

RECONNAISSANCE SURVEY OF ROCK OUTCROP COMMUNITIES IN THE KIMBALL GRASSLANDS OF NEBRASKA



Prepared for the Nebraska Natural Heritage Program
Nebraska Game and Parks Commission

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SUMMARY

The Kimball Grasslands is recognized as a Biologically Unique Landscape by the Nebraska Natural Legacy Project. Located in the southwest part of the Nebraska Panhandle, the Kimball Grasslands hosts a significant number of Nebraska plants of conservation concern (S1-S2). Most of these species are associated with the Rock Outcrop community type, which has been identified by NNLP as a priority for conservation in the Kimball Grasslands. A reconnaissance survey was conducted to gain a better understanding of the ecology of the Rock Outcrop community type in the Kimball Grasslands and of the state-rare species associated with it. The survey targeted historical occurrences of ten species of conservation concern in Nebraska: *Astragalus hyalinus*, *Astragalus shortianus*, *Eriogonum nebraskense*, *Linanthus cespitosus*, *Mentzelia multiflora*, *Oxytropis multiceps*, *Pediomelum linearifolium*, *Phlox muscoides*, *Physaria ovalifolia*, and *Scutellaria brittonii*. Additional areas of potential habitat were also surveyed. Most of these species have a globally secure conservation status (G4-G5) but are known from only a limited number of occurrences in Nebraska at the periphery of the overall range of the species. The rock outcrop habitat in which these species occur is widespread in the Kimball Grasslands and the Rock Outcrop community type associated with this habitat is generally in good ecological condition and not seriously threatened. Four intergrading types of vegetation were distinguished in the Rock Outcrop community type: Caprock, Stony Upland, Outcrop Margin, and Outcrop Slope. The Rock Outcrop communities of the Kimball Grasslands harbor regional endemics, sensitive plant species that occur nowhere else in Nebraska, and unique vegetation, and likely support animal species of conservation concern. For these reasons, occurrences of this natural community are of significant ecological value and important for the conservation of biological diversity in Nebraska and the Great Plains.

INTRODUCTION

Purpose of Project

The Kimball Grasslands is recognized as a Biologically Unique Landscape by the Nebraska Natural Legacy Project (NNLP). Located in the southwest part of the Nebraska Panhandle, the Kimball Grasslands hosts a significant number of Nebraska plants of conservation concern (S1-S2). Most of these species are associated with the Rock Outcrop community type, which has been identified by NNLP as a priority for conservation in the Kimball Grasslands. A reconnaissance survey was conducted to gain a better understanding of the ecology of the Rock Outcrop community type in the Kimball Grasslands and of the following state-rare species associated with it: *Astragalus hyalinus*, *Astragalus shortianus*, *Eriogonum nebraskense*, *Linanthus cespitosus*, *Mentzelia multiflora*, *Oxytropis multiceps*, *Pediomelum linearifolium*, *Phlox muscoides*, *Physaria ovalifolia*, and *Scutellaria brittonii*.

Plan of Work

The survey was conducted during two time periods in 2014. The first, May 28-June 2, was timed to correspond with the late-spring to early-summer flowering periods of *Astragalus shortianus*, *Linanthus cespitosus*, *Oxytropis multiceps*, *Phlox muscoides*, *Physaria ovalifolia*, and *Scutellaria brittonii*. The second, July 23-25, was timed to the mid- to late-summer flowering seasons of *Astragalus hyalinus*, *Eriogonum nebraskense*, *Mentzelia multiflora*, and *Pediomelum linearifolium*.

Survey work was guided by locality data provided by the Nebraska Natural Heritage Program database, and by data derived from herbarium specimens held by the Bessey Herbarium of the University of the Nebraska State Museum. These data provided a list of historical occurrences to locate and search for extant occurrences of the target species. Search for previously unrecorded occurrences was accomplished by locating potential habitat with the aid of topographic maps and attempting to reach the habitat via county roads. A total of about 40 occurrences of rock outcrop habitat were surveyed during the study. Some of these were visited during both the May 28-June 2 and July 23-25 survey periods.

Previous Investigations

The flora and plant communities of the Kimball Grasslands region were first reported on by Pound and Clements (1900) in *Phytogeography of Nebraska*, in which they took note of the unique vegetation associated with escarpments and rock outcrops in the “Lodge Pole district” of western Nebraska, identifying it as part of the “Mat and Rosette Formation of Buttes, Cliffs, and Hills.” Rydberg botanized in the region during the summer of 1891 (Kiener 1951), during which time he collected the type specimens of three species that were targets of the present study—*Astragalus hyalinus*, *Eriogonum nebraskense*, and *Physaria ovalifolia*. During this survey he also collected specimens of two other targeted species—*Oxytropis multiceps* and *Phlox muscoides*. Botanical surveys of nearby areas were made by Hardy (1991) in Banner County, Nebraska to the north and by Hazlett (1998) in the Pawnee National Grassland of northeastern Colorado.

KIMBALL GRASSLANDS OVERVIEW

Location

The study area is the region of western Nebraska identified by NNLP as the “Kimball Grasslands” (Schneider et al. 2005). As delineated by NNLP, the Kimball Grasslands occupies most of the western half of Kimball County, Nebraska. The Kimball Grasslands is located within a larger North American grassland priority conservation area recognized as the “Pawnee Grasslands,” which is centered on the Pawnee National Grassland of northeastern Colorado and extends into the southern portions of Kimball and Cheyenne counties of Nebraska and adjacent southeastern Wyoming (CEC & TNC 2005; Pool and Panjabi 2011).

Physiography

The Kimball Grasslands is situated in the northern portion of the High Plains section of the Great Plains Physiographic Province (Fenneman 1931). The surface geology and soils of the northern High Plains are influenced by Tertiary-age non-marine deposits extending eastward from the Hartville and Laramie uplifts in Wyoming, primarily the Ogallala Group (Miocene to earliest Pliocene) and the Arikaree Group (Late Oligocene to Early Miocene) (Swinehart et al. 1985).

The Kimball Grasslands are located within a region referred to in Nebraska geographical, geological, and ecological literature as the “Cheyenne Plains” (Condra 1906; Weaver & Albertson 1956), “Cheyenne

Table” (Condra 1920; Weaver 1965), and “Cheyenne Tableland” (Hardy 1991; Maher et al. 2003). This relatively flat to rolling tableland is a remnant of the original High Plains surface. It comprises the whole of Kimball and Cheyenne counties, along with much of Deuel, the southern parts of Banner and Morrill counties, and the southwestern part of Garden County. The term “Cheyenne Tablelands” has been applied to a larger region in western Nebraska, southeastern Wyoming, and northeastern Colorado that represents the preserved interfluvium between the North and South Platte rivers capped by Ogallala sediments (McMillan et al. 2002).

