentle to steep and northwest-facing. Soils are well-drained loamy sands. Ground cover is variable with 10-80% litter and duff and 10-75% bare soil.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open to moderately dense (20-40% cover) canopy codominated by *Pseudotsuga menziesii* and *Abies concolor*. *Pinus ponderosa* and *Juniperus scopulorum* may also be present. The shrub layer is sparse with less than 5% cover and may include *Symphoricarpos* ssp., *Artemisia frigida*, and *Ribes leptanthum*. Herbaceous cover ranges from 5-45% and is graminoid-dominated, but with a moderately diverse sparse forb component. Dominant species include *Festuca arizonica* with 10-20% cover and *Poa fendleriana* with 3-10% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Abies concolor*, *Pseudotsuga menziesii*
Herb (field)	Graminoid	*Festuca arizonica*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Abies concolor*, *Festuca arizonica*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Abies concolor - Pseudotsuga menziesii / Festuca thurberi - Danthonia parryi* Woodland (CEGL005350)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur near Cold Creek, Medano Creek drainage, Horse Canyon, and North Zapata Creek drainage.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4291, 5210, 3106, 5062.
Local Description Authors: K.E. Sabo

Abies lasiocarpa - Picea engelmannii / Juniperus communis Woodland

Subalpine Fir - Engelmann Spruce / Common Juniper Woodland
Identifier: CEGL000919

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on dry slopes in the upper subalpine. It is documented from a single plot at 3602 m elevation with a south aspect and slope of 33 degrees. The plot is located near treeline in an area which may be prone to avalanches. Ground cover is generally rocky, with small and large rocks and bedrock making up 35% of the total ground cover, followed by bare soil and litter, each with 30%. Soils are well-drained and include sandy loam.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Picea engelmannii* forms a sparse tree stratum, with *Abies lasiocarpa* and *Pinus aristata* present in trace amounts. Trees are stunted and mostly between 2-5 m in height, but overall larger than true krummholz form. *Juniperus communis* forms a short-shrub layer with 15% cover over a dwarf-shrub layer of *Vaccinium myrtillus* with 15% cover. Herbaceous species total <5% cover and include *Poa alpina, Carex rossii, Thermopsis* sp., and *Phlox multiflora*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*
Short shrub/sapling	Needle-leaved shrub	*Juniperus communis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Abies lasiocarpa*, *Vaccinium myrtillus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3); **Exotic/Invasive**: *Bromus tectorum* (invasive/exotic, High)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Abies concolor / Juniperus communis* Forest (CEGL000249)
- *Abies lasiocarpa - Picea engelmannii / Carex siccata* Forest (CEGL000303)--also supports a mixed canopy and subcanopy of *Abies lasiocarpa* and *Picea engelmannii*. It hosts a fairly sparse shrub layer. *Juniperus communis* can occur, and *Carex siccata>/i> dominates the understory.*
- *Picea engelmannii / Juniperus communis* Forest (CEGL005925)
- *Pinus contorta / Juniperus communis* Woodland (CEGL000764)
- *Populus tremuloides - Abies lasiocarpa / Juniperus communis* Forest (CEGL000527)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from one location in the upper Medano Creek drainage but likely occurs elsewhere throughout the upper subalpine.

Global Range: This spruce-fir woodland association occurs in localized areas within the subalpine to upper montane zones of the western United States from Montana to Washington south to Arizona and New Mexico.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 351.
Local Description Authors: K. Forrest

Pinus aristata / Festuca arizonica Woodland

Bristlecone Pine / Arizona Fescue Woodland
Identifier: CEGL000759

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from colluvial slopes and ridges between 2985 and 3285 m in elevation. Sites are generally found on warm aspects (SE through NW), with moderately steep slopes of 16 to 36 degrees (average 29 degrees). Soils are well-drained to rapidly-drained, with loamy sand the most common. Litter and duff make up 30-60% of the ground cover, followed by bare soil (3-30%), gravel (2-30%), rock (2-25%), and basal area (3-10%). Wood is present in all plots with 2-8% ground cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Pinus aristata* forms an open woodland with between 15 and 30% cover. The understory is mostly herbaceous and is often the same as adjacent open meadows. This association tends to have a very high species count with many trace forbs. Scattered shrubs may be present with up to 15% cover, especially beneath the trees. These include *Symphoricarpos* spp., *Ribes cereum*, and *Holodiscus dumosus*. *Festuca arizonica* and *Muhlenbergia montana* (and sometimes *Danthonia parryi*) are the most prevalent graminoids, with a combined cover of 15-40%, and *Koeleria macrantha* is consistently present in trace amounts. Forbs may include *Artemisia frigida, Heterotheca villosa, Eriogonum jamesii, Erigeron subtrinervis, Hymenoxys richardsonii, Oxytropis* sp., *Silene scouleri, Achillea millefolium var. occidentalis, Arenaria fendleri, Campanula rotundifolia, Heuchera parvifolia, Machaeranthera bigelovii, Oreochrysum parryi, Packera fendleri, Potentilla hippiana*, and many others.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus aristata*
Herb (field)	Graminoid	*Festuca arizonica*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Artemisia frigida*, *Koeleria macrantha*, *Muhlenbergia montana*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: **Vulnerable**: *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Great Sand Dunes National Park and Preserve Comments: This association is related to *Pinus flexilis / Festuca arizonica* Woodland [Park Special 3], which has a different dominant tree. It is also closely related to, and often adjacent to, *Festuca arizonica - Muhlenbergia montana* Herbaceous Vegetation (CEGL001606). In rare cases, *Danthonia parryi* can dominate the graminoid stratum when the other characteristic species are present.

Global Similar Associations:

- *Pinus aristata / Trifolium dasyphyllum* Woodland (CEGL000762)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from the southern half of the project area, in Big South Canyon, above Buck Creek, Garden Creek and Mosca Pass, and above South Zapata Creek. It likely exists in subalpine bristlecone pine stands throughout this range.

Global Range: This association is known from the southern Rocky Mountains and from the Colorado Plateau regions of Colorado and New Mexico.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 4280, 5260, 51, 4204, 3242, 2292, 5236.

Local Description Authors: K. Forrest

Pinus aristata / Festuca thurberi Woodland

Bristlecone Pine / Thurber's Fescue Woodland

Identifier: CEGL000760

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from colluvial slopes between 3150 and 3590 m in elevation. Sites are south-facing and moderate to steeply sloped (24-38 degrees). The soils are well-drained sandy loam, sandy clay loam and silt. Litter and duff make up most of the ground cover with 30-75%. Bare soil can have up to 40% cover, and basal area ranges from 5-20%. Large rocks cover 15% in one plot.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Pinus aristata* forms an open-canopy (35-50%) woodland over a *Festuca thurberi*-dominated herbaceous layer. Short shrubs *Ribes montigenum, Symphoricarpos* sp., and *Holodiscus dumosus* can have up to 15% cover, but do not exceed herbaceous cover. Forbs are generally sparse, with less than 10% cover between the bunchgrasses. Trace forb species often include *Erigeron formosissimus, Lupinus argenteus, Achillea millefolium var. occidentalis, Anaphalis margaritacea, Antennaria rosea, Arenaria fendleri, Besseya alpina, Draba streptocarpa, Oreochrysum parryi, Packera fendleri, Penstemon whippleanus, Polemonium pulcherrimum, Potentilla* spp., *Pseudocymopterus montanus*, and *Androsace septentrionalis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus aristata*
Herb (field)	Graminoid	*Festuca thurberi*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Lupinus argenteus*, *Packera fendleri*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from Horse Canyon, Sawmill Canyon, and North Zapata Ridge.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3223, 3235, 5243, 3277, 2362.
Local Description Authors: K. Forrest

Pinus aristata / Ribes montigenum Woodland

Bristlecone Pine / Western Prickly Gooseberry Woodland
Identifier: CEGL000761

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a west-facing colluvial slope at 3474 m in elevation. The stand is dry and rocky, with a slope of 22 degrees, and is adjacent to an open talus field. Large rocks make up 35% of the ground cover, followed by litter and duff (25%), bare soil and basal area (15% each), and wood and lichens (5% each). Charred stumps and snags were noted as present in the area of the plot. Soils are well-drained silt loam.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Pinus aristata* forms a canopy with 30% cover over an open understory. *Ribes montigenum* grows low to the ground between rocks and logs, barely forming a shrub layer with 15% cover, and drops out of the understory farther into the stand where tree cover increases. Scattered individuals of *Picea engelmannii* are present in the canopy. Other trace species include *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda), Carex* sp., *Saxifraga bronchialis ssp. austromontana, Poa* sp., *Calamagrostis purpurascens, Trisetum spicatum, Elymus trachycaulus, Sedum lanceolatum, Frasera speciosa, Trifolium dasyphyllum, Heuchera parvifolia, Androsace septentrionalis, Polemonium pulcherrimum*, and *Saxifraga flagellaris*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus aristata*
Short shrub/sapling	Broad-leaved deciduous shrub	*Ribes montigenum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Saxifraga bronchialis* ssp. *austromontana*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Pinus aristata / Trifolium dasyphyllum* Woodland (CEGL000762)
- *Pinus contorta / Juniperus communis* Woodland (CEGL000764)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from one plot in the Jones Creek side drainage of Sand Creek.
Global Range: The association is described as occurring in northern Arizona, northern New Mexico, and Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4064.
Local Description Authors: K. Forrest

Pinus aristata / Vaccinium myrtillus Woodland

Bristlecone Pine / Whortleberry Woodland
Identifier: CEGL002895

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a colluvial slope at 3364 m in elevation. The site faces SSW and has a slope of 21 degrees. Litter and duff cover about half of the ground, with small rocks and bare soil splitting the other half. Soil is a well-drained loamy sand.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Pinus aristata* grows in a nearly pure stand with trace amounts of *Picea engelmannii* and *Populus tremuloides*. *Vaccinium myrtillus* forms a dwarf-shrub layer of 20% cover. *Juniperus communis* and *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda)* are present as short shrubs with <5% cover. Herbaceous species include *Festuca thurberi*, *Fragaria virginiana*, and *Lupinus argenteus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus aristata*
Herb (field)	Dwarf-shrub	*Vaccinium myrtillus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments: This association is known from only one observation point in Great Sand Dunes. At other places in this stand, *Festuca thurberi* or *Juniperus communis* are dominant.
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from one location near Music Pass, along the trail to Sand Creek Lakes.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4207, 5012.
Local Description Authors: K. Forrest

Pinus edulis - (Juniperus monosperma) / Bouteloua gracilis Woodland
Two-needle Pinyon - (One-seed Juniper) / Blue Grama Woodland
Identifier: CEGL002151

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on alluvial fans, shoulder slopes, and eolian sand ramps between 2475 and 2555 m elevation. Slopes are variable, ranging from flat to moderately steep. Soils are well-drained sandy loams with 30-70% bare soil, 10-40% gravel, and 0-15% rock.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open canopy of *Pinus edulis* (10% cover). *Juniperus scopulorum* is codominant when present. The shrub layer is sparse and may include scattered *Cercocarpus montanus, Chrysothamnus* spp., *Ericameria nauseosa, Holodiscus dumosus, Ribes* spp., *Symphoricarpos oreophilus*, and *Yucca glauca*. The herbaceous layer ranges in cover from 5-30% and is generally graminoid-dominated. *Bouteloua gracilis* (10-20%) is dominant, but *Muhlenbergia montana, Piptatherum micranthum, Poa fendleriana, Sporobolus cryptandrus*, and other grasses may be present. Forb cover is sparse. Common species include *Opuntia polyacantha* and *Heterotheca villosa*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Juniperus scopulorum*, *Pinus edulis*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Pinus edulis - (Juniperus osteosperma) / Bouteloua gracilis* Woodland (CEGL000778)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur near Mosca Creek, near Denton Spring, in Tellurium Gulch, and Urraca Creek drainage.
Global Range: This widespread woodland association occurs in southern Colorado, western Oklahoma, New Mexico, and possibly Texas and east-central Arizona.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 217, 3217, 434, 3070.
Local Description Authors: K.E. Sabo

Pinus edulis - Juniperus spp. / *Cercocarpus montanus* - Mixed Shrubs Woodland

Two-needle Pinyon - Juniper species / Alderleaf Mountain-mahogany - Mixed Shrubs Woodland
Identifier: CEGL000780

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This woodland association ranges from the alluvial fan to colluvial slopes and ridges, between 2610 and 3090 m in elevation. Sites are generally steep and south-facing, with an average slope of 28 degrees, and with aspects ranging southeast to northwest. Soils are loamy sand and sandy loam. Litter covers 5-58% of the ground, bare soil averages 25%, and bedrock, large rocks and gravel can have significant cover as well.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This community is characterized by an open to moderately dense canopy of *Pinus edulis* and *Juniperus scopulorum* with a short- or tall-shrub stratum with 10-20% cover dominated by *Cercocarpus montanus*. Scattered individuals of *Pinus ponderosa, Pseudotsuga menziesii*, and *Pinus flexilis* may be present in the canopy or as emergent trees. Characteristic understory species include *Artemisia frigida, Opuntia polyacantha, Muhlenbergia montana*, and *Eriogonum jamesii*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus edulis*
Shrub/sapling (tall & short)	Broad-leaved evergreen shrub	*Cercocarpus montanus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Artemisia frigida*, *Eriogonum jamesii*, *Juniperus scopulorum*, *Muhlenbergia montana*, *Opuntia polyacantha*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Pinus edulis - Juniperus osteosperma / Artemisia bigelovii* Woodland (CEGL002118)
- *Pseudotsuga menziesii / Cercocarpus montanus* Woodland (CEGL000898)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association has been documented throughout the pinyon-juniper lifezone from the Baca Grande subdivision south to near the edge of the project boundary.
Global Range: This widespread woodland association is found from southern Colorado and north-central New Mexico to the Mogollon Rim of Arizona, north across the Colorado Plateau into western Colorado and adjacent Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2175, 4203, 2082, 3064, 3023, 3012, 4205, 4263, 5022, 4202, 3236, 4115, 5238, 35, 858.
Local Description Authors: K. Forrest

Pinus edulis / Rockland Woodland

Two-needle Pinyon / Rockland Woodland
Identifier: CEGL000794

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This woodland is known from colluvial slopes and ridges between 2765 and 2885 m in elevation. Bedrock outcrops are typically present with 20-40% ground cover. Combined with large rocks and gravel, they make up at least 50% of the ground cover. Bare soil can also be prevalent, leaving litter to cover between 10-25% of the ground surface. Slopes range from 40 degrees on steep colluvial slopes to 12 degrees on rocky ridgetops. Substrates tend to be loose and actively eroding. Soils are rapidly to well-drained loamy sand.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Pinus edulis* forms an open to moderately dense canopy with 10-50% cover. The understory is generally sparse, with no stratum exceeding 10% cover. *Cercocarpus montanus* may be present, but does not form a shrub layer. Characteristic species include *Juniperus scopulorum, Ribes cereum, Bouteloua gracilis, Muhlenbergia montana, Opuntia polyacantha*, and *Heterotheca villosa*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus edulis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Bouteloua gracilis*, *Cercocarpus montanus*, *Juniperus scopulorum*, *Muhlenbergia montana*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments: *Pinus edulis* / Sparse Understory Forest (CEGL000795) is a related association that occurs on the alluvial fans at lower elevations and tends to occupy lower slopes and no bedrock outcrops.
Global Similar Associations:
- *Pinus edulis* / Sparse Understory Forest (CEGL000795)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from colluvial slopes in the southern half of the project area, and potentially exists throughout the upper pinyon-juniper lifezone.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4100, 3273, 4080, 4079.
Local Description Authors: K. Forrest

Pinus flexilis / Festuca arizonica - Muhlenbergia montana Woodland
Limber Pine / Arizona Fescue - Mountain Muhly Woodland
Identifier: CEGL005416

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from colluvial slopes and ridges between 2780m and 3150m in elevation. Sites are located on warm aspects SE through NW, and on slopes ranging from 6° on a high ridge to 38° on a steep colluvial slope. The ground cover is generally over 50% bare soil, gravel and rock, with about 30% litter and <10% each of basal area and wood (although one plot had 76% litter and few rocks). Soils are well-drained and high in sand. Past fires were noted at several plots.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open canopy of *Pinus flexilis* with an herbaceous understory high in graminoids *Festuca arizonica* and *Muhlenbergia montana*. The tree strata may have scattered individuals of Pinus ponderosa, Pinus aristata, Pinus edulis, Abies concolor, Pseudotsuga menziesii or Juniperus scopulorum. Stands on ridge tops or otherwise on the edge of sharp gradients are more prone to mixing. Short shrubs are often present with up to 15% cover, but do not exceed herbaceous cover. Species can include: *Symphoricarpos* spp., *Juniperus communis*, *Ribes cereum*, *Cercocarpus montanus* and *Rosa woodsii*. The herbaceous layer is diverse, often supporting more than 30-40 forb and graminoid species. *Festuca arizonica* and *Muhlenbergia montana* typically codominate, but one or the other may be absent. Frequently encountered graminoids include: *Koeleria macrantha*, *Elymus elymoides*, *Blepharoneuron tricholepis*, *Carex foenea* var. *foenea* (*Carex siccata*), *Poa fendleriana* and *Bromus ciliatus*. Forbs found in at least half of the plots include: *Heterotheca villosa*, *Packera fendleri*, *Achillea millefolium* var. *occidentalis*, *Eriogonum alatum*, *Penstemon* sp., *Artemisia frigida*, *Potentilla hippiana*, *Astragalus* sp., *Castilleja linariifolia*, *Antennaria parvifolia, Erigeron spp.* and *Eriogonum jamesii*. Other trace species include: *Artemisia ludoviciana*, *Arenaria fendleri*, *Clematis hirsutissima* var. *scottii*, *Frasera speciosa*, *Machaeranthera bigelovii*, *Oreochrysum parryi*, *Sedum lanceolatum*, *Comandra umbellata*, *Draba smithii*, *Penstemon linarioides* ssp. *coloradoensis*, *Thermopsis* sp., and many others. Stands may border or contain inclusions of *Festuca arizonica – Muhlenbergia montana* Herbaceous Vegetation.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus flexilis*
Herb (field)	Graminoid	*Festuca arizonica, Muhlenbergia montana*
Herb (field)	Forb	*Heterotheca villosa, Packera fendleri*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Great Sand Dunes National Park and Preserve Comments: This association is similar in structure and understory composition to the existing association *Pinus aristata* / *Festuca arizonica* Woodland (CEGL000759). The main difference is in the dominant tree species.

Global Similar Associations:

- *Pinus flexilis / Festuca campestris* Woodland (CEGL000806)
- *Pinus flexilis / Juniperus communis* Woodland (CEGL000807)
- *Pseudotsuga menziesii / Arctostaphylos uva-ursi* Forest (CEGL000424)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from the southern half of the project area, with most of the occurrences in the Medano Creek drainage, including Big South Canyon. Other locations include: Garden Creek, Mosca Creek and Raspberry Canyon.

Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 3271, 4043, 5237, 5244, 3270, 4258, 5235, 4269, 4274, 4278, 5254, 5256, 2034, 5063.

Local Description Authors: K. Forrest

Pinus flexilis / Juniperus communis Woodland

Limber Pine / Common Juniper Woodland

Identifier: CEGL000807

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from warm aspect colluvial slopes and southwest-facing granite ridge between 3045 and 3370 m in elevation. Slopes of the three sites sampled are moderate to steep (12-38 degrees), with lots of exposed rock and soil, and shows signs of past fires. Aspect ranges from 130 to 265 degrees. Soils are rapidly to well-drained sand and sandy loam. Litter can have 10-45% cover on the ground, mostly beneath trees and shrubs. Small and large rocks, bare soil make up 10-78% of the ground cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Pinus flexilis* is the most abundant species in the tree canopy but can be codominant with *Pinus aristata*. Scattered *Populus tremuloides, Abies concolor*, or *Picea engelmannii* may be present. Total canopy cover is up to 35%. Beneath this open woodland, *Juniperus communis* forms a patchy short-shrub layer with 15-30% cover *Arctostaphylos uva-ursi* may be present with less cover than *Juniperus communis*. Herbaceous species are sparse and can include *Blepharoneuron tricholepis, Festuca thurberi, Carex* sp., *Poa fendleriana, Thermopsis montana, Solidago multiradiata, Antennaria parvifolia, Packera fendleri, Campanula rotundifolia, Arenaria fendleri, Androsace septentrionalis, Draba smithii, Frasera speciosa, Heuchera parvifolia*, and *Saxifraga bronchialis.*

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus flexilis*
Short shrub/sapling	Needle-leaved shrub	*Juniperus communis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Pinus aristata*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Draba smithii* (globally imperiled, G2), *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Picea engelmannii / Juniperus communis* Forest (CEGL005925)
- *Pinus flexilis / Arctostaphylos uva-ursi* Woodland (CEGL000802)
- *Pinus flexilis / Cercocarpus montanus - Amelanchier utahensis* Woodland (CEGL005320)
- *Pinus flexilis / Symphoricarpos oreophilus* Woodland (CEGL005321)
- *Pinus ponderosa / Juniperus horizontalis* Woodland (CEGL000860)
- *Pseudotsuga menziesii / Juniperus communis* Forest (CEGL000439)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from two locations in the Medano Creek drainageand one in the Sand Creek drainage
Global Range: This limber pine woodland association is found in the montane and subalpine zones of the western United States, from Montana, Idaho, and Oregon south to Colorado and Utah. It may also occur in Nevada and California.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 5026, 5255.
Local Description Authors: K. Forrest

Pinus ponderosa / (Ericameria nauseosa) /Achnatherum hymenoides Woodland
Ponderosa Pine / (Rubber Rabbitbrush) / Indian Ricegrass Woodland
Identifier: CEGL001490

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This woodland association is known from five locations on the sand ramp at the north and east margin of the main dune field. Stands were located on slopes of less than 10 degrees with mostly south and west facing aspects at elevations between 2453 m and 2600 m. The soils of these sites were nearly 100% sand. Ground cover consisted of 30 to 75% litter and duff with the remainder in bare ground. These are upland sites with rapidly drained soils.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by a sparse and patchy cover of *Pinus ponderosa* with *Ericameria nauseosa* and *Achnatherum hymenoides* in the understory. Vegetation in this type forms a sparse cover of tree, shrub, and graminoid species with a high percentage of bare ground present. The tree canopy is formed by a sparse cover of *Pinus ponderosa* of 5% to 20%. Additional tree species that may be present in and around the site include *Pinus edulis* and *Juniperus scopulorum*. An equally sparse short shrub layer consisting largely of *Ericameria nauseosa* may comprise cover of 0% to 10%. Other shrub species noted from the plots include *Tetradymia canescens*, *Artemisia dracunculus*, *Ribes aureum*, *Ribes cereum*, and *Chrysothamnus viscidiflorus*. The herbaceous layer is composed of a diverse mix of forb and graminoid species which forms a sparse canopy of 5 to 20% in the stands sampled. Dominant graminoid species include *Achnatherum hymenoides, Hesperostipa comata, Sporobolus cryptandrus, Pascopyrum smithii,* and *Bouteloua gracilis.* Forbs present in this type may include *Heterotheca villosa, Psoralidium lanceolatum, Opuntia polyacantha, Yucca glauca,* and *Equisetum laevigatum.*

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve:

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Short shrub/sapling	Broad-leaved deciduous shrub	*Ericameria nauseosa*
Herb (field)	Graminoid	*Achnatherum hymenoides*
Herb (field)	Forb	*Opuntia polyacantha*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Pinus ponderosa, Ericameria nauseosa*, *Achnatherum hymenoides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: *Sporobolus cryptandrus, Hesperostipa comata, Psoralidium lanceolatum, Yucca glauca, Artemisia frigida, Ribes cerrum, Ribes aureum*

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Known from five plots collected for GRSA vegetation inventory project 2005-2010 from the base of the sand ramp along the east and north margins of the main dune field.

Global Range: Known from two locations along the southern portion of the Rocky Mountains: near Espanola, New Mexico (north-central New Mexico) and the eastern edge of Great Sand Dunes National Park and Preserve, Mosca, Colorado (south-central Colorado) (DeVelice et al 1986).

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes: GRSA Vegetation Inventory plot numbers 3052, 3100, 3103, 4014, and 5013.

Local Description Authors: J.E. Stevens

Pinus ponderosa / Festuca arizonica Woodland

Ponderosa Pine / Arizona Fescue Woodland
Identifier: CEGL000856

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single observation point on a high interfluve at 2906 m elevation. Slope is gentle and west-facing. Soils are somewhat poorly drained loams with 84% cover of litter and duff.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand is characterized by a sparse overstory of *Pinus ponderosa* and *Pinus flexilis*. The herbaceous understory consists of *Festuca arizonica* with 35-45% cover .

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus flexilis*, *Pinus ponderosa*
Herb (field)	Graminoid	*Festuca arizonica*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Festuca arizonica*, *Pinus ponderosa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Mosca Creek drainage.

Global Range: This association is known from mountains in Colorado, New Mexico, Arizona and the Trans-Pecos Mountains (Mt. Livermore in the Davis Mountains) of Texas.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4113.
Local Description Authors: K.E. Sabo

Pinus ponderosa / Juniperus scopulorum **Woodland**

Ponderosa Pine / Rocky Mountain Juniper Woodland
Identifier: CEGL000861

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a sand ramp at 2534 m elevation. Slope is moderately steep and north-facing. Soils are well-drained sands with 72% cover of litter and duff and 20% of sand.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This open woodland association is dominated by 20% cover of *Pinus ponderosa*, with a subcanopy of 10% *Juniperus scopulorum*. The sparse shrub layer includes *Ribes cereum, Cercocarpus montanus*, and *Symphoricarpos* spp. The herbaceous layer is also sparse and includes trace amounts of graminoid species such as *Festuca dasyclada, Hesperostipa comata, Koeleria macrantha, Pascopyrum smithii*, and *Piptatherum micranthum*. Forb species include *Artemisia dracunculus, Chenopodium leptophyllum, Heterotheca villosa*, and *Psoralidium lanceolatum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus ponderosa*
Tree subcanopy	Needle-leaved tree	*Juniperus scopulorum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juniperus scopulorum*, *Pinus ponderosa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Festuca dasyclada* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Juniperus scopulorum / Piptatherum micranthum* Woodland (CEGL000747)--Stands dominated by both *Pinus ponderosa* and *Juniperus scopulorum*, but with less than 25% *Pinus ponderosa*, are placed in this type.
- *Juniperus scopulorum* Woodland (CEGL003550)--is very similar, but the density of *Juniperus scopulorum* is high.
- *Pinus ponderosa / (Andropogon gerardii, Schizachyrium scoparium)* Woodland (CEGL000841)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Cold Creek drainage.

Global Range: This community is found along the eastern edge of the Rocky Mountains and on escarpments into the adjacent Great Plains, extending from the United States-Canadian border in Montana and North Dakota south to New Mexico.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3085, 5046
Local Description Authors: K.E. Sabo

Pinus ponderosa / Muhlenbergia montana Woodland

Ponderosa Pine / Mountain Muhly Woodland
Identifier: CEGL000862

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This woodland association occurs on colluvial slopes and toeslopes that range in elevation from 2755 to 2880 m. Slopes are gentle to moderately steep and east-facing. Soils are either well-drained loamy sand or rapidly drained silt. Ground cover is variable with 10-50% litter and duff, 40% bare soil, 0-20% gravel, and 2-20% rock.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open canopy of *Pinus ponderosa* with a scattering of *Pinus flexilis*. The shrub layer includes *Tetradymia canescens, Symphoricarpos* spp., and *Cercocarpus montanus* with total cover for all species under 10%. The graminoid-dominated herbaceous layer is also sparse (5-25% total cover). Common species include *Muhlenbergia montana, Hesperostipa comata*, and *Bouteloua gracilis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus flexilis*, *Pinus ponderosa*
Herb (field)	Graminoid	*Muhlenbergia montana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Muhlenbergia montana*, *Pinus flexilis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Pinus ponderosa / Bouteloua gracilis* Woodland (CEGL000848)
- *Pseudotsuga menziesii / Muhlenbergia montana* Forest (CEGL000443)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Medano Creek drainage.

Global Range: This widespread woodland occurs at foothill and lower montane elevations in the southern Rocky Mountains, extending south to the mountains of western Texas, and west to the Mogollon Rim and Colorado Plateau of New Mexico, Arizona and Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4044, 5248.
Local Description Authors: K.E. Sabo

Populus angustifolia - Juniperus scopulorum Woodland

Narrowleaf Cottonwood - Rocky Mountain Juniper Woodland
Identifier: CEGL002640

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on sandsheets, floodplains, toeslopes, drainage channels, dunes, and streambanks. Elevation ranges from 2360 to 2720 m. Terrain is generally flat, but stands can have moderately steep slopes. Soils are well-drained sand, silt loam, loamy sand, and sandy loam. Ground cover is dominated by 20-93% litter and duff and 0-75% bare soil.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open to moderately open canopy of *Populus angustifolia* (20-60%) and *Juniperus scopulorum* (10-50%). Other tree species present include *Abies concolor, Betula occidentalis, Pinus edulis*, and *Picea pungens*. A shrub layer may be present with up to 50% cover and include *Acer glabrum, Rosa woodsii, Rhus trilobata, Ribes* spp., *Ericameria nauseosa, Cornus sericea*, and *Prunus virginiana*. The herbaceous layer is sparse with up to 30% cover and includes numerous graminoid and forb species. Common components include *Poa pratensis, Pascopyrum smithii, Juncus balticus, Thermopsis divaricarpa, Thalictrum fendleri, Maianthemum stellatum*, and *Achillea millefolium var. occidentalis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*
Tree subcanopy	Needle-leaved tree	*Juniperus scopulorum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juniperus scopulorum*, *Populus angustifolia*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Exotic/Invasive: *Poa pratensis* (invasive/exotic, Medium)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Juniperus scopulorum - Cercocarpus ledifolius* Woodland (CEGL000744)
- *Juniperus scopulorum / Cornus sericea* Woodland (CEGL000746)
- *Populus angustifolia - Pinus ponderosa* Woodland (CEGL000935)

- *Populus angustifolia - Pseudotsuga menziesii* Woodland (CEGL002641)
- *Populus angustifolia / Rosa woodsii* Forest (CEGL000653)
- *Populus angustifolia / Symphoricarpos (albus, occidentalis, oreophilus)* Woodland (CEGL002648)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the following drainages: Spanish Creek, Deadman Creek, Sand Creek, Medano Creek, North Zapata Creek, and Pinyon Flats campground.
Global Range: This association has been documented in north-central Wyoming, western Colorado and northern New Mexico. It may occur in Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2110, 3102, 4109, 5070, 5002, 5279, 3001.
Local Description Authors: K.E. Sabo

Populus angustifolia / Alnus incana Woodland

Narrowleaf Cottonwood / Gray Alder Woodland
Identifier: CEGL002642

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This woodland association occurs in valley floors, riverbeds, and floodplains. Elevation ranges from 2450 to 2620 m with flat terrain. Soils are well-drained loamy sands and loams. Ground cover is 55-60% litter and duff, 1-10% wood, 3-30% bare soil, and 2-10% rock. In general, surveyed stands occur near riparian areas with small streams or along creeks.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a moderately open canopy of *Populus angustifolia* (30-50%) with a subcanopy of *Populus tremuloides* and *Abies concolor*. The tall-shrub layer ranges in cover from 25-75% and is dominated by *Alnus incana* (20-60%). Other commonly occurring species include *Acer glabrum, Juniperus scopulorum*, and *Betula occidentalis*. Short-shrub species include *Rosa woodsii* and *Ribes leptanthum*. The herbaceous layer is variable with sparse to 45% cover. Species found have variable cover and frequency across surveyed stands, but the most commonly occurring species include *Poa pratensis, Calamagrostis canadensis, Maianthemum stellatum*, and *Osmorhiza depauperata*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree (canopy & subcanopy)	Broad-leaved deciduous tree	*Populus angustifolia*
Tree subcanopy	Broad-leaved deciduous tree	*Populus tremuloides*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Alnus incana* ssp. *tenuifolia*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Alnus incana* ssp. *tenuifolia*, *Populus angustifolia*, *Populus tremuloides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Exotic/Invasive: *Poa pratensis* (invasive/exotic, Medium)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Populus angustifolia / Cornus sericea* Woodland (CEGL002664)
- *Populus angustifolia / Salix exigua* Woodland (CEGL000654)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek drainage.
Global Range: This riparian forest association occurs in the southern Rocky Mountains of Colorado and New Mexico. It has been reported from western Wyoming and Oregon.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5017, 4074, 3074.
Local Description Authors: K.E. Sabo

Populus angustifolia / Betula occidentalis Woodland

Narrowleaf Cottonwood / Water Birch Woodland
Identifier: CEGL000648

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This woodland association occurs in stream terraces and floodplains from 2410 to 2740 m elevation. Terrain is flat to gently sloping with southeast-facing slopes. Soils are intermittently to temporarily flooded with well-drained sand soils. Ground cover can have significant amount of rock (35%) but is generally dominated by litter and duff or bare soil.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Canopy cover ranges from 10-60% and is dominated by *Populus angustifolia* with 10-30% cover. *Populus tremuloides* and *Abies concolor* may also be present in the canopy. The tall-shrub layer is dominated by *Betula occidentalis* (10-60%). Other species include *Acer glabrum* and *Jamesia americana*. Herbaceous cover is sparse, generally forb-dominated, and absent in some stands due to a recent flood event. Cover is under 5% and species include *Pyrola asarifolia* and *Clematis ligusticifolia*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Betula occidentalis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Betula occidentalis*, *Populus angustifolia*, *Populus tremuloides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Acer negundo / Betula occidentalis* Woodland (CEGL000936)
- *Picea pungens / Betula occidentalis* Woodland (CEGL002637)
- *Populus fremontii / Betula occidentalis* Wooded Shrubland (CEGL002981)
- *Populus tremuloides / Betula occidentalis* Forest (CEGL002650)
- *Pseudotsuga menziesii / Betula occidentalis* Woodland (CEGL002639)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek drainage.
Global Range: This association occurs in the mountains and canyons of Utah, Nevada, Idaho, Wyoming, and Colorado. These riparian woodlands are a major type in the Wasatch Mountains but appear to be a minor association elsewhere.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5057, 5016.
Local Description Authors: K.E. Sabo

Populus angustifolia / Rhus trilobata Woodland

Narrowleaf Cottonwood / Skunkbush Sumac Woodland
Identifier: CEGL000652

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in dune fields and streambanks at 2345 to 2410 m elevation. Slope is variable due to the undulating dune structure. These riverine and upland systems can have seasonally flooded areas with rapidly drained sand or loamy sand soils.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open canopy of *Populus angustifolia* (15-35%). The shrub layer is sparse. *Rhus trilobata* is the most common species, but stands may also include *Ericameria nauseosa, Juniperus scopulorum*, and *Rosa woodsii*. The herbaceous layer is also sparse with less than 10% cover and may include *Pascopyrum smithii, Clematis ligusticifolia, Psoralidium lanceolatum*, and *Chenopodium* spp.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Populus angustifolia*, *Rhus trilobata*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek drainage.
Global Range: This riparian woodland occurs locally in small stands in the mountains and canyons of Utah, Wyoming, Colorado and Idaho. It is likely to occur along any perennial tributary stream where low gradients allow for the development of cottonwood gallery forests.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 380, 578, 4003.
Local Description Authors: K.E. Sabo

Populus angustifolia / Salix (monticola, drummondiana, lucida) Woodland

Narrowleaf Cottonwood / (Park Willow, Drummond's Willow, Whiplash Willow) Woodland
Identifier: CEGL002645

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association was sampled in floodplains and benches within basin floors. Elevation of the two surveyed stands is 2318 and 2331 m. Stands can be intermittently flooded with sandy soils. Ground cover is generally dominated by either bare soil or litter and duff, but there can be a significant amount of wood cover (30%). There can also be significant damage to willows and cottonwoods by elk grazing.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open canopy structure dominated by *Populus angustifolia* (5-25% cover). The tall-shrub layer is dominated by *Salix lucida* and *Salix lutea* with a combined cover of 5-25%. The short-shrub layer is sparse with *Ericameria nauseosa*. Total herbaceous cover ranges from 5-35% with 1-15% graminoid cover and 0-25% forb cover. Commonly occurring species include *Juncus balticus, Pascopyrum smithii, Chenopodium* spp., and *Packera tridenticulata*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Populus angustifolia*, *Salix lucida*, *Salix lutea*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Deadman Creek drainage.
Global Range: The range essentially includes the Great Basin, between the Sierra Nevada, the Rocky Mountains, and the deserts of the southwestern U.S.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 256, 5283.
Local Description Authors: K.E. Sabo

Populus angustifolia / Salix drummondiana - Acer glabrum Woodland

Narrowleaf Cottonwood / Drummond's Willow - Rocky Mountain Maple Woodland
Identifier: CEGL002646

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from two plots on streambeds and valley floors at 2677 and 2685 m elevation. Slopes are gently rolling and southwest-facing. Ground cover is predominantly litter and duff, but there is significant amount of rock, wood, and water. These stands can either be intermittently or permanently flooded and certain areas may be subject to flash flooding.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This riparian association is characterized by an open canopy of *Populus angustifolia* (10-30%) where *Populus tremuloides* may be present to codominant (10-30%). Stands may include scattered *Pseudotsuga menziesii*. The tall-shrub layer is moderately dense, with cover ranging from 35-45%, and is dominated by *Salix drummondiana, Acer glabrum*, and *Salix lutea*. Short-shrub cover ranges from 15-35% with *Rosa woodsii, Ribes leptanthum*, and *Physocarpus monogynus*. Herbaceous cover is variable (1-45%) and forb-dominated, with common species including *Equisetum arvense, Pyrola asarifolia*, and *Oreochrysum parryi*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*, *Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Populus angustifolia*, *Populus tremuloides*, *Salix drummondiana*, *Salix lutea*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate

Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Spanish Creek and Sand Creek drainages.
Global Range: Description is based on only one occurrence in one basin in Colorado, but the type is suspected to occur more widely.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3114, 4076.
Local Description Authors: K.E. Sabo

Populus angustifolia / Salix exigua Woodland

Narrowleaf Cottonwood / Coyote Willow Woodland
Identifier: CEGL000654

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a riverbed at 2449 m elevation. Terrain is flat with seasonal flooding that deposits alluvial sands. There is significant mortality of *Populus angustifolia* from fire, but healthy regeneration is evident. Ground cover is dominated by litter and duff (80%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a sparse overstory of mature *Populus angustifolia*. The tall-shrub layer is dominated by *Salix exigua* (40%) and young *Populus angustifolia* (20%). The herbaceous understory (35-45%) is dominated by graminoids including *Muhlenbergia minutissima*, *Juncus balticus, Juncus longistylis, Leymus triticoides*, and *Agrostis scabra*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Salix exigua*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Populus angustifolia*, *Salix exigua*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Populus angustifolia / Alnus incana* Woodland (CEGL002642)
- *Populus deltoides (ssp. wislizeni, ssp. monilifera) / Salix exigua* Woodland (CEGL002685)
- *Populus fremontii - Salix gooddingii / Salix exigua* Forest (CEGL002684)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Medano Creek drainage.