Topography and Landforms

The surface of the Cheyenne Tableland is generally level to moderately rolling and mantled with soil. Elevation in the Kimball Grasslands region ranges from 1,653 m (5,424 ft) at Panorama Point in southwestern Kimball County, the highest point in Nebraska, to 1350 m (4,430 ft) along Lodgepole Creek at the Kimball/Cheyenne county line. Significant areas of exposed rock, broken topography, and bluffs occur along the northern and southern escarpments of the tableland, the northern located in Banner County, Nebraska and the southern just south of the Nebraska-Colorado state line in Weld and Logan counties, Colorado. The northern escarpment stands 60 to 120 m (200 to 400 feet) above the valley of Pumpkin Creek, a tributary of the North Platte River. The southern escarpment demarks the boundary between the High Plains and the lower Colorado Piedmont, and forms a dramatic and irregular line of cliffs, breaks, and erosional outliers in the vicinity of the Pawnee National Grassland. In addition, significant areas of exposed rock and broken topography are found along the valley of Lodgepole Creek and its tributaries, notably Sand Draw and Sidney Draw. Another area of rugged topography occurs along Lawrence Fork, a tributary of Pumpkin Creek that flows east to join the North Platte River near Bridgeport, Nebraska. The upper portion of the Lawrence Fork occurs in an area of breaks and canyons along the Banner/Kimball county line referred to as Rocky Hollow.

Bedrock Geology

The surface geology of the Kimball Grasslands region is dominated by the Ash Hollow Formation of the Ogallala Group (Swinehart & Diffendal 1997). The Ash Hollow Formation is typified by hard calcium carbonate or silica-cemented layers of sandstone or siltstone that form gray ledges that are as much as several feet thick and are separated from one another by softer materials. Significant exposures of the Ash Hollow Formation are associated with incised stream channels and drainageways and appear in the landscape as bedrock ledges and bluffs. Over a broad region of the Kimball Grasslands, bedrock is partially exposed on upland divides and on the crests of rolling hills, ridges, shoulder slopes, and breaks where it has weathered into small fragments of rock and gravel.

Soils

The principal soil associations of the Kimball Grasslands region are Rosebud, Rosebud-Canyon, and Rock Land-Canyon-Rosebud (Jackson 1962). The Ash Hollow Formation of the Ogallala Group is the parent material of all of these associations. The Rosebud Association occurs on high tablelands and is mostly in cultivation. Rosebud soils are deep and moderately deep loamy soils that have a silty subsoil and have developed in calcareous, moderately sandy materials weathered from sandstone and siltstone. The Rosebud-Canyon Association occurs mainly along small, intermittent streams and drainageways. This association is a complex of Rosebud and Canyon soils, the Canyon series consisting of very shallow and shallow loamy soils that overlie sandstone and limestone. The Rock Land-Canyon-Rosebud Association occurs in steep, rocky slopes in the most rugged areas of the region, primarily in association with Lodgepole Creek, Sidney Draw, and Rocky Hollow. Soils of this association are poorly developed to absent with bedrock at or near the surface, stony, and with little organic matter. Where soil formation has occurred it consists of very shallow sandy loams or silty loams.

Regional Climate

The climate of the region is semiarid and continental, with cold winters, short summers, and extremes of temperature. The average growing season is 137 days. Average annual precipitation in the region is 42 cm (16.5 in). Periods of consecutive wet and dry years tend to occur. The region is subjected to strong winds. Prevailing winds are from the southeast from May through August and from the northwest the rest of the year. Wind velocities are strongest in the spring and weakest in the summer (Jackson 1962).

Regional Vegetation

Mixed-grass prairie is the typical vegetation of upland areas of the Kimball Grasslands that have not been converted to agricultural cropland. This matrix vegetation is classified at the community level as Threadleaf Sedge Western Mixed-Grass Prairie, which is a component community of the Western Great Plains Mixed-Grass Prairie ecological system (Rolfsmeier & Steinauer 2010). This community is dominated by short and mid-height (0.5-1 m tall) cool-season graminoids, primarily *Carex filifolia* (threadleaf sedge), along with the warm-season *Bouteloua gracilis*, and a sparse to moderate layer of mid-grasses, usually dominated by *Hesperostipa comata*.

Land Use

Most of the deep, loamy tableland soils of the Kimball Grasslands region have been converted to agricultural production. Winter wheat is the major crop, occupying 87,009 acres of land in Kimball County in 2007 (USDA Census of Agriculture). Non-cultivated areas are managed as rangeland for grazing domestic livestock. The landscape is also impacted by energy development operations and by military installations associated with U.S. Air Force intercontinental ballistic missile launch sites.

THE ROCK OUTCROP COMMUNITY IN THE KIMBALL GRASSLANDS

Classification and Characteristics

The subject of this reconnaissance survey is the natural community type recognized as “Rock Outcrop” in the Terrestrial Ecological Systems and Natural Communities of Nebraska (Rolfsmeier & Steinauer 2010). This community is a component of the Western Great Plains Cliff and Outcrop ecological system of NatureServe (2014). It is characteristic of exposed, rocky uplands in the Nebraska Panhandle where the surface geology is dominated by sandstones of the Arikaree or Ogallala Groups and parent material is at or near the surface with soils thin or absent. The Rock Outcrop community is sparsely vegetated, with an herbaceous cover of < 25%. It occurs in small to sometimes large patch areas within the matrix of mixed-grass prairie vegetation.

Rock outcrop habitat presents environmental conditions more stressful than that supporting the surrounding grassland vegetation. These conditions include soils that are poorly developed or absent with little moisture-retaining organic matter that dry more quickly than adjacent areas during much of the growing season. Such conditions mostly exclude the surrounding grassland vegetation and result in habitat that experiences full exposure to the sun and wind, which desiccates plant tissues and makes the environment even more xeric by increasing runoff of rainfall and hindering accumulation of moisture-replenishing snow cover in winter. Rock outcrop habitat also experiences high light levels during the daytime and radiation of heat to the sky at night, which in turn results in wider fluctuations in daily temperatures than would be experienced in other habitats.