Global Range: This association is widespread in mountainous regions of the San Juan, Pecos, and Rio Grande river basins in northern and central New Mexico and widely distributed throughout the Rocky Mountain region and Intermountain West.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 425.

Local Description Authors: K.E. Sabo

Pseudotsuga menziesii / Cercocarpus montanus Woodland

Douglas-fir / Alderleaf Mountain-mahogany Woodland

Identifier: CEGL000898

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This evergreen woodland association occurs on colluvial slopes and ridges at 2770 and 2920 m elevation. Terrain is moderate to very steep with east-facing slopes. Soils are rapidly drained loamy sands with 25-30% cover of litter and duff, 21-50% of bare soil, 5-27% of gravel and 5% of rock.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open canopy of *Pseudotsuga menziesii* (20%) intermixed with scattered *Pinus ponderosa* The tall-shrub layer includes *Pseudotsuga menziesii, Juniperus scopulorum*, and *Pinus edulis* in small amounts. The shrub layer ranges in cover from 35-65% and includes *Cercocarpus montanus, Prunus virginiana, Symphoricarpos* spp., and *Juniperus communis*. The herbaceous layer is dominated by grasses *Muhlenbergia montana* (30%) and *Festuca arizonica* (3%), together with a variety of other graminoids and forbs present in small amounts.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*
Tall shrub/sapling	Broad-leaved evergreen shrub	*Cercocarpus montanus*
Herb (field)	Graminoid	*Muhlenbergia montana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Great Sand Dunes National Park and Preserve Comments:

Global Similar Associations:

- *Juniperus scopulorum / Cercocarpus montanus* Woodland (CEGL000745)
- *Pinus edulis - Juniperus* spp. / *Cercocarpus montanus* - Mixed Shrubs Woodland (CEGL000780)

- *Pinus ponderosa / Cercocarpus montanus* Woodland (CEGL000851)
- *Pseudotsuga menziesii / Symphoricarpos oreophilus* Forest (CEGL000462)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek drainage.

Global Range: This association has been documented from central and southern Utah and northwestern Colorado. It is likely to occur in cool canyons throughout the Colorado Plateau and also in the foothills of southwestern Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 558, 4072.

Local Description Authors: K.E. Sabo

Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland

Douglas-fir / Glandular Oceanspray Scree Woodland

Identifier: CEGL000902

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This woodland association occurs on steep shoulder, talus, and colluvial slopes as well as ravines. Stands occur at 2695 to 3060 m elevation with variable aspects. Soils are moderately well-drained silt loams, well-drained sandy loams, or rapidly drained loamy sands, sit loams, or sandy loams. Ground surface cover is dominated by rock (3-62%) and wood (2-20%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: These woodland stands are dominated by *Pseudotsuga menziesii* with 20-40% canopy cover, and may also include *Pinus edulis*, *Pinus flexilis*, and *Juniperus scopulorum*. The shrub layer is dominated by *Holodiscus dumosus* (5-30% cover) but includes many other species such as *Acer glabrum, Jamesia americana, Physocarpus monogynus, Ribes* spp., *Rosa woodsii*, and *Symphoricarpos oreophilus*. The herbaceous understory is generally sparse but occasionally includes significant cover of grasses such as *Festuca arizonica* or *Poa fendleriana*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pseudotsuga menziesii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Holodiscus dumosus*, *Juniperus scopulorum*, *Pinus edulis*, *Pinus flexilis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Great Sand Dunes National Park and Preserve Comments:

Global Similar Associations:

- *Abies concolor - (Pseudotsuga menziesii) / Jamesia americana - Holodiscus dumosus* Scree Woodland (CEGL000890)
- *Abies concolor / Leymus triticoides* Woodland (CEGL000886)
- *Abies lasiocarpa / Holodiscus dumosus* Scree Woodland (CEGL000918)
- *Abies lasiocarpa / Jamesia americana* Forest (CEGL000312)
- *Pseudotsuga menziesii* Scree Woodland (CEGL000911)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Wilcox Gulch, Willow Creek drainage, Cleavland Gulch, Sand Creek drainage, and Garden Creek drainage.

Global Range: This limited-range endemic is reported from the Mogollon Mountains (Fitzhugh et al. 1987) and Sangre de Cristo Mountains (DeVelice et al. 1986) in New Mexico and the Gunnison Basin in Colorado, but it is expected to occur elsewhere at high elevations in New Mexico and Arizona.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 5053, 4105, 4126, 414, 3095.

Local Description Authors: K.E. Sabo

III. Shrubland

Abies concolor - Pseudotsuga menziesii / Jamesia americana Avalanche Chute Shrubland [Park Special]

White Fir - Douglas-fir / Five-petal cliffbush Avalanche Chute Shrubland [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from one plot located in a narrow northwest facing avalanche chute at 2924 m elevation. The terrain is very steep (39 degrees) and rocky. Soil was a well drained sandy loam. Ground cover includes a large proportion of large and small rocks and woody debris of both large and small sizes. Although the site is a ravine, there is no evidence of normal water conveyance.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open canopy tall shrubland of *Abies concolor* and *Pseudotsuga menziesii* saplings with a total of 50% cover. The species present in the shrub layer include *Picea engelmannii*, *Jamesia americana*, *Holodiscus dumosus*, *Symphoricarpos* spp., *Physocarpus monogynus*, *Rosa woodsii*, *Acer glabrum*, *Rubus ideaus,* and *Ribes montigenum.* Likely due to the rocky nature of the site, the herbaceous understory is sparse, with less than 30% cover. Common species include the graminoids *Carex siccata*, *Bromus ciliata*, *Trisetum spicatum*, and *Festuca brachyphylla*. Forbs include *Oreochrysum parryi*, *Fragaria virginiana*, *Androsace septentrionalis*, *Artemisia franserioides*, and *Saxifraga bronchialis ssp. austromontana*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Abies concolor, Pseudotsuga menziesii Jamesia americana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Upper slope avalanche chutes of the Sangre de Cristo Mountains in and around the Great Sand Dunes National Park and Preserve

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 739.

Local Description Authors: J.E. Stevens

Abies lasiocarpa - Picea engelmannii / Salix (brachycarpa, glauca) Krummholz Shrubland

Subalpine Fir - Engelmann Spruce / (Short-fruit Willow, Grayleaf Willow) Krummholz Shrubland
Identifier: CEGL000986

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This variable association is known from near treeline in alpine valleys, including basin floors and the surrounding ridges and colluvial slopes, between 3525 and 3720 m in elevation. Sites are generally flat or face northeast to southeast, and can slope up to 43 degrees. The trees are stunted by high winds and exposure above snowpack, or can be kept small by frequent avalanches. Ground cover is typically high in litter (55-90%) but may sometimes contain significant cover of moss (in flat riparian sites) or bedrock outcrops. Surficial geology is granite or conglomerate. Soils range from sandy loam and silt loam on upland occurrences to muck along saturated streambanks and pond edges.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This broad association includes all krummholz shrublands which contain at least 25% relative cover of short-shrub willow species (*Salix brachycarpa* and *Salix planifolia*). *Picea engelmannii* and *Salix brachycarpa* are the most common shrubs in this association, typifying the dry, rocky, windswept upland sites. *Abies lasiocarpa* occasionally has up to 10% cover but may be absent. *Salix planifolia* is more common in wetter areas, such as basin floors and along small snowmelt streams through otherwise well-drained soils. The understory layers vary by local environmental conditions also, with *Caltha leptosepala*, *Senecio triangularis, Swertia perennis, Cardamine cordifolia, Calamagrostis canadensis, Rhodiola integrifolia*, and *Pedicularis groenlandica* more frequent in the wetter sites, and *Juniperus communis, Vaccinium myrtillus var. oreophilum, Luzula parviflora*, and *Polemonium pulcherrimum* common in drier areas. Species found throughout include *Achillea millefolium var. occidentalis, Geum rossii var. turbinatum*, and *Chamerion angustifolium*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*
Short shrub/sapling	Broad-leaved deciduous shrub	*Salix brachycarpa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Abies lasiocarpa*, *Salix planifolia*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments: This association is intermediate between all-conifer *Abies lasiocarpa - Picea engelmannii* Krummholz Shrubland (CEGL000985) and all-willow *Salix brachycarpa* / Mesic Forbs Shrubland (CEGL001135). It can be distinguished by a 1:3 minimum ratio of conifers to willows.
Global Similar Associations:

- *Abies lasiocarpa - Picea engelmannii* Krummholz Shrubland (CEGL000985)
- *Salix brachycarpa* / Mesic Forbs Shrubland (CEGL001135)--has similar species composition (but less cover of conifers) and is less exposed to wind than this krummholz type.

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from alpine valleys in the northern half of the project area, including the Sand Creek, Little Sand Creek, Medano Creek, and the South Crestone Lake drainages.
Global Range: This shrubland association occurs as krummholz near treeline in the southern Rocky Mountains of Colorado and possibly the Uinta Mountains in Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4024, 2104, 28, 404, 607, 660, 4249, 4250.
Local Description Authors: K. Forrest

Abies lasiocarpa - Picea engelmannii Krummholz Shrubland
Subalpine Fir - Engelmann Spruce Krummholz Shrubland
Identifier: CEGL000985

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from the high slopes of windswept ridges and alpine cirques. Stands occur as a fringe of shrubland at the upper reaches of treeline. The two stands sampled are 3634 and 3749 m in elevation. Substrates are granitic, with rapidly to well-drained sandy loams and loamy sands. Slope ranges from 26-40 degrees, and aspects include east to southeast exposures. Bedrock outcrops and large rocks can occupy 35% of the ground cover; litter and duff averages 40% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Picea engelmannii* forms a gnarled, patchy shrubland, often with *Abies lasiocarpa* or *Pinus aristata*. The trees are short (0.5-2 m in height) and sometimes transition gradually away from stands of taller trees. The two stands sampled have 40-50% krummholz cover. *Juniperus communis, Vaccinium myrtillus, Vaccinium caespitosum, Ribes montigenum*, and *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda)* can be present as dwarf- to short shrubs. Alpine dry-turf species fill the gaps between patches of shrubs; species found in both plots include *Carex elynoides, Carex rupestris var. drummondiana, Luzula spicata, Minuartia obtusiloba, Arenaria fendleri, Tetraneuris acaulis, Allium geyeri, Silene acaulis var. subacaulescens, Geum rossii var. turbinatum, Sedum lanceolatum, Saxifraga bronchialis ssp. austromontana, Pedicularis parryi*, and *Selaginella densa*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Abies lasiocarpa*, *Arenaria fendleri*, *Carex elynoides*, *Dasiphora fruticosa* ssp. *floribunda*, *Minuartia obtusiloba*, *Selaginella densa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Pinus aristata* (globally vulnerable, G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Abies lasiocarpa - Picea engelmannii / Salix (brachycarpa, glauca)* Krummholz Shrubland (CEGL000986)
- *Abies lasiocarpa - Picea engelmannii* Ribbon Forest (CEGL000328)
- *Abies lasiocarpa - Picea engelmannii* Tree Island Forest (CEGL000329)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from two plots in the Medano Creek drainage: one in the cirque above Medano Lake and the other in a nameless drainage (informally known to field crews as the "Heinous Drainage") off the main Medano Creek drainage.
Global Range: These shrublands occur near upper treeline in the Rocky Mountains. Stands have only been described from Colorado, Montana and Alberta, but likely occur in similar habitats in adjacent states.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4023, 4211.
Local Description Authors: K. Forrest

Alnus incana - Betula occidentalis Shrubland

Gray Alder - Water Birch Shrubland
Identifier: CEGL001142

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot located on a valley floor at 2588 m elevation. Terrain is generally flat and intermittently flooded. Soils are poorly drained loams. Ground cover is comprised of 40% litter and duff, 20% bare soil, 5% rock, and 10% water.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a dense canopy of *Betula occidentalis* (50%) and *Alnus incana* (30%). Small amounts of other tall or short shrubs are also present, including *Acer glabrum, Salix lucida ssp. caudata, Ribes leptanthum*, and *Rosa woodsii*. Herbaceous cover is graminoid-dominated but includes trace amounts of numerous forb species. *Glyceria striata* is the dominant graminoid with 30% cover. Other species present in with more than trace amounts include *Equisetum arvense, Carex* spp., and *Pyrola asarifolia*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Alnus incana*, *Betula occidentalis*

Herb (field)	Graminoid	*Glyceria striata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek drainage.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4075.
Local Description Authors: K.E. Sabo

Alnus incana - Salix drummondiana Shrubland

Gray Alder - Drummond's Willow Shrubland
Identifier: CEGL002652

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot in a streambed at 2926 m elevation. Slopes are gently rolling. This stand is permanently flooded with very poorly drained muck soils. Ground cover is 55% litter and duff, 10% water, and 20% moss.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand has a dense canopy of tall shrubs with 40% *Alnus incana ssp. tenuifolia*, 20% *Salix monticola*, 10% *Salix drummondiana*, and 10% *Salix bebbiana*. Herbaceous cover is also dense, consisting of 40% *Calamagrostis canadensis* and 30% *Carex utriculata* with a scattering of mesic forbs.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tall shrub/sapling	Broad-leaved deciduous shrub	*Alnus incana* ssp. *tenuifolia*, *Salix monticola*
Herb (field)	Graminoid	*Calamagrostis canadensis*, *Carex utriculata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Alnus incana* ssp. *tenuifolia*, *Salix bebbiana*, *Salix drummondiana*, *Salix monticola*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Alnus incana - Salix (monticola, lucida, ligulifolia)* Shrubland (CEGL002651)
- *Alnus incana / Equisetum arvense* Shrubland (CEGL001146)
- *Alnus incana ssp. tenuifolia - Salix irrorata* Shrubland (CEGL002687)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Medano Ditch.
Global Range: This montane to subalpine riparian shrubland association is common in the mountains of Colorado and western Wyoming and likely occurs in adjacent New Mexico. In Colorado it is commonly found in the Rio Grande, Gunnison, Saint Vain and Arkansas river basins.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3042.
Local Description Authors: K.E. Sabo

Atriplex canescens / Achnatherum hymenoides Shrubland
Fourwing Saltbush / Indian Ricegrass Shrubland
Identifier: CEGL001289

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from two plots on low toeslopes at 2449 and 2465 m elevation. Slopes are gently rolling. Stands can be intermittently flooded and have well-drained or rapidly drained sand soils.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a short-shrub layer dominated by *Atriplex canescens* (30%), with smaller amounts of *Ericameria nauseosa* and *Krascheninnikovia lanata*. Sampled stands have generally sparse herbaceous cover ranging from 5-35% and are dominated by disturbance-tolerant species such as *Portulaca oleracea* (10%),*Machaeranthera tanacetifolia* (10%), and *Salsola tragus*. Cover of native graminoids is sparse and includes *Achnatherum hymenoides, Hesperostipa comata*, and *Sporobolus cryptandrus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved evergreen shrub	*Atriplex canescens*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Atriplex canescens*, *Machaeranthera tanacetifolia*, *Portulaca oleracea*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: **Exotic/Invasive**: *Salsola tragus* (invasive/exotic)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Atriplex canescens / Pleuraphis jamesii* Shrubland (CEGL001288)
- *Atriplex canescens / Sporobolus airoides* Shrubland (CEGL001291)
- *Atriplex canescens* Shrubland (CEGL001281)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Evans Gulch.
Global Range: This shrubland is found on the western slope of the Colorado Rocky Mountains, adjacent northeastern Utah and the Great Salt Lake Desert. This association may have a wider distribution as both diagnostic species are common in the semi-arid western U.S.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5083, 5081.
Local Description Authors: K.E. Sabo

Cercocarpus montanus / Muhlenbergia montana Shrubland
Alderleaf Mountain-mahogany / Mountain Muhly Shrubland
Identifier: CEGL002914

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from colluvial slopes, ridges, and bedrock outcrops. Elevation ranges from 2540 to 3090 m with moderately steep to steep south-facing slopes. Soils are either well-drained or rapidly drained loamy sands or sandy loams. Soil surfaces may be dominated by litter or have significant amounts of bare ground.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by a moderately dense shrub layer of *Cercocarpus montanus* with 10-50% cover. Other shrub species are usually present and may include *Holodiscus dumosus, Ribes cereum, Symphoricarpos* spp., *Rosa woodsii*, and *Artemisia frigida*. Scattered coniferous trees such as *Pinus edulis* and *Pinus flexilis* are often present, but with cover less than 5%. The herbaceous layer is dominated by 10-30% *Muhlenbergia montana*, together with other graminoids such as *Bouteloua gracilis, Festuca arizonica*, and *Koeleria macrantha*. Forb cover is generally less than 20%, and species commonly present include *Artemisia frigida, Castilleja* spp., *Eriogonum* spp., *Heliomeris multiflora, Heterotheca villosa*, and *Machaeranthera bigelovii*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved evergreen shrub	*Cercocarpus montanus*
Herb (field)	Graminoid	*Muhlenbergia montana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Artemisia frigida*, *Cercocarpus montanus*, *Festuca arizonica*, *Heterotheca villosa*, *Muhlenbergia montana*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Cercocarpus montanus / Hesperostipa comata* Shrubland (CEGL001092)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek drainage, Cold Creek drainage, Medano Creek drainage, Evans Gulch, and Raspberry Canyon.
Global Range: This foothill to lower montane shrubland association occurs on the east slope of the southern Rocky Mountains in Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 302, 3088, 5011, 5048, 4262, 4017, 3237.
Local Description Authors: K.E. Sabo

Dasiphora fruticosa ssp. floribunda Subalpine Shrubland

Shrubby-cinquefoil Subalpine Shrubland
Identifier: CEGL003499

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on a mixture of rock and gravel mid colluvial slopes, ridges, and colluvial U-shaped valleys between 3485 and 3705 m elevation. Slope is variable and can range from gentle to steep (5-35 degrees), and aspect is southwest or northwest. Soil types are rapidly or well-drained sandy loams or loamy sands, and bare soil can account for up to 30% of the total ground surface area. Other components of nonvegetative cover include 25-56% litter and duff, 10-27% rock, and 3-40% gravel.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Sampled stands are sparsely shrubby meadows where *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda)* ranges from 10-20% cover at an average height <0.5 m, and *Ribes montigenum* or *Salix brachycarpa* may be present with low cover. The herbaceous layer is fairly dense, with 20-60% cover, and may be either forb- or graminoid-dominated. Commonly occurring graminoid species are *Carex elynoides* (3-20%), *Carex rupestris var. drummondiana* (0-10%) *Elymus* spp., and *Festuca brachyphylla*. Forb species diversity is high, but only *Geum rossii var. turbinatum* is present with more than 5% cover. Species present in most stands with cover of <5% include *Arenaria fendleri, Cirsium scopulorum, Heuchera parvifolia, Minuartia obtusiloba, Saxifraga bronchialis ssp. austromontana, Sedum lanceolatum, Tetraneuris acaulis*, and *Trifolium dasyphyllum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Dwarf-shrub	*Dasiphora fruticosa* ssp. *floribunda*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex elynoides*, *Carex rupestris* var. *drummondiana*, *Geum rossii* var. *turbinatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Dasiphora fruticosa ssp. floribunda / Deschampsia caespitosa* Shrubland (CEGL001107)
- *Dasiphora fruticosa ssp. floribunda* Shrubland [Provisional] (CEGL001105)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is found in a side drainage west of the Medano Lake Trail, near Medano Lake, and in side drainages of Little Medano Creek.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3214, 4255, 3213, 299.
Local Description Authors: K.E. Sabo

Ericameria nauseosa / Sporobolus airoides Shrubland
Rubber Rabbitbrush / Alkali Sacaton Shrubland
Identifier: CEGL002918

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is found on valley floors and sandsheets at elevations ranging from 2310 to 2335 m. Terrain is flat and can be intermittently flooded. Soils are variable, ranging from somewhat poorly drained to rapidly drained sandy clay loam, sand, and silt loam. Ground cover is predominantly bare soil and litter.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open to moderately dense short-shrub layer of *Ericameria nauseosa* (10-60%), often with *Sarcobatus vermiculatus*, and a graminoid-dominated herbaceous layer with significant cover of *Sporobolus airoides* (10-50%). Additional common species include *Distichlis spicata, Juncus balticus, Pascopyrum smithii, Spartina gracilis, Iris missouriensis*, and *Equisetum laevigatum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Ericameria nauseosa*
Herb (field)	Graminoid	*Sporobolus airoides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Ericameria nauseosa*, *Juncus balticus*, *Sarcobatus vermiculatus*, *Sporobolus airoides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Ericameria nauseosa* Desert Wash Shrubland (CEGL002261)
- *Ericameria nauseosa* Sand Deposit Sparse Shrubland (CEGL002980)
- *Ericameria nauseosa* Shrubland (CEGL002713)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Deadman Creek, Little Spring Creek, and Zapata Creek drainages.
Global Range: This association has been documented from southeastern Utah and reported from Colorado. It is likely to occur in small, isolated patches throughout the Colorado Plateau.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5269, 329, 101, 53, 4022, 2125, 4050, 4082.
Local Description Authors: K.E. Sabo

Ericameria nauseosa Sand Deposit Sparse Shrubland

Rubber Rabbitbrush Sand Deposit Sparse Shrubland
Identifier: CEGL002980

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on dune fields, sandsheets, and alluvial fans with elevation ranging from 2305 to 2760 m. Slopes are variable, ranging from flat to gently rolling. Bare soil, sand or gravel account for 60-95% of the surface cover, with occasional samples having up to 30% cover of litter.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a sparse short-shrub layer dominated by *Ericameria nauseosa* (10-20%). Scattered individuals of other shrub species, such as *Krascheninnikovia lanata* and *Sarcobatus vermiculatus*, or individual *Pinus edulis* trees may occasionally be present. The herbaceous layer is sparse as well (0-30%) and characterized by species well-adapted to eolian-influenced substrates. Common species include *Redfieldia flexuosa, Psoralidium lanceolatum, Helianthus* spp., *Hesperostipa comata*, and *Achnatherum hymenoides*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Ericameria nauseosa*
Herb (field)	Graminoid	*Achnatherum hymenoides*, *Redfieldia flexuosa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Achnatherum hymenoides*, *Ericameria nauseosa*, *Psoralidium lanceolatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Ericameria nauseosa / Bromus tectorum* Semi-natural Shrubland (CEGL002937)
- *Ericameria nauseosa / Sporobolus airoides* Shrubland (CEGL002918)
- *Ericameria nauseosa* Shrubland (CEGL002713)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the central valley portion of Great Sand Dunes National Park and Monument, Cold Creek drainage, and Medano Creek drainage.
Global Range: This association has been described from southern and eastern Utah, northeastern Arizona and western Colorado but is likely more common in similar habitats throughout the interior western U.S.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4282, 4121, 4102, 774, 602, 374, 4004, 384, 310, 365, 5232, 3117, 192, 5284, 4122, 3097, 5291.
Local Description Authors: K.E. Sabo

Ericameria parryi / Achnatherum hymenoides Shrubland

Parry's Rabbitbrush / Indian Ricegrass Shrubland
Identifier: CEGL003751

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a colluvial low slope at 2670 m elevation. Slope is moderately steep and southeast-facing. Soils are well-drained loamy sands. Ground cover is dominated by bare soil with 80% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a sparse short-shrub layer of 10% *Ericameria parryi*. Herbaceous layer is sparse as well with 5-15% graminoid cover and 15-25% forb cover. Species present in more than trace amounts include *Senecio spartioides, Achnatherum hymenoides, Hesperostipa comata, Sporobolus cryptandrus*, and *Psoralidium lanceolatum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Ericameria parryi*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Ericameria parryi*, *Senecio spartioides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Achnatherum hymenoides* Shale Barren Herbaceous Vegetation (CEGL001651)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Cold Creek drainage.
Global Range: This shrubland association is described from Middle Park in central Colorado and Black Canyon National Park and Curecanti National Recreation Area in the Gunnison River valley and likely occurs elsewhere in western Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3086.
Local Description Authors: K.E. Sabo

Pinus aristata Krummholz Shrubland

Bristlecone Pine Krummholz Shrubland
Identifier: CEGL005415

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This rocky alpine shrubland association occurs on colluvial slopes at 3605m to 3735m elevation. Slopes are very steep and range from southeast, southwest, or west-facing slopes. Soils are rapidly drained loamy sands. Ground cover is dominated by 10% gravel, 25-40% rock, and 0-30% bedrock.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: These are tree-line stands dominated by an open canopy of stunted *Pinus aristata* with 10-30% cover. *Pinus flexilis* may be present in some stands. A sparse short or dwarf shrub layer may include *Dasiphora floribunda*, *Ribes* spp., or *Salix brachycarpa*. Herbaceous cover is variable (10-60%), depending on the amount of rock present, and includes both forbs and graminoids.. Typical forb species include *Achillea millefolium* var. *occidentalis, Aquilegia caerulea, Arenaria fendleri, Chamerion angustifolium, Cirsium scopulorum, Erigeron pinnatisectus, Eriogonum flavum, Frasera speciosa, Geum rossii* var. *turbinatum, Heuchera parvifolia, Pseudocymopterus montanus, Rhodiola integrifolia, Sedum lanceolatum*, *Selaginella densa, Tetraneuris acaulis, Trifolium dasyphyllum,* as well as species . Graminoids include *Carex elynoides*, *Carex rupestris* var. *drummondiana, Festuca brachyphylla,* and *Poa* species.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus aristata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Pinus aristata, Dasiphora floribunda*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in on high slopes above the following drainages: Sand Creek, Hudson Branch, and Medano Creek.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4256, 4254, 492.
Local Description Authors: K.E. Sabo

Prunus virginiana - (Prunus americana) Shrubland

Chokecherry - (American Plum) Shrubland
Identifier: CEGL001108

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This shrubland association occurs in small patches on colluvial slopes, toeslopes, and sand ramps at 2620 to 2850 m elevation. Slopes are gentle, ranging from 0-15 degrees. This association tends to be transitional, located between valley shrub and forested ecosystems. These upland systems have well-drained or rapidly drained loamy sand, sandy loam, or sandy soils. Ground cover is typically bare soil (30-70%) with moderate amounts of litter.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association has an open to moderately dense short-shrub canopy together with generally smaller amounts of tall- or dwarf-shrub species. *Prunus virginiana* (10-50%) is always present and may be dominant or codominant with other shrub species such as *Ribes leptanthum, Rhus trilobata, Rosa woodsii*, or *Chrysothamnus viscidiflorus*. Additional shrub species that may be present include *Artemisia frigida, Artemisia dracunculus, Ericameria* spp., *Holodiscus dumosus, Symphoricarpos rotundifolius*, and *Tetradymia canescens*. The herbaceous layer is sparse with 5-25% cover and few graminoid species. Common species include *Psoralidium lanceolatum, Heterotheca villosa*, and *Artemisia frigida*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Prunus virginiana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Ribes leptanthum*, *Rosa woodsii*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Fraxinus pennsylvanica - Ulmus americana / Prunus virginiana* Woodland (CEGL000643)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Cold Creek and the Medano Creek drainages.
Global Range: This widespread small-patch shrubland is known from the Columbia Plateau of eastern Washington and eastern Oregon, throughout much of the western Great Plains, Rocky Mountain and interior western U.S.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 391, 4201, 906, 5015.
Local Description Authors: K.E. Sabo

Salix exigua - Salix ligulifolia Shrubland
Coyote Willow - Strapleaf Willow Shrubland
Identifier: CEGL002655

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This palustrine shrubland association is documented from a single plot on a valley floor at 2314 m elevation. The stand is permanently flooded with very poorly drained muck soils. There is heavy grazing by cattle in this stand.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand has a dense overstory of tall shrubs (2-5 m tall) dominated by *Salix lutea* (40% cover) and *Salix exigua* (30%) with 10% cover of *Salix lucida*. The understory is dominated by mesic graminoids, with about 50% total cover. *Carex utriculata* and *Eleocharis acicularis* are dominant with 20-30% cover each, while *Beckmannia syzigachne, Eleocharis palustris*, and *Poa pratensis* are also present with <5% cover. Forb species diversity is fairly low and includes several weedy species

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tall shrub/sapling	Broad-leaved deciduous shrub	*Salix exigua*, *Salix lutea*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex utriculata*, *Eleocharis acicularis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Exotic/Invasive: *Poa pratensis* (invasive, Medium)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Salix ligulifolia* Shrubland (CEGL001218)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur along Crestone Creek.
Global Range: This association is documented in Colorado and suspected to occur in New Mexico. Closely related *Salix lutea* communities occur in Montana, eastern Wyoming, western Idaho, and Nevada.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4095.
Local Description Authors: K.E. Sabo

Salix exigua - Salix lucida ssp. caudata Shrubland
Coyote Willow - Shining Willow Shrubland
Identifier: CEGL001204

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This riparian shrubland association occurs along drainage channels, in floodplains and stream terraces. Elevation ranges from 2315 to 2335 m on flat terrain. Stands are seasonally or temporarily flooded. Soils are very poorly drained muck, poorly drained sandy loam, or well-drained sand. Ground cover is variable with 10-83% litter and duff, 0-70% bare soil, and 0-65% sand.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by a tall (2-5 m) shrub layer ranging in cover from 15-85%. *Salix exigua* and *Salix lucida ssp. caudata* are codominant, ranging in cover from 10-40% each. *Alnus incana, Salix lutea*, and *Populus angustifolia* may be present in with less than 1% cover. Herbaceous cover is generally graminoid-dominated and somewhat weedy. Common species that have more than 3% cover include *Juncus balticus, Carex utriculata, Cirsium arvense, Bromus inermis, Artemisia frigida, Mentha arvensis*, and *Equisetum arvense*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tall shrub/sapling	Broad-leaved deciduous shrub	*Salix exigua*, *Salix lucida* ssp. *caudata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Exotic/Invasive: *Bromus inermis* (invasive, High/Medium), *Cirsium arvense* (invasive/exotic, High/Medium)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur along Crestone Creek and Little Medano Creek.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5282, 4097, 3077.
Local Description Authors: K.E. Sabo

Salix exigua Temporarily Flooded Shrubland
Coyote Willow Temporarily Flooded Shrubland
Identifier: CEGL001197

In California, the overstory shrub canopy is open to continuous and dominated by *Salix exigua*, with *Rubus discolor* often present. Trees such as *Ailanthus altissima*, *Fraxinus latifolia*, and *Salix laevigata* sometimes occur as scattered emergents. Other shrubs that may be present include *Rhus trilobata var. trilobata (= Rhus aromatica var. trilobata), Quercus gambelii, Rosa woodsii, Rosa nutkana, Ericameria nauseosa, Arctostaphylos patula*, and *Dasiphora fruticosa ssp. floribunda* The herbaceous layer is typically open and often includes *Artemisia douglasiana*. The composition of this community, especially the herbaceous layer, varies from year to year with succession or renewed disturbance.