Despite these challenging environmental conditions, rock outcrop habitat in the Kimball Grasslands supports a unique assemblage of plant species. These communities are dominated by perennial forbs,

many of which have the distinctive low stature and dense, compact form of “cushion plants” that are characteristic of alpine and subpolar ecosystems (Figures 2, 5, 8). The cushion growth form is due to a combination of tightly interlocking apical meristems coupled with a dense sub-canopy composed of stems and senesced leaves (Butterfield et al. 2013). The term “cushion plant” is used broadly to include species that are not mounded in outline but still form dense mats of stems and foliage. Cushion plants are tap-rooted, which allows them to find footing in the crevices and fractures of exposed bedrock. They are long-lived perennials. These unique plants are habitat specialists and only occur in rock outcrop habitat.

Community Structure

Four intergrading types of vegetation were discerned within the Rock Outcrop community type in the Kimball Grasslands. These are here termed Caprock, Stony Upland, Outcrop Margin, and Outcrop Slope.

Caprock (CR): This vegetation is associated with open, relatively level exposures of bedrock that “cap” escarpments, bluffs, and ledges (Figures 1, 2). It is dominated by forbs, most of which are cushion plants. Several species of cushion plants are ubiquitous in Caprock vegetation in the Kimball Grasslands, notably *Crypantha cana*, *Eremogone hookeri*, *Eriogonum flavum*, *Paronychia depressa*, and *Tetranuris acaulis*. Other commonly occurring cushion plants include *Astragalus sericoleucus*, *Astragalus spatulatus*, *Paronychia sessiliflora*, *Physaria reediana*, and *Stenotus armerioides*. Another important cushion plant in these communities is *Phlox muscoides*, which is not found in all Rock Outcrop communities in the Kimball Grasslands but is almost always the dominant forb where it does occur.

A number of low-growing, non-cushion forbs are associated with Caprock vegetation, but are often of secondary importance. These include *Musineon tenuifolium*, *Oenothera lavandulifolia*, *Packera cana*, and *Phlox hoodii*.

Grasses contribute little to vegetation cover in Caprock habitat, except around the margins of the outcrop exposure or where soil has accumulated in depressions in the bedrock. *Achnatherum hymenoides* is the most commonly occurring grass in Caprock vegetation.

Stony Upland (SU): This vegetation is associated with shallow to very shallow soils on relatively broad ridge crests and uplands of rolling terrain (Figure 3). Species composition depends on depth of soil and percentage and size of rock fragments present. Sites with stony, relatively shallow soils have a species composition similar to that of Caprock habitat while sites with somewhat deeper soils support a grassland formation that corresponds to Threadleaf Sedge Western Mixed-Grass Prairie (Rolfmeier & Steinauer 2010), dominated by *Carex filifolia* and *Bouteloua gracilis*. This vegetation type corresponds to the “Very Shallow Range Site” rangeland classification (Jackson 1962) and is often described as “rocky prairie” on herbarium specimen labels. Because it is comprised of species typical of the Caprock and Outcrop Margin types plus the surrounding matrix grassland, Stony Upland is probably the most species-rich of the four Rock Outcrop community vegetation types.

Outcrop Margin (OM): This vegetation occurs in the context of rock outcroppings in relatively level terrain where soil depth gradually increases away from the outer edges of exposed bedrock (Figure 1). The result is an ecotone between the vegetation of the exposed rock and the surrounding matrix of mixed-grass prairie. *Schizachyrium scoparium* and *Bouteloua curtipendula* are common at outcrop edges. Common forbs in this zone include *Castilleja sessiliflora*, *Erysimum asperum*, *Lithospermum incisum*, *Phlox andicola*, and *Zigadenus venenosus* var. *gramineus*. *Yucca glauca* is often present, along with the subshrubs *Artemisia frigida*, *Eriogonum effusum*, and *Krascheninnikovia lanata*.

Outcrop Slope (OS): This vegetation is associated with moderate to steep slopes below escarpments and rock outcrop ledges (Figure 4). It is characterized by an open shrub layer dominated by *Rhus aromatica*

var. *trilobata* in association with grasses *Schizachyrium scoparium* and *Achnatherum hymenoides*. Other shrubs include *Yucca glauca*, *Eriogonum effusum*, and *Prunus pumila* var. *besseyi*. This vegetation shares some of the same forb species with Outcrop Margin. In the Kimball Grasslands, this is the typical habitat of *Pediomelum linearifolium* and *Scutellaria brittonii*, two species of conservation concern.

Characteristic Species

The following species were those most commonly observed in association with the Rock Outcrop community type in the Kimball Grasslands. The abbreviation(s) indicates the vegetation type(s) in which the species most commonly occurred (see above). Nebraska species of conservation concern are in boldface type.

<i>Achnatherum hymenoides</i>	CR, SU, OS	
<i>Artemisia frigida</i>	OM, OS	
Astragalus hyalinus	CR	
<i>Astragalus sericoleucus</i>	CR, SU	
<i>Astragalus spatulatus</i>	CR, SU	
<i>Bouteloua curtipendula</i>	OM, OS	
<i>Bouteloua gracilis</i>	SU	
<i>Carex filifolia</i>	OM, SU	
<i>Castilleja sessiliflora</i>	OM, SU	
<i>Cryptantha cana</i>	CR, SU	
<i>Cryptantha thrysiflora</i>	CR, SU	
<i>Dalea candida</i>	OM, OS	
<i>Eremogone hookeri</i>	CR, SU	[= <i>Arenaria hookeri</i>]
<i>Eriogonum alatum</i>	CR	
<i>Eriogonum effusum</i>	CR, OS	
<i>Eriogonum flavum</i>	CR, SU	
<i>Eriogonum pauciflorum</i>	CR	[subsp. <i>gnaphalodes</i>]
<i>Erysimum asperum</i>	OM	
<i>Hedeoma drummondii</i>	CR, SU	
<i>Hesperostipa comata</i>	OM	
<i>Ipomopsis spicata</i>	CR	
<i>Krascheninnikovia lanata</i>	OM	
<i>Liatris punctata</i>	OM	
<i>Lithospermum incisum</i>	OM, SU	
<i>Mentzelia decapetala</i>	CR	
Mentzelia multiflora	CR	
<i>Musineon tenuifolium</i>	CR, SU	
<i>Oenothera lavandulifolia</i>	CR, SU	[= <i>Calylophus lavandulifolius</i>]
<i>Oxytropis lambertii</i>	SU, OM	
<i>Packera cana</i>	CR, SU	
<i>Paronychia depressa</i>	CR	
<i>Paronychia sessiliflora</i>	CR, SU	
<i>Pediomelum esculentum</i>	SU	
<i>Penstemon albidus</i>	OM	
<i>Phlox andicola</i>	OM, SU	
<i>Phlox hoodii</i>	CR, SU	
Phlox muscoides	CR, SU	[= <i>P. bryoides</i>]
<i>Physaria reediana</i>	CR, SU	[formerly included in <i>Lesquerella alpina</i>]
<i>Prunus pumila</i> var. <i>besseyi</i>	OS	