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This willow shrubland association was documented from a single plot at 2501 m elevation along a streambed that is intermittently flooded. The drainage is bounded by both vegetated and active sand dunes. Soils are rapidly drained sands and the soil surface is dominated by bare ground.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Vegetation is sparse with total cover of about 15%. *Salix exigua* (10%) forms a sparse shrubland with scattered saplings of *Populus angustifolia*. The herbaceous layer is very sparse, with low species diversity. *Juncus longistylis* is the only species having cover greater than 1%.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Salix exigua*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juncus longistylis*, *Populus angustifolia*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Cornus drummondii - Amorpha fruticosa - Cornus sericea* Shrubland (CEGL005220)
- *Salix exigua* / Mesic Graminoids Shrubland (CEGL001203)--This type may be essentially the same, or this type is a later successional stage.
- *Salix interior - Salix eriocephala* Sandbar Shrubland (CEGL005078)--of the Great Lakes states/provinces.
- *Salix interior* Temporarily Flooded Shrubland (CEGL008562)--is a related type from the central states dominated by a different nominal *Salix* species.

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur along Medano Creek.
Global Range: This willow shrubland community is found along rivers and streams at lower elevations throughout the western United States and Great Plains, ranging sporadically from Oklahoma northwest to the Dakotas and Manitoba, into the Rocky Mountains of Colorado, Wyoming, Montana and Idaho, west to Washington, and south to the Rio Grande, San Juan and Canadian River watersheds in northern New Mexico. In California, this association has been sampled along the Sacramento River, in the Central Coast Ranges, northern and central Sierra Nevada foothills, and Cascade Range foothills. Part of this type's former range in the Great Plains and eastward is actually occupied, at least in part, by *Salix interior* [see *Salix interior* Temporarily Flooded Shrubland (CEGL008562)].

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4034.
Local Description Authors: K.E. Sabo

Salix brachycarpa / Mesic Forbs Shrubland

Short-fruit Willow / Mesic Forbs Shrubland
Identifier: CEGL001135

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from near and above treeline in broad alpine valleys and the surrounding colluvial slopes and ridges. It occurs on all aspects on flat to sloping ground up to 28 degrees. Elevations range from 3355 to 3700 m. Sites are typically dry, although they may sometimes border riparian areas or have small seeps or snowmelt streams running through them. In general, this association does not occur in distinct riparian areas. Soils include well-drained to poorly drained loam, silt loam and sandy loam. Litter and duff generally make up the majority of the ground cover, but in some stands bedrock, rock, gravel and bare soil can cover up to half of the ground. Basal area can be high due to the cover of alpine cushion plants between groups of shrubs.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by large upland stands of *Salix brachycarpa* on valley floors and extending up into the alpine.

They may be adjacent to and blend with more mesic stands of *Salix planifolia* or subalpine conifer krummholz. *Salix brachycarpa* has between 40 and 70% cover, and *Salix planifolia* can have up to 30% cover but is often absent. The herbaceous layer is influenced by local hydrology and neighboring subalpine, alpine turf or wetland communities, and can include an eclectic mix of plants. Common understory species include *Mertensia ciliata, Cirsium scopulorum, Polygonum bistortoides, Carex* spp., *Geum rossii var. turbinatum, Trisetum spicatum, Achillea millefolium var. occidentalis, Deschampsia caespitosa, Silene acaulis var. subacaulescens*, and *Senecio amplectens var. holmii*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Salix brachycarpa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Cirsium scopulorum*, *Mertensia ciliata*, *Salix planifolia*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Great Sand Dunes National Park and Preserve Comments: This association differs from *Salix planifolia* associations by the clear dominance of *Salix brachycarpa* and the tendency to occupy more upland habitats. Equally mixed stands do exist to some extent, but are generally ecotonal and divided based on hydrology.

Global Similar Associations:

- *Abies lasiocarpa - Picea engelmannii / Salix (brachycarpa, glauca)* Krummholz Shrubland (CEGL000986)
- *Salix brachycarpa / Carex aquatilis* Shrubland (CEGL001244)
- *Salix planifolia / Caltha leptosepala* Shrubland (CEGL002665)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association has been documented near treeline in the northern half of the project area, in the San Isabel Creek, South Crestone Lake, Willow Creek, Spanish Creek, Sand Creek, and Little Sand Creek drainages.

Global Range: This seasonally flooded shrubland association occurs in the upper subalpine-lower alpine zones in the southern Rocky Mountains across Colorado and into Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 5039, 1012, 4224, 2319, 356, 4228, 2136, 5218, 4251.

Local Description Authors: K. Forrest

Salix drummondiana / Mesic Forbs Shrubland
Drummond's Willow / Mesic Forbs Shrubland
Identifier: CEGL001192

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This riparian shrubland association occurs along low to midslope channels and streambeds at 3065 to 3245 m elevation. Stands are permanently flooded with somewhat poorly drained to moderately well-drained sandy loam soils. Ground cover is a mix of litter, water, and vegetation basal area.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Salix drummondiana* forms a moderately dense tall-shrub canopy with cover of about 50%. *Salix monticola* and *Salix planifolia* may also be present, along with scattered *Picea pungens*. Herbaceous cover may be sparse to moderately dense, ranging from 5-55%. Commonly occurring species include *Mertensia ciliata, Equisetum arvense, Helianthus maximiliani*, and *Delphinium robustum*, all with 10% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tall shrub/sapling	Broad-leaved deciduous shrub	*Salix drummondiana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Picea pungens*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Delphinium robustum* (globally imperiled, G2?)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Salix drummondiana / Calamagrostis canadensis* Shrubland (CEGL002667)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur along Sand Creek, Cleavland Creek, and Horse Canyon Gulch.
Global Range: This plant association occurs in Colorado, Montana and Alberta, Canada. It is likely to be more widespread, but is currently undocumented elsewhere.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4233, 4032, 3279.
Local Description Authors: K.E. Sabo

Salix monticola / Mesic Forbs Shrubland
Park Willow / Mesic Forbs Shrubland
Identifier: CEGL002658

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot found on a valley floor at 3064 m elevation. There is a slight southwest-facing slope of 3 degrees. This palustrine community is semipermanently flooded with poorly drained silt loam soils. Ground cover is dominated by litter and duff (77%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand is dominated by a tall (2-5 m) shrub layer dominated by *Salix monticola* (60%), with <5% cover of *Salix drummondiana* and scattered *Picea pungens*. The herbaceous layer is characterized by mesic forbs with 30% total cover. Species richness for the surveyed stand is high, but few species have greater than trace amount of cover. *Erigeron elatior* is the most abundant forb species with 10% cover, while *Fragaria virginiana, Geranium richardsonii, Hydrophyllum fendleri, Maianthemum stellatum, Mertensia ciliata*, and *Senecio triangularis* are all present with <5% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tall shrub/sapling	Broad-leaved deciduous shrub	*Salix monticola*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Erigeron elatior*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Salix monticola* / Mesic Graminoids Shrubland (CEGL002659)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek drainage.
Global Range: This plant association is known only from Colorado; however, within the state it is widespread in the Southern Rocky Mountains ecoregion. It has also been found in the eastern portions (the Colorado portions) of the Utah High Plateaus and the Colorado Plateau ecoregions.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5009.
Local Description Authors: K.E. Sabo

Salix planifolia / Carex aquatilis Shrubland
Planeleaf Willow / Aquatic Sedge Shrubland
Identifier: CEGL001227

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is know from one plot located in the basin of an alpine cirque at 3611 m in elevation. Soils are permanently flooded, very poorly drained organic muck. Basal area from a dense sedge mat accounts for 40% of the ground cover, followed by water with 30%, litter and duff with 27%, moss 2% and bare soil 1%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Salix planifolia* forms a short-shrub layer (individual heights ranging from 0.5-2 m) with 15% cover. *Carex aquatilis* is the dominant graminoid, forming a thick mat with 70% cover. *Pedicularis groenlandica, Caltha leptosepala var. leptosepala*, and *Rhodiola rhodantha* each have 3% cover. Trace herbaceous species include *Deschampsia caespitosa, Carex albonigra, Swertia perennis, Potentilla* sp., and *Thalictrum alpinum*. Mosses have 10% cover beneath the herbaceous layer.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Salix planifolia*
Herb (field)	Graminoid	*Carex aquatilis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Caltha leptosepala* var. *leptosepala*, *Pedicularis groenlandica*, *Rhodiola rhodantha*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments: This association is known from one plot, and it is likely that the composition and cover will vary from the exact numbers reported here.
Global Similar Associations:
- *Salix (farriae, planifolia) / Carex utriculata* Shrubland (CEGL001228)
- *Salix planifolia / Calamagrostis canadensis* Shrubland (CEGL001225)
- *Salix planifolia / Caltha leptosepala* Shrubland (CEGL002665)
- *Salix planifolia / Carex scopulorum* Shrubland (CEGL001229)
- *Salix planifolia / Carex utriculata* Shrubland (CEGL005937)
- *Salix planifolia / Deschampsia caespitosa* Shrubland (CEGL001230)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from one plot along the South Zapata Lakes trail.
Global Range: This riparian association is found in the montane and subalpine zones in the Rocky Mountains from northern New Mexico to Montana and Idaho.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3238.
Local Description Authors: K. Forrest

Salix planifolia / Carex scopulorum Shrubland
Planeleaf Willow / Holm's Rocky Mountain Sedge Shrubland
Identifier: CEGL001229

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is found on stream terraces and cirque basins from 3440 to 3675 m in elevation. Stands are flat to gently sloping, with an aspect of northeast to east to southeast. Soils are saturated to permanently flooded silty clay loam, silt loam, sandy clay loam or muck. Mosses can cover up to 60% of the ground surface, but litter more commonly has at least 50% cover. Basal area of the plants is also high, with 10-44% ground cover. One plot has 30% bare soil. Elk browse was noted on some plots.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Salix planifolia* forms a short-shrub stratum with 30-70% cover. Between and beneath the shrubs, *Carex scopulorum* is the most prevalent graminoid in the herbaceous layer. These shrublands often have denser patches of willows near running streams or lakeshores, or gradually transition into herbaceous *Carex scopulorum - Caltha leptosepala var. leptosepala* wetlands in broad alpine cirques and valleys. The herbaceous layer is varied, with the most frequently encountered graminoid species being *Deschampsia caespitosa, Juncus drummondii*, and *Luzula parviflora*, and forbs including *Caltha leptosepala var. leptosepala, Rhodiola rhodantha, Senecio triangularis*, and *Swertia perennis*. One plot sampled has 70% moss cover beneath the herbaceous layer.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Salix planifolia*
Herb (field)	Graminoid	*Carex scopulorum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Caltha leptosepala* var. *leptosepala*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Salix planifolia / Calamagrostis canadensis* Shrubland (CEGL001225)
- *Salix planifolia / Caltha leptosepala* Shrubland (CEGL002665)
- *Salix planifolia / Carex aquatilis* Shrubland (CEGL001227)
- *Salix planifolia / Carex utriculata* Shrubland (CEGL005937)
- *Salix planifolia / Deschampsia caespitosa* Shrubland (CEGL001230)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from high-elevation subalpine and alpine valleys in the northern half of the project area: near Medano Lake, upper Sand Creek, south of Crestone Peak above Cottonwood Creek, and Groundhog Basin off the north fork of the North Crestone Creek.
Global Range: This wetland association occurs in the alpine and upper subalpine zones in the southern and central Rocky Mountains from Colorado to northwestern Wyoming and eastern Washington.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4056, 5223, 1108, 411, 4226.
Local Description Authors: K. Forrest

Salix planifolia / Carex utriculata Shrubland
Planeleaf Willow / Northwest Territory Sedge Shrubland
Identifier: CEGL005937

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one plot in a gently sloping, east-facing wetland at the low end of a drainage channel with an elevation of 3484 m. The soils are saturated, poorly drained organic muck, and account for 37% of the ground cover. Moss makes up 30% of the ground cover, basal area 25%, and the remaining 8% is open water. The ground surface is cut through with small channels, and there are open areas of drying mud, indicating that this stand had been previously flooded.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a short shrubland of *Salix planifolia* with an understory of *Carex utriculata*. The sampled stand occurs around the edges of a large herbaceous wetland. *Salix planifolia* is dense in places, with an overall cover of 60%. *Carex utriculata* dominates the varied herbaceous layer with 20% cover. *Senecio triangularis* and *Carex scopulorum* each have 3% cover. Trace herbaceous species include *Calamagrostis canadensis, Deschampsia caespitosa, Carex microptera, Juncus drummondii, Rhodiola rhodantha, Mertensia ciliata, Cardamine cordifolia, Veronica wormskjoldii, Caltha leptosepala var. leptosepala, Swertia perennis, Aconitum columbianum, Oxypolis fendleri*, and *Cirsium scopulorum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Salix planifolia*
Herb (field)	Graminoid	*Carex utriculata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex scopulorum*, *Senecio triangularis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:

Great Sand Dunes National Park and Preserve Comments: This association is known from one plot, and it is likely that the composition and cover will vary from the exact numbers reported here.

Global Similar Associations:

- *Salix planifolia / Caltha leptosepala* Shrubland (CEGL002665)
- *Salix planifolia / Carex aquatilis* Shrubland (CEGL001227)
- *Salix planifolia / Carex scopulorum* Shrubland (CEGL001229)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from one location along the upper Sand Creek drainage.

Global Range: This association is known from central and northern Utah, central and western Idaho, north through the Rocky Mountains to southwestern Montana, western and north-central Wyoming, and throughout the mountains of western Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 4028.

Local Description Authors: K. Forrest

Salix planifolia / Mesic Forbs Shrubland

Planeleaf Willow / Mesic Forbs Shrubland

Identifier: CEGL002893

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This subalpine to alpine willow shrubland is found in the bottom of broad alpine valleys and along stream terraces and channels from 3445 to 3675 m in elevation. Stands are gently to moderately sloping (2-21 degrees) and face east to south to west. Soils are temporarily to intermittently flooded, poorly to moderately well-drained silt loam or sand loam. In steeper riparian stands, large rocks may be present, accounting for around 5% ground cover. Rock types include Crestone conglomerate and diorite. Basal area, litter and moss make up most of the ground cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a short-shrub layer of mostly *Salix planifolia* over a lush forb-dominated herbaceous layer. *Salix brachycarpa* can have up to 35% relative cover in the short-shrub stratum, but in general tends to be a more upland species and not as prevalent in habitats where this association is found. The forb layer ranges in cover from 20-70%; typical species include *Mertensia ciliata, Senecio triangularis, Caltha leptosepala var. leptosepala, Saxifraga odontoloma, Oxypolis fendleri*, and *Polygonum bistortoides*. Graminoid cover ranges from 10-30% and includes *Carex scopulorum, Deschampsia caespitosa, Juncus drummondii*, and *Trisetum spicatum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Salix planifolia*
Herb (field)	Forb	*Mertensia ciliata*, *Senecio triangularis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex scopulorum*, *Salix brachycarpa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence:

Great Sand Dunes National Park and Preserve Comments:

Global Similar Associations:

- *Salix planifolia / Caltha leptosepala* Shrubland (CEGL002665)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from high subalpine drainages in the northern half of the project area: Willow Creek, Spanish Creek, Cottonwood Creek, and Sand Creek.

Global Range: This association is documented to occur in Colorado and Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 1144, 3045, 2148, 996.

Local Description Authors: K. Forrest

Salix planifolia / Calamagrostis canadensis Shrubland

Planeleaf Willow / Bluejoint Shrubland

Identifier: CEGL001225

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from one plot along a subalpine stream / drainage channel at 3586 m in elevation. This stand is west-facing with a slope of 2 degrees, and is located directly downstream from a beaver dam. Braided channels traverse the plot, and most of the vegetation is growing in saturated or submerged soils. Water covers 40% of the ground surface, with moss accounting for 30%, basal area 25%, and bare soil 5%. Soils are semipermanently flooded, poorly drained organic muck.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Salix planifolia* dominates this shrubland with occasional *Salix brachycarpa*, with a combined cover of 50%. *Calamagrostis canadensis* is the most prevalent graminoid with 30% cover, followed by *Carex scopulorum* with 10% cover. *Senecio triangularis* and *Mertensia ciliata* each have 3% cover, followed by trace amounts of other mesic forbs, including *Aconitum columbianum, Rhodiola rhodantha, Cardamine cordifolia, Pedicularis groenlandica, Polygonum bistortoides, Trollius laxus ssp. albiflorus (= Trollius albiflorus), Caltha leptosepala ssp. leptosepala, Saxifraga rivularis, Oxypolis fendleri, Erigeron peregrinus*, and *Veronica* sp. Mosses form a thick layer beneath the herbaceous vegetation.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Salix planifolia*
Herb (field)	Graminoid	*Calamagrostis canadensis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex scopulorum*, *Mertensia ciliata*, *Senecio triangularis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments: This association is known from one plot, and it is likely that the composition and cover will vary from the exact numbers reported here.
Global Similar Associations:

- *Salix planifolia / Caltha leptosepala* Shrubland (CEGL002665)
- *Salix planifolia / Carex aquatilis* Shrubland (CEGL001227)
- *Salix planifolia / Carex scopulorum* Shrubland (CEGL001229)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from one plot northwest of Big Sand Creek Lake.
Global Range: This shrubland association occurs in the subalpine zone in the southern Rocky Mountains, Uinta Mountains and Bighorn Mountains from southwestern Colorado to northeastern Utah and north-central Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4031.
Local Description Authors: K. Forrest

Salix planifolia / Deschampsia caespitosa Shrubland

Planeleaf Willow / Tufted Hairgrass Shrubland
Identifier: CEGL001230

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a north-facing bench in an alpine colluvial slope at 3769 m in elevation. A small stream runs through the plot with a slope of 7 degrees. Ground cover is high in rock and bare soil, with 15% ground cover of granite outcrops, 40% bare soil, and 5% each of large and small rocks. Litter and duff account for 10%, basal area 10%, and lichens 5%. The soil is somewhat poorly drained silty clay loam.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Salix planifolia* forms a short-shrub stratum with 35% cover, along with trace amounts of stunted *Picea engelmannii*. The herbaceous layer is a mix of mesic and alpine turf species. *Deschampsia caespitosa* leads a long list of graminoids, with 10% cover. *Kobresia myosuroides* also has 10%, and *Carex scopulorum* and *Carex nova* each have 3%. Trace species include *Poa alpina, Trisetum spicatum, Juncus drummondii*, *Luzula spicata*, *Festuca brachyphylla, Phleum alpinum*, and *Carex* spp. *Geum rossii var. turbinatum* and *Artemisia scopulorum* are each present with 3% in the herbaceous layer. Trace forbs include *Polygonum bistortoides, Castilleja occidentalis, Pedicularis* *groenlandica, Caltha leptosepala var. leptosepala, Potentilla gracilis, Polygonum viviparum, Thalictrum alpinum, Senecio crassulus, Erigeron melanocephalus, Saxifraga rhomboidea, Oreoxis bakeri*, and *Gentiana algida*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Salix planifolia*
Herb (field)	Graminoid	*Deschampsia caespitosa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex scopulorum*, *Geum rossii* var. *turbinatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Oreoxis bakeri* (globally vulnerable, G3?)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Salix planifolia / Caltha leptosepala* Shrubland (CEGL002665)
- *Salix planifolia / Carex aquatilis* Shrubland (CEGL001227)
- *Salix planifolia / Carex scopulorum* Shrubland (CEGL001229)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur near Cleavland Peak and in the Little Sand Creek drainage.
Global Range: This subalpine riparian shrubland association occurs in the southern Rocky Mountains, Uinta Mountains, Beartooth Mountains and Plateau, and Big Horn Mountains from Colorado to northwestern Wyoming and Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3057.
Local Description Authors: K. Forrest

Sarcobatus vermiculatus / Distichlis spicata Shrubland

Greasewood / Inland Saltgrass Shrubland
Identifier: CEGL001363

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This shrubland association occurs on sandsheets, playas, and valley floors at 2295 to 2340 m elevation. Stands can be seasonally flooded with a wide range of soil textures, but generally soils are well-drained loamy sands. Bare soil is the dominant nonvegetative cover ranging from 70-95%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Vegetation is characterized by an open short-shrub canopy dominated by *Sarcobatus vermiculatus* (3-20%) with a sparse to moderately dense herbaceous layer dominated by *Distichlis spicata* (10-40%). Associated short-shrub species may include *Atriplex canescens* and *Ericameria nauseosa*. Species diversity is generally low. *Scirpus nevadensis* and *Cleome multicaulis* are among the few commonly occurring herbaceous species.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Sarcobatus vermiculatus*
Herb (field)	Graminoid	*Distichlis spicata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Cleome multicaulis* (G2G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Sarcobatus vermiculatus / Distichlis spicata - (Puccinellia nuttalliana)* Shrub Herbaceous Vegetation (CEGL002146)--similar but known from the northern Great Plains and not flooded.
- *Sarcobatus vermiculatus / Elymus elymoides* Shrubland (CEGL001372)
- *Sarcobatus vermiculatus / Ericameria nauseosa* Shrubland (CEGL001362)--also occurs on playa in NV.
- *Sarcobatus vermiculatus / Leymus cinereus* Shrubland (CEGL001366)--occurs in similar habitats those not as saline.
- *Sarcobatus vermiculatus / Sporobolus airoides* Shrubland (CEGL001368)
- *Sarcobatus vermiculatus* Disturbed Shrubland (CEGL001357)--similar but no herbaceous layer.

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Cotton Lake, Big Spring Creek drainage, Little Spring Creek drainage, near San Luis Lake, and Dry Lakes.
Global Range: This shrubland association occurs throughout much of the interior West from western Montana to Washington, south to Nevada, Utah and Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 80, 3009, 4007, 3255, 93, 3030.
Local Description Authors: K.E. Sabo and K. Decker

Sarcobatus vermiculatus / Ericameria nauseosa Shrubland
Greasewood / Rubber Rabbitbrush Shrubland
Identifier: CEGL001362

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This common shrubland association is found primarily on sandsheets, but also on valley floors, sabkhas, valley floors, and toeslopes. Elevation ranges from 2295 to 2355 m. Bare soil is the dominant ground surface cover ranging from 50-96%. There is significant evidence of heavy grazing on herbaceous species in every surveyed stand.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Sarcobatus vermiculatus* (3-40%) and *Ericameria nauseosa* (3-40%) form an open to moderately dense short-shrub layer (0.5-1 m) with almost no understory. Other commonly occurring short-shrub species include *Chrysothamnus greenei* (0-10%) and *Atriplex canescens* (0-10%). The sparse (<10% total cover) herbaceous layer may include a variety of graminoids such as *Achnatherum hymenoides, Distichlis spicata, Juncus balticus, Spartina gracilis*, and *Sporobolus airoides*, as well as *Opuntia polyacantha* and *Psoralidium lanceolatum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Ericameria nauseosa*, *Sarcobatus vermiculatus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Exotic/Invasive: *Salsola tragus* (invasive/exotic)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Sarcobatus vermiculatus / Distichlis spicata* Shrubland (CEGL001363)
- *Sarcobatus vermiculatus* Disturbed Shrubland (CEGL001357)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Sand Creek, San Luis Creek, Deadman Creek, Big Spring Creek, Big Spring Creek, and Little Spring Creek drainages and near Twin Lakes.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 114, 257, 213, 1, 421, 4021, 877, 1029, 3256, 5288, 5068, 2002, 5287, 4132, 3016, 533, 4247, 897, 17, 1080, 3257, 3258, 4085, 3029, 2083, 3027.
Local Description Authors: K.E. Sabo and K. Decker

Sarcobatus vermiculatus / Sporobolus airoides Shrubland
Greasewood / Alkali Sacaton Shrubland
Identifier: CEGL001368

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This shrubland association occurs on sabkhas, valley floors, and playas. Elevation ranges from 2300 to 2310 m with flat terrain. Stands can be intermittently flooded and have a range of soil textures including loamy sand, sandy clay, sandy clay loam, and sandy loam. The soils are dry and cracked with a few areas of standing water. Bare soil is the dominant ground cover ranging from 83-94%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: These are sparsely vegetated sites with 5-25% cover by short-shrub species and 5-25% by graminoid species. The short-shrub layer is dominated by *Sarcobatus vermiculatus* (10-20% cover) that can range in height from 0.5 to 3 m. *Sporobolus airoides* is the dominant graminoid species ranging in cover from 3-10%. Other shrub species that may be present in small amounts include *Ericameria nauseosa* and *Chrysothamnus greenei*. In the herbaceous layer, *Achnatherum hymenoides, Distichlis spicata, Opuntia polyacantha*, and other species are likely to be present.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Sarcobatus vermiculatus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Sporobolus airoides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Sarcobatus vermiculatus / Distichlis spicata - (Puccinellia nuttalliana)* Shrub Herbaceous Vegetation (CEGL002146)
- *Sarcobatus vermiculatus / Distichlis spicata* Shrubland (CEGL001363)
- *Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus)* Shrub Herbaceous Vegetation (CEGL001508)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near San Luis Lakes and Cottonwood Creek drainage.
Global Range: This association occurs in the Columbia and Wyoming basins, Colorado Plateau and western Great Plains from eastern Oregon, central and northeastern Wyoming, northwestern and southeastern Colorado, and eastern Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4085, 3019, 2083, 3027.

Local Description Authors: K.E. Sabo and K. Decker

Sarcobatus vermiculatus Disturbed Shrubland
Greasewood Disturbed Shrubland
Identifier: CEGL001357

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This shrubland association occurs on sabkhas, playas, sandsheets, and valley floors at elevations ranging from 2295 to 2310 m. The majority of surveyed stands experience intermittent flooding with a wide range of soil textures. Stands are characterized by large areas of bare soil and sand with small patches of vegetation.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Total vegetation is generally sparse, ranging from 5-25%, but can cover up to 35%. Short-shrub species make up the dominant layer with *Sarcobatus vermiculatus* as the dominant species ranging in cover from 10-30%. Herbaceous cover is very sparse and may include species such as *Distichlis spicata* and *Suaeda calceoliformis* that would be more common in undisturbed *Sarcobatus vermiculatus* communities, as well as weedy and/or exotic species such as *Halogeton glomeratus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Sarcobatus vermiculatus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Sarcobatus vermiculatus / Artemisia tridentata* Shrubland (CEGL001359)
- *Sarcobatus vermiculatus / Distichlis spicata* Shrubland (CEGL001363)
- *Sarcobatus vermiculatus / Ericameria nauseosa* Shrubland (CEGL001362)
- *Sarcobatus vermiculatus* Dune Shrubland (CEGL001364)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the San Luis Creek drainage, near Deadman Lakes, and San Luis Lakes.
Global Range: This association is likely to be widespread on floodplains and valley floors throughout the interior western United States. It is currently documented from the Colorado Plateau, Great Basin, Uinta Basin and San Luis Valley from northwestern New Mexico, southern and western Colorado, Utah, Nevada, and eastern California.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 2382, 4086, 2041, 3203, 3026, 2376, 4087.
Local Description Authors: K.E. Sabo and K. Decker

Sarcobatus vermiculatus Dune Shrubland
Greasewood Dune Shrubland
Identifier: CEGL001364

ENVIRONMENTAL DESCRIPTION
Great Sand Dunes National Park and Preserve Environment: This association is found in dunefields, sandsheets, and stabilized dunes at 2300 to 2390 m elevation. Stands are generally on flat terrain, but slopes can be up to 17 degrees. The majority of stands are characterized by large patches of bare soil with shrubs interspersed. Sand and bare soil dominate the ground cover, although some stands have significant cover of litter.

VEGETATION DESCRIPTION
Great Sand Dunes National Park and Preserve Vegetation: Vegetative cover is extremely variable for this association. Total cover can range from 1-85%. *Sarcobatus vermiculatus* is always present (20-80%), typically in combination with other short shrubs such as *Atriplex canescens, Chrysothamnus greenei, Ericameria nauseosa*, and *Krascheninnikovia lanata* with cover ranging from 0-10%. Herbaceous cover is sparse, generally 20% or less. Species present in some stands with up to 5-10% cover include *Kochia americana, Achnatherum hymenoides, Artemisia frigida, Chenopodium leptophyllum*, and *Opuntia polyacantha*.

MOST ABUNDANT SPECIES
Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Sarcobatus vermiculatus*

CHARACTERISTIC SPECIES
Great Sand Dunes National Park and Preserve: *Chrysothamnus greenei*

OTHER NOTEWORTHY SPECIES
Great Sand Dunes National Park and Preserve:

CLASSIFICATION
Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Sarcobatus vermiculatus* Disturbed Shrubland (CEGL001357)

ELEMENT DISTRIBUTION
Great Sand Dunes National Park and Preserve Range: This association is known to occur near Arena Creek, Head Lake, near Cotton Lake, Big Spring Creek drainage, and Little Spring Creek drainage.
Global Range: Data not available

ELEMENT SOURCES
Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3013, 3014, 864, 4091, 5234, 137, 318, 125, 3254, 4089.

Local Description Authors: K.E. Sabo and K. Decker

Suaeda moquinii Shrubland
Shrubby Seepweed Shrubland
Identifier: CEGL001991

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a sabkha, or salt flat, at 2300 m elevation. This palustrine community is intermittently flooded with very poorly drained clay soil. Bare soil is the dominant ground cover with 94% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Total vegetation cover is less than 10%, and only a few species are present. *Suaeda moquinii* (3%), *Suaeda calceoliformis*, and scattered *Sarcobatus vermiculatus* form a sparse shrubland with a meager herbaceous layer of *Distichlis spicata*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Dwarf-shrub	*Suaeda moquinii*
Herb (field)	Graminoid	*Distichlis spicata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Atriplex obovata / Tidestromia carnosa* Dwarf-shrubland (CEGL004575)
- *Atriplex obovata* Badland Sparse Vegetation (CEGL002928)
- *Sarcobatus vermiculatus / Atriplex confertifolia - (Picrothamnus desertorum, Suaeda moquinii)* Shrubland (CEGL001371)
- *Sarcobatus vermiculatus / Suaeda moquinii* Shrubland (CEGL001370)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the San Luis Creek drainage.
Global Range: This broadly defined shrubland association occurs in saline overflow areas in bottomlands in the Great Basin, Mojave, Colorado, and Sonoran deserts, and in the southern part of the Great Central Valley of California. The species occurs throughout the western U.S., so this type may be more widespread.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2434.

Local Description Authors: K.E. Sabo

Symphoricarpos oreophilus Shrubland
Mountain Snowberry Shrubland
Identifier: CEGL002951

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on low to mid colluvial slopes, valley floors, and sand ramps at 2760 to 3030 m elevation. Terrain ranges from gently rolling to moderate slopes with all aspects. Soils are generally derived from granitic parent material and are well-drained or rapidly drained sandy loam or loamy sand. Ground cover is dominated by litter and duff but can have significant (0-20%) bare soil.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a moderately open (20-40% cover) canopy of short shrubs (often <0.5 m tall) with a graminoid-dominated understory. The dominant species is *Symphoricarpos rotundifolius* or *Symphoricarpos oreophilus*, but other shrubs are present with low percent cover, including *Rosa woodsii, Chrysothamnus viscidiflorus, Artemisia dracunculus*, and others. Total herbaceous cover ranges from 15-55% with 20-40% graminoid cover and up to 20% forb cover. Graminoid species composition is variable but typically includes *Bouteloua gracilis, Festuca arizonica*, and *Hesperostipa comata*. Forb richness is moderately high, but composition is variable among surveyed stands. Species present in more than trace amounts include *Psoralidium lanceolatum, Heterotheca villosa*, and *Artemisia frigida*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Bouteloua gracilis*, *Festuca arizonica*, *Hesperostipa comata*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Dimick Gulch and in the Cold Creek, Little Medano Creek, Medano Creek, and Mosca Creek drainages.
Global Range: This association is known from western Wyoming, Colorado, on the Colorado Plateau and in the high plateaus of Utah, and Oregon.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 3205, 307, 3105, 5211, 4200, 4217.

Local Description Authors: K.E. Sabo

IV. Dwarf-shrubland

Kraschenninnikovia lanata / Achnatherum hymenoides Dwarf-shrubland
Winterfat / Indian Ricegrass Dwarf-shrubland
Identifier: CEGL001323

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on alluvial fans, toeslopes, and sand ramps at elevations ranging from 2460 to 2755 m. Terrain ranges from flat to gently rolling. Soils are well-drained or rapidly drained sandy loams, silts, sands, or loamy sands. Ground cover is comprised of bare soil and litter and duff with some stands having significant amounts of gravel.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a moderately dense short-shrub canopy dominated by *Krascheninnikovia lanata* (10-50%). Other shrub species that are present include *Ericameria nauseosa, Chrysothamnus viscidiflorus, Artemisia frigida*, and *Artemisia dracunculus*. Herbaceous cover is sparse (<35%), growing in clumps between shrubs in these stands. Constant species include *Opuntia polyacantha* (0.5-30%), *Hesperostipa comata* (0-10%), *Bouteloua gracilis* (0.5-10%), and -*Achnatherum hymenoides* (0.5-10%). Introduced or weedy species present in disturbed sites include *Bromus tectorum, Descurainia sophia, Heterotheca villosa, Lappula occidentalis var. occidentalis, Machaeranthera tanacetifolia*, and *Salsola* spp.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Dwarf-shrub	*Krascheninnikovia lanata*
Herb (field)	Graminoid	*Achnatherum hymenoides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Achnatherum hymenoides*, *Artemisia frigida*, *Bouteloua gracilis*, *Krascheninnikovia lanata*, *Opuntia polyacantha*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Krascheninnikovia lanata / Hesperostipa comata* Dwarf-shrubland (CEGL001327)
- *Krascheninnikovia lanata / Pleuraphis jamesii* Dwarf-shrubland (CEGL001322)
- *Krascheninnikovia lanata / Poa secunda* Dwarf-shrubland (CEGL001326)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Medano Creek drainage, Horse Canyon, Morris Gulch, and Horse Gulch.

Global Range: This dwarf-shrubland is reported from the San Luis Valley and Western Slope in the southern Rocky Mountains, the northern Great Basin and western Wyoming. It likely is more widespread in the intermountain western U.S.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4033, 4287, 5082, 342, 4020, 4288.
Local Description Authors: K.E. Sabo and K. Decker

Paronychia pulvinata - Silene acaulis Dwarf-shrubland
Rocky Mountain Nailwort - Cushion Pink Dwarf-shrubland
Identifier: CEGL001976

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This rocky alpine tundra association is located on mid to high colluvial slopes and ridges at 3735 to 3865 m elevation. Slopes are moderate to steep, ranging from 20-26 degrees with north-, southeast-, and southwest-facing aspects. The ground surface is covered by gravel (0-30%), rock (30-45%), litter and duff (10-20%), and bare soil (3-20%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by low-growing, mat-forming alpine plants that have an average cover of 40%. *Paronychia pulvinata* (10%) may share dominance with *Trifolium dasyphyllum* and/or *Minuartia obtusiloba*. Many other characteristic alpine species may be present with low cover, including *Androsace chamaejasme, Arenaria fendleri, Carex rupestris var. drummondiana, Erigeron pinnatisectus, Festuca brachyphylla, Geum rossii var. turbinatum, Phlox condensata, Polygonum bistortoides, Potentilla pulcherrima*, and *Tetraneuris acaulis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Paronychia pulvinata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex rupestris* var. *drummondiana*, *Minuartia obtusiloba*, *Trifolium dasyphyllum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Trifolium nanum* Herbaceous Vegetation (CEGL005939)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: All surveyed sites are located near Medano Lakes and Mount Seven.

Global Range: This association is known from dry alpine habitats in Colorado, northern New Mexico, northeastern Utah and southern Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4209, 4210, 3039.
Local Description Authors: K.E. Sabo and K. Decker

Salix nivalis / Geum rossii Dwarf-shrubland
Snow Willow / Ross' Avens Dwarf-shrubland
Identifier: CEGL005936

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on high colluvial and talus slopes at 3490 to 3850 m elevation. Slopes are variable, ranging from gently rolling to steep (14-40 degrees), with aspects of north, northeast, and northwest. Soils range from poorly drained to well-drained, and textures include silty clay loam, clay loam, loam, silt loam, and sandy loam. Dominant components of nonvegetative cover include bare soil (3-45%), litter and duff (1-50%), gravel (2-10%), and rock (3-25%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This alpine dwarf-shrubland is dominated by *Salix nivalis* (10-50% cover), although *Vaccinium myrtillus var. oreophilum* and *Dryas octopetala* may also occur with <30% cover. Herbaceous cover is generally <40% and is made up primarily of forbs. *Geum rossii var. turbinatum* or *Sibbaldia procumbens* may be dominant. Other herbaceous species present may include *Carex elynoides, Carex rupestris, Deschampsia caespitosa, Festuca brachyphylla, Poa alpina, Trisetum spicatum, Artemisia scopulorum, Castilleja* spp., *Cirsium scopulorum, Erigeron* spp., *Minuartia obtusiloba*, and *Silene acaulis*. Moss and lichens may contribute significant cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Dwarf-shrub	*Salix nivalis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex elynoides*, *Geum rossii* var. *turbinatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Salix arctica - Salix nivalis* Dwarf-shrubland (CEGL001432)
- *Salix arctica / Geum rossii* Dwarf-shrubland (CEGL001430)
- *Salix nivalis / Festuca brachyphylla* Dwarf-shrubland (CEGL001434)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is found near Willow Creek Lakes, Spanish Creek, Cottonwood Creek drainage, near Milwaukee Peak, Little Sand Creek Lakes, and at the southernmost site in California Gulch.

Global Range: This association has been described several times from areas in and around Rocky Mountain National Park in northern Colorado and once from the West Elk Mountains of south-central Colorado. It is to be expected in other high mountain ranges in Colorado and possibly in alpine areas in adjacent states.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 3054, 5222, 4242, 4246, 5003, 4230, 332, 3247, 4237.

Local Description Authors: K.E. Sabo and K. Decker

Vaccinium (caespitosum, scoparium) Dwarf-shrubland

(Dwarf Bilberry, Grouseberry) Dwarf-shrubland

Identifier: CEGL001140

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This alpine dwarf-shrubland occurs on mid to high colluvial slopes at 3480 to 3690 m elevation. Slopes are moderately steep (19-30 degrees), with northeast- and southeast-facing aspects. Soil types are rapidly drained to well-drained sandy loams and clay loams; bare soil ranges from 5-60% of the ground surface area. Other components of nonvegetative cover include litter and duff (10-60%), rock (1-20%), and gravel (2-24%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This treeline dwarf-shrub association is dominated by *Vaccinium caespitosum* or *Vaccinium scoparium* with 20-30% cover, and includes scattered short-statured (0.5-2 m) *Picea engelmannii* trees. Herbaceous cover is sparse to moderately dense (10-50%) and includes both graminoids, such as *Carex elynoides, Danthonia intermedia, Festuca brachyphylla*, and *Trisetum spicatum*, as well as forbs, including *Achillea millefolium var. occidentalis, Antennaria rosea, Erigeron* spp., *Phlox* spp., *Selaginella densa*, and *Solidago nana*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Dwarf-shrub	*Vaccinium caespitosum*, *Vaccinium scoparium*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex elynoides*, *Danthonia intermedia*, *Festuca brachyphylla*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

Great Sand Dunes National Park and Preserve Comments:

Global Similar Associations:

- *Vaccinium caespitosum - (Salix farriae) / Danthonia intermedia* Dwarf-shrubland (CEGL000484)
- *Vaccinium caespitosum / Calamagrostis breweri* Dwarf-shrub Herbaceous Vegetation (CEGL008655)
- *Vaccinium caespitosum / Carex filifolia* Dwarf-shrubland (CEGL008653)
- *Vaccinium caespitosum / Sanguisorba officinalis* Dwarf-shrubland (CEGL003438)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Cottonwood Creek drainage and near Music Pass and Mount Seven.

Global Range: This association has been documented from the southern Rocky Mountains of Colorado and Wyoming. It is reported to occur in the Ruby Mountains of northeastern Nevada, as well as in Banff National Park in Alberta, Canada.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 2196, 4206, 5007.

Local Description Authors: K.E. Sabo and K. Decker

V. Herbaceous Vegetation

Achnatherum hymenoides - Psoralidium lanceolatum Herbaceous Vegetation
Indian Ricegrass - Lemon Scurfpea Herbaceous Vegetation
Indian Ricegrass - Lemon Scurfpea Mixedgrass Prairie
Identifier: CEGL001650

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on dunefields and sandsheets at 2320 to 2355 m elevation. Stands are generally flat to slightly rolling. Soils are rapidly drained sands, and ground cover is dominated by bare soil. The majority of stands are located near stabilized dunefields.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This is a sparsely vegetated (<30% total cover) community of active or stabilized dunes. *Achnatherum hymenoides* (10-30%) is dominant to codominant with *Psoralidium lanceolatum* (<10%). The few other species present may include scattered *Ericameria nauseosa* shrubs and trace amounts of graminoids and forbs such as *Hesperostipa comata, Redfieldia flexuosa, Sporobolus* spp., *Helianthus* spp. *Salsola* spp., and *Lygodesmia juncea*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Psoralidium lanceolatum*
Herb (field)	Graminoid	*Achnatherum hymenoides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Achnatherum hymenoides - Sporobolus contractus* Herbaceous Vegetation (CEGL001652)
- *Redfieldia flexuosa - (Psoralidium lanceolatum)* Herbaceous Vegetation (CEGL002917)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the central valley of Great Sand Dunes National Park and Preserve and near Mosca Creek.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4005, 4012, 3015, 281, 274, 4120.
Local Description Authors: K.E. Sabo and K. Decker

Bouteloua gracilis Herbaceous Vegetation

Blue Grama Herbaceous Vegetation
Blue Grama Shortgrass Prairie
Identifier: CEGL001760

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from one surveyed plot located on gently sloping (3-degree), northwest-facing, middle colluvial slopes at 2776 m in elevation. The soil is sandy loam and well-drained. There is no exposed bedrock, but bare soil is high (40% cover) as well as litter (50%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This herbaceous association is characterized by 50% cover of graminoid species dominated by *Bouteloua gracilis* (20%) and *Festuca arizonica* (10%). Forb biodiversity is high, but total cover is less than 10%. Scattered dwarf-shrub individuals of *Chrysothamnus viscidiflorus* and *Artemisia frigida* contribute a small percentage of the total cover (<5%).

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Festuca arizonica*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Bouteloua eriopoda - Bouteloua gracilis* Herbaceous Vegetation (CEGL001748)
- *Bouteloua gracilis - Bouteloua curtipendula* Herbaceous Vegetation (CEGL001754)
- *Bouteloua gracilis - Bouteloua hirsuta* Herbaceous Vegetation (CEGL001755)
- *Bouteloua gracilis - Buchloe dactyloides* Herbaceous Vegetation (CEGL001756)
- *Bouteloua gracilis - Eragrostis intermedia* Herbaceous Vegetation (CEGL001758)
- *Bouteloua gracilis - Hesperostipa neomexicana* Herbaceous Vegetation (CEGL001763)
- *Bouteloua gracilis - Pleuraphis jamesii* Herbaceous Vegetation (CEGL001759)
- *Bouteloua gracilis - Sporobolus cryptandrus* Herbaceous Vegetation (CEGL001761)
- *Bouteloua gracilis - Sporobolus flexuosus* Herbaceous Vegetation (CEGL001762)
- *Hesperostipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation (CEGL002037)
- *Pleuraphis mutica - Bouteloua gracilis* Herbaceous Vegetation (CEGL001638)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is found west of Morris Gulch.

Global Range: This minor plant association occurs in Arizona, Colorado, New Mexico, Utah and Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3228.
Local Description Authors: K.E. Sabo and K. Decker

Cardamine cordifolia - Caltha leptosepala Herbaceous Vegetation

Large Mountain Bittercress - White Marsh-marigold Herbaceous Vegetation
Identifier: CEGL001958

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one occurrence located on a high cirque floor at 3536 m elevation. Slopes are moderately steep and northwest-facing. The site is seasonally flooded with poorly drained silt loam soils. Ground cover is dominated by bare soil (50%) and litter and duff (30%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation cover ranges from 75-85% with 55-65% forb cover and 15-25% graminoid cover. Dominant species include *Caltha leptosepala* (30%) and *Cardamine cordifolia* (30%). Other commonly occurring species with 10% cover each include *Carex scopulorum, Polygonum bistortoides*, and *Juncus drummondii*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Caltha leptosepala*, *Cardamine cordifolia*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juncus drummondii*, *Polygonum bistortoides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Caltha leptosepala* Herbaceous Vegetation (CEGL001954)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near San Isabel Lake.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5038.
Local Description Authors: K.E. Sabo

Cardamine cordifolia - Mertensia ciliata - Senecio triangularis Herbaceous Vegetation
Large Mountain Bittercress - Mountain Bluebells - Arrowleaf Ragwort Herbaceous Vegetation
Identifier: CEGL002662

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This alpine wetland association occurs in drainage channels, colluvial slopes, cirques, valley floors, and streambeds, with elevation ranging from 3460 to 3730 m. Slope can vary from gentle to steep (0-30 degrees) with northeast-, southeast-, and northwest-facing aspect. Soils are permanently, semipermanently, or seasonally flooded and can be saturated, and are either poorly or very poorly drained sandy clay loam, loam, or muck. There can be a significant amount of rock (8-35%), gravel (0-10%), and bedrock (0-10%) within sampled stands. In general, ground surfaces also have standing water (0-20%) and mosses (0-20%). In addition, the majority of sites have a stream running either through or just outside the sampled area.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Within stands of this association, herbaceous cover ranges from 65-95%. Forb species tend to dominate with 55-75% cover. Dominant species include *Mertensia ciliata, Senecio triangularis*, and *Cardamine cordifolia*. Other commonly occurring forb species include *Caltha leptosepala, Cirsium scopulorum, Erigeron peregrinus, Geum rossii var. turbinatum, Oxypolis fendleri, Polygonum bistortoides, Rhodiola rhodantha*, and *Saxifraga odontoloma*. Graminoid cover ranges from 0-55%, but in general averages around 10%. Dominant graminoid species include *Carex scopulorum, Calamagrostis canadensis*, and *Luzula parviflora*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Mertensia ciliata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Cardamine cordifolia*, *Senecio triangularis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Calamagrostis canadensis - Carex scopulorum - Mertensia ciliata* Herbaceous Vegetation (CEGL001560)
- *Calamagrostis canadensis - Senecio triangularis* Herbaceous Vegetation (CEGL001561)
- *Deschampsia caespitosa - Mertensia ciliata* Herbaceous Vegetation (CEGL001887)
- *Mertensia ciliata* Herbaceous Vegetation (CEGL001944)
- *Senecio triangularis - Mimulus guttatus* Herbaceous Vegetation (CEGL001988)
- *Senecio triangularis - Veratrum californicum* Herbaceous Vegetation (CEGL001989)
- *Senecio triangularis* Herbaceous Vegetation (CEGL001987)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the northern half of the project area in Spanish Creek drainage, Upper Sand Creek Lake, Deadman Creek drainage, and Little Sand Creek Lakes.

Global Range: This alpine and subalpine wetland association occurs in the southern Rocky Mountains in Colorado but may be more widespread in the Rocky Mountains.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 3058, 5207, 3056, 4229, 5005.

Local Description Authors: K.E. Sabo

Carex utriculata Herbaceous Vegetation

Northwest Territory Sedge Herbaceous Vegetation
Beaked Sedge Wet Meadow
Identifier: CEGL001562

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a meandering stream reach at 2323 m elevation. The area is saturated with poorly drained muck soils. Bare soil dominates the ground surface with 55% cover. Deep hoof prints were observed throughout surveyed area, but there is little sign of grazing.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand is a narrow streamside band dominated by *Carex utriculata* (80% cover). Other graminoids include small amounts of *Beckmannia syzigachne, Eleocharis acicularis, Eleocharis palustris, Schoenoplectus acutus*, and others. Forb cover is <10% and dominated by *Mentha arvensis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex utriculata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 1 - Strong

Great Sand Dunes National Park and Preserve Comments:

Global Similar Associations:

- *Carex aquatilis - Carex utriculata* Herbaceous Vegetation (CEGL001803)
- *Carex utriculata* Perched Wetland Herbaceous Vegetation (CEGL002922)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs within the Crestone Creek drainage.

Global Range: This wetland association in found at montane and subalpine elevations throughout much of the western U.S.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4096.
Local Description Authors: K.E. Sabo and K. Decker

Carex utriculata Perched Wetland Herbaceous Vegetation

Northwest Territory Sedge Perched Wetland Herbaceous Vegetation
Identifier: CEGL002922

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a gentle west-facing slope at 2985 m elevation. This substantial wetland site occurs on a broad, relatively flat extent of Willow Creek, and is permanently flooded with very poorly drained muck soils. Water covers 55% of the ground surface with 35% cover of litter and duff. The surveyed stand encompasses a large wet area that is homogeneous in cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand is essentially a monoculture of *Carex utriculata* with 80% cover. Trace amounts of *Calamagrostis canadensis* are present, along with scattered individuals of *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda)* and *Salix planifolia*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex utriculata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Carex utriculata* Herbaceous Vegetation (CEGL001562)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Willow Creek drainage in the northern half of the project area.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA:3068.
Local Description Authors: K.E. Sabo and K. Decker

Carex aquatilis - Pedicularis groenlandica Herbaceous Vegetation
Aquatic Sedge - Bull Elephant's-head Herbaceous Vegetation
Identifier: CEGL001804

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a stream terrace at 3445 m elevation. Slope is gentle (3 degrees) and northeast-facing. The sampled stand has saturated soils that are poorly drained muck. Ground surface cover has bare soil (46%), mosses (25%), and standing water (7%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand is a meadow surrounded by *Picea engelmannii* and *Vaccinium myrtillus* forest and bordered by *Salix planifolia*. *Carex aquatilis* is dominant with 40% cover. Additional graminoids present include other *Carex* species, *Calamagrostis scopulorum, Deschampsia caespitosa*, and *Eriophorum angustifolium*. *Pedicularis groenlandica* is the most common forb species (20%). Other forb species include *Caltha leptosepala, Castilleja sulphurea, Dodecatheon pulchellum, Oxypolis fendleri, Rhodiola rhodantha, Senecio triangularis, Swertia perennis*, and *Veronica wormskjoldii*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex aquatilis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Pedicularis groenlandica*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Carex aquatilis* Herbaceous Vegetation (CEGL001802)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Upper Sand Creek Lake.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4027.
Local Description Authors: K.E. Sabo and K. Decker

Carex aquatilis Herbaceous Vegetation

Aquatic Sedge Herbaceous Vegetation
Identifier: CEGL001802

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from stream terraces, benches of toeslopes, and cirques. Elevations range from 3500 to 3700 m with little to no slope. Stands can be located within palustrine systems and can be permanently flooded or saturated. Soils are somewhat to very poorly drained, and texture ranges from silty clay loam to muck. Mosses form the dominant ground cover with 0-90% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This graminoid-dominated association is generally fairly densely vegetated, with up to 70% cover. *Carex aquatilis* is dominant (30-40% cover) and accompanied by other graminoid species such as *Calamagrostis scopulorum*, other *Carex* spp., *Deschampsia caespitosa, Eriophorum* spp., and *Juncus* spp. Forb cover is typically <10% and includes typical wet meadow species such as *Caltha leptosepala, Cardamine cordifolia, Pedicularis groenlandica, Rhodiola rhodantha, Senecio triangularis*, and *Swertia perennis*. Scattered individuals of *Salix planifolia* may also be present.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex aquatilis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Deschampsia caespitosa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Carex aquatilis - Carex utriculata* Herbaceous Vegetation (CEGL001803)
- *Carex aquatilis - Pedicularis groenlandica* Herbaceous Vegetation (CEGL001804)
- *Carex aquatilis var. dives* Herbaceous Vegetation (CEGL001826)
- *Carex limosa* Herbaceous Vegetation (CEGL001811)
- *Carex praegracilis - Carex aquatilis* Herbaceous Vegetation (CEGL001821)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs within the San Isabel Creek drainage, Groundhog Basin, and near San Isabel Lake.
Global Range: This association is common and located in mountainous areas throughout the western U.S. and Canada.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5041, 4057, 3240.
Local Description Authors: K.E. Sabo and K. Decker

Carex elynoides - Geum rossii Herbaceous Vegetation
Blackroot Sedge - Ross' Avens Herbaceous Vegetation
Identifier: CEGL001853

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from two sites on mid to high colluvial and shoulder slopes at elevations of 3670 and 3896 m. Slopes are steep and southeast- and southwest-facing. Soils are moderately or well-drained silt loam. Sites are generally rocky (10-17% cover) and can have exposed bedrock (0-20%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Graminoids and forbs contribute more-or-less equally to this densely vegetated alpine herbaceous association, with total cover of 70-80%. *Carex elynoides* is the most abundant graminoid (up to 20%) and is found with other species such as *Carex microptera, Elymus trachycaulus*, and *Trisetum spicatum*. *Geum rossii var. turbinatum* is the dominant forb with up to 30% cover. Other typical forbs include *Cirsium scopulorum, Polygonum bistortoides*, and *Trifolium dasyphyllum*. Scattered shrubs of *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda)* or *Salix brachycarpa* may be included with <10% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Geum rossii* var. *turbinatum*
Herb (field)	Graminoid	*Carex elynoides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Dasiphora fruticosa* ssp. *floribunda*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Carex elynoides - Lupinus argenteus* Herbaceous Vegetation (CEGL001854)
- *Carex elynoides - Oreoxis* spp. Herbaceous Vegetation (CEGL001855)
- *Carex elynoides - Oxytropis sericea* Herbaceous Vegetation (CEGL001856)
- *Carex elynoides* Herbaceous Vegetation (CEGL001852)--*Trifolium dasyphyllum* is prominent in Eddleman's stands (Eddleman 1967).

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near North Crestone Lake and South Crestone Lake.
Global Range: This dry alpine turf association is found in windswept upland subalpine and alpine environments in the Rocky Mountains.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 2056, 5220.
Local Description Authors: K.E. Sabo and K. Decker

Carex elynoides Herbaceous Vegetation
Blackroot Sedge Herbaceous Vegetation
Identifier: CEGL001852

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This is a common association of alpine fell-fields found on mid to high colluvial slopes, benches, and ridges at 3530 to 3905 m elevation. Slopes are moderately steep to very steep (12-45 degrees) and aspect is variable. Nonvegetative cover includes bare soil (3-54%), litter and duff (5-60%), gravel (0-80%), and rock (0-30%). There is extensive elk use within the majority of sampled areas.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous cover for this association is typically 50% or more, but occasionally lower. Graminoid cover (10-70%) is usually slightly higher than forb cover (<30%). *Carex elynoides* is the characteristic dominant graminoid (10-30%). Other common graminoid species include *Calamagrostis purpurascens, Carex rupestris var. drummondiana, Elymus trachycaulus, Festuca brachyphylla, Luzula spicata, Poa glauca ssp. rupicola*, and *Trisetum spicatum*. Common forb species include *Achillea millefolium var. occidentalis, Arenaria fendleri, Castilleja* spp., *Geum rossii var. turbinatum, Heuchera parvifolia, Minuartia obtusiloba*, and *Trifolium dasyphyllum*. In some stands, a dwarf-shrub layer is present that may include *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda), Picea engelmannii, Salix planifolia*, or *Pinus aristata* with up to 10% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex elynoides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Festuca brachyphylla*, *Trifolium dasyphyllum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Carex elynoides - Geum rossii* Herbaceous Vegetation (CEGL001853)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is found in the Lake Fork/North Crestone Creek drainage, near Upper Sand Creek Lake, Mount Seven, Medano Lake, Smith Creek drainage, North Zapata Ridge, and Sheep Ridge.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 543, 3259, 116, 14, 4035, 5209, 27, 3234, 4212, 2014, 3222.
Local Description Authors: K.E. Sabo and K. Decker

Carex nebrascensis Herbaceous Vegetation

Nebraska Sedge Herbaceous Vegetation
Nebraska Sedge Wet Meadow
Identifier: CEGL001813

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: These wet meadows of the valley floor occur at elevations ranging from 2310 to 2335 m on flat terrain. Sites are either semipermanently, temporarily, or seasonally flooded. Soils are poorly drained or very poorly drained muck or somewhat poorly drained sandy loam. Generally, bare soil is the dominant ground cover with 3-90% cover. Sampled sites have experienced heavy grazing from bison.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This herbaceous association is dominated by *Carex nebrascensis* with 20-40% cover. *Juncus balticus* may be a codominant when present, with cover ranging from 10-20%. Other common graminoids include *Agrostis gigantea, Carex simulata, Eleocharis palustris, Muhlenbergia richardsonis*, and *Pascopyrum smithii*. Forb cover is typically <10%; common species include *Argentina anserina, Erigeron philadelphicus, Glaux maritima, Ranunculus cymbalaria*, and introduced species such as *Sonchus asper* and *Trifolium repens*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex nebrascensis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juncus balticus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Erigeron philadelphicus* (state-critically imperiled, G5)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Carex nebrascensis - Carex microptera* Herbaceous Vegetation (CEGL001815)
- *Deschampsia caespitosa - Carex nebrascensis* Herbaceous Vegetation (CEGL001601)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs within the Big Spring Creek drainage and near Zapata Ranch.

Global Range: This sedge meadow type is widely distributed from the western Great Plains into the western mountains of the United States, ranging from South Dakota and Montana to possibly as far west as Washington, south to California and east to New Mexico.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2189, 4270, 925.
Local Description Authors: K.E. Sabo and K. Decker

Carex pellita Herbaceous Vegetation
Woolly Sedge Herbaceous Vegetation
Identifier: CEGL001809

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: These typically seasonally flooded wet meadows of the valley floor occur on flat terrain at elevations ranging from 2300 to 2330 m. Soils are generally poorly drained. Soil texture can range from loam to sandy loam. Surveyed stands show evidence of bison, deer, and elk grazing.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This densely vegetated graminoid-dominated association is dominated by *Carex pellita* (20-60% cover). Within a stand, drier patches may be dominated by *Juncus balticus* with up to 10% cover. Other common graminoids include *Carex praegracilis, Eleocharis palustris, Hordeum jubatum, Muhlenbergia richardsonis, Pascopyrum smithii*, and *Schoenoplectus americanus*. Forb cover is generally <10%; common species include *Argentina anserina* and *Mentha arvensis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex pellita*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juncus balticus*, *Mentha arvensis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Carex pellita - Calamagrostis stricta* Herbaceous Vegetation (CEGL002254)
- *Populus deltoides / Carex pellita* Woodland (CEGL002649)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is found in the Big Spring Creek drainage, Dollar Lake, Deadman Creek drainage, and Spanish Creek.
Global Range: This plant association is a minor wetland type in Colorado, Utah, Idaho, Montana, Washington, Oregon, and British Columbia, Canada. *Carex pellita* is a common sedge

that occurs throughout the northern and western United States. It is likely that this or a closely related association occurs in Wyoming, California, and New Mexico.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5091, 4048, 4046, 5074.
Local Description Authors: K.E. Sabo and K. Decker

Carex praegracilis Herbaceous Vegetation
Clustered Field Sedge Herbaceous Vegetation
Identifier: CEGL002660

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from two valley floor plots at 2320 m elevation. Stands are intermittently flooded with poorly drained sandy soil or well-drained sandy clay soil.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Stands are densely vegetated with up to 70% total cover. *Carex praegracilis* (10-60%) is dominant to codominant with *Juncus balticus* (10%). Species diversity is limited. Other species that may be present include *Elymus trachycaulus, Spartina gracilis, Iris missouriensis*, and *Pyrrocoma lanceolata*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex praegracilis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Iris missouriensis*, *Juncus balticus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Carex praegracilis - Carex aquatilis* Herbaceous Vegetation (CEGL001821)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Little Spring Creek drainage.
Global Range: This association occurs in appropriate habitat across the Rocky Mountain and northern Great Basin states, southern Arizona and southern Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 293, 5077.
Local Description Authors: K.E. Sabo and K. Decker

Carex rupestris - Geum rossii Herbaceous Vegetation
Curly Sedge - Ross' Avens Herbaceous Vegetation
Identifier: CEGL001861

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association generally occurs on very rocky high colluvial slopes and ridgetops at 3810 to 3850 m elevation. Slope is generally steep (14-40 degrees), and aspects include northeast-, southwest-, and northwest-facing slopes. Soils are loam or sandy loam that is somewhat poorly drained, well-drained, or rapidly drained. Nonvegetative cover includes litter and duff (0-40%), gravel (3-5%), and rock (4-85%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Sampled stands include both densely vegetated alpine turf and scree slopes where vegetation is confined to small areas between rocks. *Carex rupestris* dominates this herbaceous association with up to 40% cover, accompanied by trace amounts of a few other graminoids such as *Danthonia parryi, Elymus trachycaulus, Festuca brachyphylla*, and *Luzula spicata*. Commonly occurring forb species include *Geum rossii var. turbinatum* (10%) and *Minuartia obtusiloba* (10%). Scattered shrubs may be present, including *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda)* and *Paronychia pulvinata*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex rupestris*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Geum rossii* var. *turbinatum*, *Minuartia obtusiloba*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Carex rupestris - Potentilla ovina* Herbaceous Vegetation (CEGL001862)
- *Carex rupestris - Trifolium dasyphyllum* Herbaceous Vegetation (CEGL001863)--is similar but more xeric and is more often found east of the Continental Divide.
- *Carex rupestris var. drummondiana* Herbaceous Vegetation (CEGL001864)
- *Geum rossii - Minuartia obtusiloba* Herbaceous Vegetation (CEGL001965)
- *Geum rossii - Polygonum bistortoides* Herbaceous Vegetation (CEGL001967)
- *Geum rossii - Sibbaldia procumbens* Herbaceous Vegetation (CEGL001969)
- *Geum rossii - Trifolium* spp. Herbaceous Vegetation (CEGL001970)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is located near Litter Sand Creek Lakes, Mount Seven, and California Gulch.

Global Range: This dry alpine turf association is found in upland subalpine and alpine environments along the Continental Divide and on the western slope in southern Rocky Mountains and in the Uinta Mountains.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA:532, 3246, 270.
Local Description Authors: K.E. Sabo and K. Decker

Carex scopulorum - Caltha leptosepala Herbaceous Vegetation

Holm's Rocky Mountain Sedge - White Marsh-marigold Herbaceous Vegetation
Identifier: CEGL001823

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This common herbaceous association of higher elevations is documented from a variety of topographic settings, including valley floors, stream terraces, lake margins and drainage channels. Elevation ranges from 3505 to 3790 m with little to no slope. Sites are seasonally to permanently flooded, and soils are generally poorly drained muck, silty clay loams, and clay loams. Ground surface cover consists of bare soil (0-60%), mosses (2-30%), standing water (0-50%), and litter and duff (0-40%). Evidence of animal use was observed as well as human trails through some of the sampled sites.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This mixed graminoid and forb herbaceous association is generally densely vegetated, with up to 90% cover. Graminoid cover is 20-70%, while forbs contribute 10-40% cover. *Carex scopulorum* (20-50%) is dominant to codominant with *Caltha leptosepala* (10-40%). Other common graminoids include *Deschampsia caespitosa* (up to 30%), other *Carex* spp., *Juncus drummondii, Phleum alpinum, Poa* spp., and *Trisetum spicatum*. Commonly occurring forbs include *Cardamine cordifolia, Epilobium hornemannii, Geum rossii var. turbinatum, Mertensia ciliata, Pedicularis groenlandica, Polygonum bistortoides, Rhodiola rhodantha, Senecio triangularis*, and *Sibbaldia procumbens*. *Salix planifolia* may also be present with up to10% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex scopulorum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Caltha leptosepala*, *Deschampsia caespitosa*, *Rhodiola rhodantha*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Carex scopulorum - Elymus trachycaulus* Herbaceous Vegetation (CEGL001824)

- *Carex scopulorum* Herbaceous Vegetation (CEGL001822)
- *Carex scopulorum var. bracteosa - Pedicularis groenlandica* Herbaceous Vegetation (CEGL008664)--know from California.

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the South Crestone Creek, Spanish Creek, Cottonwood Creek, Upper Sand Creek Lake, and Smith Creek drainages and Mount Seven.

Global Range: This association is reported from the Rocky Mountains from Colorado to Montana.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 4238, 4231, 4026, 4208, 2367, 3264, 4245.

Local Description Authors: K.E. Sabo and K. Decker

Carex scopulorum Herbaceous Vegetation

Holm's Rocky Mountain Sedge Herbaceous Vegetation

Identifier: CEGL001822

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from colluvial slopes, stream terraces, and U-shaped valleys. Elevation ranges from 3440 to 3915 m with little to no slope. Stands can be semipermanently to permanently flooded with very poorly or poorly drained clay loam, muck, loam, or silt loam soils. Ground cover can be variable with standing water (0-45%), litter and duff (0-70%), and mosses (0-30%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Species composition of these herbaceous stands is similar to stands of *Carex scopulorum - Caltha leptosepala* Herbaceous Vegetation (CEGL001823), but noticeably graminoid-dominated. *Carex scopulorum* is dominant with 20-80% cover. Many other *Carex* species may be present with significant cover, including *Carex albonigra, Carex arapahoensis, Carex canescens, Carex ebenea, Carex illota*, and *Carex saxatilis*. Other graminoid species include *Deschampsia caespitosa, Juncus drummondii, Poa alpina*, and *Trisetum spicatum*. Total forb cover is less than 20%. Commonly occurring forb species include *Artemisia scopulorum, Caltha leptosepala, Cardamine cordifolia, Castilleja* spp., *Geum rossii var. turbinatum, Minuartia obtusiloba, Pedicularis groenlandica, Polygonum viviparum, Sibbaldia procumbens, Rhodiola rhodantha, Silene acaulis var. subacaulescens*, and *Swertia perennis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex scopulorum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Deschampsia caespitosa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Carex arapahoensis* (G2G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Carex scopulorum - Caltha leptosepala* Herbaceous Vegetation (CEGL001823)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from Cottonwood Creek drainage, Upper Sand Creek Lakes, and Sand Creek.
Global Range: This association occurs from California to British Columbia (Christy 2004) and eastward.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4241, 3245, 4030, 4243, 40.
Local Description Authors: K.E. Sabo and K. Decker

Carex siccata - Geum rossii Herbaceous Vegetation

Dry-spike Sedge - Ross' Avens Herbaceous Vegetation
Identifier: CEGL001808

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a moderately steep, east-facing, low colluvial slope at 3498 m elevation. The soil is well-drained and has a loam texture. Litter and duff have the highest percent cover (40%), with other nonvegetative components including rock (5%), gravel (10%), and bare soil (10%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The sampled stand is fairly densely vegetated, with 40% graminoid cover and 30% forb cover. *Carex siccata (= Carex foenea var. foenea)* is dominant with 20% cover. Other commonly occurring graminoid species with 10% cover are *Poa glauca ssp. rupicola* and *Trisetum spicatum*. Forb species with 10% cover include *Achillea millefolium var. occidentalis, Geum rossii var. turbinatum*, and *Antennaria pulcherrima*. Scattered low-statured (1 m) *Picea engelmannii* are also present.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex siccata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Geum rossii* var. *turbinatum*, *Poa glauca* ssp. *rupicola*, *Trisetum spicatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak

Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: The one occurrence of this association is found near Carbonate Mountain.
Global Range: This southern Rocky Mountain alpine and upper subalpine herbaceous association is known from Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3.
Local Description Authors: K. Forrest and K. Decker

Carex simulata Herbaceous Vegetation
Analogue Sedge Herbaceous Vegetation
Identifier: CEGL001825

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is found in basin floor meander belts and drainage channels at 2325 m elevation. The surveyed site is permanently flooded with somewhat poorly drained muck soils. Water covers between 27-57% of the ground surface.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation ranges from 65-75% with the majority of that cover being dominated by graminoid species. *Carex simulata* is the dominant species with cover ranging from 60-70%. *Carex nebrascensis* is also present (3-10%). All other species have less than 3% cover and do not have consistent coverage in all surveyed stands. A short-shrub layer can be present, but only occurs in areas that exhibit more upland characteristics. Within the river channel, vegetation may be *Carex simulata*-dominated or *Carex nebrascensis*-dominated with inclusions of *Glyceria striata* and *Mimulus glabratus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex simulata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex nebrascensis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs within Big Spring Creek.
Global Range: This association is known from Idaho, Montana, Nevada, Oregon, Utah, Wyoming and Colorado, and may possibly occur in California.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3083, 5071.
Local Description Authors: K.E. Sabo

Cirsium scopulorum - Polemonium viscosum Herbaceous Vegetation

Alpine Thistle - Sticky Jacob's-ladder Herbaceous Vegetation
Identifier: CEGL001959

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from mid to high talus, scree, and colluvial slopes at 3525 to 3890 m elevation. Slope ranges from moderate to very steep (19-45 degrees) with variable aspects. Soils are rapidly drained sandy loam, loamy sand, sand, and sandy clay. Stands are dominated by rock cover (25-95%) and gravel (0-58%). There is evidence of marmot and pika in the sampled areas.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is sparse with less than 10% cover. *Cirsium scopulorum* has the greatest cover (up to 10%) along with *Polemonium viscosum* (up to 3%). Other frequent species with trace amounts of cover include *Trisetum spicatum, Trifolium dasyphyllum, Silene acaulis var. subacaulescens, Senecio fremontii, Geum rossii var. turbinatum*, and *Festuca brachyphylla*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Cirsium scopulorum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Polemonium viscosum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This is association is known from the northern end of the project area near Groundhog Basin, Milwaukee Peak, and Upper Sand Creek Lake, as well as the Middle Fork, Cottonwood Creek, Deadman Creek, Medano Creek, and Smith Creek drainages, and at the southern end of the project area on Carbonate Mountain.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 12, 44, 4040, 3261, 5206, 6001, 4239, 4244, 5213, 3038.
Local Description Authors: K.E. Sabo

Danthonia parryi Herbaceous Vegetation
Parry's Oatgrass Herbaceous Vegetation
Identifier: CEGL001795

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from colluvial slopes and ridges between 2955 and 3370 m in elevation. Slopes range from 8-22 degrees, and sites are located on all aspects except east. Soils are well-drained sandy loam to loam, although this association seems to occur on slightly wetter sites than the other upland montane grasslands. Grass litter dominates the ground cover (65-91%), followed by basal area (8-15%). The remainder is bare soil and gravel.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a thick layer of bunch grasses and a long list of forb species. *Danthonia parryi* is the most prevalent graminoid, with 20-40% cover. *Festuca arizonica* (*Festuca thurberi* at higher elevations) is usually present with 10-20% cover. *Pinus aristata* or *Pinus flexilis* are often present on the periphery of the grassland. Other common graminoids include *Muhlenbergia montana, Poa fendleriana*, and *Koeleria macrantha*. Forbs include *Antennaria parvifolia, Campanula rotundifolia, Artemisia frigida, Oxytropis sericea, Achillea millefolium var. occidentalis, Allium cernuum, Androsace septentrionalis, Erysimum capitatum, Potentilla* sp., *Taraxacum officinale, Agoseris aurantiaca, Arenaria fendleri, Besseya plantaginea*, and *Hymenoxys richardsonii*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Danthonia parryi*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Antennaria parvifolia*, *Festuca arizonica*, *Oxytropis sericea*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments: This association is closely related to *Festuca arizonica - Muhlenbergia montana* Herbaceous Vegetation (CEGL001606). The two often coexist in the same meadows and share many of the same associated species. *Danthonia parryi* seems to favor slightly more mesic locations, *Muhlenbergia montana* takes the dry slopes, and *Festuca arizonica* grows throughout. This association can be distinguished by having higher cover of *Danthonia parryi* than *Festuca arizonica*.