<i>Rhus aromatica</i> var. <i>trilobata</i>	OS	
<i>Schizachyrium scoparium</i>	OM, OS	
Scutellaria brittonii	OS	
<i>Stenotus armerioides</i>	CR, SU	
<i>Tetraneuris acaulis</i>	CR	
<i>Thelisperma filifolium</i>	CR	
<i>Townsendia</i> sp.	CR, SU	
<i>Viola nuttallii</i>	SU	
<i>Xanthisma spinulosum</i>	SU	
<i>Yucca glauca</i>	OM, OS	
<i>Zigadenus venenosus</i>	OM, OS	[var. <i>gramineus</i>]

SPECIES OF CONSERVATION CONCERN

Ten species of conservation concern are associated with the Rock Outcrop community type in the Kimball Grasslands. Profiles summarizing observations made during the reconnaissance survey of the region are provided below (NNHP = Nebraska Natural Heritage Program). Descriptions of these species, all of which are perennial herbs, can be found in *Flora of Nebraska* (Kaul et al. 2011).

Astragalus hyalinus M. E. Jones Summer Orophaca

NNHP STATUS: G4/S2

Astragalus hyalinus M. E. Jones, Proc. Calif. Acad. Sci., ser. 2. 5: 648. 1895 [*Orophaca hyalina* (M. E. Jones) Isely, Syst. Bot. 8: 424. 1983]

History: Rydberg collected *Astragalus hyalinus* in the study area on 10 August 1891, the location on the specimen label (*Rydberg 80*; NEB!) stating “Kimball County, Nebraska” and “Upper Lawrence Fork.” This specimen appears to be the holotype of the species (Isely 1983), although this is not entirely clear from the original description (Jones 1895) or subsequent systematic treatments (Barneby 1964).

GLOBAL DISTRIBUTION: CO, KS, MT, NE, SD, WY

NEBRASKA DISTRIBUTION: Banner, Cheyenne, Kimball, Morrill, Scotts Bluff, and Sioux counties

KIMBALL GRASSLAND OCCURRENCES: 5 observed (2 historical + 3 new); individuals common within occurrences (Figures 5, 6)

KIMBALL GRASSLANDS HABITAT: Caprock; Outcrop Slope; often in association with *Phlox muscoides*; one occurrence associated with *Pinus flexilis* woodland

Astragalus shortianus Nuttall ex Torrey & A. Gray Short’s Milkvetch

NNHP STATUS: G4/S1

Astragalus shortianus Nuttall ex Torrey & A. Gray, Fl. N. Amer. 1: 331. 1838

GLOBAL DISTRIBUTION: CO, MT, NE, NM, WY

NEBRASKA DISTRIBUTION: Banner and Kimball counties

KIMBALL GRASSLANDS OCCURRENCES: None observed (4 historical sites searched)

KIMBALL GRASSLANDS HABITAT: Extant occurrences were not observed during the study but the vegetation of the sites of historical occurrences would be classified as Stony Upland. Hardy

(1991) described the habitat of this species in Banner County as “Gravelly outcroppings in prairie.”

Eriogonum nebraskense Rydberg
Nebraska Wild Buckwheat

NNHP STATUS: None

Eriogonum nebraskense Rydberg, Fl. Rocky Mts. 224, 1061. 1917 [*E. multiceps* Nees subsp. *nebraskense* (Rydberg) S. Stokes, *Eriogonum* 94. 1936; *E. pauciflorum* Pursh var. *nebraskense* (Rydberg) Reveal, *Great Basin Nat.* 27: 113. 1967]

History: Rydberg collected the type material in the study area on 12 August 1891, the location on the specimen label (*Rydberg 337*; holotype at NY!; isotypes at NY!, US!) stating “Kimball County, Nebraska” and “Prairies.” The taxonomic status of this entity is currently uncertain but it may prove to be a good species. It was originally described by Rydberg (1917) as *Eriogonum nebraskense*. Reveal (1967) treated it as *E. pauciflorum* var. *nebraskense* then submerged it into *E. effusum* var. *effusum* (Reveal 1971). In his treatment of *Eriogonum* for the *Flora of North America*, Reveal (2005) recognized it as a hybrid (*E. x nebraskense*) between *E. pauciflorum* and *E. effusum*. I recently sent Dr. Reveal a photograph of a specimen I collected from Kimball County and he confirmed that it is the taxon *nebraskense*. He is interested in revisiting the taxonomic status of *nebraskense* if I can provide him with fresh herbarium specimens and leaf samples for molecular analysis.

GLOBAL DISTRIBUTION: Range extent: CO (Weld), NE, WY (Platte)

NEBRASKA DISTRIBUTION: Cheyenne and Kimball counties

KIMBALL GRASSLANDS OCCURRENCES: 2 observed (1 historical + 1 new); individuals uncommon within occurrences (Figure 7)

KIMBALL GRASSLANDS HABITAT: Caprock; Stony Upland

Linanthus cespitosus (Nuttall) J. M. Porter & L. A. Johnson
Matted Prickly-Phlox

NNHP STATUS: G4/S1

Linanthus cespitosus (Nuttall) J. M. Porter & L. A. Johnson, *Aliso* 19: 82. 2000 [*Leptodactylon caespitosum* Nuttall, *Proc. Acad. Nat. Sci. Philadelphia* 4: 12. 1848]

History: Thomas Nuttall collected the type material in May of 1834 “On the borders of the Platte, and hills near Scott’s Bluffs” (Nuttall 1848). Nuttall was traveling west with the Wyeth Expedition along the route that would later become the Oregon Trail.

GLOBAL DISTRIBUTION: CO, MT, NE, NV, UT, WY

NEBRASKA DISTRIBUTION: Kimball and Scotts Bluff counties

KIMBALL GRASSLANDS OCCURRENCES: None observed. While there are several occurrences of this species north of the study region in the Wildcat Hills and at Scotts Bluff, the only record for the Kimball Grasslands is *Locklear 124* (KANU), which I collected on 12 May 1989 “ca. 6 miles east of Kimball in low, rocky hills south of Interstate Highway 80.” I was unable to relocate this occurrence.

KIMBALL GRASSLANDS HABITAT: Extant occurrences were not observed in the Kimball Grasslands during the study but the vegetation of the sites of occurrences at Scotts Bluff corresponds to Caprock and Outcrop Slope.

Mentzelia multiflora (Nuttall) A. Gray
Yellow Stickleaf

NNHP STATUS: G5/S2S4

Mentzelia multiflora (Nuttall) A. Gray, Pl. Fendler. 48. 1849

GLOBAL DISTRIBUTION: AZ, CA, CO, NE, NM, OK, TX, UT, WY

NEBRASKA DISTRIBUTION: Kimball County

KIMBALL GRASSLANDS OCCURRENCES: 4 observed (all historical occurrences); individuals uncommon within occurrences (Figures 9, 10)

KIMBALL GRASSLANDS HABITAT: Caprock

Oxytropis multiceps Torrey & A. Gray
Dwarf Locoweed

NNHP STATUS: G5/S2

Oxytropis multiceps Torrey & A. Gray, Fl. N. Amer. 1: 341. 1838

GLOBAL DISTRIBUTION: CO, NE, UT, WY

NEBRASKA DISTRIBUTION: Banner, Chase, Dundy, and Kimball counties

KIMBALL GRASSLANDS OCCURRENCES: None observed (3 historical sites searched)

KIMBALL GRASSLANDS HABITAT: Extant occurrences were not observed during the study but vegetation of the sites of historical occurrences would be classified as Stony Upland. Hardy (1991) described the habitat of this species in Banner County as “pebbly hillside outcrops of Cheyenne Tableland.”

Pediomelum linearifolium (Torrey & A. Gray) J. W. Grimes
Slim-leaf Scurfpea

NNHP STATUS: G4/S1

Pediomelum linearifolium (Torrey & A. Gray) J. W. Grimes, Mem. New York Bot. Gard. 61:72. 1990
[*Psoralea linearifolia* Torrey & A. Gray, Fl. N. Amer. 1: 300. 1838]

GLOBAL DISTRIBUTION: CO, KS, NE, NM, OK, TX, WY

NEBRASKA DISTRIBUTION: Garden, Keith, and Kimball counties

KIMBALL GRASSLANDS OCCURRENCES: 1 observed (historical); individuals uncommon within occurrence (Figures 4, 11, 12)

KIMBALL GRASSLANDS HABITAT: Outcrop Slope

Phlox muscoides Nuttall
Shoshone Phlox, Moss Phlox, Musk Phlox

NNHP STATUS: G5/S2

Phlox muscoides Nuttall, J. Acad. Nat. Sci. Philadelphia 7: 42. 1831 [*P. bryoides* Nuttall, J. Acad. Nat. Sci. Philadelphia, ser. 2, i. 153]

GLOBAL DISTRIBUTION: CA, CO, ID, MT, NE, NV, OR, UT, WY

NEBRASKA DISTRIBUTION: Banner, Cheyenne, Kimball, and Sioux counties
KIMBALL GRASSLANDS OCCURRENCES: 9 observed (6 historical + 3 new); individuals common to abundant within occurrences (Figures 2, 8)
KIMBALL GRASSLANDS HABITAT: Caprock; Stony Upland

Physaria ovalifolia (Rydberg) O’Kane & Al-Shehbaz
Oval-Leaf Bladderpod

NNHP STATUS: G5/S1

Physaria ovalifolia (Rydberg) O’Kane & Al-Shehbaz, Novon 12: 326. 2002 [*Lesquerella ovalifolia* Rydberg in N. L. Britton & A. Brown, Illus. Fl. N. U.S. 2: 137. 1897]

History: Rydberg collected the type material in the study area on 11 August 1891, the location on the specimen label (*Rydberg 22*; holotype at NY!; isotypes at NEB! NY! US!) stated as “Kimball County, Nebraska” and “Hills of upper Lawrence Fork.”

GLOBAL DISTRIBUTION: Range extent: CO, KS, NE, NM, OK, TX

NEBRASKA DISTRIBUTION: Banner or Kimball counties

KIMBALL GRASSLANDS OCCURRENCES: None observed. The only known occurrence of this species in Nebraska is the type collection made by Rydberg in 1891. The locality data is too vague to facilitate relocation of the collection site but a forthcoming paper on the itinerary of Rydberg’s 1891 travels by Robert Kaul and David Sutherland may help target an area for future search. No new occurrences were found.

KIMBALL GRASSLANDS HABITAT: Extant occurrences were not observed during present study but Rydberg’s description of the habitat of his collection #22 as “Hills of upper Lawrence Fork” would indicate the habitat of Caprock vegetation, which is consistent with occurrences of this species I have observed in the main part of its range to the south.

Scutellaria brittonii Porter
Britton’s Skullcap

NNHP STATUS: G4G5/S2

Scutellaria brittonii Porter, Bull. Torrey Bot. Club 21: 177. 1894

GLOBAL DISTRIBUTION: CO, KS, NE, NM, WY

NEBRASKA DISTRIBUTION: Cheyenne and Kimball counties

KIMBALL GRASSLANDS OCCURRENCES: 4 observed (all historical occurrences); individuals uncommon within occurrences (Figures 13, 14)

KIMBALL GRASSLANDS HABITAT: Outcrop Slope; one occurrence associated with *Pinus flexilis* woodland

CONSERVATION ISSUES

Species of Conservation Concern – Peripheral Species

Eight of the ten species targeted for the reconnaissance survey are widely distributed and secure in their core range (having a rank of G4-G5) but are known from only a limited number of occurrences in Nebraska where they are at the periphery of their overall range. These species are listed below by region of biogeographic affinity.

Southern Great Plains: *Pediomelum linearifolium*; *Physaria ovalifolia*

Southern Rocky Mountains: *Astragalus shortianus*; *Scutellaria brittonii*

Wyoming Basin: *Linanthus cespitosus*; *Mentzelia multiflora*; *Oxytropis multiceps*; *Phlox muscoides*

Peripheral populations such as these may be genetically distinct from those located in the core of the species distribution and thus important to the conservation of the species. Nebraska occurrences of *Pediomelum linearifolium* and *Physaria ovalifolia* are particularly notable since they are significantly disjunct from the core distribution of these species, and the latter is known from only one collection (the holotype) in Nebraska. Further survey is warranted to locate occurrences of both of these species.

Species of Conservation Concern – Regional Endemics

Two of the ten species targeted for the reconnaissance survey are regional endemics—*Astragalus hyalinus* and *Eriogonum nebraskense*. The distribution of *Astragalus hyalinus* is centered in the northern High Plains (western Nebraska and adjacent parts of northeastern Colorado, northwestern Kansas, and southeastern Wyoming) and the eastern portion of the Wyoming Basin (south-central Montana and central Wyoming).

The distribution of *Eriogonum nebraskense* is even more limited, with the only known occurrences being confined to the Cheyenne Tableland region of western Nebraska, southeastern Wyoming, and northeastern Colorado. As noted in its profile above, the taxonomic status of this entity is uncertain but further study may prove it to be a good species or subspecific taxon. Further survey is warranted.

A number of species associated with the Rock Outcrop community type in the Kimball Grasslands are not tracked as species of conservation concern but are largely endemic to a floristic region of the Great Plains that I have identified as the “Cheyenne Tablelands” (Locklear, in prep.). This region is located at the northern end of the High Plains section of the Great Plains physiographic province and is centered in western Nebraska and adjacent parts of southeastern Wyoming and northeastern Colorado where the ancient High Plains tableland has been entrenched by the North Platte, South Platte, and Niobrara rivers and their tributaries into escarpments, bluffs, buttes, and other rough, broken topography. Endemics of this region that occur in the Kimball Grasslands are *Astragalus sericoleucus*, *Cryptantha cana*, *Eriogonum pauciflorum* var. *gnaphaloides*, *Musineon tenuifolium*, and *Paronychia depressa*.

Threats

The rock outcrop habitat in which these species occur is widespread in the Kimball Grasslands and the Rock Outcrop community type associated with this habitat is generally in good ecological condition and not seriously threatened.

Habitat loss: Some rock outcrop habitat in the Kimball Grasslands has been lost or altered due to road construction, gravel quarrying, extractive energy development, and wind energy development, but such losses appear minor relative to the extensive tracts of this habitat still found throughout the region.

Grazing: While ranching is the prevailing land use of non-cultivated areas in the Kimball Grasslands, the sparse, low-growing vegetation of rock outcrop communities presents little forage for grazing livestock.

Spread of exotic species: Alien plant species were sparse or absent in Rock Outcrop communities except in places where sediments had accumulated or shallow soils formed, most often at the base of slopes below outcrops. Cheatgrass (*Bromus* spp.) and/or yellow sweetcover (*Melilotus officinalis*) were

occasionally present in such situations. Otherwise, alien species are apparently intolerant of the environmental conditions that support Rock Outcrop communities (Rolfmeier & Steinauer 2010). The near-absence of weed species in cushion plant communities has also been noted in studies in Wyoming (Handley & Heidel 2010; Jones 2004, 2005).

Other: Fire suppression may lead to the development of more dense woody vegetation on the slopes below rock outcrops, which could pose a threat to the persistence of populations of *Scutellaria brittonii* by increasing the degree of shading in this habitat.

SIGNIFICANCE OF KIMBALL GRASSLANDS ROCK OUTCROP COMMUNITIES

Uniqueness

The Rock Outcrop communities of the Kimball Grasslands are ecologically distinct in several ways from those occurring elsewhere in western Nebraska.

As defined in the Terrestrial Ecological Systems and Natural Communities of Nebraska (Rolfmeier & Steinauer 2010), the Rock Outcrop community type is not limited to the Kimball Grasslands but occurs throughout western Nebraska. It is found to the north in the Wildcat Hills, the upper Niobrara River Valley, and the Pine Ridge where the surface geology is dominated by rocks of the older Arikaree Group (rather than the Ogallala Group as is the case in the Kimball Grasslands). A number of species associated with rock outcrop habitat in the Kimball Grasslands are also common in these regions, including *Astragalus spatulatus*, *Cryptantha cana*, *Eremogone hookeri*, *Musineon tenuifolium*, *Phlox hoodii*, and *Tetraneuris acaulis*.

Despite these shared species, the Nebraska distributions of six plants of conservation concern are essentially restricted to Rock Outcrop communities in the Kimball Grasslands or, more broadly, to the Cheyenne Tableland, and occur nowhere else in Nebraska: *Astragalus shortianus*, *Eriogonum nebraskense*, *Mentzelia multiflora*, *Phlox muscoides*, *Physaria ovalifolia*, and *Scutellaria brittonii*.

A unique aspect of the vegetation of the Kimball Grasslands is the abundance of rock outcrop habitat dominated by *Phlox muscoides* (Figure 2). While this species is often the dominant herbaceous plant in rock outcrop habitat in the Wyoming Basin of south-central and southwestern Wyoming (Handley & Heidel 2010; Jones 2004, 2005), such occurrences of *P. muscoides* in the Great Plains are essentially limited to the Kimball Grasslands. *Phlox hoodii* often replaces *P. muscoides* in rock outcrop habitat north of the Kimball Grasslands.

Another unique feature of rock outcrop habitat in the Kimball Grasslands is the only occurrence *Pinus flexilis* (limber pine) woodland in Nebraska (Figure 14). These stands are confined to rocky hills near the Nebraska/Wyoming state line just east of Pine Bluffs, Wyoming and are part of a complex of scattered, isolated populations that occur along the High Plains escarpment in southeastern Wyoming and northeastern Colorado (Schuster et al. 1995). These scarp woodlands of *Pinus flexilis* have an open canopy with an herbaceous layer composed of grasses and forbs shared with adjacent rock outcrop communities and/or mixed-grass prairie.

Notable by apparent absence from the Kimball Grasslands are several species of conservation concern associated with rock outcrop habitat in the nearby Wildcat Hills region. These are *Ericamaria parryi* var. *howardii*, *Eriogonum brevicaulis*, *Lomatium nuttallii*, *Phacelia hastata*, *Physaria brassicoides*, and *Stephanomeria runcinata*. The apparent absence of these species from the Kimball Grasslands seems due to differences in surface geology between the two regions. The species in question are associated with habitat formed in the Brule Formation of the White River Group which is exposed in the more deeply

eroded terrain of the Wildcat Hills region. The siltstones of the Brule Formation weather into fine-textured substrates that present a root-inhibiting combination of high rates of erosion, high shrink-swell capacity, low organic matter, low infiltration rate, low fertility, and high alkalinity. In the Wildcat Hills region, the Brule Formation has been eroded into badland terrain and is also exposed as barren slopes below the younger Arikaree Group sandstones that form the caprock of escarpments and buttes. Such habitat is not found in the Kimball Grasslands, where the surface geology is dominated by the sandstones of the Ash Hollow Formation of the Ogallala Group and the older sediments of the White River Group are only exposed in a small area west of Bushnell near Pine Bluffs, Wyoming. Interestingly, *Eriogonum brevicaule*, *Lomatium nuttallii*, and *Phacelia hastata* occur south of the Kimball Grasslands in association with siltstone “barrens” of the Brule Formation where it has been exposed in the deeply dissected terrain of the Pawnee Buttes region.

Importance to Biological Diversity

The Rock Outcrop communities of the Kimball Grasslands harbor regional endemics, sensitive plant species that occur nowhere else in Nebraska, and unique vegetation, and likely support animal species of conservation concern. As such, occurrences of this natural community are of significant ecological value and important for the conservation of biological diversity in Nebraska and the Great Plains.

Rock outcrop habitat in the Kimball Grasslands supports islands of native vegetation in a region where a considerable amount of land has been converted into agricultural production. The biological diversity supported by rock outcrop habitat in the Kimball Grasslands provides ecosystem services that are otherwise absent or greatly diminished in an agricultural landscape. Additionally, Rock Outcrop communities have a more structurally-complex vegetation and higher overall diversity of plant species than the mixed-grass prairie that forms the matrix vegetation on zonal soils in the Kimball Grasslands (Rolfmeier & Steinauer 2010).

The abundance of cushion plant species associated with the Rock Outcrop community type in the Kimball Grasslands likely supports an attendant abundance of pollinating insects. This vegetation is similar to that found in alpine and subpolar regions of the world where cushion plants have been shown to have significantly higher visitation rates and support a greater diversity of pollinators and other arthropods than non-cushion plants (Reid & Lortie 2012). Research in non-alpine rock outcrop habitat on the Laramie Plains of south-central Wyoming has demonstrated the role of cushion plants (notably *Phlox muscoides*, a common rock outcrop species in the Kimball Grasslands) in providing patches or “islands” of floral resources for pollinating bees as well as microhabitat for other arthropods within the context of shortgrass steppe (Tepedino 1979; Tepedino & Stanton 1976, 1980). I observed a considerable amount of insect activity associated with Kimball Grasslands Rock Outcrop communities, particularly during the May 28-June 2 survey, with bumblebees and diurnal sphinx moths being most noticeable.

Some of the insects associated with Rock Outcrop communities in the Kimball Grasslands are likely species of conservation concern. I observed a distinctive green-colored butterfly visiting the flowers of *Eriogonum alatum* in rock outcrop habitat on 24 July 2014. Based on my description, University of Nebraska butterfly-expert Steve Spomer (personal communication, 02 August 2014) identified the species as Western Green Hairstreak (*Callophrys affinis homoperplexa*), which is ranked S1S2 in Nebraska. Steve noted that a number of other butterfly species are localized in rock outcrop communities in the region.

Rock Outcrop communities may also play a role in sustaining populations of grassland birds. A primary reason for recognizing the Kimball Grasslands as a Biologically Unique Landscape in Nebraska is that the region is important to the breeding of grassland bird species that are of conservation concern. The rarest and most well-known of these is Mountain Plover (*Charadrius montanus*), but the Kimball Grasslands

also hosts breeding populations of Chestnut-collared Longspur (*Calcarius ornatus*), McCown's Longspur (*Calcarius mccownii*), Lark Bunting (*Calamospiza melanocorys*), and Horned Lark (*Eremophila alpestris*). The young of these species are fed almost exclusively on a diet of insects, which the parents gather near the nesting area (Johnsgard 2001; Rising 1996). It is possible that Rock Outcrop communities provide productive foraging "pastures" for these grassland birds, particularly in the context of agricultural lands but also as patches of additional insect-attracting floral resources within the context of native prairie vegetation. Most of the forbs associated with Rock Outcrop communities flower in May and early June, and would be at the peak of their attractiveness to flower-visiting insects about the same time chicks are hatching and in need of feeding.

LITERATURE CITED

- Barneby, R. C. 1964. Atlas of North American *Astragalus*. Memoirs of the New York Botanical Garden 13: 1-1188. Parts I and II.
- Butterfield, B. J., et cetera. 2013. Alpine cushion plants inhibit the loss of phylogenetic diversity in severe environments. *Ecology Letters* 16(4): 478-486.
- Commission for Environmental Cooperation and The Nature Conservancy [CEC and TNC]. 2005. North American Central grassland priority conservation areas: technical report and documentation. Eds. J. W. Karl and J. Hoth. Commission for Environmental Cooperation and the Nature Conservancy. Montreal, Quebec.
- Condra, G. E. 1906. Geography of Nebraska. The University Publishing Company, Lincoln, Nebraska.
- Condra, G. E. 1920. The soil resources of Nebraska. University of Nebraska Conservation and Soil Survey Bulletin 15.
- Fenneman, N. M. 1931. Physiography of the Western United States. McGraw-Hill Book Company, New York.
- Handley, J. and B. Heidel. 2010. Status of *Sphaeromeria simplex* (Laramie false sagebrush), south-central Wyoming. Report prepared for the USDI Bureau of Land Management – Wyoming State Office and Rawlins Field Office by the Wyoming Natural Diversity Database – University of Wyoming, Laramie, Wyoming.
- Hardy, J. P. 1991. The vascular flora of Banner County, Nebraska. *Transactions of the Nebraska Academy of Sciences*, 18: 109-126.
- Hazlett, D. L. 1998. Vascular plant species of the Pawnee National Grassland. General Technical Report RMRS-GTR-17. Fort Collins, Colorado: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.
- Heidel, B. and J. Handley. 2004. *Parthenium alpinum* (Nutt.) Torr. & Gray (alpine feverfew): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: <http://www.fs.fed.us/r2/projects/scp/assessments/partheniumalpinum.pdf>.
- Isely, D. 1983. New combinations and two new varieties in *Astragalus*, *Orophaca*, and *Oxytropis* (Leguminosae). *Systematic Botany* 8(4): 420-426.
- Jackson, R. K. 1962. Soil Survey of Kimball County, Nebraska. U.S. Department of Agriculture Soil Conservation Service in Cooperation with University of Nebraska Conservation and Survey Division.
- Johnsgard, P. A. 2001. *Prairie Birds: Fragile Splendor in the Great Plains*. University Press of Kansas, Lawrence, Kansas.
- Jones, G. P. 2004. Cushion-plant vegetation on public lands in the BLM Rock Springs Field Office, Wyoming. Unpublished report prepared for the Bureau of Land Management – Rock Springs Field Office by the Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming.
- Jones, G. P. 2005. Cushion-plant vegetation on public lands in the BLM Rawlins Field Office, Wyoming. Unpublished report prepared for Bureau of Land Management Wyoming State Field Office by the Wyoming Natural Diversity Database, Laramie, Wyoming.

- Jones, M. E. 1895. Contributions to western botany, no. 7. Proceedings of the California Academy of Sciences 5: 611-732.
- Kaul, R. B., D. Sutherland, and S. Rolfsmeier. 2011. The flora of Nebraska, ed. 2. School of Natural Resources, University of Nebraska-Lincoln, Lincoln, Nebraska.
- Kelso, S.; Hall, C.; Maentz, G. 2001. The role of landscape anomalies in regional plant conservation. In: J. Maschinski and L. Holter, tech. eds. Southwestern rare and endangered plants: Proceedings of the Third Conference; 2000 September 25-28; Flagstaff, AZ. Proceedings RMRS-P-23. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Pp. 13-19.
- Kiener, W. 1951. P. A. Rydberg's "Report of a botanical exploration made in western Nebraska in the summer of 1891, as a special agent of the Department of Agriculture. Nebraska History 32: 217-239, 306-331.
- Maher, H.D., Jr., G. F. Engelmann, and R. D. Shuster. 2003. Roadside Geology of Nebraska. Mountain Press Publishing Company, Missoula, Montana.
- McMillan, M. E., C. L. Angevine, and P. L. Heller. 2002. Postdepositional tilt of the Miocene-Pliocene Ogallala Group on the western Great Plains: evidence of late Cenozoic uplift of the Rocky Mountains. Geology 30 (1): 63-66.
- Nuttall, T. 1848. Description of plants collected by Mr. William Gambel in the Rocky Mountains and Upper California. Proceedings of the Academy of Natural Sciences of Philadelphia 4: 7-26.
- Pool, D. and A. Panjabi. 2011. Assessment and revisions of North American Grassland Priority Conservation Areas. Background Paper, Commission for Environmental Cooperation.
- Pound, R. and F. E. Clements. 1900. Phytogeography of Nebraska, ed. 2. Published by the Botanical Seminar of the University of Nebraska, Lincoln, Nebraska.
- Reid, A.M. and C. J. Lortie. 2012. Cushion plants are foundation species with positive effects extending to higher trophic levels. Ecosphere 3(11): Article 96. <http://dx.doi.org/10.1890/ES12-00106.1>.
- Reveal, J. L. 1967. Notes on *Eriogonum* – III: on the status of *Eriogonum pauciflorum* Pursh. Great Basin Naturalist 27(2): 102 – 117.
- Reveal, J. L. 1971. Notes on *Eriogonum* – VI: A revision of the *Eriogonum microthecum* complex (Polygonaceae). Brigham Young University Science Bulletin, Biological Series 13 (1): 1-45.
- Reveal, J. L. 2005. *Eriogonum* Michaux. In Flora of North America North of Mexico, vol. 5. Oxford University Press, New York, pp. 221-430.
- Rising, J. D. 1996. A Guide to the Identification and Natural History of the Sparrows of the United States and Canada. Academic Press, San Diego, California.
- Rolfsmeier, S.B. and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska; Nebraska Natural Heritage Program, Nebraska Game and Parks Commission, Lincoln, Nebraska.
- Rydberg, P. A. 1917. Flora of the Rocky Mountain and Adjacent Plains. Published by the author, New York.
- Schneider, R., M. Humpert, K. Stoner, and G. Steinauer. 2005. The Nebraska Natural Legacy Project: A Comprehensive Wildlife Conservation Strategy. Nebraska Game and Parks Commission, Lincoln, Nebraska.
- Schuster, W. S. F., J. B. Mitton, D. K. Yamaguchi, and C. A. Woodhouse. 1995. A comparison of limber pine (*Pinus flexilis*) ages at upper and lower treeline sites east of the Continental Divide in Colorado. American Midland Naturalist 133(1): 101-111.
- Spomer, Steve, Research Technologist, Department of Entomology, University of Nebraska-Lincoln (personal communication, 02 August 2014).
- Swinehart, J. B. and R. F. Diffendal, Jr. 1997. Geologic Map of the Scottsbluff 1 x 2 Degree Quadrangle, Nebraska and Colorado (GMC-30)
- Swinehart, J. B., V. L. Souders, H. M. DeGrew, and R. F. Diffendal, Jr. 1985. Cenozoic paleogeography of western Nebraska. In: R.M. Flores and S.S. Kaplan, eds. Cenozoic paleogeography of the

- west-central United States. Rocky Mountain Paleogeography Symposium 3, Society of Economic Paleontologists and Mineralogists, Rocky Mountain Section, Denver, Colorado. Pp. 209 – 229.
- Tepedino, V. J. 1979. Bee visitation of *Phlox bryoides* [= *P. muscoides*] (Polemoniaceae). Great Basin Naturalist 39: 197-198.
- Tepedino, V. J. and N. L. Stanton. 1976. Cushion plants as islands. *Oecologia* 25: 243-256.
- Tepedino, V. J. and N. L. Stanton. 1980. Spatiotemporal variation in phenology and abundance of floral resources on shortgrass prairie. Great Basin Naturalist 40: 197-215.
- Weaver, J. E. 1965. Native Vegetation of Nebraska. University of Nebraska Press, Lincoln.
- Weaver, J. E. and F. W. Albertson. 1956. Grasslands of the Great Plains: Their Nature and Use. Johnsen Publishing Company, Lincoln, Nebraska.

Figure 1: Kimball Grasslands Rock Outcrop community with Caprock vegetation in foreground transitioning into Outcrop Margin vegetation. An active golden eagle nest was located on the distant bluff in 2014. Photo taken 30 May 2014



Figure 2: Caprock vegetation of Rock Outcrop community dominated by *Phlox muscoides* and *Cryptantha cana*. Photo taken 30 May 2014



Figure 3: Stony Upland vegetation of Rock Outcrop community in the context of Threadleaf Sedge Western Mixed-Grass Prairie. Photo taken 01 June 2014



Figure 4: Outcrop Slope vegetation of Rock Outcrop community at site of *Pediomelum linearifolium* occurrence. Photo taken 24 July 2014



Figure 5: *Astragalus hyalinus* plant. Photo taken 24 July 2014



Figure 6: *Astragalus hyalinus*, close-up of foliage and flowers. Photo taken 24 July 2014



Figure 7: *Eriogonum nebraskense* plant. Photo taken 25 July 2014



Figure 8: *Phlox muscoides* plant. Photo taken 30 May 2014



Figure 9: *Mentzelia multiflora* plant. Photo taken 24 July 2014



Figure 10: *Mentzelia multiflora*, close up of flower. Photo taken 24 July 2014



Figure 11: *Pediomelum linearifolium* plant. Photo taken 24 July 2014



Figure 12: *Pediomelum linearifolium*, close up of flower clusters and foliage. Photo taken 24 July 2014



Figure 13: *Scutellaria brittonii* plant. Photo taken 01 June 2014



Figure 14: *Scutellaria brittonii* occurrence in *Pinus flexilis* woodland. Photo taken 01 June 2014