Global Similar Associations:

- *Festuca arizonica - Muhlenbergia montana* Herbaceous Vegetation (CEGL001606)--often coexists in the same meadows and shares many of the same associated species.

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from the Mosca Pass area and the Castle Creek drainage.
Global Range: This grassland association is reported from the southern Rocky Mountains in Colorado, mainly from the South Platte, Arkansas, and Rio Grande river drainages, but with a few reports from the Colorado River drainage. The association also occurs in southern Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3209, 3207, 467, 5242.
Local Description Authors: K. Forrest and K. Decker

Deschampsia caespitosa - Caltha leptosepala Herbaceous Vegetation

Tufted Hairgrass - White Marsh-marigold Herbaceous Vegetation
Tufted Hairgrass - Marsh-marigold Wet Meadow
Identifier: CEGL001882

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This wetland association has one known occurrence located in a basin valley floor at 3560 m elevation. The site is a gentle (4-degree) north-facing slope. The stand is semipermanently flooded with poorly drained sandy clay loam soils. Ground cover is dominated by mosses (50%) and litter and duff (29%). There is a small stream of running water through the plot and significant evidence from overgrazed willows of heavy elk use.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is the dominant layer with 75-85% cover. Graminoid cover ranges from 45-55% and forb cover ranges from 25-35%. Dominant graminoid species include *Deschampsia caespitosa, Carex scopulorum, Elymus trachycaulus*, and *Phleum alpinum*. Dominant forb species include *Achillea millefolium var. occidentalis, Caltha leptosepala*, and *Potentilla pulcherrima*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Deschampsia caespitosa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Caltha leptosepala*, *Carex scopulorum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:

Global Similar Associations:
- *Caltha leptosepala* Herbaceous Vegetation (CEGL001954)
- *Deschampsia caespitosa - Achillea millefolium var. occidentalis* Herbaceous Vegetation (CEGL001880)
- *Deschampsia caespitosa - Carex microptera* Herbaceous Vegetation (CEGL001883)
- *Deschampsia caespitosa - Carex* spp. Herbaceous Vegetation (CEGL001603)
- *Deschampsia caespitosa - Geum rossii* Herbaceous Vegetation (CEGL001884)
- *Deschampsia caespitosa - Luzula multiflora* Herbaceous Vegetation (CEGL001886)
- *Deschampsia caespitosa - Mertensia ciliata* Herbaceous Vegetation (CEGL001887)
- *Deschampsia caespitosa - Phleum alpinum* Herbaceous Vegetation (CEGL001888)
- *Deschampsia caespitosa - Polygonum bistortoides* Herbaceous Vegetation (CEGL003485)
- *Deschampsia caespitosa - Potentilla diversifolia* Herbaceous Vegetation (CEGL001889)
- *Deschampsia caespitosa* Herbaceous Vegetation (CEGL001599)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is located near Deadmans Lakes.
Global Range: This alpine to upper subalpine mesic meadow association occurs in the Rocky Mountains from Colorado to Montana.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2459.
Local Description Authors: K.E. Sabo

Deschampsia caespitosa - Carex microptera Herbaceous Vegetation
Tufted Hairgrass - Small-wing Sedge Herbaceous Vegetation
Identifier: CEGL001883

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is found in stream terraces and valley floors at 3495 to 3510 m elevation. Sites are generally flat. Soils are somewhat poorly drained silt loam or silty clay loams. Ground surface cover is primarily litter and duff (30-60%) and bare soil (15-20%). One area sampled has signs of heavy human use such as multiple campsites and trash.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This graminoid-dominated association is densely vegetated with total cover of 70-80%. *Carex microptera* (30-40%) is dominant to codominant with *Deschampsia caespitosa* (20%). Few other graminoid or forb species provide significant cover. Common species with low cover include *Carex canescens, Poa alpina, Phleum pratense, Mertensia ciliata, Cardamine cordifolia, Carex norvegica*, and *Carex scopulorum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Carex microptera*, *Deschampsia caespitosa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Deschampsia caespitosa - Caltha leptosepala* Herbaceous Vegetation (CEGL001882)
- *Deschampsia caespitosa - Carex nebrascensis* Herbaceous Vegetation (CEGL001601)
- *Deschampsia caespitosa - Geum rossii* Herbaceous Vegetation (CEGL001884)
- *Deschampsia caespitosa* Herbaceous Vegetation (CEGL001599)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Willow Creek and Sand Creek drainages.
Global Range: This association is widespread in Wyoming, and may occur in adjacent areas of Idaho and Montana, but has not been reported for either state.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4029, 3096.
Local Description Authors: K.E. Sabo and K. Decker

Deschampsia caespitosa Herbaceous Vegetation

Tufted Hairgrass Herbaceous Vegetation
Tufted Hairgrass Meadow
Identifier: CEGL001599

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on colluvial slopes, in U-shaped valleys, on terraces, and benches at 3460 to 3800 m elevation. Slopes are flat to moderately steep (0-20 degrees) with south- and west-facing aspects. Soils can be semipermanently flooded or saturated and in general somewhat poorly drained. Soil texture ranges from clay loam to sandy clay loam, sandy loam, or silt loam. Ground surface cover can be variable with some sites being rocky and others having no rock cover. In general, ground surface cover includes litter and duff (10-56%), bare soil (0-15%), rock (0-50%), bedrock (0-15%), and mosses (0-15%). Deer and elk browse is significant in some of the sampled areas causing severe damage to surrounding willows.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This graminoid-dominated herbaceous association is generally densely vegetated, except in rocky areas. Total herbaceous cover ranges from 60-90%. *Deschampsia caespitosa* is dominant with 20-40% cover. Other common graminoids include numerous *Carex* spp., *Danthonia intermedia, Elymus trachycaulus, Juncus drummondii, Luzula spicata, Phleum alpinum, Poa alpina*, and *Trisetum spicatum*. Forb species may contribute up to 30% cover, with *Artemisia scopulorum, Caltha leptosepala, Cirsium scopulorum, Geum rossii var. turbinatum, Polygonum bistortoides*, and *Sibbaldia* *procumbens* the most common species. Small amounts of short willow species such as *Salix brachycarpa, Salix nivalis*, and *Salix planifolia* may also be present.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Deschampsia caespitosa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Sibbaldia procumbens*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Deschampsia caespitosa - Achillea millefolium var. occidentalis* Herbaceous Vegetation (CEGL001880)
- *Deschampsia caespitosa - Artemisia lindleyana* Herbaceous Vegetation (CEGL003425)
- *Deschampsia caespitosa - Caltha leptosepala* Herbaceous Vegetation (CEGL001882)
- *Deschampsia caespitosa - Carex douglasii* Herbaceous Vegetation (CEGL001602)
- *Deschampsia caespitosa - Carex microptera* Herbaceous Vegetation (CEGL001883)
- *Deschampsia caespitosa - Carex nebrascensis* Herbaceous Vegetation (CEGL001601)
- *Deschampsia caespitosa - Carex* spp. Herbaceous Vegetation (CEGL001603)
- *Deschampsia caespitosa - Danthonia californica* Herbaceous Vegetation (CEGL001604)
- *Deschampsia caespitosa - Geum rossii* Herbaceous Vegetation (CEGL001884)
- *Deschampsia caespitosa - Horkelia marinensis* Herbaceous Vegetation (CEGL003461)
- *Deschampsia caespitosa - Ligusticum tenuifolium* Herbaceous Vegetation (CEGL001885)
- *Deschampsia caespitosa - Luzula multiflora* Herbaceous Vegetation (CEGL001886)
- *Deschampsia caespitosa - Mertensia ciliata* Herbaceous Vegetation (CEGL001887)
- *Deschampsia caespitosa - Phleum alpinum* Herbaceous Vegetation (CEGL001888)
- *Deschampsia caespitosa - Polygonum bistortoides* Herbaceous Vegetation (CEGL003485)
- *Deschampsia caespitosa - Potentilla diversifolia* Herbaceous Vegetation (CEGL001889)
- *Deschampsia caespitosa - Symphyotrichum foliaceum* Herbaceous Vegetation (CEGL001881)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs within Crestone Peaks, Deadman Creek drainage, and Little Sand Creek Lakes.
Global Range: This association is known from throughout the western U.S. and Alberta, Canada.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2028, 5205, 3055, 4235.
Local Description Authors: K.E. Sabo and K. Decker

Deschampsia caespitosa - Geum rossii Herbaceous Vegetation

Tufted Hairgrass - Ross' Avens Herbaceous Vegetation
Identifier: CEGL001884

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a high shoulder slope at 3935 m elevation. The stand is moderately steep (28 degrees) and southeast-facing. The soil is well-drained and loamy sand in texture. Bare soil is the dominant ground cover with 30% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This alpine herbaceous association is characterized by a mixture of graminoids and forbs with up to 70% cover. In the sampled stand, *Geum rossii var. turbinatum, Carex elynoides, Deschampsia caespitosa*, and *Elymus trachycaulus* contribute equally to total cover (10% each). Species diversity is high and includes many characteristic alpine species such as *Festuca brachyphylla, Trisetum spicatum, Achillea millefolium var. occidentalis, Artemisia scopulorum, Heterotheca pumila, Trifolium dasyphyllum, Silene acaulis var. subacaulescens, Campanula uniflora*, and *Polygonum bistortoides*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Geum rossii* var. *turbinatum*
Herb (field)	Graminoid	*Carex elynoides*, *Deschampsia caespitosa*, *Elymus trachycaulus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Deschampsia caespitosa - Achillea millefolium var. occidentalis* Herbaceous Vegetation (CEGL001880)
- *Deschampsia caespitosa - Caltha leptosepala* Herbaceous Vegetation (CEGL001882)
- *Deschampsia caespitosa - Carex microptera* Herbaceous Vegetation (CEGL001883)
- *Deschampsia caespitosa - Carex* spp. Herbaceous Vegetation (CEGL001603)
- *Deschampsia caespitosa - Luzula multiflora* Herbaceous Vegetation (CEGL001886)
- *Deschampsia caespitosa - Mertensia ciliata* Herbaceous Vegetation (CEGL001887)
- *Deschampsia caespitosa - Phleum alpinum* Herbaceous Vegetation (CEGL001888)
- *Deschampsia caespitosa - Polygonum bistortoides* Herbaceous Vegetation (CEGL003485)
- *Deschampsia caespitosa - Potentilla diversifolia* Herbaceous Vegetation (CEGL001889)
- *Deschampsia caespitosa* Herbaceous Vegetation (CEGL001599)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the upper northern half of the project area near Venable Peak.
Global Range: This mesic meadow association occurs in alpine and subalpine in the southern and central Rocky Mountains.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2321.
Local Description Authors: K.E. Sabo and K. Decker

Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation

Inland Saltgrass - (Nevada Bulrush) Herbaceous Vegetation
Identifier: CEGL001773

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This graminoid association is found in playas and sandsheets at 2295 to 2320 m elevation. Stands are intermittently flooded and may have poorly or well-drained loamy sand or sandy clay soils. Ground cover is primarily bare soil with 70-91% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association may be found as a distinct band around frequently flooded areas, or as continuous cover in shrubland openings with salty, frequently inundated soils. Vegetation cover is generally sparse (<10%) but can be dense in places. *Scirpus nevadensis* is dominant in wetter areas and may have up to 90% cover. *Distichlis spicata* is present with <5% cover. The few other species present represent typical regional salty soil species such as *Cleome multicaulis, Suaeda calceoliformis, Spartina gracilis, Triglochin maritima*, and scattered individuals of *Sarcobatus vermiculatus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Scirpus nevadensis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Cleome multicaulis* (G2G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Distichlis spicata* Herbaceous Vegetation (CEGL001770)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Big Spring Creek and San Luis Lake.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4218, 221, 4006.
Local Description Authors: K.E. Sabo and K. Decker

Distichlis spicata Herbaceous Vegetation
Inland Saltgrass Herbaceous Vegetation
Saltgrass Saline Prairie
Identifier: CEGL001770

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This is a common grassland association of sandsheets, found in playas and sabkhas, where it may form extensive stands. Elevations range from 2290 to 2325 m. Stands may be intermittently or seasonally flooded. Soil textures include silt, sandy loam, silt loam, loamy sand, sand, and silty clay. Soils can be hard-packed and poorly drained. Bare soil is generally cover >80% of the ground surface.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This sparsely to moderately vegetated grassland of salty soils is dominated by *Distichlis spicata* (10-30% cover). Other common graminoids include *Spartina gracilis, Scirpus nevadensis, Triglochin maritima*, and *Juncus balticus*. Forb cover is low, and species composition likely depends on soil salinity. Common species include *Cleome multicaulis, Equisetum laevigatum*, and *Pyrrocoma lanceolata*, among others. Scattered *Ericameria nauseosa* or *Sarcobatus vermiculatus* shrubs may also be present.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Distichlis spicata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Distichlis spicata*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Cleome multicaulis* (G2G3); **Exotic/Invasive**: *Poa pratensis* (invasive/exotic, Medium), *Salsola tragus* (invasive/exotic)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Distichlis spicata - (Hordeum jubatum, Poa arida, Sporobolus airoides)* Herbaceous Vegetation (CEGL002042)--currently described only from the Great Plains.
- *Distichlis spicata - (Scirpus nevadensis)* Herbaceous Vegetation (CEGL001773)
- *Distichlis spicata - Hordeum jubatum - (Poa arida, Iva annua)* Herbaceous Vegetation (CEGL002031)--currently described only from the Great Plains.
- *Distichlis spicata - Hordeum jubatum - Puccinellia nuttalliana - Plantago maritima* Herbaceous Vegetation (CEGL002551)--currently described only from the Great Plains.

- *Distichlis spicata* - *Hordeum jubatum* - *Puccinellia nuttalliana* - *Suaeda calceoliformis* Herbaceous Vegetation (CEGL002273)--currently described only from the Great Plains.
- *Distichlis spicata* - *Lepidium perfoliatum* Herbaceous Vegetation (CEGL001772)
- *Distichlis spicata* - Mixed Herb Herbaceous Vegetation (CEGL001771)
- *Distichlis spicata* - *Schoenoplectus maritimus* - *Salicornia rubra* Herbaceous Vegetation (CEGL002043)--currently described only from the Great Plains.
- *Distichlis spicata* - *Spartina* spp. Herbaceous Vegetation (CEGL002275)--currently described only from the Great Plains.
- *Eleocharis palustris* - *Distichlis spicata* Herbaceous Vegetation (CEGL001834)
- *Leymus cinereus* - *Distichlis spicata* Herbaceous Vegetation (CEGL001481)
- *Pascopyrum smithii* - *Distichlis spicata* Herbaceous Vegetation (CEGL001580)
- *Polygonum* spp. - *Echinochloa* spp. - *Distichlis spicata* Playa Lake Herbaceous Vegetation (CEGL002039)
- *Sporobolus airoides* - *Distichlis spicata* Herbaceous Vegetation (CEGL001687)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Antelope Springs, Head Lake and San Luis Lake.
Global Range: This grassland association occurs in low areas in semi-arid and arid western North America from southern Saskatchewan, Canada, west to Washington and south to Arizona, California, New Mexico, and possibly northern Mexico.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 65, 5251, 5043, 4083, 369, 3017, 3022, 5095.
Local Description Authors: K.E. Sabo and K. Decker

Dryas octopetala - *Carex rupestris* Dwarf-shrub Herbaceous Vegetation
Eight-petal Mountain-avens - Curly Sedge Dwarf-shrub Herbaceous Vegetation
Identifier: CEGL001892

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: The one surveyed plot is found above treeline on a high slope ridge at 3832 m elevation. It occurs on a steep (40-degree), north-facing, rocky colluvial slope. The combined percent cover of bare ground, bedrock, litter, gravel, and rock is greater than 85% of the total ground surface.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Dryas octopetala* is the dominant species for this association with 30% cover. *Silene acaulis var. subacaulescens* and *Carex rupestris var. drummondiana* are codominants with 10% cover each.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Dwarf-shrub	*Dryas octopetala*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex rupestris* var. *drummondiana*, *Silene acaulis* var. *subacaulescens*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments: This association differs from *Dryas octopetala - Carex* spp. Dwarf-shrub Herbaceous Vegetation (CEGL001893) by the clear codominance of *Carex rupestris var. drummondiana*.
Global Similar Associations:

- *Dryas integrifolia - Carex* spp. Dwarf-shrub Herbaceous Vegetation (CEGL001890)
- *Dryas octopetala - Carex* spp. Dwarf-shrub Herbaceous Vegetation (CEGL001893)
- *Dryas octopetala - Polygonum viviparum* Dwarf-shrub Herbaceous Vegetation (CEGL001894)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is documented from near Little Sand Creek Lakes.
Global Range: This alpine fell-field association is found throughout Colorado's Rocky Mountains, and in western and central Montana north into Alberta. It is likely to occur elsewhere in the alpine of western North America.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 276.
Local Description Authors: K.E. Sabo

Dryas octopetala - Carex spp. Dwarf-shrub Herbaceous Vegetation

Eight-petal Mountain-avens - Sedge species Dwarf-shrub Herbaceous Vegetation
Identifier: CEGL001893

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from above treeline on moderately steep (20-degree), north-facing colluvial slopes at 3605 and 3840 m elevation. The soils are well-drained with sandy loam and loamy sand textures. Rock and litter/duff make up the majority of the ground cover generally covering over half of the ground surface. Lichens can also have a large percentage of ground cover (25%), but this is variable.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by *Dryas octopetala* which can occur as a dwarf-shrub and or a forb in the herbaceous layer. *Dryas octopetala* generally tends to prefer sites that are drier, rocky, and on north-facing slopes. *Carex elynoides* can be quite prevalent and could be considered codominant. Other species that are less dominant are *Minuartia obtusiloba, Trifolium dasyphyllum, Sibbaldia procumbens*, and *Selaginella densa*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Dwarf-shrub	*Dryas octopetala*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex elynoides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Dryas octopetala - Carex rupestris* Dwarf-shrub Herbaceous Vegetation (CEGL001892)
- *Dryas octopetala - Polygonum viviparum* Dwarf-shrub Herbaceous Vegetation (CEGL001894)
- *Dryas octopetala* Dwarf-shrub Herbaceous Vegetation (CEGL001891)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Medano Creek Trail drainage and near the peak of Mount Seven.
Global Range: This association occurs in alpine areas of southwestern Montana and western Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4257, 4214.
Local Description Authors: K.E. Sabo

Eleocharis palustris Herbaceous Vegetation

Common Spikerush Herbaceous Vegetation
Common Spikerush Wet Meadow
Identifier: CEGL001833

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This wet meadow association is found on sandsheets, sabkhas and valley floors at 2295 to 2310 m elevation. Surveyed stands may be temporarily to permanently flooded. Soils tend to be very poorly drained loam, silty clay, muck, silty clay loam, and sandy loam in texture. Ground cover is variable with bare soil and litter and duff having the highest percent covers. A few stands have significant amounts of standing water. Evidence of bison use was observed with signs of heavy grazing and trampling.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This generally densely vegetated (up to 90% total cover) graminoid association is dominated by *Eleocharis palustris* (20-90%). Other species that may contribute significant cover include *Juncus balticus, Carex pellita, Carex simulata, Carex nebrascensis*, and *Typha latifolia*. Forb cover is low, except for the occasional submerged or emergent species such as *Polygonum amphibium* or *Ranunculus* spp.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Eleocharis palustris*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Eleocharis macrostachya* Herbaceous Vegetation (CEGL005303)
- *Eleocharis palustris - (Eleocharis compressa) - Leptochloa fusca ssp. fascicularis* Herbaceous Vegetation (CEGL002259)
- *Eleocharis palustris - Distichlis spicata* Herbaceous Vegetation (CEGL001834)
- *Eleocharis palustris - Juncus balticus* Herbaceous Vegetation (CEGL001835)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near San Luis Lakes and Dry Lakes.
Global Range: This spikerush wet meadow community is found in the central Great Plains of the United States and Canada and throughout the western United States including the desert Southwest.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 69, 305, 49, 4265, 352, 3250, 3251.
Local Description Authors: K.E. Sabo and K. Decker

Eleocharis acicularis Herbaceous Vegetation

Needle Spikerush Herbaceous Vegetation
Identifier: CEGL001832

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This herbaceous wetland association is documented from two plots on valley floors and sand ramps on low slopes at 2298 and 2475 m elevation. These palustrine systems are seasonally flooded with very poorly drained silty clay and sandy clay loam soils. Bare soil is the dominant ground cover with 70-75% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is dominated by *Eleocharis acicularis* with 60-90% cover. Additional species present with >5% cover include *Populus angustifolia* seedlings, *Rorippa palustris*, and *Eleocharis palustris*. A few other species may be present in trace amounts.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Eleocharis acicularis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Sand Creek drainage and Dollar Lake.
Global Range: This wet meadow type is know from California, Oregon, Colorado, Idaho, Nevada and Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5059, 480.
Local Description Authors: K.E. Sabo and K. Decker

Ericameria nauseosa / Bouteloua gracilis Shrub Herbaceous Vegetation

Rubber Rabbitbrush / Blue Grama Shrub Herbaceous Vegetation
Identifier: CEGL003495

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is common within the study area and occurs primarily on sandsheets, but can also be found in alluvial fans, stream terraces, and valley floors. Terrain is generally flat. Ground cover is variable across surveyed stands and is comprised of bare soil (0-90%), sand (0-94%), and litter and duff (0-51%). There is also significant evidence of elk grazing in the majority of stands.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Vegetation is sparse in both shrub and herbaceous layers. *Ericameria nauseosa* is the dominant shrub species with 10-20% cover. Commonly occurring herbaceous species include *Bouteloua gracilis* and *Opuntia polyacantha*. Other species present, but at low cover values, include *Senecio spartioides, Hesperostipa comata, Elymus elymoides, Chenopodium leptophyllum*, *Artemisia frigida*, and *Achnatherum hymenoides*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Ericameria nauseosa*
Herb (field)	Graminoid	*Bouteloua gracilis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Bouteloua gracilis*, *Ericameria nauseosa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Ericameria nauseosa / Muhlenbergia pungens - Achnatherum hymenoides* Shrub Herbaceous Vegetation (CEGL002921)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Big Spring Creek, Sawmill Canyon, and the Cottonwood Creek, Deadman Creek, and Sand Creek drainages.
Global Range: This association has been documented from widely scattered sites in southern Utah, northern Arizona, from the upper Rio Puerco watershed in northern New Mexico (Francis 1986), Petrified Forest National Park in northeastern Arizona, and is likely to occur across the central part of the Colorado Plateau.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5274, 477, 4118, 594, 5275, 3004, 5276, 5278, 5272, 5270, 5277, 5080.
Local Description Authors: K.E. Sabo

Ericameria nauseosa / Muhlenbergia pungens - Achnatherum hymenoides Shrub Herbaceous Vegetation

Rubber Rabbitbrush / Sandhill Muhly - Indian Ricegrass Shrub Herbaceous Vegetation
Identifier: CEGL002921

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on sandsheets at 2300 to 2505 m elevation. Terrain is flat with ground cover dominated by bare soil.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Vegetation is sparse for both shrub and herbaceous species. *Ericameria nauseosa* is the dominant shrub species with 10-20% cover. Dominant herbaceous species include *Muhlenbergia pungens* and *Achnatherum hymenoides*. Other commonly occurring species with low cover values include *Sporobolus airoides, Sarcobatus vermiculatus, Psoralidium lanceolatum, Opuntia polyacantha, Lygodesmia juncea, Hesperostipa comata*, and *Eriogonum cernuum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Ericameria nauseosa*
Herb (field)	Graminoid	*Muhlenbergia pungens*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Achnatherum hymenoides*, *Ericameria nauseosa*, *Muhlenbergia pungens*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Ericameria nauseosa / Bouteloua gracilis* Shrub Herbaceous Vegetation (CEGL003495)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in Sawmill Canyon and near San Luis Lake and Zapata Creek.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 277, 793, 5096, 4119, 457, 5285, 3050, 3025, 5, 4013, 5290.
Local Description Authors: K.E. Sabo

Festuca arizonica - Muhlenbergia montana Herbaceous Vegetation

Arizona Fescue - Mountain Muhly Herbaceous Vegetation
Identifier: CEGL001606

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from colluvial slopes and ridges between 2795 and 3080 m in elevation. These meadows are found on all aspects with a slope between 5 and 30 degrees. Soils are well-drained sandy loam, loamy sand, and silt loam, and tend to be gravelly. One plot had evidence of a past fire event. Litter usually has the highest ground cover with 40-60%, although bare ground or gravel can prevail in some stands. Basal area ranges from 5-25% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Festuca arizonica* dominates or codominates this grassland along with *Muhlenbergia montana*. Total graminoid cover ranges from 25-60% and is usually around 40%. Forbs add another 3-20% cover. Vegetation may be sparse on steep and gravelly slopes. *Chrysothamnus viscidiflorus, Ericameria parryi*, and *Symphoricarpos* sp. can be present as dwarf- or short shrubs, but do not form a distinct stratum. This grassland occurs in the montane zone and is often adjacent to or surrounded by *Pinus edulis - Juniperus scopulorum* woodlands or *Pinus aristata - Pinus flexilis* woodlands. Above about 3100 m, *Festuca arizonica* is replaced by *Festuca thurberi*. Other herbaceous species frequently encountered include *Artemisia frigida, Koeleria macrantha, Hymenoxys richardsonii, Elymus elymoides, Bouteloua gracilis, Allium cernuum, Erysimum capitatum, Poa fendleriana, Heterotheca villosa, Erigeron subtrinervis*, and *Selaginella densa*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Festuca arizonica*, *Muhlenbergia montana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Artemisia frigida*, *Chrysothamnus viscidiflorus*, *Koeleria macrantha*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Danthonia parryi* Herbaceous Vegetation (CEGL001795)
- *Muhlenbergia montana* Herbaceous Vegetation (CEGL001646)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This montane grassland is known from the mountainsides near Zapata Falls and Uraca Creek north to Cold Creek Canyon.
Global Range: The association is reported from Texas and southern Colorado, and possibly occurs in northern New Mexico with isolated localities in central New Mexico, and in northern and eastern Arizona.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5021, 5024, 835, 3089, 5020, 3227, 4112, 5069.
Local Description Authors: K. Forrest

Festuca brachyphylla - Trisetum spicatum Herbaceous Vegetation

Shortleaf Fescue - Narrow False Oats Herbaceous Vegetation
Identifier: CEGL001896

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on gently rolling (8-degree), northeast-facing, upper colluvial slopes at 3723 m in elevation. The soils are well-drained and have a sandy loam texture. The site has significant cover of small rocks (58%) and litter and duff (26%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This dry alpine turf association is characterized by an open cover (40%) of mixed graminoid and forb species. *Festuca brachyphylla* and *Trisetum spicatum* are the most abundant graminoids. Typical forb species include *Polygonum bistortoides, Erigeron simplex*, and *Lupinus argenteus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Festuca brachyphylla*, *Trisetum spicatum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Lupinus argenteus*, *Polygonum bistortoides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Festuca brachyphylla - Geum rossii var. turbinatum* Herbaceous Vegetation (CEGL001895)
- *Festuca brachyphylla* Herbaceous Vegetation (CEGL001797)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: The surveyed site is located at North Zapata Ridge.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3221.
Local Description Authors: K.E. Sabo and K. Decker

Festuca brachyphylla Herbaceous Vegetation

Shortleaf Fescue Herbaceous Vegetation
Identifier: CEGL001797

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a steep (32-degree), west-facing high colluvial slope at 3612 m elevation. The soil is moderately well-drained with a silt loam texture. Ground surface is generally covered in vegetation (40%) and rocks (40%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This moderately vegetated treeline stand is dominated by *Festuca brachyphylla* with 30% cover. Forb species such as *Minuartia obtusiloba, Eriogonum flavum*, and *Achillea millefolium* make up another 30% cover. *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda)* is present in trace amounts.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Festuca brachyphylla*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Achillea millefolium*, *Eriogonum flavum*, *Minuartia obtusiloba*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments: This association differs from *Festuca brachyphylla - Trisetum spicatum* Herbaceous Vegetation (CEGL001896) because *Festuca brachyphylla* is the only dominant graminoid found in this association.
Global Similar Associations:
- *Festuca brachyphylla - Geum rossii var. turbinatum* Herbaceous Vegetation (CEGL001895)
- *Festuca brachyphylla - Trisetum spicatum* Herbaceous Vegetation (CEGL001896)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is located on North Zapata Ridge.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2030.
Local Description Authors: K.E. Sabo and K. Decker

Festuca thurberi Subalpine Grassland Herbaceous Vegetation
Thurber's Fescue Subalpine Grassland Herbaceous Vegetation
Identifier: CEGL001631

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from colluvial slopes and upland stream terraces of the subalpine and lower alpine life zones found at 3205 to 3660 m in elevation. Aspects are generally south-facing, but range in aspect from 75 to 246 degrees. Slopes are consistently moderate, with and average of 26 degrees (6-38 degrees). Stands often occur at the base of rock outcrops, in broad avalanche chutes and in openings in subalpine forests and woodlands. They also extend above treeline on south-facing slopes. Grass litter dominates the ground cover, although some plots have up to 58% large rocks. Basal area is usually between 10-30%, due to the high basal area of bunch grasses.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Festuca thurberi* dominates this herbaceous grassland with 25-70% cover. The rest of the herbaceous layer varies by elevation and may take on components of adjacent communities. The most commonly encountered species are *Dasiphora fruticosa ssp. floribunda (= Dasiphora floribunda), Campanula rotundifolia, Elymus trachycaulus, Pseudocymopterus montanus, Sedum lanceolatum*, and *Taraxacum officinale*. *Carex elynoides* may have 10% cover at higher elevations. *Vaccinium myrtillus* may have 20% cover beneath the grasses. Possible trace species include *Antennaria rosea, Phleum alpinum, Agoseris aurantiaca, Allium geyeri, Androsace septentrionalis, Antennaria umbrinella, Carex siccata (= Carex foenea var. foenea), Frasera speciosa*, and *Penstemon whippleanus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Festuca thurberi*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Campanula rotundifolia*, *Dasiphora fruticosa* ssp. *floribunda*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments: This association is closely related to *Dasiphora floribunda - Festuca thurberi* Subalpine Shrubland (Park Special 12), which has enough *Dasiphora fruticosa ssp. floribunda* to constitute a dwarf-shrub stratum.
Global Similar Associations:

- *Festuca thurberi* - (*Lathyrus lanszwertii var. leucanthus, Potentilla* spp.) Herbaceous Vegetation (CEGL001630)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from subalpine and alpine meadows throughout the project area. Drainages include North Zapata Creek, Big South Canyon (Medano Creek), Little Medano Creek, Cleveland Gulch, Sand Creek, Deadman Creek, Cottonwood Creek and San Isabel Creek.
Global Range: This association occurs in the subalpine areas of Colorado and New Mexico.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3283, 2004, 2142, 2020, 3046, 3212, 5037, 926, 3044, 2078, 2398.
Local Description Authors: K. Forrest

Geum rossii - Polygonum bistortoides Herbaceous Vegetation

Ross' Avens - American Bistort Herbaceous Vegetation
Identifier: CEGL001967

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on high, northeast-facing, steep colluvial slopes at 3700 to 3785 m elevation. Soils are somewhat to moderately well-drained silt loams or sandy loams. The association can occur in areas that are likely covered by snow in winter and receive substantial run-off. In addition, it can occur in wet alpine meadows. Ground cover is variable with nonvegetative cover including litter and duff (0-30%), bare soil (5-71%), gravel (3-5%), rock (5-25%), and bedrock (3-4%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association has a dominant forb layer with cover ranging from 30-60%. *Geum rossii var. turbinatum* is the dominant forb with 20% cover. Other commonly occurring forbs include *Mertensia lanceolata, Senecio amplectens var. holmii, Polygonum bistortoides*. Graminoid cover ranges from 20-30%. *Poa fendleriana* and *Carex microptera* are the dominant graminoids with 20% cover each.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Geum rossii* var. *turbinatum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex microptera*, *Poa fendleriana*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Carex rupestris - Geum rossii* Herbaceous Vegetation (CEGL001861)
- *Festuca brachyphylla - Geum rossii var. turbinatum* Herbaceous Vegetation (CEGL001895)
- *Geum rossii - Carex albonigra* Herbaceous Vegetation (CEGL001966)
- *Geum rossii - Minuartia obtusiloba* Herbaceous Vegetation (CEGL001965)
- *Geum rossii - Selaginella densa* Herbaceous Vegetation (CEGL001968)
- *Geum rossii - Sibbaldia procumbens* Herbaceous Vegetation (CEGL001969)
- *Geum rossii - Trifolium* spp. Herbaceous Vegetation (CEGL001970)
- *Geum rossii* Herbaceous Vegetation (CEGL001964)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near North Crestone Lake and Lower Sand Creek Lake.
Global Range: This alpine plant association occurs in the Southern Rocky Mountains in Colorado and extends north into northwestern Wyoming.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 52, 4036.
Local Description Authors: K.E. Sabo

Geum rossii - Sibbaldia procumbens Herbaceous Vegetation
Ross' Avens - Creeping Glow-wort Herbaceous Vegetation
Identifier: CEGL001969

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is found in U-shaped valleys, basins, and high colluvial slopes. It can occur in areas that experience snowpack in the winter, near lakes, and in dry meadows. The elevation ranges from 3735 to 3915 m on northeast- or southwest-facing slopes that can be variably gently rolling to steep (8-38 degrees). Soils are moderately well-drained with loam or sandy loam textures. Ground surface can be rocky, but is usually dominated by litter/duff or bare soil. Marmots were observed in all of the sampled plots.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a low-growing herbaceous layer of forbs and graminoids codominated by *Geum rossii var. turbinatum* and *Sibbaldia procumbens*. Some sites can have a small dwarf-shrub layer composed of *Salix nivalis*. The remaining herbaceous layer is comprised of a variety of species such as *Silene acaulis var. subacaulescens, Saxifraga rhomboidea, Luzula parviflora, Deschampsia caespitosa, Carex scopulorum, Carex elynoides*, and *Artemisia scopulorum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Geum rossii* var. *turbinatum*, *Sibbaldia procumbens*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Deschampsia caespitosa*, *Silene acaulis* var. *subacaulescens*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Carex rupestris* - *Geum rossii* Herbaceous Vegetation (CEGL001861)
- *Festuca brachyphylla* - *Geum rossii var. turbinatum* Herbaceous Vegetation (CEGL001895)
- *Geum rossii* - *Carex albonigra* Herbaceous Vegetation (CEGL001966)
- *Geum rossii* - *Minuartia obtusiloba* Herbaceous Vegetation (CEGL001965)
- *Geum rossii* - *Polygonum bistortoides* Herbaceous Vegetation (CEGL001967)
- *Geum rossii* - *Trifolium* spp. Herbaceous Vegetation (CEGL001970)
- *Geum rossii* Herbaceous Vegetation (CEGL001964)
- *Sibbaldia procumbens* - *Polygonum bistortoides* Herbaceous Vegetation (CEGL001933)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: The northern occurrence of this association is found near Venable Pass, Cottonwood Lake, Cottonwood drainage, Mount Seven, and then as far south at North Fork Creek drainage.
Global Range: This vegetation association is found near alpine snowbanks of the Front Range of Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2044, 4054, 2278, 4213.
Local Description Authors: K.E. Sabo

Geum rossii Herbaceous Vegetation

Ross' Avens Herbaceous Vegetation
Ross' Avens Dry Alpine Meadow
Identifier: CEGL001964

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in cirque and valley floors, high colluvial slopes, and along ridgelines. The elevation ranges from 3700 to 3835 m on predominantly northwest-facing slopes. Slopes are generally steep and very rocky. Soils are well-drained and sandy loam or silt loam in texture. Ground surface cover can be variable with bare soil (0-20%), litter and duff (10-77%), gravel (0-15%), rock (2-20%), bedrock (0-15%), and mosses (0-40%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The herbaceous layer dominates this association with *Geum rossii var. turbinatum* ranging in cover from 20 to 50%. *Artemisia scopulorum* is also found within the majority of sites surveyed with up to 10% cover. Carices are present within all of the sampled sites (up to 20%) with a wide variety of species including *Carex heteroneura, Carex haydeniana, Carex elynoides, Carex microptera, Carex siccata (= Carex foenea var. foenea)*, and *Carex albonigra*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Geum rossii* var. *turbinatum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Artemisia scopulorum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Geum rossii - Minuartia obtusiloba* Herbaceous Vegetation (CEGL001965)
- *Geum rossii - Polygonum bistortoides* Herbaceous Vegetation (CEGL001967)
- *Geum rossii - Sibbaldia procumbens* Herbaceous Vegetation (CEGL001969)
- *Geum rossii - Trifolium* spp. Herbaceous Vegetation (CEGL001970)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: The northern range of this association as surveyed is located near Eureka Mountain. It then extends south to Willow Creek Lakes, Carbonate Mountain, and the southernmost site near South Zapata Lakes.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5214, 43, 5217, 4060, 3241.
Local Description Authors: K.E. Sabo

Hesperostipa comata - Achnatherum hymenoides Herbaceous Vegetation

Needle-and-Thread - Indian Ricegrass Herbaceous Vegetation
Needle-and-Thread - Indian Ricegrass Mixedgrass Prairie
Identifier: CEGL001703

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This grassland association occurs on dunefields, stream terraces, toeslopes, sandsheets, alluvial fans, stabilized dunes, and valley floors ranging in elevation from 2340 to 2750 m. Slopes are flat to gently sloping and may be oriented in any aspect. Soils tend to be well-drained or rapidly drained sand or sandy loam, and may be derived from eolian sources. Bare soil is the dominant ground cover ranging from 30-95%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: These open grasslands are dominated by *Hesperostipa comata* (10-40% cover), with lesser amounts of other graminoid species including *Achnatherum hymenoides, Bouteloua gracilis, Koeleria macrantha, Pascopyrum smithii, Sporobolus cryptandrus*, and others. Forbs may contribute up to 20% cover, and common species include *Artemisia dracunculus, Artemisia frigida, Cryptantha fendleri, Heterotheca villosa, Machaeranthera* spp., *Opuntia polyacantha, Psoralidium lanceolatum*, and *Senecio spartioides*. Sparse (<15%) short- or dwarf-shrub layers are present in some stands and include *Artemisia frigida, Chrysothamnus* spp., *Ericameria nauseosa, Symphoricarpos* spp., and *Tetradymia canescens*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Hesperostipa comata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Achnatherum hymenoides*, *Bouteloua gracilis*, *Psoralidium lanceolatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Artemisia frigida - (Bouteloua gracilis, Achnatherum hymenoides, Poa secunda)* - Lichens Rocky Mesa Dwarf-shrubland (CEGL002344)
- *Hesperostipa comata* Great Basin Herbaceous Vegetation (CEGL001705)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Sand Creek drainage, between Alpine and Pole creeks, Little Medano Creek, Medano Creek, Horse Canyon, Buck Creek, near Morris Gulch and park entrance station, and near North and South Arrastre Creek drainages.
Global Range: This type has been described from western Colorado, northeastern Utah and the Great Divide Basin of south-central Wyoming. Other basins in south-central and southwestern Wyoming are similar in climate and geology, and this association may well extend over a wide area of the two states.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 361, 87, 3109, 3069, 4045, 4019, 3206, 290, 237, 406.
Local Description Authors: K.E. Sabo and K. Decker

Hippuris vulgaris Herbaceous Vegetation
Common Mare's-tail Herbaceous Vegetation
Identifier: CEGL003315

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in flat valleys at 2300 m elevation. Associated landforms include valley floors, ponds/marshes, and lakes. These sites are generally permanently flooded with very poorly drained muck or silty clay loam soils. Ground cover of the sampled areas is variable with one stand having 100% cover standing water and the other only 10% cover. Bare soil can range from 0-85% cover; one sampled site is a recently dried pond bottom. There is significant evidence of elk use.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation cover ranges from 75-95% with 0-25% graminoid cover and 55-95% forb cover, which can be nearly all *Hippuris vulgaris*. Other forb species include *Polygonum amphibium* and *Ranunculus aquatilis*. *Eleocharis palustris* is the only graminoid found within this association. There can also be islands of *Schoenoplectus acutus* along the margins of ponds.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Submerged aquatic	Aquatic herb (floating & submergent)	*Hippuris vulgaris*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Eleocharis palustris*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Head Lake.
Global Range: This association occurs from California to Alaska and eastward.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5066, 3049, 3280.
Local Description Authors: K.E. Sabo

Hordeum jubatum Herbaceous Vegetation

Foxtail Barley Herbaceous Vegetation
Foxtail Barley Meadow
Identifier: CEGL001798

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot on a sandsheet at 2300 m elevation. The sampled stand is seasonally flooded with well-drained clay soil.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This grassland association is dominated by graminoids (65-75% cover) with *Hordeum jubatum* accounting for 50% of the total cover. Other common graminoid species with 10% cover each include *Eleocharis palustris, Juncus balticus*, and *Carex praegracilis*. Total forb cover is <10% and includes *Pyrrocoma lanceolata, Astragalus agrestis, Polygonum aviculare*, and *Ranunculus cymbalaria*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Hordeum jubatum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex praegracilis*, *Eleocharis palustris*, *Juncus balticus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Distichlis spicata - (Hordeum jubatum, Poa arida, Sporobolus airoides)* Herbaceous Vegetation (CEGL002042)
- *Distichlis spicata - Hordeum jubatum - (Poa arida, Iva annua)* Herbaceous Vegetation (CEGL002031)
- *Distichlis spicata - Hordeum jubatum - Puccinellia nuttalliana - Plantago maritima* Herbaceous Vegetation (CEGL002551)
- *Distichlis spicata - Hordeum jubatum - Puccinellia nuttalliana - Suaeda calceoliformis* Herbaceous Vegetation (CEGL002273)
- *Pascopyrum smithii - Hordeum jubatum* Herbaceous Vegetation (CEGL001582)
- *Schoenoplectus robustus - Juncus gerardii - Hordeum jubatum - Atriplex patula* Herbaceous Vegetation (CEGL006234)
- *Sporobolus airoides* Northern Plains Herbaceous Vegetation (CEGL002274)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Antelope Springs.

Global Range: This foxtail barley community type is found in the northern and central Great Plains of the United States and Canada, ranging from Colorado to Saskatchewan and in Alberta occurs north into the Boreal Plains. It is also described from Utah and may occur elsewhere in the interior West.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3071.
Local Description Authors: K.E. Sabo and K. Decker

Juncus balticus Herbaceous Vegetation

Baltic Rush Herbaceous Vegetation
Baltic Rush Wet Meadow
Identifier: CEGL001838

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in dunefields, playas, sandsheets, valley floors, and floodplains with elevations ranging from 2295 to 2375 m. Sites are located in upland, palustrine or wetland systems and are intermittently or seasonally flooded. Soils are variable, ranging from well-drained to poorly drained, but in general are moderately well-drained. Soil texture is predominantly sandy loam, but can be loam, sand, silt, loamy sand, or sandy clay.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Stands of this graminoid-dominated association are open to densely vegetated with 20-90% total cover. *Juncus balticus* is dominant with 10-70% cover. Other graminoid species that may contribute significantly to total cover include *Calamagrostis stricta, Distichlis spicata, Hordeum jubatum, Muhlenbergia asperifolia*, and *Sporobolus airoides*. *Poa pratensis* may have up to 20% cover in disturbed stands. Forb cover is typically <10%; the most common species include *Argentina anserina, Crepis runcinata, Cryptantha fendleri*, and *Iris missouriensis*. Common introduced species include *Cirsium arvense, Descurainia* spp., *Mentha arvensis, Plantago major*, and *Salsola tragus*. Scattered shrubs of *Sarcobatus vermiculatus* may also be present, and *Ericameria nauseosa* may contribute up to 10% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Juncus balticus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Eleocharis palustris - Juncus balticus* Herbaceous Vegetation (CEGL001835)

- *Juncus balticus - (Juncus mexicanus)* Herbaceous Vegetation (CEGL003486)
- *Juncus balticus - Carex rossii* Herbaceous Vegetation (CEGL001839)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near North Crestone ditch, Spanish Creek drainage and Baca Ranch, Sand Creek drainage, Big Spring Creek and Head Lake, near Cotton Lake, and Little Spring Creek.
Global Range: This Baltic rush wet meadow community is found widely throughout the western United States, ranging from South Dakota and Nebraska west to Washington, south to California, and east to New Mexico. It also occurs in western Canada.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4009, 3268, 21, 3253, 3002, 3267, 3018, 1009, 2231, 5064, 3003.
Local Description Authors: K.E. Sabo and K. Decker

Kobresia myosuroides - Geum rossii Herbaceous Vegetation
Pacific Bog Sedge - Ross' Avens Herbaceous Vegetation
Identifier: CEGL001908

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on high rocky ridges, moraines, valley floors, and colluvial slopes between 3660 and 3765 m elevation. Slope can range from 2-28 degrees, and aspect is southeast, southwest, and northwest. Surficial geology can be granite, Crestone conglomerate or colluvial conglomerate. Soils are well-drained loamy sand, silt loam, or loam. Litter/duff is the predominant ground cover ranging from 0-70%, but bare soil can account for up to 50% of total cover. Other components of nonvegetative ground cover include rock (0-15%) and lichens (0-15%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: These are moderately dense, dry-mesic, graminoid-dominated (40-60% cover) alpine turfs. *Kobresia myosuroides* (30-50%) is the dominant graminoid; other common graminoids include *Calamagrostis purpurascens, Carex elynoides, Carex rupestris var. drummondiana, Danthonia* spp., *Festuca brachyphylla, Luzula spicata, Poa glauca ssp. rupicola*, and *Trisetum spicatum*. *Geum rossii var. turbinatum* is present on most surveyed sites (10-20%), along with other typical alpine forb species such as *Artemisia scopulorum, Minuartia obtusiloba, Polygonum bistortoides, Silene acaulis var. subacaulescens*, and *Trifolium dasyphyllum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Kobresia myosuroides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex rupestris* var. *drummondiana*, *Geum rossii* var. *turbinatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Kobresia myosuroides - Carex rupestris var. drummondiana* Herbaceous Vegetation (CEGL001907)
- *Kobresia myosuroides - Euphrasia disjuncta* Herbaceous Vegetation (CEGL005872)
- *Kobresia myosuroides - Thalictrum alpinum* Herbaceous Vegetation (CEGL002900)
- *Kobresia myosuroides - Trifolium dasyphyllum* Herbaceous Vegetation (CEGL001909)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is located near Willow Creek Lakes at the northern edge of the sampling area, at Little Sand Creek Lakes, near Medano Lake, Smith Creek drainage, and near Slide Rock Canyon.
Global Range: This association is a major upland alpine turf community of the southern Rocky Mountains and extends north into the Uinta Mountains from northern New Mexico to northeastern Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3037, 3260, 756, 5216, 3265.
Local Description Authors: K.E. Sabo and K. Decker

Minuartia obtusiloba Herbaceous Vegetation

Alpine Stitchwort Herbaceous Vegetation
Alpine Fell-field
Identifier: CEGL001919

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association can occur on mid- to high-slope ridges, drainage channels, colluvial slopes, interfluves, and saddles. Elevation ranges from 3475 to 3875 m with southeast-, southwest-, and west-facing slopes that can range from 0-30 degrees. Sites are generally rocky with rock (0-40%) and gravel (3-60%). Soils are well-drained sandy loams or somewhat poorly drained loams. In general, the presence of deer, sheep, and pika grazing was observed.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The total herbaceous layer cover ranges from 10-60%, with 10-20% graminoid cover and 10-60% forb cover. Dominant graminoid *Carex elynoides* has up to 20% cover. Other common graminoids at low cover include *Festuca brachyphylla* and *Trisetum spicatum*. Dominant forbs at low cover include *Minuartia obtusiloba, Silene acaulis var. subacaulescens, Geum rossii var. turbinatum*, and *Trifolium dasyphyllum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Minuartia obtusiloba*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex elynoides*, *Silene acaulis* var. *subacaulescens*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the North Fork drainage, North Crestone Lake drainage, between Spanish and Cottonwood creeks, Music Pass, near Little Sand Creek Lakes, and Medano Creek drainage.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4227, 463, 3053, 4037, 2096, 5008.
Local Description Authors: K.E. Sabo

Muhlenbergia asperifolia Herbaceous Vegetation
Alkali Muhly Herbaceous Vegetation
Identifier: CEGL001779

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This wetland association is documented from a wide range of landforms including swales, sabkhas, dunefields, valley floors, and floodplains. Stands occur on flat terrain, and elevations range from 2295 to 2420 m. Surveyed sites are seasonally or intermittently flooded. Soils range from very poorly drained to moderately well-drained, and soil textures include loamy sand, silt loam, sandy clay, and silty clay loam.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This grassland of sandy areas is generally densely vegetated, but may have significantly reduced cover in areas with heavy bison use. *Muhlenbergia asperifolia* is dominant with 30-70% cover. Other *Muhlenbergia* species may also be present but not dominant. Typical graminoid species include *Hordeum jubatum, Juncus balticus, Leymus triticoides, Pascopyrum smithii*, and *Schoenoplectus* spp. Forb cover is generally <10%, except in disturbed areas. Common species include *Argentina anserina, Chenopodium* spp., *Cirsium arvense, Equisetum arvense*, and *Cleome* spp.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Muhlenbergia asperifolia*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juncus balticus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the San Luis Creek drainage, Sand Creek, Arena Creek, Cotton Lake, Big Spring Creek drainage, and near San Luis Lake.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3006, 5001, 5029, 96, 2021, 5233, 3082, 5249.
Local Description Authors: K.E. Sabo and K. Decker

Muhlenbergia montana Herbaceous Vegetation
Mountain Muhly Herbaceous Vegetation
Identifier: CEGL001646

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is not well-documented on the park. It is known from two observation points: one on steep (32-degree), southwest-facing colluvial slopes at 3131 m elevation, and the other on a valley floor at 2900 m. Surficial geology is granite with well- to moderately drained soils of either silt loam or sandy loam soil textures. Litter and duff cover is similar, ranging between 50 and 60% cover of total ground surface. In addition, basal area is similar for these two locations, ranging from 10-15%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Graminoid vegetation dominates this association, ranging in cover from 30-60%. *Muhlenbergia montana* is the dominant graminoid, but a combination of graminoid species such as *Bouteloua gracilis* and *Juncus balticus* are present. This association is variable in vegetation composition due to environmental factors such as slope and location. *Holodiscus dumosus, Symphoricarpos rotundifolius*, and *Ericameria nauseosa*, and other short and dwarf-shrubs may be present.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Muhlenbergia montana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Bouteloua gracilis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Festuca arizonica - Muhlenbergia montana* Herbaceous Vegetation (CEGL001606)
- *Muhlenbergia montana - Hesperostipa comata* Herbaceous Vegetation (CEGL001647)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range:
Global Range: This plant association has been described from meadows in the mountains, plateaus and foothills of Colorado, Arizona, Utah, and north-central New Mexico.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3215, 4248.
Local Description Authors: K.E. Sabo and K. Decker

Muhlenbergia pungens Herbaceous Vegetation

Sandhill Muhly Herbaceous Vegetation
Identifier: CEGL002363

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one surveyed stand on a sandsheet at 2443 m elevation. The site has well-drained sandy soils. The surveyed stand is located in a low spot between old stabilized dunes.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous cover is low, ranging from 15-25%. Graminoid cover is dominant; *Muhlenbergia pungens* and *Achnatherum hymenoides*, both of which have 10% cover, codominate. Other species occurring within the surveyed stand in trace amounts include many forb species such as *Psoralidium lanceolatum*, *Machaeranthera canescens*, and *Senecio spartioides*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Achnatherum hymenoides*, *Muhlenbergia pungens*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Pinus edulis - Juniperus osteosperma / Muhlenbergia pungens* Woodland (CEGL002373)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Denton Spring.
Global Range: This association has been documented from southern Utah and northwestern Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5084.
Local Description Authors: K.E. Sabo

Myriophyllum sibiricum Herbaceous Vegetation

Siberian Water-milfoil Herbaceous Vegetation
Identifier: CEGL002000

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from a single pond located at 2296 m elevation. The site is permanently flooded with very poorly drained muck soils. Ground cover is dominated by 99% standing water.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association has 100% cover of *Myriophyllum sibiricum* with trace amounts of *Lemna minuta*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Submerged aquatic	Aquatic herb (floating & submergent)	*Myriophyllum sibiricum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Lemna minuta*, *Myriophyllum sibiricum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Stuckenia pectinata - Myriophyllum (sibiricum, spicatum)* Herbaceous Vegetation (CEGL002003)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in a pond near Dry Lakes.
Global Range: This association has been described from Colorado mountain lakes and ponds, and from the Rocky Mountain Front in Alberta. It is likely to be more widespread than reported.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3031.
Local Description Authors: K.E. Sabo

Pascopyrum smithii Herbaceous Vegetation
Western Wheatgrass Herbaceous Vegetation
Western Wheatgrass Mixedgrass Prairie
Identifier: CEGL001577

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association was sampled on valley floors at 2295 and 2340 m elevation. Stands can be intermittently flooded with moderately well-drained sandy loam soils. Ground cover is dominated by bare soil. Both surveyed stands have experienced heavy grazing pressure from bison and elk.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a moderately dense (30-40% cover) herbaceous layer dominated by *Pascopyrum smithii*. Scattered individuals of *Sarcobatus vermiculatus* or *Ericameria nauseosa* may be present. Other common graminoid species include *Juncus balticus, Bouteloua gracilis, Muhlenbergia asperifolia, Salsola tragus*, and *Sporobolus airoides*. Forbs are scarce and typically weedy.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Pascopyrum smithii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Pascopyrum smithii*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Pascopyrum smithii - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation (CEGL001579)--northern Great Plains.
- *Pascopyrum smithii - Bouteloua gracilis* Herbaceous Vegetation (CEGL001578)--association of the southern Great Plains and Chihuahuan Desert.
- *Pascopyrum smithii - Distichlis spicata* Herbaceous Vegetation (CEGL001580)--northern Great Plains.
- *Pascopyrum smithii - Eleocharis* spp. Herbaceous Vegetation (CEGL001581)--northern Great Plains.
- *Pascopyrum smithii - Hordeum jubatum* Herbaceous Vegetation (CEGL001582)--northern Great Plains.
- *Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation (CEGL001583)--northern Great Plains.

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Deadman Creek drainage and near Head Lake.

Global Range: This midgrass prairie type is found in the northern and western Great Plains, Rocky Mountains, intermountain western United States and Canada, ranging from North Dakota and Saskatchewan, south to Nebraska and Colorado, and west to northern Arizona, Utah and Idaho.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4133, 5073.
Local Description Authors: K.E. Sabo and K. Decker

Phragmites australis Western North America Temperate Semi-natural Herbaceous Vegetation

Common Reed Western North America Temperate Semi-natural Herbaceous Vegetation
Western Reed Marsh
Identifier: CEGL001475

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one location found on a sandsheet at 2325 m elevation. This stand is intermittently flooded with well-drained sand soils. Ground cover is dominated by litter and duff (85%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Vegetation is dominated by graminoids *Phragmites australis* and *Spartina gracilis* with a scattering of shrubs which include *Sarcobatus vermiculatus*. Graminoid cover ranges from 55-65%.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Phragmites australis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Phragmites australis*, *Spartina gracilis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Phragmites australis* Eastern North America Temperate Semi-natural Herbaceous Vegetation (CEGL004141)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Big Spring Creek.
Global Range: This reed marsh type is found across the temperate regions of the western United States and Canada, ranging from western North Dakota and Saskatchewan to Oregon, south to California and Texas. Its distribution is somewhat incomplete as not all states have listed semi-natural types in their state.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA:3225
Local Description Authors: K.E. Sabo

Polygonum amphibium Permanently Flooded Herbaceous Vegetation [Placeholder]

Water Smartweed Permanently Flooded Herbaceous Vegetation
Water Smartweed Wetland
Identifier: CEGL002002

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This palustrine association is known from one occurrence located in a sabkha at 2298 m elevation. The site is permanently flooded with very poorly drained muck soils. Ground cover is dominated by standing water (75%) and bare soil (15%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is comprised of *Polygonum amphibium* (60%) and *Potamogeton foliosus* (30%). The majority of vegetation is submerged under several centimeters of water. Other species that are present at low cover values include *Eleocharis palustris, Schoenoplectus pungens, Argentina anserina*, and *Alisma gramineum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Submerged aquatic	Aquatic herb (floating & submergent)	*Polygonum amphibium*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Polygonum amphibium*, *Potamogeton foliosus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Nonstandard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- Lake Mudflats Sparse Vegetation (CEGL002313)
- *Polygonum amphibium - (Polygonum hydropiperoides)* Seasonally Flooded Herbaceous Vegetation (CEGL004699)
- River Mudflats Sparse Vegetation (CEGL002314)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near San Luis Lake.
Global Range: This association is found primarily in the western United States and Canada but may extend further east.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3072.
Local Description Authors: K.E. Sabo

Potamogeton foliosus Herbaceous Vegetation
Leafy Pondweed Herbaceous Vegetation
Montane Floating/Submergent Palustrine Wetland
Identifier: CEGL002742

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one location in a flat valley floor at 2300 m elevation. The site is permanently flooded with very poorly drained muck soils. Ground surface cover is 99% standing water. There is evidence that ungulates use this area as a water source.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation cover ranges from 65-75%, with the large majority of the cover dominated by *Potamogeton foliosus* with trace amounts of *Alisma gramineum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Submerged aquatic	Aquatic herb (floating & submergent)	*Potamogeton foliosus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Alisma gramineum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near San Luis Lake.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3048.
Local Description Authors: K.E. Sabo

Puccinellia nuttalliana Herbaceous Vegetation
Nuttall's Alkali Grass Herbaceous Vegetation
Identifier: CEGL001799

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from one plot and two observation points on sabkhas and sandsheets at 2295 to 2325 m elevation. Stands are intermittently flooded with somewhat poorly drained or well-drained sandy clay loam, silty clay, or silt loam soils. In general, bare soil dominates the ground surface with up to 80% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Stands are generally sparsely vegetated and dominated by *Puccinellia nuttalliana*, which occurs with *Leymus triticoides* and *Distichlis spicata*. Surveyed stands also include patches of *Juncus balticus, Iris missouriensis*, and *Cleome multicaulis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Distichlis spicata*, *Leymus triticoides*, *Puccinellia nuttalliana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Cleome multicaulis* (G2G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Little Spring Creek drainage and near Dry Lakes.
Global Range: This association occurs on moist soils of intermediate salinity in seasonally wet meadow habitats of South Park, Colorado (Ungar 1974c). It is a minor type in southeastern Alberta, found in saline or alkali basins, swales pond and lake margins and seep areas (Thompson and Hansen 2002), but also occurs in a broad band of solonetizic soils to central Alberta and possibly into the Boreal Plains in disjunct areas of solonetizic soils. Possible stands of this association have been noted by researchers in the eastern (Nebraska) and northern plains regions to Saskatchewan and through the Intermountain West region to Utah and California (Ungar 1974c). Thompson and Hansen (2002) have documented stands in Montana, Saskatchewan, and Alberta.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4216, 777, 3033.
Local Description Authors: K.E. Sabo and K. Decker

Ranunculus aquatilis - Callitriche palustris Herbaceous Vegetation
Whitewater Crowfoot - Vernal Water Starwort Herbaceous Vegetation
Identifier: CEGL001984

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is located within basin floor lakes, ponds, and depressions. Sampled areas are flat and elevation ranges from 2300 to 2365 m. Sites are usually permanently flooded. Soils are very poorly drained muck with nearly 100% cover by standing water. There is significant evidence of bison use due to grazed vegetation and tracks.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation cover ranges from 1-9% with the variability occurring in the forb cover. *Ranunculus trichophyllus* is the dominant forb with 1-10% cover along with trace cover of *Callitriche palustris*. *Eleocharis palustris* is common (3%) in most of the sampled plots.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Ranunculus trichophyllus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Eleocharis palustris*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Cotton Lake.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 112, 3008, 4001.
Local Description Authors: K.E. Sabo

Redfieldia flexuosa - (Psoralidium lanceolatum) Herbaceous Vegetation
Blowout Grass - (Lemon Scurfpea) Herbaceous Vegetation
Identifier: CEGL002917

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in dunefields, sand ramps, sandsheets, and parabolic dunes. Dunes are generally sparsely vegetated areas within the surrounding shrub-dominated communities. Elevation ranges from 2325 to 2775

m. Slope is variable, ranging from flat terrain to moderately steep. Bare soil is the dominant ground cover with over 90% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This is a very sparsely vegetated (<20% total cover) active dune community characterized by a suite of a few species that are adapted to the constantly shifting substrate. *Redfieldia flexuosa, Psoralidium lanceolatum*, and *Helianthus annuus* are the most characteristic species, although small amounts of species from neighboring shrub communities may also be present.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Redfieldia flexuosa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Psoralidium lanceolatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Achnatherum hymenoides - Psoralidium lanceolatum* Herbaceous Vegetation (CEGL001650)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Big Spring Creek, Sand Creek, and Little Medano Creek drainages.
Global Range: This plant association occurs on active sand dunes in the shortgrass prairie and San Luis Valley in Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 509, 5116, 3118, 3120, 518, 3065, 4008, 86, 70, 301, 3115, 3021.
Local Description Authors: K.E. Sabo and K. Decker

Rhus trilobata Rocky Mountain Shrub Herbaceous Vegetation
Skunkbush Sumac Rocky Mountain Shrub Herbaceous Vegetation
Identifier: CEGL002910

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This lower montane shrubland occurs in small patches on moderately steep (23-degree) colluvial slopes and dunefields at 2520 and 2880 m elevation. Soils are well-drained sands with the majority of ground cover being dominated by sand or bare soil.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The vegetation is characterized by a moderately dense short-shrub layer that ranges in cover from 25-45%. *Rhus trilobata* is the dominant short shrub with 30-40% cover. Other short-shrub species include *Symphoricarpos oreophilus* and *Cercocarpus montanus*. The herbaceous layer is sparse, ranging in cover from 15-25%. Graminoid species make up the majority of the herbaceous layer and include *Sporobolus cryptandrus, Hesperostipa comata*, and *Bouteloua gracilis*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Rhus trilobata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Sporobolus cryptandrus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Rhus trilobata - Prunus serotina* Shrubland (CEGL001119)
- *Rhus trilobata / Calamovilfa longifolia* Shrub Herbaceous Vegetation (CEGL001457)
- *Rhus trilobata / Carex filifolia* Shrub Herbaceous Vegetation (CEGL001504)
- *Rhus trilobata / Festuca idahoensis* Shrub Herbaceous Vegetation (CEGL001505)
- *Rhus trilobata / Pseudoroegneria spicata* Shrub Herbaceous Vegetation (CEGL001120)
- *Rhus trilobata / Schizachyrium scoparium* Shrub Herbaceous Vegetation (CEGL001506)
- *Rhus trilobata* Intermittently Flooded Shrubland (CEGL001121)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs along the Cold Creek drainage.
Global Range: This association is known from one stand in the montane zone in the southern Rocky Mountains from Rocky Mountain National Park and the Gunnison National Forest in Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3084, 3094.
Local Description Authors: K.E. Sabo

Salicornia rubra Herbaceous Vegetation
Red Saltwort Herbaceous Vegetation
Identifier: CEGL001999

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This herbaceous wetland association is known from one location and occurs in a sabkha or playa at 2295 m elevation. The site is semipermanently flooded with very poorly drained silt soil. The ground surface is dominated by a well-formed salt crust (95% cover).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Total herbaceous cover is sparse (5-15%). There were only three species documented for this association, and the dominant species is *Salicornia rubra* with 10% cover. The other two species present are *Sarcobatus vermiculatus* and *Distichlis spicata*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Salicornia rubra*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- Saline Spring Mudflats Sparse Vegetation (CEGL002581)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Dry Lakes.
Global Range: This community is associated with highly alkaline wetlands or lakes in the northern Great Plains and Great Basin of the United States and adjacent Canada, north into Boreal Plains, ranging from western Minnesota to Saskatchewan and Alberta, south to Colorado and possibly Nevada and California.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3036.
Local Description Authors: K.E. Sabo

Schoenoplectus acutus Herbaceous Vegetation
Hardstem Bulrush Herbaceous Vegetation
Bulrush Marsh
Identifier: CEGL001840

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in flat basin floor playas and sabkhas at 2300 m elevation. These palustrine systems are either permanently, seasonally, or semipermanently flooded. Soils are generally very poorly drained muck or silty clay loam. Ground cover can be variable and dominated either by standing water (90-100%) or bare soil (80%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This herbaceous vegetation association is dominated by *Schoenoplectus acutus* with 10-40% cover. *Eleocharis palustris* can be present with 10% cover but is not common in all plots. Vegetation can be heavily grazed by bison.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Schoenoplectus acutus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Schoenoplectus acutus - (Schoenoplectus fluviatilis)* Freshwater Herbaceous Vegetation (CEGL002225)
- *Schoenoplectus acutus - Typha latifolia - (Schoenoplectus tabernaemontani)* Sandhills Herbaceous Vegetation (CEGL002030)
- *Schoenoplectus tabernaemontani* Temperate Herbaceous Vegetation (CEGL002623)
- *Typha* spp. - *Schoenoplectus acutus* - Mixed Herbs Midwest Herbaceous Vegetation (CEGL002229)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Cotton Lake and Dry Lakes.
Global Range: This association is a common emergent wetland found mostly in the interior western U.S. from Washington to Montana south to California, Nevada and Utah.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3007, 48, 3252.
Local Description Authors: K.E. Sabo

Schoenoplectus americanus - Carex spp. Herbaceous Vegetation
Chairmaker's Bulrush - Sedge species Herbaceous Vegetation
Identifier: CEGL004144

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is located in swales and floodplains of basins surrounded by sand dunes at 2335 m elevation. Surveyed sites are most often semipermanently to temporarily flooded. Soils are poorly drained sandy loams or very poorly drained muck. Ground cover is dominated by either litter and duff (68%) or bare soil (75%). The surveyed areas experience heavy use by bison, elk, and deer.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is dominated by *Schoenoplectus americanus* with 20-40% cover. *Iris missouriensis* can be a codominant, but does not occur in every surveyed stand. Additionally, *Carex praegracilis* can occur at high cover levels, but does not have a consistent dominant presence. Other commonly occurring species that can have variable percent covers, ranging from 10-20%, include *Carex utriculata, Argentina anserina*, and *Hordeum jubatum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Schoenoplectus americanus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex praegracilis*, *Carex utriculata*, *Iris missouriensis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Big Spring Creek drainage.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA:3081, 4271.
Local Description Authors: K.E. Sabo

Schoenoplectus americanus - Eleocharis palustris Herbaceous Vegetation
Chairmaker's Bulrush - Common Spikerush Herbaceous Vegetation
Identifier: CEGL001585

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in basin floors, swales, sabkhas, and ponds at 2300 to 2340 m elevation. Areas are semipermanently or seasonally flooded. Soils include somewhat poorly drained sandy loam, poorly drained sandy clay loam, or very poorly drained muck. Litter and duff are the dominant ground cover. All of the surveyed stands experience extensive grazing by bison, elk, and deer.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The herbaceous layer is dominated by *Schoenoplectus americanus* (40-50% cover). *Eleocharis palustris* can be considered a codominant with cover ranging from 30-50%. There are additional species (3-20% cover) that can occur within this association, but not at every surveyed site; they may include *Juncus balticus, Argentina anserina, Polygonum amphibium, Hordeum brachyantherum*, and *Carex simulata*. In general, this association can be found surrounded by *Sarcobatus* spp. shrublands.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Schoenoplectus americanus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Eleocharis palustris*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Big Spring Creek and Little Spring Creek drainages and near San Luis Lake.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4018, 4266, 4264, 5065.
Local Description Authors: K.E. Sabo

Schoenoplectus americanus Western Herbaceous Vegetation

Chairmaker's Bulrush Western Herbaceous Vegetation
Identifier: CEGL001841

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is found within basin floor sabkhas, swales, or dunefields at elevations ranging from 2300 to 2340 m. This palustrine system can be seasonally flooded, temporarily flooded, or saturated. Soils are very poorly drained clays or very poorly to poorly drained loamy sands. Ground cover includes litter and duff (30-35%) and bare soil (10-40%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation cover ranges from 55-95%, which is largely comprised of *Schoenoplectus americanus* with 20-70% cover. Additional species that occur in lesser amounts include *Cleome multicaulis, Distichlis spicata*, and *Juncus balticus*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Schoenoplectus americanus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Cleome multicaulis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Cleome multicaulis* (G2G3)

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Schoenoplectus pungens* Herbaceous Vegetation (CEGL001587)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Little Spring Creek drainage and near San Luis Lake.
Global Range: The association is a minor type in the Great Basin and southern Rocky Mountains.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5075, 3066, 3202.
Local Description Authors: K.E. Sabo

Schoenoplectus maritimus Herbaceous Vegetation
Saltmarsh Clubrush Herbaceous Vegetation
Alkali Bulrush Marsh
Identifier: CEGL001843

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This wetland association is known from one occurrence in a basin floor at 2296 m elevation. The surveyed area is permanently flooded with 98% cover of standing water. The soil is very poorly drained muck.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is dominated by *Schoenoplectus maritimus* with 30% cover. Additional species that occur with trace amounts of cover include *Schoenoplectus acutus, Typha* spp., and *Ranunculus* spp. Vegetation tends to grow in patches throughout the wetland with some open water. *Potamogeton perfoliatus* occurs submerged in water with about 85% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Schoenoplectus maritimus*
Submerged aquatic	Aquatic herb (floating & submergent)	*Potamogeton perfoliatus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 1 - Strong
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs on the southernmost edge of the sampling area near Dry Lakes.

Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 3034.

Local Description Authors: K.E. Sabo

Sibbaldia procumbens - Polygonum bistortoides Herbaceous Vegetation

Creeping Glow-wort - American Bistort Herbaceous Vegetation

Identifier: CEGL001933

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is found in glacial valleys, high swales, and colluvial slopes from 3630 to 3830 m elevation. Slopes are gentle (7-11 degrees) and face southeast, southwest, and north. Soils are intermittently flooded, poorly to moderately well-drained silt loam or sandy clay loam. Stands can be rocky, with gravel (1-10%), rock (5-15%), and bedrock (0-2%). Significant bare soil (2-75%) can also be present.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by a short herbaceous layer dominated by forbs. Total cover ranges from 50-80% with 10-40% graminoid cover and 30-50% forb cover. *Sibbaldia procumbens* is the dominant forb with 20-30% cover. Other commonly occurring forbs with low cover are *Senecio crassulus* and *Geum rossii var. turbinatum*. The graminoid layer is dominated by *Juncus drummondii* with 10-30% cover. Other typical species include *Phleum alpinum* and *Deschampsia caespitosa*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb *Sibbaldia procumbens*	
Herb (field)	Graminoid	*Juncus drummondii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Geum rossii* var. *turbinatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard

Classification Confidence: 2 - Moderate

Great Sand Dunes National Park and Preserve Comments:

Global Similar Associations:

- *Carex nigricans - Sibbaldia procumbens* Herbaceous Vegetation (CEGL005824)
- *Carex paysonis - Sibbaldia procumbens* Herbaceous Vegetation (CEGL005865)
- *Carex spectabilis - Sibbaldia procumbens* Herbaceous Vegetation (CEGL003140)
- *Geum rossii - Sibbaldia procumbens* Herbaceous Vegetation (CEGL001969)
- *Juncus parryi / Sibbaldia procumbens* Herbaceous Vegetation (CEGL005871)
- *Phyllodoce glanduliflora / Sibbaldia procumbens* Dwarf-shrubland (CEGL005877)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from the Middle Fork Crestone Creek and South Crestone Creek drainages.
Global Range: This low-growing subalpine and alpine meadow type has been described from the Wind River Mountains of west-central Wyoming and the Medicine Bow Mountains of south-central Wyoming and from the Front Range of north-central Colorado.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5221, 4039, 5219.
Local Description Authors: K.E. Sabo

Sparganium eurycarpum Herbaceous Vegetation
Giant Bur-reed Herbaceous Vegetation
Identifier: CEGL003323

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one surveyed stand occurring in a channel at 2293 m elevation. The site is seasonally flooded with somewhat poorly drained sandy clay loam soil. Litter and duff dominate the ground surface with 80% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Total herbaceous vegetation ranges from 75-85%. Signification species include *Sparganium eurycarpum* (50%), *Mentha arvensis* (30%), and *Argentina anserina* (10%). Other commonly occurring species include *Eleocharis palustris* and *Polygonum persicaria*, both with 3% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Sparganium eurycarpum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Argentina anserina*, *Mentha arvensis*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: Vulnerable: *Sparganium eurycarpum* (state-imperiled, G5)

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs along Big Spring Creek.
Global Range: This association occurs from California to British Columbia (Christy 2004).

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 5060.
Local Description Authors: K.E. Sabo

Spartina gracilis Herbaceous Vegetation
Alkali Cordgrass Herbaceous Vegetation
Identifier: CEGL001588

ENVIRONMENTAL DESCRIPTION
Great Sand Dunes National Park and Preserve Environment:

VEGETATION DESCRIPTION
Great Sand Dunes National Park and Preserve Vegetation:

MOST ABUNDANT SPECIES
Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Spartina gracilis*

CHARACTERISTIC SPECIES
Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES
Great Sand Dunes National Park and Preserve:

CLASSIFICATION
Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION
Great Sand Dunes National Park and Preserve Range: This association occurs near Dollar Lake and Head Lake.
Global Range: This association has been described from plots in northern Colorado, Utah and Oregon. It is likely to occur throughout the western U.S.

ELEMENT SOURCES
Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5072, 5289.
Local Description Authors:

Sporobolus airoides Monotype Herbaceous Vegetation
Alkali Sacaton Monotype Herbaceous Vegetation
Alkali Sacaton (Mixed Prairie)
Identifier: CEGL001688

ENVIRONMENTAL DESCRIPTION
Great Sand Dunes National Park and Preserve Environment: This upland or palustrine association generally occurs on valley floors, but it can be found on sandsheets and bolsons. Elevations range from 2300 to 2335 m. Terrain is flat and stands can be intermittently flooded. Soils are somewhat to moderately drained silt, sandy loam, or loamy sand and derived from alluvial deposits. Bare soil is the dominant ground surface cover ranging from 0-88%. Many of the surveyed stands have experienced heavy grazing by bison, cattle, and elk.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Total herbaceous vegetation ranges from 35-85% and is dominated by graminoid species. Surveyed stands can have large areas of bare soil and clumps of graminoid species, but in general tend to have a high percentage of herbaceous cover with surrounding areas and inclusions of wetland vegetation. *Sporobolus airoides* is the dominant species with cover ranging from 20-70%. Species richness is moderately high, but few species have significant cover or are found consistently across all surveyed stands. *Juncus balticus* and *Cleome serrulata* are the only two other species that occur in the majority of the stands, but have low cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Sporobolus airoides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Cleome serrulata*, *Juncus balticus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Sporobolus airoides* Southern Plains Herbaceous Vegetation (CEGL001685)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near North Crestone Ditch, Spanish Creek, Deadman Creek, near Dollar Lake, and Sand Creek.
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2275, 4047, 4049, 4130, 4010.
Local Description Authors: K.E. Sabo

Sporobolus airoides - Distichlis spicata Herbaceous Vegetation

Alkali Sacaton - Inland Saltgrass Herbaceous Vegetation
Identifier: CEGL001687

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in valley floors at 2300 to 2330 m elevation. Terrain is flat with rapidly drained sand or silt loam soils. Bare soil is the dominant nonvegetative ground cover ranging from 65-95%. In the majority of surveyed stands, there is evidence of heavy grazing by cattle.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This moderately densely vegetated grassland of the valley floor is dominated by short-statured *Distichlis spicata* (20-40% cover) and *Sporobolus airoides* (10-20%). Species diversity is generally low; additional graminoids may include *Juncus balticus, Muhlenbergia asperifolia*, and *Pascopyrum smithii*, together with a few forbs such as *Iris missouriensis* and *Pyrrocoma lanceolata*, and occasionally a few *Sarcobatus vermiculatus* shrubs.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Distichlis spicata*, *Sporobolus airoides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juncus balticus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Distichlis spicata* Herbaceous Vegetation (CEGL001770)
- *Sporobolus airoides* Southern Plains Herbaceous Vegetation (CEGL001685)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the Crestone Creek drainage and near San Luis Lake.
Global Range: This association is found in Colorado, Utah, Oregon, and the Tularosa Basin of south-central New Mexico (Otero County). It may also occur in California, Texas and adjacent Mexico.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5028, 3024, 4084.
Local Description Authors: K.E. Sabo and K. Decker

Suaeda calceoliformis Herbaceous Vegetation
Tundra Clover Herbaceous Vegetation
Identifier: CEGL005939

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs in basin floor sabkhas at 2300m elevation. Sites can be temporarily, intermittently, or seasonally flooded with bare dry cracked soils in the dry season. Soils range from poorly drained silty clay or sandy clay, to somewhat poorly drained silt, or well-drained silt loam. Bare soil is the dominant nonvegetative ground cover ranging from 70-95%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Stands are sparsely to moderately densely vegetated, with up to 60% cover, and are generally herbaceous, with occasional scattered short shrubs of *Sarcobatus vermiculatus. Suaeda calceoliformis* is the dominant species with cover ranging from 20-40%. *Distichlis spicata* was also present in all stands with up to 20% cover. Other species present include *Kochia americana, Schoenoplectus maritimus, Cleome multicaulis,* and *Chenopodium foliosum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	**Lifeform**	**Species**
Herb (field)	Graminoid	*Distichlis spicata*
Herb (field)	Forb	*Suaeda calceoliformis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex elynoides*, *Carex rupestris* var. *drummondiana*, *Paronychia pulvinata*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Paronychia pulvinata - Silene acaulis* Dwarf-shrubland (CEGL001976)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association can be found running north to south along the San Luis Creek and at Dry Lakes..
Global Range: Data not available

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4099, 2009, 3067, 2105, 5067
Local Description Authors: K.E. Sabo

Trifolium nanum Herbaceous Vegetation
Tundra Clover Herbaceous Vegetation
Identifier: CEGL005939

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This alpine fell-field association occurs on ridges at 4060 and 4075 m elevation. Terrain is flat to gently sloping with northwest-facing aspect. Soils are moderately well-drained sandy loams. Ground cover is dominated by gravel (15-25%), rock (15%), and bedrock (10-20%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is sparse with total cover ranging from 35-55%. Vegetation is characterized by dense clumps interspersed with exposed rock and bedrock. Forbs are the dominant species, with 25-35% cover, and include *Trifolium nanum, Paronychia pulvinata*, and *Minuartia obtusiloba*, all with 10% cover. Dominant graminoid species include *Carex rupestris var. drummondiana* and *Carex elynoides*, both with 10% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Minuartia obtusiloba*, *Trifolium nanum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Carex elynoides*, *Carex rupestris* var. *drummondiana*, *Paronychia pulvinata*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Paronychia pulvinata - Silene acaulis* Dwarf-shrubland (CEGL001976)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs on Venable Peak and Mount Seven.
Global Range: This fellfield cushion plant association is found in the high alpine of the southern Rocky Mountains of Colorado and may extend elsewhere in the Rocky Mountains.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4055, 3211.
Local Description Authors: K.E. Sabo

Typha (latifolia, angustifolia) Western Herbaceous Vegetation

(Broadleaf Cattail, Narrowleaf Cattail) Western Herbaceous Vegetation
Broadleaf Cattail Marsh
Identifier: CEGL002010

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one location in a lake at 2297 m elevation. The soil is very poorly drained muck that is permanently flooded.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Total herbaceous vegetation averages 83% with *Typha latifolia* as the dominant species (80% cover) forming dense stands. The only other species present in the surveyed stand is *Typha domingensis* with 3% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Typha latifolia*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Schoenoplectus acutus - Typha latifolia - (Schoenoplectus tabernaemontani)* Sandhills Herbaceous Vegetation (CEGL002030)--occurs in Great Plains, but is codominated by *Schoenoplectus* spp.
- *Typha (angustifolia, domingensis, latifolia) - Schoenoplectus americanus* Herbaceous Vegetation (CEGL002032)--occurs in Great Plains, but is codominated by *Schoenoplectus* spp.
- *Typha latifolia - Equisetum hyemale - Carex (hystericina, pellita)* Seep Herbaceous Vegetation (CEGL002033)--occurs in Great Plains, but is codominated by *Equisetum* and *Schoenoplectus* spp.
- *Typha latifolia* Southern Herbaceous Vegetation (CEGL004150)--occurs in the southern Great Plains and is very similar, but has not been reported further west than Arkansas, Oklahoma and Texas; further review is need to clarify differences.
- *Typha* spp. - *Schoenoplectus* spp. - Mixed Herbs Great Plains Herbaceous Vegetation (CEGL002228)
- *Typha* spp. Great Plains Herbaceous Vegetation (CEGL002389)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs within Dry Lakes.
Global Range: This association is widely distributed, occurring across the western United States and western Great Plains.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3032.
Local Description Authors: K.E. Sabo

Typha domingensis Western Herbaceous Vegetation

Southern Cattail Western Herbaceous Vegetation
Identifier: CEGL001845

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one surveyed stand located in a marsh pond at 2300 m elevation. The palustrine system is permanently flooded with very poorly drained muck soils. Standing water is the dominant cover (55%) along with litter and duff (25%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is a near monoculture of *Typha domingensis* with 70% cover. The only other species occurring within the stand is *Schoenoplectus acutus* with 3% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Typha domingensis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

- *Typha (angustifolia, domingensis, latifolia) - Schoenoplectus americanus* Herbaceous Vegetation (CEGL002032)--is only reported from the southeastern U.S.
- *Typha domingensis - Pontederia cordata* Herbaceous Vegetation (CEGL003988)--is only reported from the southeastern U.S.
- *Typha domingensis - Setaria magna* Herbaceous Vegetation (CEGL004138)--is only reported from the southeastern U.S.
- *Typha domingensis* Seasonally Flooded Gulf Coastal Plain Herbaceous Vegetation (CEGL004137)--is only reported from the southeastern U.S.
- *Typha domingensis* Semipermanently Flooded Tropical Herbaceous Vegetation (CEGL003987)--is only reported from the southeastern U.S.
- *Typha domingensis* Tidal Herbaceous Vegetation (CEGL008456)--is only reported from the southeastern U.S.

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs in the southernmost edge of the study area located near Dry Lakes.
Global Range: This wetland association is widespread across the southwestern United States and Great Basin.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2017.
Local Description Authors: K.E. Sabo

VII. Sparse Vegetation

Aquilegia caerulea - Cirsium scopulorum Scree Sparse Vegetation
Colorado Blue Columbine - Alpine Thistle Scree Sparse Vegetation
Identifier: CEGL001938

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one location on a north-facing high talus slope at 3600 m elevation. Slope is moderately steep (15 degrees) and the soil is rapidly drained. The site is very rocky with gravel (20%) and large rock (70%).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is sparse due to the large amount of rock cover. Total herbaceous vegetation cover is 10%. The most common species are *Aquilegia caerulea, Cirsium scopulorum*, and *Deschampsia caespitosa*, with 3% cover each.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Aquilegia caerulea*, *Cirsium scopulorum*
Herb (field)	Graminoid	*Deschampsia caespitosa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs at Upper Sand Creek Lake.
Global Range: This sparsely vegetated scree field association is known from the northern Front Range of Colorado. It likely has a wider distribution, because scree and boulderfields are poorly sampled.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3043.
Local Description Authors: K.E. Sabo

Holodiscus dumosus Rock Outcrop Sparse Vegetation
Glandular Oceanspray Rock Outcrop Sparse Vegetation
Identifier: CEGL002801

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on talus slopes at 2645 and 3140 m elevation. Terrain is steep to very steep 22-45 colluvial slopes with variable aspect. Soils are well-drained loams and silt loams. Ground cover is dominated by rock (35-80%). Bare ground and litter was also significant is some stands.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Vegetation is variable ranging from very open to moderately open shrub layer, but all surveyed stands were dominated by *Holodiscus dumosus* (15-40%). There can be a scattering of emergent trees, *Juniperus scopulorum, Pinus edulis,* or *Pinus flexilis* on dryer sites or *Abies concolor* or *Pseudotsuga menziesii* (on relatively mesic sites). Additional shrub species that commonly occur in this association include *Symphoricarpos* spp., *Ribes cereum* and *Ribes leptanthum*. If *Cercocarpus montanus* is present then it has low cover (<5%). *Muhlenbergia montana* or *Heterotheca villosa* is abundant in some of the stands and may form an herbaceous layer.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Holodiscus dumosus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Holodiscus dumosus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments: These *Holodiscus dumosa* dominated stands were generally not sparse (> 10% total vegetation cover) although many some stands occurred on talus as well as large rock colluvial slopes. Two stands had open herbaceous layers dominated by of *Muhlenbergia monanta.* This type needs further review globally to consider making moving to a shrubland alliance or splitting out a *Holodiscus dumosa* / *Muhlenbergia monanta* Shrubland.
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs on steep talus slopes in the Spanish Creek and North Arrastre Creek drainages and in open shrubby hillside along South Crestone Trail and in Big South Canyon.
Global Range: This association is described from Curecanti National Recreation Area, Gunnison and Rio Grande national forests in south-central Colorado, but it likely occurs elsewhere in the southern Rocky Mountains.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 3112, 3231, 4127, 4259.
Local Description Authors: K.E. Sabo. Mod by K.A. Schulz

Sarcobatus vermiculatus / Juncus balticus **Sparse Vegetation**
Greasewood / Baltic Rush Sparse Vegetation
Identifier: CEGL002919

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This shrubland association documented from two plots intermittently flood sites at 2293and 2304 m elevation. The soil is well drained to somewhat poorly drained sandy loam or sand. Litter is the dominant with 30-40% cover and bare ground 10-45% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This sparse shrubland is dominated by *Sarcobatus vermiculatus* with 10-30% cover. The graminoid-dominated understory has 50-70% cover of *Juncus balticus* with *Distichlis spicata, Muhlenbergia asperifolia, Spolobolus airoides, Cleome multicaulis* was present in one stand. Introduced species *Circium canadensis*, and *Lepidium latifolia* were present.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved evergreen shrub	*Sarcobatus vermiculatus*
Herb (field)	Graminoid	*Junicus balticus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments: These stands were generally not sparse (> 10% total vegetation cover). This type needs further review globally to consider making moving to a shrubland alliance
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Stands were sampled on the valley floor at Big Spring Creek
Global Range: Data unavailable

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3078, 4090
Local Description Authors: K.A. Schulz

Saxifraga bronchialis Scree Slope Sparse Vegetation
Yellow-spot Saxifrage Scree Slope Sparse Vegetation
Identifier: CEGL005902

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known from one location on a steep, northeast-facing talus slope at 3435 m elevation. Soils are rapidly drained sands. Ground cover is dominated by gravel (35%) and rock (35%). The site is located on loose scree in a steep ravine which may be gradually moving.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation is sparse with an average of 5% cover. *Saxifraga bronchialis ssp. austromontana* and *Artemisia arctica* are the dominant species with 3% cover each.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Artemisia arctica*, *Saxifraga bronchialis* ssp. *austromontana*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Standard
Classification Confidence: 3 - Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
- *Dasiphora fruticosa ssp. floribunda / Artemisia michauxiana* Shrub Herbaceous Vegetation [Provisional] (CEGL005833)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs near Cleveland Gulch.
Global Range:

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 94.
Local Description Authors: K.E. Sabo

VIII. Hierarchy Placement Undetermined

Abies concolor / Betula occidentalis Forest [Park Special]
White Fir - Douglas-fir / Rocky Mountain Maple Forest [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from 1 plot located on a stream terrace on very low-sloping terrain (6°) facing southwest, at 2671 meters of elevation. Soil is alluvial sandy loam and is moderately well drained. Large rock makes up 50% of the ground cover with litter and duff comprising another 33%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The tree canopy is the dominant layer with 50% cover over a tall shrub layer of 30% cover. The understory component is sparse with cover of less than 5% graminoid and mosses. The tree canopy is comprised of 30% cover of *Abies concolor* and 20% *Pseudotsuga menziesii*. The tall shrub layer consists of 30% cover of *Betula occidentalis*. Herbaceous

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Abies concolor, Pseudotsuga menziesii*
Tall shrub	Broad-leaved deciduous shrub	*Betula occidentalis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve: *Juniperus scopulorum, Holodiscus dumosus, Symphoricarpos sp.*

CLASSIFICATION

Status: Park Special
Classification Confidence: 3-Weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Located from one plot north of the park at the mouth of the Cottonwood Creek Canyon.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4123
Local Description Authors: J.E. Stevens

Abies lasiocarpa – Picea engelmannii / Sparse Understory Forest [Park Special]

Subalpine Fir - Engelmann Spruce / Sparse Understory Forest [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is known to occur on mid to high colluvial slopes and occurs within the elevation range of 3155m to 3585m. Sites generally have moderate to steep slopes ranging from 29-40° with the majority of plots occurring on north-west facing slopes and the other plots occurring on southwest and southeast-facing slopes. Surficial geology is granite and soils are well-drained predominantly sandy loam in texture. Litter can range in cover from 40-83% and wood cover can range from 7-20% of the total ground surface.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: These are open to closed canopy stands dominated by *Picea engelmannii* (30-60%) with 10% *Abies lasiocarpa* in the tree or short shrub layer. *Pinus aristata, Pinus flexilis,* or *Pseudotsuga menziesii* may also be present. The understory is almost devoid of vegetation (<5%) due to the dominant overstory of *Picea* and large amounts of woody debris. Scattered dwarf shrubs may include *Linnaea borealis, Rosa woodsii*, and *Vaccinium myrtillus* var. *oreophilum.* Herbaceous vegetation is very sparse, and consists primarily of forbs. Species present may include *Poa fendleriana, Arnica cordifolia, Oreochrysum parryi, Polemonium pulcherrimum*, and others.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Picea engelmannii, Abies lasiocarpa*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Picea engelmannii, Abies lasiocarpa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: The northern part of this association was found within the Little Medano Creek drainage, Horse Canyon, Garden Creek and North Zapata Creek drainage at the southern end.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 139, 203, 3220, 3266, 3278, 5240.
Local Description Authors: K.E. Sabo

Dasiphora floribunda / Festuca thurberi Subalpine Shrubland [Park Special]

Subalpine Fir - Engelmann Spruce / Sparse Understory Forest [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on mid to high colluvial slopes from 3480m to 3690m elevation. Slopes are steep (30-40°), with an aspect of southeast to southwest. Soils are well-drained sandy loams, clay loams, and loamy sands. Stands are rocky, with 10-30% gravel, 5-20% rock, and 0-10% bedrock. Bare ground can maye up from 5-45% of cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Dasiphora floribunda* forms a short shrub layer with 10-20% cover. The herbaceous layer includes 30-40% graminoid cover and 10-20% forb cover. *Festuca thurberi* is the dominant graminoid with 20-30% cover. Other graminoid species that may be present include *Calamagrostis purpurascens*, *Carex elynoides Carex rupestris* var. *drummondiana, Danthonia intermedia, Elymus* species, *Festuca brachyphylla, Luzula spicata,* and *Poa* species. Forb diversity is high; typical species include *Achillea millefolium* var. *occidentalis, Arenaria fendleri, Campanula rotundifolia,Chamerion angustifolium, Geum rossii* var. *turbinatum, Heterotheca villosa, Heuchera parvifolia, Minuartia obtusiloba, Phacelia sericea, Pseudocymopterus montanus, Saxifraga bronchialis* ssp. *austromontana, Sedum lanceolatum,* and *Trifolium dasyphyllum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Dasiphora floribunda*
Herb (field)	Graminoid	*Festuca thurberi*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Dasiphora floribunda, Festuca thurberi, Carex elynoides*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known from San Isabel Creek, Cottonwood Creek, and Smith Creek drainages and near Upper Sand Creek Lake.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3263, 2124, 4225, 5006.
Local Description Authors:

Glyceria grandis - Schoenoplectus acutus Herbaceous Vegetation [Park Special]

American Mannagrass - Hardstem Bulrush Herbaceous Vegetation [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from a single plot in a swale surrounded by stabilized sand dune at 2339m elevation. The site is semi-permanently flooded with very poorly drained muck soils. Ground surface cover is 55% litter and duff, 10% bare soil, and 10% water.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This graminoid dominated marsh is densely vegetated with 90% cover. *Schoenoplectus acutus* and *Glyceria grandis* are co-dominant species with 30% each. *Eleocharis palustris* also has significant cover with 20%. *Carex utriculata, Muhlenbergia asperifolia, Schoenoplectus americanus, Bidens cernua, Polygonum pensylvanicum,* and *Potentilla* were present in trace amounts.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Glyceria grandis*, *Schoenoplectus acutus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Eleocharis palustris, Glyceria grandis*, *Schoenoplectus acutus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur near Indian Springs and within the Sand Dunes.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3080.
Local Description Authors: K.E. Sabo

Halogeton glomeratus Semi-Natural Herbaceous Vegetation [Park Special]

Saltlover Semi-Natural Herbaceous Vegetation [Park Special
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This vegetation type is documented from a single plot in a dry playa surrounded by greasewood flats and semi-desert shrub steppe at 2302m elevation on the valley floor. The site is intermittently flooded. It has been observed on several other large playas and in disturbed areas. Substrate is sabkha (carbonated cemented sand). Ground surface cover is dominated by bare soil (95% cover). This playa where this type was sampled is dissected by a built-up road.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The vegetation is dominated by introduced annual forb *Halogeton glomeratus* which invades intermittently flooded playas and disturbed areas. No other species were recorded.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb *Halogeton globeratus*	

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments: *Halogeton globeratus* is a common invasive species of the intermountain Western U.S.
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This vegetion type was sampled in a large playa on the valley floor in the western portion of the GRSA project area.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: #5030.
Local Description Authors: K.A. Schulz

Juncus balticus - Pascopyrum smithii Herbaceous Vegetation [Park Special]

Baltic Rush - Western Wheatgrass Herbaceous Vegetation [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association documented from two plots on valley floors and sand sheets at 2306m and 2317m elevation. These upland systems have moderately well-drained loamy sand or poorly drained sandy clay loam soils.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Sampled stands are graminoid meadows co-dominated by *Juncus balticus* and *Pascopyrum smithii* with 20-40% cover each. The only other recorded species is *Pascopyrum smithii*, growing in dense small patches throughout the meadow.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Juncus balticus, Pascopyrum smithii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Spanish Creek drainage and near Cotton Lake.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4131, 4267.
GLocal Description Authors: K.E. Sabo

Juncus balticus (Iris missouriensis) Mixed Herbaceous Vegetation [Park Special]

Baltic Rush – (Rocky Mountain Iris) Mixed Herbaceous Vegetation [Park Special
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This mixed herbaceous vegetation association occurs primarily in basin floor sand sheets, but also can occur in bolsons, valley floors, and sabkhas with elevation ranging from 2295m to 2325m. This association can occur in both upland and wetland areas with the majority of the surveyed stands occurring in wetland areas. Surveyed stands are generally intermittently flooded. Soils are variable including somewhat poorly drained sandy clay loam and silt loam or moderately well-drained loamy sand, sandy loam, sandy clay loam, silty clay, sandy clay, silt loam, or sand. There can be a significant amount of bare soil ranging from 3-72% of the total ground surface cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This herbaceous association is moderately densely to densely vegetated with total cover of 40-90%. Some stands are forb dominated, while others are graminoid dominated.*Carex praegracilis, Juncus balticus, Pyrrocoma lanceolata,*and *Iris missouriensis*, may be dominant to codominant, with 10-30% cover. Other common graminoids include *Distichlis spicata*, *Hordeum jubatum, Muhlenbergia asperifolia, Muhlenbergia wrightii,Pascopyrum smithii, Sporobolus airoides,* and *Triglochin maritimum,*. Additional forbs include *Argentina anserina, Astragalus* species, *Equisetum laevigatum, Glaux maritima, Orthocarpus luteus,* and others

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Graminoid	*Juncus balticus*
Herb (field)	Forb	*Iris missouriensis, Pyrrocoma lanceolata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur near Crestone Creek, Cottonwood Creek, Head Lake, Arena Creek drainage, Big Spring Creek drainage, and Little Spring Creek.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 5286, 4281, 4221, 521, 4219, 64, 5250, 2179, 141, 2007, 5281.
Local Description Authors: K.E. Sabo

Pinus aristata - (*Picea engelmannii*) / *Juniperus communis* Woodland [Park Special]

Bristlecone Pine – (Engelmann Spruce) / Common Juniper Forest [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: : This association is documented from high ridges, ravines, shoulder, and convex colluvial slopes with elevations ranging from 3395m to 3485m. Slopes are moderately steep ranging from 27° to 34° and have variable aspects including northeast, southeast, and southwest-facing. Soils are sand, sandy loam or sandy clay loam and are generally well-drained. There is a large percentage of rock (7-30%) cover as well as bare soil or sand which ranges from 33-72%. In addition, two of the surveyed sites experienced a wildfire that resulted in overstory mortality and reduction in understory cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: *Picea engelmannii* (10-20%) and *Pinus aristata* (10-20%) co-dominate an open woodland of trees ranging in height from 7m to 27m. A short shrub layer includes *Juniperus communis* (10-30%) as well as saplings of *Picea engelmannii* and *Pinus aristata*, and scattered other shrubs such as *Dasiphora floribunda*, *Lonicera involucrata*, and *Shepherdia canadensis*. Dwarf shrub species include A*rctostaphylos uva-ursi*, *Vaccinium myrtillus*, and *Rosa woodsii*. Herbaceous vegetation is sparse (10 to 20% cover), and includes both forbs and graminoids. Typical forb species include Achillea millefolium var. occidentalis, *Arenaria fendleri*, *Chamerion angustifolium, Frasera speciosa, Oreochrysum parryi, Potentilla pulcherrima, Saxifraga bronchialis ssp. austromontana*, *Solidago multiradiata*, and *Thermopsis montana*. Graminoids include *Bromus ciliatus, Carex rossii, Festuca thurberi,* and *Poa fendleriana*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus aristata, Picea engelmannii*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juniperus communis, Festuca thurberi*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:

Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association was found in the Middle Fork, Jones Creek, Medano Creek, and Little Medano Creek drainage on high slopes and ridges.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 495, 4038, 3073, 123.
Local Description Authors: K.E. Sabo

Pinus edulis – Juniperus scopulorum / Holodiscus dumosus Woodland [Park Special]

Two-needle Pinyon – Rocky Mountain Juniper / Glandular Oceanspray Woodland [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: The association is documented from colluvial and talus slopes, between 2610m and 2915m in elevation. Sites are generally steep (25-43°). Aspect is variable with sampled plots found on southeast, southwest and northwest-facing slopes. The soils are generally well-drained sandy loam, silt loam, and loamy sand and average 40% of the ground surface. Litter covers 25 to 60% of the ground surface with large exposed colluvial or igneous rocks and gravel covering 10 to 35% of the ground surface.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is characterized by an open canopy of *Pinus edulis* and *Juniperus scopulorum* with combined cover of up to 50%. *Pseudotsuga menziesii* may also be present in small amounts. The short shrub stratum is dominated by *Holodiscus dumosus* (10%), accompanied by a variety of other shrub species that may include *Artemisia frigida, Cercocarpus montanus, Chrysothamnus* spp., *Physocarpus monogynus, Ribes* spp., *Symphoricarpos oreophilus,* and *Yucca glauca.* The understory is generally graminoid dominated, and common species may include *Festuca arizonica, Muhlenbergia montana* and *Koeleria macrantha.* Forb cover is <10%, and may include species such as *Artemisia carruthii, Eriogonum jamesii,Erysimum capitatum, Opuntia polyacantha, Packera* spp., and others.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Tree canopy	Needle-leaved tree	*Pinus edulis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Pinus edulis, Juniperus scopulorum, Holodiscus dumosus, Koeleria macrantha*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:

Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association has been documented in the northern half of the project area near Dry Gulch and Dimick Gulch and the town of Cottonwood to the southeast section near Garden Creek. The association is known from low to midslopes and on rocky ridges.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2279, 3216, 4106, 3107.
Local Description Authors: K.E. Sabo

Populus angustifolia - Abies concolor / Betula occidentalis Woodland [Park Special]

Narrowleaf Cottonwood – White Fir / Water Birch Woodland [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from 2 riverine plots located on the valley floor in the lower canyon of two creeks draining the Sangre de Cristo range. The association was found on very low-sloping terrain (3-5°) facing southwest, between 2500 and 2592 meters of elevation. Soils are fluvial deposits of loam to sandy loam and are somewhat poorly drained. Sites may be intermittently or seasonally flooded.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by a mixed canopy of *Populus angustifolia* and *Abies concolor* with an understory shrub layer of *Betula occidentalis*. The tree canopy is the dominant layer with 30-40% cover of *Populus angustifolia* and 10-20% cover of *Abies concolor*. Additional tree species possibly present include *Pseudotsuga menziesii* and *Juniperus scopulorum*. The tall shrub layer is dominated by 30-50% cover of *Betula occidentalis*. Other shrub species present may include *Alnus incana, Acer glabrum, Cornus sericea*, and *Rosa woodsii*. The herbaceous understory is sparse with up to 20% cover of *Pyrola rotundifolia, Maianthemum stellatum, Thalictrum fendleri, and Equisetum hyemale*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Abies concolor*
Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Betula occidentalis*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:

Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Known to occur on the valley floor of some lower canyons of the Sangre de Cristo Mountains in and around Great Sand Dunes National Park and Preserve.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4061, 5058
Local Description Authors: J.E. Stevens

Local Description Authors:***Populus angustifolia / Ribes aureum*** **Woodland [Park Special]**
Narrowleaf Cottonwood / Golden Currant Woodland [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from 2 plots collected from the north and northeast margins of the main dune field. Both are located adjacent to stream channels that abut the dunes field. The sites are low slopes of 6-17° with southwest aspects at an elevation of 2539 meters. The soils of these sites are very sandy to loamy sand, are well drained, with ground cover of 50-65% bare soil and 30-45% litter and duff.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by a tree canopy of *Populus angustifolia* (20-40% cover) with an understory of the short shrub *Ribes aureum* (30-50% cover). The herbaceous understory is sparse and dominated by a mix of forbs with very few graminoid species present. Individual *Juniperus scopulorum* trees may be present in the site in low numbers. Other shrub species present with low cover may include *Rosa woodsii, Prunus virginiana, Ribes cereum, an Ericameria nauseosa*. Forbs present may include *Chenopodium* spp., *Macrantha bigelovii, Senecio spartioides, Descurainia pinnata, Artemisia dracunculus, and Opuntia polyacantha*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Tree canopy	Broad-leaved deciduous tree	*Populus angustifolia*
Short shrub/sapling	Broad-leaved deciduous shrub	*Ribes aureum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence: 3 - weak
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Known from the margin of the dune fields adjacent to streams at 2538m elevation in Great Sand Dunes National Park and Preserve.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3101, 3087.
Local Description Authors: J.E. Stevens

Populus tremuloides - Abies concolor / Acer glabrum Forest [ParkSpecial

Subalpine Quaking Aspen - White Fir / Rocky Mountain MapleForest [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association can occur on low to midslope terraces, drainage channels, stream terraces, valley floors, flood plains, and colluvial slopes. Surveyed stands can have slopes ranging from flat to modestly steep (0-28°) with variable aspect and elevation ranging from 2630m to 3630m. In general stands occur in upland systems, but can be found in palustrine or riverine and can be intermittently, semi-permanently, or seasonally flooded. Soils are usually either moderately or somewhat poorly drained, but can be well-drained. Soil texture is variable and includes sandy loam, loam, loamy sand. This association can be fairly constant along riparian corridors occurring mostly within the floodplain

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This forested association is characterized by a complex multi-layer dense canopy of *Populus tremuloides*, *Acer glabrum*, and *Abies concolor*. The canopy is generally 25-85% cover and trees can be 10-35m tall. All three species range in canopy position from canopy to tall shrub. The canopy is dominated with *Populus tremuloides* with an average of 30% cover, but both *Acer glabrum* and *Abies concolor* are co-dominant species with 15% and 25% average cover respectively. The herbaceous layer is typically sparse, but some surveyed stands had significant cover ranging from 1-45% with *Thalictrum fendleri* and *Bromus ciliatus* having significant cover

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Tree canopy	Needle-leaved tree	*Abies concolor*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Acer glabrum*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:

Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:
Populus tremuloides / Acer glabrum Forest (CEGL000563)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in Cottonwood Creek, Sand Creek, Cold Creek, Horse Canyon, Medano Creek, Buck Creek, Mosca Creek, North Arrastre Creek, and South Arrastre Creek.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4261, 4124, 5056, 4092, 4077, 1126, 410, 355, 3108, 963, 714, 4268, 5033, 282.
Local Description Authors: K.E. Sabo

Populus tremuloides - Abies concolor / Physocarpus monogynus Forest [Park Special]

Quaking Aspen - White Fir / Mountain Ninebark Forest [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from 4 plots located in adjacent to drainages on colluvial slopes and terraces. The sites are on low slopes of 2-17° with varying aspects from southeast to west to northerly between 2786 and 2940 meters of elevation. Soils of these sites are loamy and are somewhat poorly to moderately well-drained.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by a forest canopy of *Populus tremuloides* and *Abies concolor* with a short shrub understory of *Physocarpus monogynus*. The tree canopy is the dominant layer with 30-50% cover of *Populus tremuloides* and 5 to 40% cover of *Abies concolor.* Other tree species that may be present with low cover include *Pseudotsuga menziesii, Juniperus scopulorum, Pinus flexilis,* and *Pinus ponderosa*. The short shrub layer is dominated by 20 to 30% cover of *Physocarpus monogynus*. Other shrub species present with low cover may include *Rosa woodsii, Rubus idaeus, Mahonia repens, Juniperus communis, Symphoricarpos sp., Shepherdia canadensis, and Arctostaphylos uva-ursi.* Forb species present may include *Artemisia franserioides, Chamerion angustifolium, Fragaria vesca, Maianthemum stellatum,* and *Oreochrysum parryi.*

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Abies concolor*
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Short shrub/sapling	Broad-leaved deciduous shrub	*Physocarpus monogynus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special

Classification Confidence: 2 - Moderate
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations: *Populus tremuloides / Physocarpus monogynus* Forest (CEGL005932)

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Drainages of the Sangre de Cristo mountains within and adjacent to the Great Sand Dunes National Park and Preserve.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4094, 4272, 4277, and 5079
Local Description Authors: J.E. Stevens

Populus tremuloides / Bromus ciliatus - (Thermopsis spp.) Forest [Park Special]

Quaking Aspen / Fringed Brome – (Golden-banner) Forest [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association is documented from 5 plots, located on benches, ridges, and colluvial slopes. Most were found on low slopes of 4-26° with varying aspects from east to south to west at between 2612 and 3186 meters of elevation. Soils of these sites are loamy and variably mixed with sand and silt. Ground cover is greater than 75% litter and duff. Soil drainage varies across plots.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by a forest cover of *Populus tremuloides* with an herbaceous understory of *Bromus ciliatus*. The tree canopy is the dominant layer with 30-80% cover of *Populus tremuloides*. Other tree species that may be present with low cover include *Pseudotsuga menziesii, Abies concolor, Picea engelmannii, Pinus aristida, Pinus edulis,* and *Juniperus scopulorum*. The herbaceous understory is dominated by up to 40% cover of *Bromus ciliatus* with a various assemblage of other graminoids and forbs in low cover. Shrub species that may be present with very low cover include *Rosa woodsii, Physocarpus monogynus, Mahonia repens, Juniperus communis, Symphoricarpos sp., Shepherdia canadensis,* and *Ericameria parryi*. Forb species present may include *Artemisia franserioides, Chamerion angustifolium, Fragaria vesca, Maianthemum stellatum,* and *Oreochrysum parryi.*

Additional characteristic species may include *Galium boreale* and *Rosa woodsii*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*
Herb (field)	Graminoid	*Bromus ciliatus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range:

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 2445, 3249, 4094, 5247, 5252
Local Description Authors: J.E. Stevens

Populus tremuloides Scree Woodland [Park Special]

Quaking Aspen ScreeWoodland [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This woodland association is documented from a single plot on a steep (30°) talus slope at 3181m elevation. Large rocks and a dense canopy of young *Populus tremuloides* dominate this system. Soils are well-drained rocky loams with large rock constituting up to 50% of the ground cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This association is dominated by a dense canopy of *Populus tremuloides* (70%) ranging from 2-5m in height. There is a sparse understory of short shrubs and dwarf-shrubs and no herbaceous layer. Species found in the shrub layer include *Ribes cereum*, *Jamesia americana*, and *Holodiscus dumosus.*

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Tree canopy	Broad-leaved deciduous tree	*Populus tremuloides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the North Arrastre Creek drainage.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3232.
Local Description Authors: K.E. Sabo

Rhus trilobata Dune Shrubland [ParkSpecial]
Skunkbush Sumac Dune Shrubland [ParkSpecial]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This shrubland association is documented from a single plot on a low gently sloping (19°) sand ramp at 2817m elevation. The soil is rapidly drained sand that comes from aeolean surficial geology. Sand comprises the majority of the ground cover with 93%.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Vegetation is characterized by a sparse short shrub layer dominated by *Rhus trilobata* with 10% cover. Other short shrub species that are common include *Chrysothamnus viscidiflorus, Ericameria nauseosa,* and *Rosa woodsii* all with <5% cover. *Artemisia frigida, Cercocarpus montanus*, and *Symphoricarpos oreophilus* were also present in small amounts. The herbaceous layer is sparse and is dominated by *Hesperostipa comata* (10% cover). Other graminoids include *Achnatherum hymenoides, Bouteloua gracilis, Festuca arizonica, Koeleria macrantha,* and *Pascopyrum smithii.* Forbs present include *Artemisia dracunculus, Cryptantha fendleri, Eriogonum umbellatum, Heterotheca villosa, Psoralidium lanceolatum,* and *Senecio spartioides.*

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved evergreen shrub	*Rhus trilobata*
Herb (field)	Graminoid	*Hesperostipa comata*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur north of the Sand Ramp Trail in Great Sand Dunes National Park and Preserve.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 170.
Local Description Authors: K.E. Sabo

Rorippa palustris Herbaceous Vegetation [Park Special]

Bog Yellowcress Herbaceous Vegetation [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This vegetation type is documented from a single plot on a dry lake bed at 2291m elevation. Surficial geology is lacustrine with very poorly drained muck soils. Ground cover is dominated by 98% bare soil. This association may only occur during dry years.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Herbaceous vegetation consists of 10% *Rorippa palustris* and a trace of *Chenopodium* and *Typha* spp.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Rorippa palustris*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association occurs at Head Lake

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3079.
Local Description Authors: K.E. Sabo

Salix exigua Dune Shrubland [Park Special]

Coyote Willow Dune Shrubland [Park Special]
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This shrubland association is documented from a single plot on a dune field at 2353m elevation. The dune is gently rolling with no single slope or aspect. Sandy soil covers 50% of the ground surface with 40% litter and duff.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The samples stand represents a dune being stabilized by vegetative growth. *Salix exigua* is the dominant canopy species with 30% cover, forming a patchy stand up to 2m tall. A small short shrub layer is dominated by *Ericameria nauseosa* with 10% cover. The herbaceous layer is sparse with cover <20%.

Redfieldia flexuosa has the greatest amount of cover with 10%. Other species found within the stand are *Psoralidium lanceolatum* and *Achnatherum hymenoides* both with <5% cover.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Tall shrub/sapling	Broad-leaved evergreen shrub	*Salix exigua*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Ericameria nauseosa, Redfieldia flexuosa*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Sand Creek drainage.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4232.
Local Description Authors: K.E. Sabo

Sarcobatus vermiculatus / Leymus triticoides Shrubland [ParkSpecial]

Subalpine Fir - Engelmann Spruce / Sparse Understory Forest
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This shrubland association documented from a single plot at 2298m elevation. The soil is somewhat poorly drained sandy clay. Bare soil is the dominant ground cover with 60% and litter and duff has 33% cover.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: This sparse shrubland is dominated by *Sarcobatus vermiculatus* with 20% cover. The graminoid-dominated understory has 30% *Leymus triticoides*, 10% *Juncus balticus*, and trace amounts of *Distichlis spicata, Spolobolus airoides, Cleome multicaulis,* and *Lepidium latifolium.*

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved evergreen shrub	*Sarcobatus vermiculatus*
Herb (field)	Graminoid	*Leymus triticoides*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Juncus balticus*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: This association is known to occur in the Big Spring Creek drainage.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 3281.
Local Description Authors: K.E. Sabo

Salsola spp. Herbaceous Vegetation [Provisional]

Russian-thistle species Semi-natural Herbaceous Vegetation [Provisional]
Identifier: CEGL004004

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This vegetation type is documented from a single plot in a dry playa at 2297 elevation on the valley floor. The site is intermittently flooded. It has been observed in disturbed areas elsewhere in the project area. Substrate is clayey soil. Ground surface cover is dominated by bare soil (90% cover).

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: The vegetation is dominated by introduced annual forb *Salsola tragus* which commonly invades disturbed areas. Three other species were recorded with trace cover were *Sarcobatus vermiculatus, Machaeranthera tanacetifolia* and *Distichlis spicata.*

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Salsola tragus.*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve:

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Found in playa aproximately 1.2 km east of canal, but Salsola iberica is a common disturbance species.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:

Great Sand Dunes National Park & Preserve Plots: GRSA: 2153
Local Description Authors: K.A. Schulz

Senecio atratus - Cirsium scopulorum Herbaceous Rockland [ParkSpecial]
Subalpine Fir - Engelmann Spruce / Sparse Understory Forest
Identifier: Park Special

ENVIRONMENTAL DESCRIPTION

Great Sand Dunes National Park and Preserve Environment: This association occurs on very rocky talus slopes, terraces, and ravines at 3200m to 3790m elevation. Slope is generally moderately steep ranging from 16° to 32° with an east, southeast, or southwest-facing aspect. Stands can be intermittently flooded and saturated. Soils are somewhat poorly drained to well-drained and sandy loam, sandy clay, sandy clay loam, and silt loam. Ground surface cover is dominated by rock with 25-70% cover and 5-15% gravel. There are clear indications of elk and marmot use in the sampled stands.

VEGETATION DESCRIPTION

Great Sand Dunes National Park and Preserve Vegetation: Forbs and graminoids make up about equal proportions of this herbaceous association, with total cover of up to 50%. Scattered short or dwarf shrubs may be present as well, including *Dasiphora floribunda*, *Lonicera involucrata, Ribes* species, *Rubus idaeus, Sambucus racemos,* and conifer saplings. *Senecio atratus* is generally dominant with 5-40% cover, and *Cirsium scopulorum* is present with <5% cover. Typical additional forb species include *Achillea millefolium* var. *occidentalis, Aquilegia caerulea, Mertensia ciliata, Oreoxis alpina, Polygonum bistortoides, Potentilla* species, and *Silene acaulis* var. *subacaulescens*. Fern species such as *Cryptogramma acrostichoides, Cystopteris fragilis*, and *Selaginella densa* are often present in small amounts. Graminoid species include *Bromus ciliatus, Carex foenea* var. *foenea*, *Deschampsia caespitosa, Festuca brachyphylla, Juncus drummondii, Luzula spicata, Poa* species, and *Trisetum spicatum*.

MOST ABUNDANT SPECIES

Great Sand Dunes National Park and Preserve

Stratum	Lifeform	Species
Herb (field)	Forb	*Senecio atratus*

CHARACTERISTIC SPECIES

Great Sand Dunes National Park and Preserve: *Achillea millefolium* var. *occidentalis, Deschampsia caespitosa,Trisetum spicatum*

OTHER NOTEWORTHY SPECIES

Great Sand Dunes National Park and Preserve:

CLASSIFICATION

Status: Park Special
Classification Confidence:
Great Sand Dunes National Park and Preserve Comments:
Global Similar Associations:

ELEMENT DISTRIBUTION

Great Sand Dunes National Park and Preserve Range: Occurs near Cottonwood Lake, Cottonwood Creek drainage, Upper Sand Creek Lake, near Slide Rock Canyon, and Mount Seven.

ELEMENT SOURCES

Great Sand Dunes National Park and Preserve Inventory Notes:
Great Sand Dunes National Park & Preserve Plots: GRSA: 4065, 220, 4240, 4236, 3210.
Local Description Authors: K.E. Sabo

Appendix J:
Great Sand Dunes National Park Vegetation Map Class Crosswalk to USFS Vegetation Maps (R2Veg Geodatabase) and USFWS National Wetland Inventory Units

Prepared by

NatureServe
Western Regional Office
Boulder, Colorado

For the NPS Rocky Mountain I & M Network

2010

Keith Schulz, Regional Vegetation Ecologist
Email: keith_schulz@natureserve.org
Phone: 703.797.4807
NatureServe, 4001 Discovery Dr. Suite 2110
Boulder, CO 80303

Introduction

The major agencies within the Great Sand Dunes National Park and Preserve (GRSA) vegetation classification and mapping project area have different vegetation classification and mapping systems. The National Park Service (NPS) Vegetation Inventory Program (VIP) uses the National Vegetation Classification Standard (NVCS) for vegetation inventory, classification and mapping. This standard is the federally adopted portion of the US National Vegetation Classification (USNVC), which is was developed by The Nature Conservancy and others and is currently managed by NatureServe (TNC and ESRI 1994a, Grossman et al. 1998). The USNVC became the NVCS when the Federal Geographic Data Committee (FGDC) adopted a modified version of the upper (physiognomic) levels as a federal standard (FGDC-STD-005, FGDC 1997). The USNVC is available on the internet at: http://www.natureserve.org/explorer/

This classification system is the basis for the GRSA map classes and is composed of USNVC alliances, groups of alliances and a few associations. The Baca National Wildlife Refuge also inventoried and mapped vegetation using USNVC alliances, which were crosswalked to GRSA Map Classes as part of this project.

The Rio Grande National Forest (RGNF) uses the R2Veg geodatabase, an Integrated Resource Inventory layer that delineated existing homogeneous units of vegetation of 5 or more acres (2 or more acres of wetland or riparian). Vegetation structure, lifeform and dominant species information are described for each polygon. Various map classes can be determined or "calculated" from the polygon data as needed as long as there are rules developed to key the vegetation type from the polygon data. The goal of R2Veg is to provide sufficient information to support forest level planning and initial landscape stratification for project level planning, implementation, and monitoring. This USFS Regional poly-veg database provides the core GIS layer for vegetation. R2Veg metatadata for R2Veg is available on the internet at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm9_012554.pdf

Another major land classification system used by natural resource managers is the National Wetlands Inventory (NWI), which is managed by the US Fish and Wildlife Service (USFWS) provide wetlands information. It uses the Cowardin classification system (Cowardin *et al.* 1979) to describe coastal and inland wetlands in detail. NWI information and data is available on the internet at: http://www.fws.gov/wetlands/

These different classification systems and map legends were created to serve different purposes. In order to create common mapping for broader natural resource planning, management and conservation, vegetation maps developed by different agencies need to be cross referenced to be understood by managers from the different agencies. This crosswalk and analysis is the focus of this project.

Overview

This project funded two tasks. The first task funded a NatureServe (NS) ecologist to participate in the GRSA Vegetation Mapping Project Close-out meeting, March 2-3, 2010 at Great Sand Dunes NP and Preserve. The previous NS contract with NPS expired before the close-out meeting could be held so additional funding was needed for NS to prepare for and participate in this meeting.

During the close-out meeting, in addition to the usual project overview and summary of products and processes; technical presentations on plant community classification, vegetation mapping, and accuracy assessment (AA); there were demonstrations of the major products (GIS vegetation map layer, photo database, plot and AA point database, plant community classification, and field keys) and discussions on potential applications for resource management and research, as well as future development of these tools. Then the morning of the second day, participants received a firsthand experience using the vegetation map, plant community and map class field keys and descriptions in the field. We visited vegetation plot and accuracy assessment point locations so participants could understand differences in scale between plant communities and map polygons and how they relate to each other for resource management applications.

The larger second task was for NS to develop methods and then crosswalk GRSA map classes to R2Veg geodatabase polygons and the NWI wetland habitat classes to supplement the GRSA vegetation classification and mapping project. This task was divided into three parts with the specific actions and products listed here:

a) Developed GRSA Map Class to R2Veg geodatabase crosswalk “rule sets” that can be programmed by USFS staff into Rio Grande National Forest R2Veg geodatabase to determine or “calculate” the GRSA map class from R2Veg polygon data.

b) Compared a GIS intersection of GRSA map class and NWI wetland habitat class layers to create a crosswalk between GRSA and NWI. A table was produced showing the crosswalk and describing any issues. This product will clarify conceptual relationships between the GRSA and NWI wetland habitat classes as well as some issues with the GIS layers.

c) Developed predicted species and cover data in a table for GIS polygons that represent the newly acquired Baca addition land of the Rio Grande National Forest. This product will allow the USFS staff to populate a GIS data gap representing the USFS Baca land addition, so it can be incorporated into the Rio Grande National Forest R2Veg geodatabase.

Each part of task 2, including background, methods, and results & discussion is further developed below. Results are presented in tables as Appendices A-D. These tables are too large to be included as part of this report, but are included with the deliverables as a separate Excel spreadsheet file. A large format plotter is necessary to adequately print and view these files.

Crosswalk GRSA Map Classes to USFS R2Veg (Task 2a)

Background

US Forest Service manages lands that are adjacent to the Great Sand Dunes National Park and Preserve to the north, east and south within the Sangre de Cristo Range. The Rio Grande NF manages its spatial vegetation data in a R2Veg geodatabase. The crosswalk developed by NS can be programmed into their geodatabase to determine or "calculate" the USNVC based GRSA vegetation map classes. When the resulting vegetation map is completed it will provide context for GRSA vegetation classification and project area and enable USFS to use USNVC map classes for natural resource planning and management.

Methods

To create a crosswalk, NatureServe first needed to develop "rule sets" or conditional statements were developed to key or "calculate" the GRSA map class within the R2Veg geodatabase using polygon data. Within R2Veg, polygons of existing homogeneous units of upland vegetation of 5 or more acres are delineated (2 or more acres for wetland or riparian vegetation) and described using cover of dominant lifeforms, ground surface, and dominant species. The lifeform and abiotic descriptors include trees (T), shrubs (S), forbs (F), graminoids (G) (grass, rush or sedge), bare soil (BS), rock (RO), wood (WO), water (W), litter/duff (LD), ice and snow (IC) and undifferentiated barren (B) with cover of each estimated for a map polygon with total summing to 100% cover (USDA 2005). Woody vegetation 5 m tall or more is considered trees; whereas < 5 m tall are shrubs. Trees and usually shrubs are identified to genus or species. Layer (strata) and size class are listed for trees and shrubs only. Herbaceous vegetation is often treated by lifeform only in R2Veg, however NS provided diagnostic species data to key grassland GRSA map classes and for future use as herbaceous species data become available from USFS land. The R2Veg Users Guide provided information on date requirements of R2Veg (USDA 2005).

NatureServe developed these stepwise auto keys or "rule sets" using predicted diagnostic life form and species canopy cover data based on 100% land cover as seen in aerial photos so ground cover and understory vegetation *under tree canopy* is not recorded. USDA Plants Acronyms were used for diagnostic species, both current and some older acronyms to match R2Veg data . In addition of lifeform and diagnostic species cover data, some environmental data (slope, aspect, elevation) and wetland/riparian vs. upland (obligate wetland, Semi-riparian, or Upland) was provided when diagnostic. A Landscape Context column was added and populated to provide landscape context as necessary to identify some map classes.

Results and Discussion

The final product of this subtask is the table "Rule sets" of that can be used to determine or "calculate" GRSA map classes from polygon data in the R2Veg geodatabase (see Appendix A). The "rule sets" in the table that can be programmed into Rio Grande National Forest R2Veg geodatabase by USFS staff using Visual Basic script. The table has a map class name with statements about the absolute cover of major lifeforms, then lists of diagnostic species with relative cover values by lifeform strata. If all statements are true the polygon is keyed to that map class. If not, then the next statement is used. It is important that these conditional statements be programmed in the order listed in the row number column to get accurate results. As part of a mapping team, NS will review interim products and suggest changes to rule sets script that ultimately creates the final RGNF vegetation maps with USNVC based map classes.

In the rule set, additional information needed to be included to provide landscape context necessary to label polygons to several map classes because of the "many to many" relationships with diagnostic species and GRSA map classes. For instance, similar wetland alliances can occur along riparian areas, emergent wetlands, and interdunal swales wetlands. This landscape context information is provided where needed in the Landscape Context column on the far right side of the table. R2Veg experts need to figure out how this context information can be incorporated in the R2Veg geodatabase.

Where herbaceous species data is lacking in R2Veg, it will not be possible to key to specific grassland map classes using species composition data. However, some environmental data such as elevation, wetland/riparian, and landscape context are also provided and may be used to distinguish some GRSA map classes. For example map classes such as Alpine Turf Alliances, Montane-Subalpine Grassland Alliances, and Piedmont Semi-Desert Grassland Alliances generally follow elevation breaks. Adjacent wetlands as Alpine - Upper Subalpine Herbaceous Wetland Alliances and Montane-Lower Subalpine Wetland Alliances can be distinguished from these upland grasslands by information on site hydrology contained in the Wetland/Riparian column.

In addition, there are possible scale issues exist between R2Veg and GRSA vegetation map, which uses 0.5 ha (1.24 ac) MMU whereas the R2Veg standard is approximately 2 ha (5 ac) for uplands and 0.8 ha (2 acre) for wetland and riparian areas. I would expect higher variation within the potentially larger R2Veg polygons.

Crosswalk GRSA Map Classes to USFWS NWI Wetland Habitat Class Level (Task 2b)

Background

As part of their inventory of wetlands at GRSA, NPS staff is interested in comparing GIS map layers of GRSA wetland map classes and NWI wetland classes with water regime modifiers. GRSA map classes are mostly derived from USNVC alliances and associations and are based on existing vegetation cover (Grossman *et al.* 1998). The NWI map classes are mostly based on site hydrology and environmental characteristics using the Cowardin classification system (Cowardin *et al.*1979). A summary from the GIS showed a total of 2548 NWI wetland polygons in GRSA project area with 50 unique codes (class + water regime classifiers) and 23 GRSA map classes that include wetland alliances. NatureServe ecologists created a crosswalk between GRSA and NWI wetland that occur within the GRSA project area to clarify and document the relationships between the classification systems.

Methods

The crosswalk between GRSA and NWI wetland classes began with a GIS intersection of the GRSA vegetation map class layer and the NWI habitat class layer with water regime modifiers that occur within the GRSA project area. NatureServe ecologists used a summary of the intersection to create the initial crosswalk with the number of polygons of each intersection combination listed in the last column. Then the conceptual relationships between these intersected map classes were reviewed (vegetation structure and hydrology) and ranked on a 1-3 scale (1 = Most Appropriate, 2 = Appropriate I, 3 = Not Appropriate). Missing crosswalk combination were added and given “0” number of occurrences. For example, Palustrine Scrub Shrub Temporarily Flooded (PSSA) should be a characteristic NWI Class at GRSA, but was not mapped in the project area. PSSA crosswalks to Montane Riparian Shrubland Alliances, however montane riparian shrublands are typically narrow and may occur below MMU of NWI classification system. In addition, some notes regarding NWI and GRSA map class issues are provided. Finally, this crosswalk was sorted by the 1-3 crosswalk rank with the #3 not appropriate intersections listed at the bottom of the table.

Results and Discussion

There are several issues that came up during the crosswalk process. When GIS data from the NWI polygons and GRSA Vegetation layers were intersected, the number of NWI wetland polygons increased 2.5 times to 6266 polygons. This large increase in the total number of polygons is primarily the result of slivers of upland GRSA types in NWI polygons, but also having multiple GRSA Wetland Map Classes in one NWI wetland polygon. For example, Emergent Marsh Alliances and San Luis Valley Mesic Meadow Alliances, or Cattail Herbaceous Alliances and Water often form mosaics with one NWI unit. Additionally, some NWI polygons were mapped by GRSA only as upland types such as Palustrine Emergent Temporarily Flooded (PEMA) = Sandsheet Rabbitbrush Shrubland and Steppe Alliances, or as Lacustrine Limnetic Unconsolidated Bottom Permanently Flooded (L1UBH) and Alpine Bedrock and Scree. In those cases it is difficult to know which label is correct without additional information.

The issues with GRSA upland vegetation types that were included in NWI polygons could be the result of several things. Assuming the NWI polygon is correct, these upland types could be the result of mapping error or changes in size of wetland. The amount of water available for wetlands can vary significantly seasonally and from year to year depending on the depth of the annual snowpack in the Sangre de Cristo Range. Some inconsistencies could also be a result of the NWI polygons being below the NPS Vegetation Mapping Program Minimum Map Unit area of 0.5 ha and included in an upland polygon. For example, 1569 of 2548 (62%) and 625 of 2548 (25%) NWI polygons are less than 0.5 ha and less than 0.1 ha, respectively. Although many GRSA wetland polygons were also mapped below the MMU area, mapping scale issues definitely contributed to many of the hydrologically inappropriate intersections (combinations) between NWI and GRSA map.

Additionally, longer term changes likely have occurred since the NWI wetland and GRSA vegetation map layers were developed from imagery from different decades. NWI imagery was from the 1980’s and GRSA was from 2006 (NAIP) and 2007 (Quickbird). Furthermore some wetlands and mesic grasslands in the project area are enhanced by irrigation practices. Given this, it is not surprising that there are a lot of wetland mapped as uplands and vise-versa.

This final crosswalk is presented in Appendices B & C. It is the same crosswalk displayed two ways, either sorted by GRSA or NWI map class first. This crosswalk is mostly conceptual being based on hydrologic and vegetation definitions of the NWI wetland habitats and GRSA vegetation map classes, but used the GIS intersection of the two map layers to show actual combinations. Additional conceptual combinations were added that were missing from the GIS intersection.

This crosswalk is useful in clarifying the conceptual relationships between the two classification systems as well as looking at an actual comparison between map layer units. NatureServe ecologists did not do a complete GIS crosswalk analysis of the layers which is beyond the scope of this project. A complete crosswalk analysis is not possible without evaluating each map polygon of the intersection in a GIS using recent imagery and then ground-truthing many of them, as there is no other way to determine which, if either, label is correct.

Develop R2Veg geodatabase polygon data for USFS Baca land addition (Task 2c)

When the Great Sand Dunes National Park and Preserve and the Baca National Wildlife Refuge were created from the Baca Grande Land Grant, approximately 12,000 acres (29,600 ac) of mountain land southwest of Crestone was also transferred to the Rio Grande National Forest (RGNF). The vegetation of this recently acquired Baca land addition was not delineated in the RGNF R2Veg geodatabase and so represented a blank area within their vegetation map.

This unmapped area in R2Veg can be filled by exporting the GRSA vegetation polygon linework to R2Veg and then edge-matched as needed within the R2Vegetation geodatabase. However, acquiring vegetation data is much more labor intensive and typically involves photo-interpretation of each polygon by an imagery analyst. To fill this R2Veg data gap, NS ecologists will adapt vegetation lifeform and dominant species canopy data from the GRSA vegetation map geodatabase. A complete R2Veg map will facilitate resource planning and management of this land by the US Forest Service until more precise photo-interpretated or field data can be acquired.

Methods

Great Sand Dunes NP and Preserve vegetation classification and mapping project has vegetation polygon linework with map class name and vegetation density information from which we derived life form and dominant/diagnostic species canopy cover and height data that was crosswalked and adapted to fill in the blank area of the R2Veg geodatabase from the recently acquired Baca land addition. Using a GIS we selected the map polygons from the US Forest Service Baca land addition. We buffered the boundary 100 m to insure complete sampling in case of boundary errors and to provide context for the edge-matching. This increased the number of polygons selected from 739 to 785 polygons (+46 polygons).

To develop specific vegetation data such as dominant Lifeform/GSC and cover of diagnostic species for each polygon, NS ecologists used GRSA map class name, basic environmental variables (elevation) and the imagery-interpreted, average vegetation canopy cover metric (density) for each polygon. These densities are “binned” into four classes; 0-9 %, 10-24 percent, 25-60 %, and 61-100 %. Mid-points were used except for the 1-9 % class where 9 percent is used because 5 % tree canopy was considered too sparse to be a dominate layer and it would not have been mapped as a woodland or shrubland. Information on typical dominant and diagnostic species can be predicted for the polygon when GRSA Map Class in known as it relates to map class description, component associations, local descriptions based on plot data, and the actual classified plot data. These initial vegetation cover estimates can then be used in R2Veg to calculate various vegetation cover types as needed by the Forest Service.

Results and Discussion

The final product is derived R2Veg data organized in a table as Appendix D. This R2Veg compatible data is provided with the rest of the polygon data from the GRSA vegetation geodatabase, which may be helpful to R2Veg analysts. The most specific and useful metric for each polygon was the dominant vegetation canopy cover (density), which was organized into four classes with Map Class and the metric. This polygon canopy cover metric of the dominant lifeform/vegetation layer was split among listed dominant/diagnostic species for the map class. The elevation classes were broad because life zones vary considerably depending on aspect with lower elevation types extending up on warmer southerly aspects. For example, I have seen individual pinyon trees at nearly 10,000 feet in elevation. Some higher elevation typed also extend further down than expected in cold air drainage areas. Again, these data are initial vegetation cover estimates can then be used to calculate a various vegetation cover type as needed by the US Forest Service until more precise photo-interpretated or field data can be acquired. Iterative refinement of polygon data is part of the R2Veg mapping strategy.

List of Deliverables

1. Travel and salary for NatureServe ecologist to participate in GRSA Vegetation Mapping Project Close-out meeting (March 2-3, 2010).
2. Final crosswalk “rule set” that can be programmed into Rio Grande National Forest R2Veg Geodatabase to calculate the GRSA map class from polygon data.
3. GRSA map class/NWI wetland habitat class crosswalk tables.
4. R2Veg geodatabase compatible data of dominant lifeform and species cover for polygons within USFS Baca land addition of the Rio Grande National Forest.
5. Final report.

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National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov