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Kaibab National Forest

Ecological Sustainability Report

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I. INTRODUCTION

The current Land Management Plan for the Kaibab National Forest (Plan) was approved in 1988 and has been amended numerous times (KNF 2008d). Forest Plans provide a framework to guide on-the ground management for forest projects and activities. The National Forest Management Act of 1976 (NFMA) requires that forest plans be revised at least every 15 years. The Kaibab National Forest (KNF or Forest) is in the process of revising the Forest Plan in accordance with NFMA. One aspect of the planning process is the determination of Forest resource sustainability. This Ecological Sustainability Report (ESR) identifies the potential ecological needs for change in the Forest Plan necessary to promote healthy sustainable ecosystems for native plant and wildlife species.

Findings from this report will be integrated with the Kaibab Social and Economic Sustainability Report (KNF 2008e) and will provide the basis for the Comprehensive Evaluation Report (CER). The CER will describe how KNF management strategies and direction have and may continue to affect ecological, social, and economic sustainability, and determine whether the information indicates a need to change the way the Kaibab National Forest is managed.

The ESR is divided into five sections. The Introduction describes the KNF and compares it to the surrounding lands. Systems unique to the KNF are identified, as well as the important contributions the KNF makes to the larger surrounding landscape.

The second section addresses ecosystem diversity. Current condition of vegetation, soils, aquatic systems, and airsheds are described and compared to historic or reference conditions. Reference conditions are assumed to be the most ecologically sustainable conditions; high departures and trends away from these conditions are indications of increased risk of unsustainable and undesirable conditions. Reference conditions are often the desired conditions in the Forest Plan; however regulations, social considerations, and factors beyond the agency's control make reference conditions either unattainable or undesirable in certain locations. This section also discusses projected future conditions and trends.

The third section examines species diversity on the KNF. From a select list of species that occur in Arizona, the list was screened to identify threatened and endangered species, species of concern, and species of interest whose ranges include the Plan area. Associated habitat and ecosystem diversity characteristics were identified for each of these species.

The fourth section summarizes the key findings in ecosystem diversity and species diversity, and identifies the ecosystems and species at risk. These risks are used to determine the ecological need for change in the fifth and final section.

Description of the Planning Unit

The Kaibab National Forest is located in north-central Arizona (Figure 1). It covers 1.56 million acres and is broken into three geographically separate Ranger Districts (Districts). The North Kaibab Ranger District (NKRD) is on the north side of Grand Canyon National Park (GCNP), and the Tusayan Ranger District (TRD) is on the south side. The Williams Ranger District (WRD) lies further to the south and is separated from the Tusayan Ranger District by private and Arizona State owned lands (Figure 2). The KNF is mostly within Coconino County, with less than 1 percent in Mohave and Yavapai Counties.

The Kaibab National Forest, along with the Coconino National Forest and Grand Canyon National Park are at higher elevations than the surrounding Mohave and Sonoran Deserts and the Great Basin. While the KNF shares the dry climate of the surrounding lands, most of it is forests

or woodlands. The KNF has been described as a desert with trees, and is particularly adapted to the frequent wildland fires that are started by lightning from spring and summer thunderstorms.

Figure 1 - Kaibab National Forest and Arizona counties. Dark polygons indicate the 3 Ranger Districts: North Kaibab (north), Tusayan (central), and Williams (south).

While all three Districts share many of the same ecosystem components across the KNF, they have subtle and marked differences. The high elevation Kaibab Plateau that makes up a large portion of the North Kaibab Ranger District, the gently rolling lands of the Tusayan Ranger District, and the cinder cone scattered Williams Ranger District include wide variations in the landscape, vegetation, and wildlife.

Most of the KNF lies between 6,000 and 8,500 feet in elevation, with a few mountains reaching above 9,000 feet. Weather includes cold winters, mild summers, and considerable diurnal temperature changes. The growing season is short, with the average first freeze around September 21st, and last freeze around June 10th.

At 6,865 feet, the average precipitation for Williams, Arizona is 22 inches per year. Average precipitation at the Grand Canyon's South Rim is 17 inches per year, and the Grand Canyon's North Rim is 25 inches per year (Western Regional Climate Center 2008). There are two distinct periods of precipitation; one in the winter from November through April, and the other during the summer rainy season, or 'monsoon,' that occurs July and August, with widespread thunderstorm activity. There is typically a dry period in May and June, and an arid fall following the summer monsoons. Summer precipitation is more reliable and less variable than winter precipitation. Much of the summer rainfall is lost to evaporation and surface runoff, and much less effective hydrologically than winter and spring moisture. Precipitation of the Southwest varies a great deal. In the past one hundred years, there was a drought from 1942 to 1978, an unusually wet period from 1978 to 1995, and another drought from 1996 to the present, which is the driest on record. Though spring precipitation has been dependable over the last ten years, ecosystems that require cool-season moisture, such as ponderosa pine, become increasingly stressed without sufficient winter precipitation (Hereford 2007).

Water is a limited resource on the KNF. North Canyon Creek is the only perennial stream. It is about one and a half miles long and is located on the North Kaibab Ranger District in North Canyon Wash, within the Saddle Mountain Wilderness. There are also seeps and springs; most notable are Big Springs, on the North Kaibab Ranger District; and the similarly named Big Spring on the Williams Ranger District. Much of the water available to wildlife and grazing animals is in the form of earthen stock tanks, artificial lakes, and ephemeral natural lakes (KNF 2008b).

Due to the range of elevations and soil types on the forest, there is a wide diversity of vegetation, but three major types dominate the landscape. Pinyon-juniper woodlands cover 40 percent of the

KNF, followed by ponderosa pine (35%), and mixed conifer forests (8%). Spruce-fir, grasslands, sagebrush and Gambel oak shrublands, and desert communities also occur. Riparian and wetland vegetation is present in small but important areas.

Most of the vegetation types on the KNF are adapted to the frequent, low intensity fire that occurred periodically prior to Euro-American settlement. In fire adapted vegetation types, ecosystem function is dependent on this regular disturbance. As the area was settled, extensive livestock grazing consumed the abundant grasses, which had played an important role in carrying fire. Early settlers also suppressed fire to protect their livelihood and homes. Without fire, understory seedlings in pine and mixed conifer forests had unprecedented survival rates. White fir, Douglas-fir, and even Engelmann spruce seedlings became established under ponderosa pine stands. Juniper and pinyon seedlings invaded former grassland savannahs. The increase in tree density and resulting buildup of woody fuels led to unnaturally large and severe wildfires, insect outbreaks, and reduced biodiversity (Friederici 2004).

Description of the Surrounding Landscape

The Kaibab National Forest shares boundaries with a variety of other landowners (Figure 2). The North Kaibab Ranger District is surrounded by lands administered by the Bureau of Land Management to the north, east, and west; and by Grand Canyon National Park to the south. The Tusayan Ranger District is bounded by Grand Canyon National Park to the north, the Navajo Nation on the east, and private and state lands to the west and south. The Williams Ranger District is bordered by private and state lands to the west and north, by the Coconino National Forest to the east, and the Prescott National Forests to the south. The KNF is mostly surrounded by lower elevation desert communities, except on the eastern boundary of the Williams Ranger District where it forms the westernmost portion of the Mogollon Rim, and is dominated by ponderosa pine.

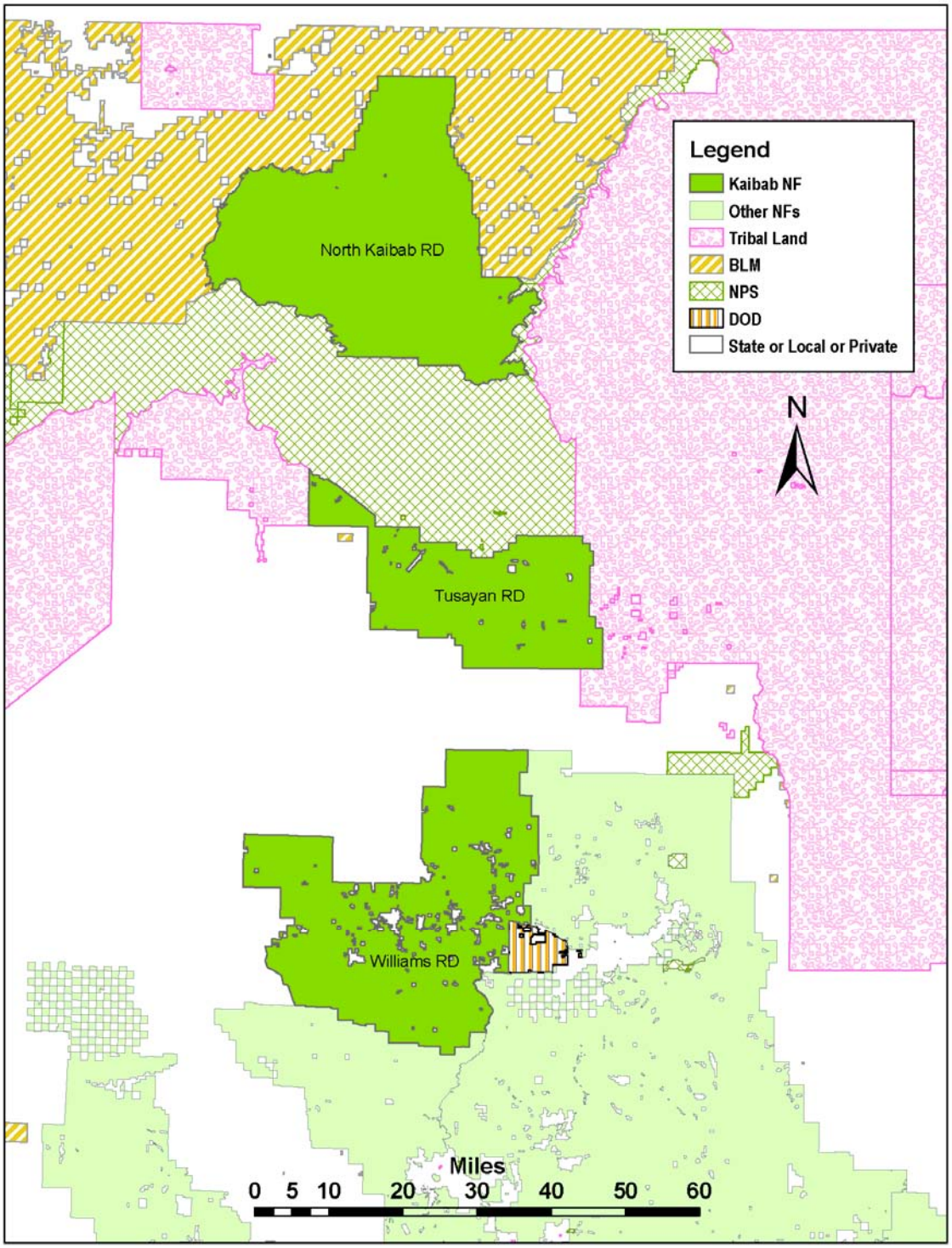

Figure 2 – Land ownership and administrative boundaries around the Kaibab National Forest. RD- Ranger District, BLM- Bureau of Land Management, NPS- National Park Service, DOD- Department of Defense.

Comparison and Importance of the Planning Unit to the Surrounding Landscape

The KNF is inherently connected to its surrounding landscape, regardless of administrative boundaries. Therefore, managers evaluated the Forest's contribution to ecological diversity to the surrounding landscape, as well as within the KNF boundaries. By comparing the KNF to the surrounding landscape, and describing the importance of the Forest to ecological diversity in a broad regional context, we defined the Forest's ecological 'niche'. On the KNF, description of the ecological niche is primarily driven by terrestrial vegetation because the KNF contains very little surface water. However, aquatic systems do play a minor role in defining the Forest's niche. Terrestrial and aquatic systems were each analyzed according to appropriate spatial units.

For the terrestrial vegetation analysis, the vegetation types that occur on the KNF were compared to the surrounding landscape using Bailey's Ecoregion Units (Bailey et al. 1994, McNab and Avers 1994). Bailey's Ecoregions are a nested classification system that divides the United States into Domains, then Divisions, and then further divides them into Provinces and Sections. Sections are described by broad areas of similar sub-regional climate, geomorphic process, geology, geomorphic origin, topography, and drainage networks.

The Kaibab National Forest is located in the Dry Domain that covers much of the western United States. Table 1 displays the distribution of Kaibab National Forest lands within Bailey's ecoregional Sections. Figure 3 displays the juxtaposition of the KNF within the Sections. Each of the three Ranger Districts falls almost entirely into separate Sections, which highlights how different the Ranger Districts are from each other.

Table 1 – Relationship of the land area between the Kaibab National Forest Ranger Districts and Bailey's Ecoregion Sections (Bailey et al. 1994).

Section (Section No.)	Total Section Acreage	KNF Ranger District	KNF Acres in Section	% of KNF in Section	KNF % of Section
Grand Canyon (313A)	19,556,212	North Kaibab	655,078	41%	3.3%
Painted Desert (313D)	8,934,546	Tusayan	331,428 *	21%	3.7%
White Mountains - San Francisco Peaks - Mogollon Rim (M313A)	13,471,798	Williams	613,459 *	38%	4.6%

*Less than 5% of the Tusayan and Williams Ranger Districts fall within the Mohave Desert Section and the Tonto Transition Section. Due to this limited percent, all acres on the Tusayan Ranger District are analyzed as part of the Painted Desert Section, and all acres of the Williams Ranger District are analyzed as part of the White Mountains – San Francisco Peaks – Mogollon Rim Section.

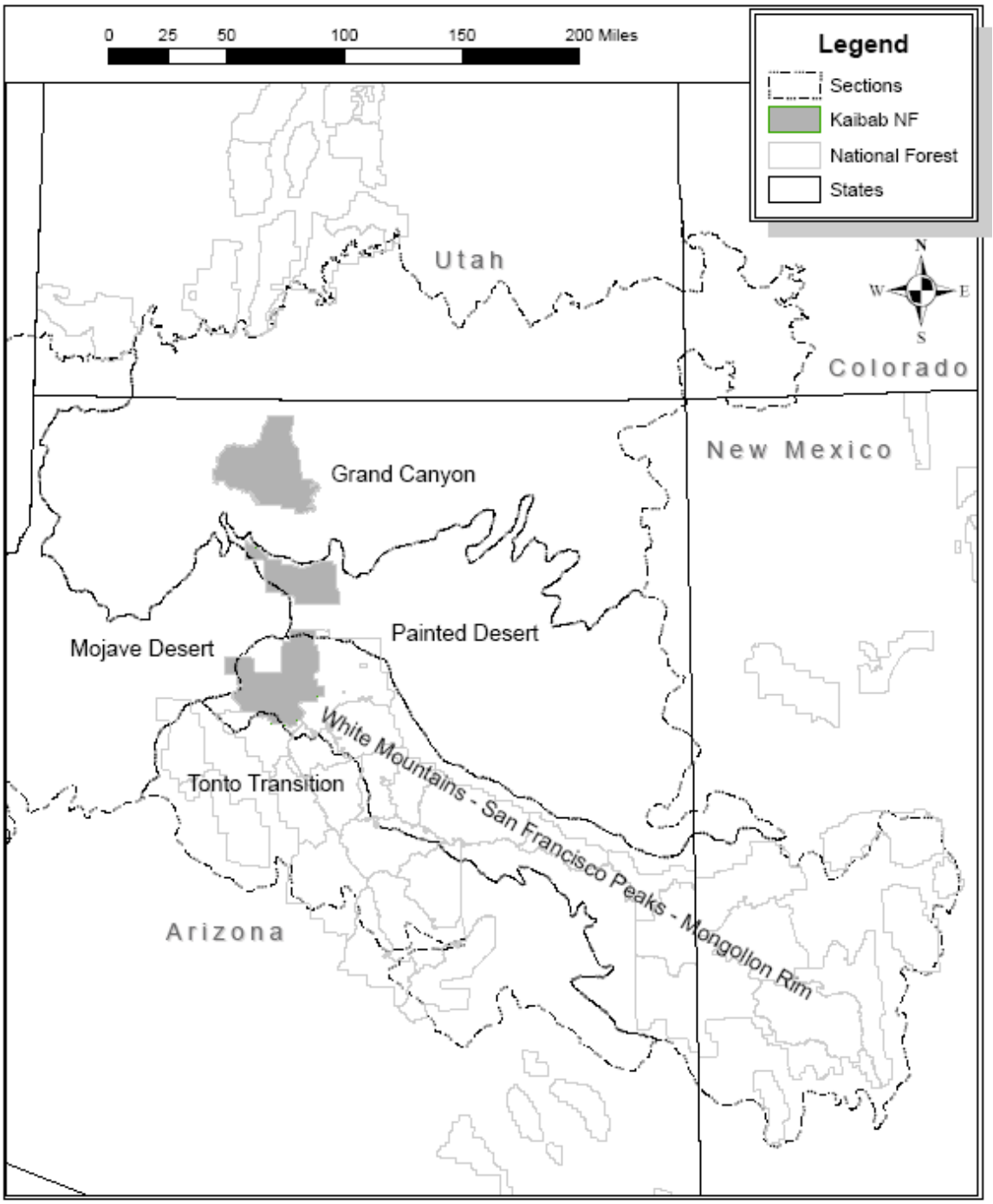

Figure 3 – Map of the Kaibab National Forest in relationship to Bailey's Ecoregion Sections

In the analysis of terrestrial vegetation on the KNF, ecoregional Sub-sections (Bailey et al. 1994) were considered in defining the Forest's spatial niche, but not used for two reasons. First, there were significant mapping inaccuracies that confused rather than focused the niche; and second, adequate definitions were developed at the Section level (Refer to Appendix 1 in the Vegetation and Fire Ecological Need for Change report [KNF 2008f]). The Ranger Districts, which fall almost entirely in separate Sections, are used instead.

Potential Natural Vegetation Type (PNVT) describes coarse-scale groupings of ecosystem types that share similar geography, vegetation, and historic ecosystem disturbances such as fire, drought, and native herbivory (USDA Forest Service 1991, Vander Lee et al. 2006). Only the PNVTs that occur on the KNF were analyzed at the Forest and Section levels, and are described in detail in the Ecosystem Diversity section of this report. Table 2 and Figure 4 display the types and extent of the PNVTs on the Forest. The PNVTs with the greatest number of acres on the KNF are Pinyon Juniper Woodlands, Ponderosa Pine, and Mixed Conifer Forests.

Table 2 – Potential Natural Vegetation Types (PNVT) that occur on the Kaibab National Forest. Acreage and percent are expressed by Forest and Ranger District (North Kaibab- NKRD, Tusayan- TRD, Williams- WRD).

PNVT	Acres on Forest	% of Forest	Acres on NKRD	% of NKRD	Acres on TRD	% of TRD	Acres on WRD	% of WRD
Pinyon Juniper Woodland	647,604	40.5%	248,242	37.9%	188,961	57.0%	210,401	34.3%
Ponderosa Pine	553,310	34.6%	155,209	23.7%	104,881	31.6%	293,219	47.8%
Mixed Conifer Forests [1]	127,848	8.0%	113,620	17.3%	0	0.0%	14,228	2.3%
Sagebrush Shrubland	89,450	5.6%	57,836	8.8%	31,614	9.5%	0	0.0%
Montane / Subalpine Grassland	48,584	3.0%	6,545	1.0%	2,211	0.7%	39,828	6.5%
Colorado Plateau / Great Basin Grassland	44,181	2.8%	0	0.0%	3,761	1.1%	40,419	6.6%
Spruce Fir Forest	29,146	1.8%	29,002	4.4%	0	0.0%	144	<0.1%
Semi-Desert Grassland	25,115	1.6%	25,115	3.8%	0	0.0%	0	0.0%
Desert Communities	13,773	0.9%	13,773	2.1%	0	0.0%	0	0.0%
Gambel Oak Shrubland	5,364	0.3%	3,931	0.6%	0	0.0%	1,433	0.2%
Wetland / Cienega	1,479	0.1%	608	0.1%	0	0.0%	871	0.1%
Cottonwood Willow Riparian Forest	1,197	<0.1%	1,197	0.2%	0	0.0%	0	0.0%
Water, Urban, Agriculture, & Other PNVTs [2]	12,907	0.8%	0	0.0%	0	0.0%	12,907	2.1%
Totals:	1,599,965	100%	655,078	100.0%	331,428	100.0%	613,459	100.0%

[1] Wet and Dry Mixed conifer forest types are combined here and throughout the report unless it is important to separate them. Refer to the Vegetation and Fire Ecological Need for Change report (KNF 2008f) for an explanation.

[2] The PNVTs of Interior Chaparral and Madrean Pine Oak Woodland account for 9 acres, or less than 0.1% of the Forest. Due to their limited extent, and the limited contribution the Forest can make in sustaining these PNVTs, they are not addressed in this report.

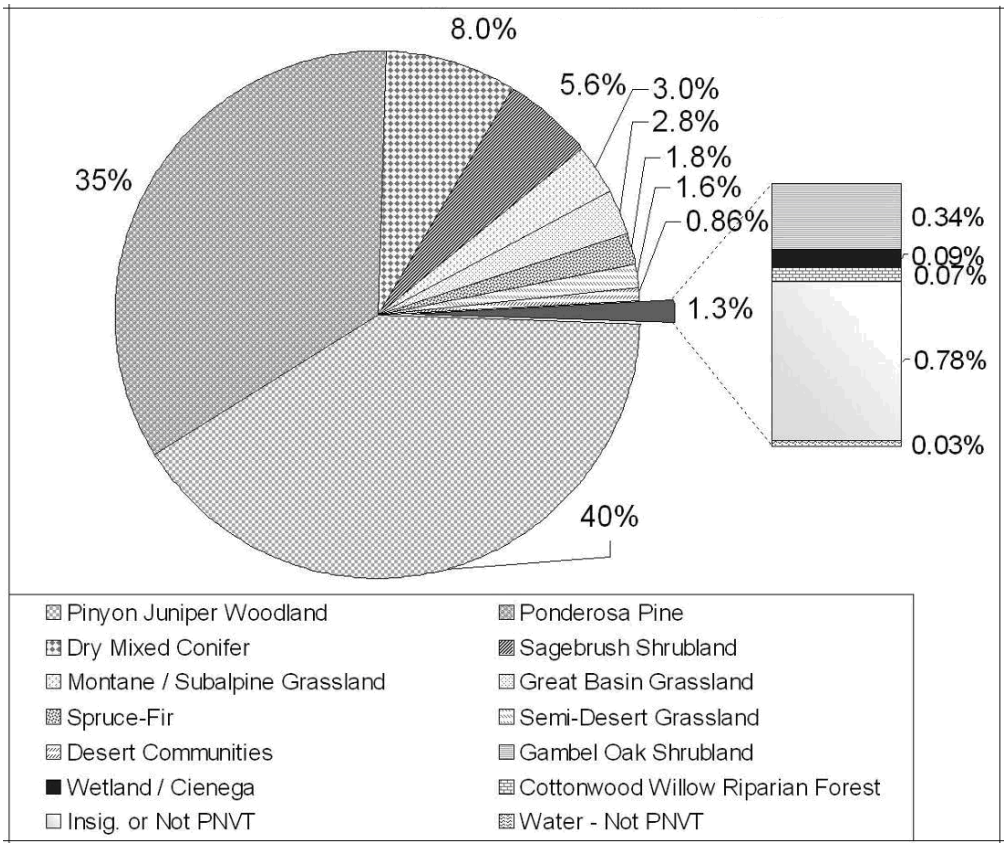

Figure 4 – Percent of Kaibab National Forest in each Potential Natural Vegetation Type (PNVT).

The importance of the contribution of Forest PNVTs to the ecological diversity of the larger landscape is determined by assessing the relative extent of a PNVT on the Forest, assessing the relative extent of a PNVT throughout an ecoregional Section, and calculating the percent of the PNVT on the Forest in the Section. Current condition of the PNVT on the Forest and throughout the Section is also considered, relative to historic "reference conditions" (e.g., TNC 2006). Together, these relationships illustrate how well the PNVTs on the Forest represent the PNVTs across the Section, and figure into the definition of the Forest's ecological niche.

First, PNVTs that exist in a disproportionately high abundance on the Forest relative to the entire Ecosystem Section (≥10% of the area of a PNVT Section-wide) are identified. Next, where the PNVT on the Forest makes up a smaller portion of the Section, it has a smaller contribution to the ecological sustainability of that PNVT in the larger landscape. However, if lands in a PNVT off-Forest throughout a Section are highly departed from reference conditions, the portion of the PNVT on-Forest may provide an important role as an ecological reservoir or refuge, as long as there is enough of the PNVT on-Forest to be useful. For purposes of this analysis, the PNVTs listed in Table 2 are assumed to have enough area on-Forest to benefit ecological diversity in the Sections listed in Table 1. Whether the Forest can actually make this contribution depends on the departure of the PNVT on-Forest, and if departed from reference conditions, whether it can be restored. Current conditions of PNVTs are presented after the following District– Section discussion.

In the following comparison tables (Tables 3-6), a shading scheme is used to identify PNVTs in the Forest's niche. Light (yellow) shading indicates a disproportionately high abundance on-Forest; dark (green) shading indicates a potential ecological reservoir or refuge.

Terrestrial Systems: Context of the Ranger Districts within the Sections

North Kaibab Ranger District in Context of the Grand Canyon Section

The Grand Canyon Section is located in Arizona, Utah, Colorado, and New Mexico. Within Arizona, it covers the area north of the Colorado River and Highway 264. It includes lands administered by the Navajo Nation, Hopi tribe, Southern Utah Paiute Tribe, Arizona Strip BLM, Grand Canyon and other National Park Service area, state and private lands, slivers of the Dixie National Forest, and all of the North Kaibab Ranger District.

The North Kaibab Ranger District covers just over 3 percent of the Section, yet it has 39 percent of the Mixed Conifer Forest PNVTs, 44 percent of the Spruce Fir PNVT, and 28 percent of the Ponderosa Pine PNVT in the Section. Other disproportionately abundant PNVTs on the Forest include Gambel Oak Shrubland (98%), Semi-Desert Grassland (84%), Montane/Subalpine Grassland (25%) and Wetland/Cienega (15%) in this dry Section. Pinyon-Juniper Woodland and Cottonwood Willow Riparian Forest may provide opportunities as species reservoir or refuge because they are departed from reference conditions Section-wide.

Table 3 – Comparison of PNVT composition on the Kaibab National Forest (KNF) within the North Kaibab Ranger District (NKRD), to that across the total Grand Canyon Section.

PNVT	Acres in the Grand Canyon Section (% of Section)	Acres in the NKRD (% of District)	KNF % of the Total PNVT Area Across the Section
Pinyon Juniper Woodland	6,194,022 (31.5%)	248,242 (37.9%)	4.0%
Ponderosa Pine	563,101 (2.9%)	155,209 (23.7%)	27.6%
Mixed Conifer Forests	292,558 (1.5%)	113,620 (17.3%)	38.8%
Sagebrush Shrubland	1,670,758 (8.5%)	57,836 (8.8%)	3.5%
Montane / Subalpine Grassland	26,400 (0.1%)	6,545 (1.0%)	24.8%
Colorado Plateau / Great Basin Grassland	8,944,852 (45.5%)	0 (0.0%)	0.0%
Spruce Fir Forest	66,364 (0.3%)	29,002 (4.4%)	43.7%
Semi-Desert Grassland	29,952 (0.2%)	25,115 (3.8%)	83.9%
Desert Communities	854,498 (4.3%)	13,773 (2.1%)	1.6%
Gambel Oak Shrubland	4,003 (<0.1%)	3,931 (0.6%)	98.2%
Wetland/Cienega	4,060 (<0.1%)	608 (0.1%)	15.0%
Cottonwood Willow Riparian Forest	67,335 (0.3%)	1,197 (0.2%)	1.8%
Other	936,241 (4.8%)	0 (0.0%)	0.0%
Total Area:	19,654,144 (100.0%)	655,078 (100.0%)	3.3%

Note: Light (yellow) shading indicates a disproportionately high abundance; dark (green) shading indicates a potential ecological reservoir/refuge; no shading indicates low abundance on-Forest and little potential for reservoir/refuge status.

Additional Ecological Attributes

The Kaibab Plateau, which is made up of the North Kaibab Ranger District and the North Rim of Grand Canyon National Park, contains a large area of forested habitat that is otherwise nonexistent for many miles, like a 'green island' above the surrounding lands. Because the area was never railroad logged, it is a rare example of a fundamentally intact ponderosa pine forest.

- The North Kaibab Ranger District has one of the highest concentrations of northern goshawks in North America.
- The North Kaibab Ranger District contains an area designated as a National Natural Landmark by the Secretary of the Interior because it is home to the Kaibab squirrel, a sub-species of the Abert squirrel endemic to the Kaibab Plateau.
- The North Kaibab Ranger District is part of the Grand Canyon Game Preserve designated by President Theodore Roosevelt.
- The House Rock Wildlife Area in the southeastern portion of the District is cooperatively managed by the Forest Service and the Arizona Game and Fish Department.
- Aspen is common component of the Ponderosa Pine and Mixed Conifer forests, and Engelmann spruce commonly mix in the overstory.
- The North Kaibab Ranger District contains a rare free-floating bog, which is a Geologic Botanical Area.
- The North Kaibab Ranger District provides foraging and nesting habitat for California condors, and has supported nesting pairs.
- The Kaibab Plateau is one of the few coniferous ecosystems in the Southwest without the significant presence of elk.

Tusayan Ranger District in Context of the Painted Desert Section

The Painted Desert Section is located in Arizona and New Mexico. In Arizona, it occupies the area south of the Grand Canyon and Highway 264. Besides the land on the Tusayan Ranger District of the Kaibab National Forest, it includes lands administered by the Navajo Nation, Hopi Tribe, a small portion of the Coconino National Forest, and state and private lands.

The Tusayan Ranger District makes up about 4 percent of the Painted Desert section (Table 4). Despite its limited extent in the section, 78 percent of the Ponderosa Pine PNVT is on the Forest, and 100 percent of the Montane Grasslands PNVT is on the Forest. Pinyon Juniper Woodland and the Sagebrush Shrubland PNVTs are also disproportionately abundant (11% and 10%, respectively). The Colorado Plateau / Great Basin Grassland PNVT may provide an opportunity for an ecological reservoir or refuge in the Painted Desert Section, since this PNVT is highly departed from reference conditions Section-wide.

Table 4 - Comparison of PNVT composition on the Kaibab National Forest (KNF) within the Tusayan Ranger District (TRD), to that across the total Painted Desert Section.

PNVT	Acres in the Painted Desert Section (% of Section)	Acres in the TRD (% of District)	KNF % of the Total PNVT Area Across the Section
Pinyon Juniper Woodland	1,698,039 (19.0%)	188,961 (57.0%)	11.1%
Ponderosa Pine	134,470 (1.5%)	104,881 (31.6%)	78%
Mixed Conifer Forests	176 (<0.1%)	0 (0.0%)	0%
Sagebrush Shrubland	298,006 (3.3%)	31,614 (9.5%)	10.6%
Montane / Subalpine Grassland	2,211 (0.0%)	2,211 (0.7%)	100%
Colorado Plateau / Great Basin Grassland	6,708,256 (75.2%)	3,761 (1.1%)	0.1%
Spruce Fir Forest	412 (<0.1%)	0 (0.0%)	0%
Semi-Desert Grassland	1,562 (<0.1%)	0 (0.0%)	0%
Desert Communities	948 (<0.1%)	0 (0.0%)	0%
Gambel Oak Shrubland	0 (0.0%)	0 (0.0%)	0%
Wetland/Cienega	374 (<0.1%)	0 (0.0%)	0%
Cottonwood Willow Riparian Forest	19,510 (0.2%)	0 (0.0%)	0%
Other	58,830 (0.7%)	0 (0.0%)	0%
Total Area:	8,922,794 (100.0%)	331,428 (100.0%)	3.7%

Note: Light (yellow) shading indicates a disproportionately high abundance; dark (green) shading indicates a potential ecological reservoir/refuge; no shading indicates low abundance on-Forest and little potential for reservoir/refuge status.

Additional Ecological Attributes

The Tusayan Ranger District includes the southern end of the Grand Canyon Game Preserve, designated by President Theodore Roosevelt. The District and the adjoining portion of Grand Canyon National Park have populations of Abert squirrels and northern goshawks. The Tusayan Ranger District provides foraging habitat for California condors, and is also known for its trophy-sized elk.

Williams Ranger District in Context of the White Mountains – San Francisco Peaks – Mogollon Rim Section

This Section is located on the Mogollon Plateau to the north of the Mogollon rim and south of the Painted Desert Section. It includes the Williams Ranger District of the Kaibab National Forest, portions of the Coconino National Forest, the Apache/Sitgreaves National Forest, the Fort Apache Indian Reservation, and state and private lands.

The Williams Ranger District occupies just over 4 percent of this section, but provides, 10 percent of the Pinyon-Juniper Woodland, 24 percent of the Montane Grassland, and all of the

Gambel Oak Shrublands PNVTs are on the Forest. The District may provide potential reservoirs or refuges for species associated with Ponderosa Pine, Mixed Conifer Forests, and Colorado Plateau / Great Basin Grasslands on-Forest in this Section (Table 5).

Table 5 - Comparison of PNVT composition on the Kaibab National Forest (KNF) within the Williams Ranger District (WRD) to that across the total White Mountain – San Francisco Peaks – Mogollon Rim Section.

PNVT	Acres in the White Mtn. - S.F. Peaks - Mogollon Rim Section (% of Section)	Acres in the WRD (% of District)	KNF % of the Total PNVT Area Across the Section
Pinyon Juniper Woodland	2,917,761 (21.8%)	210,401 (34.3%)	10%
Ponderosa Pine	4,568,209 (34.1%)	293,219 (47.8%)	4.6%
Mixed Conifer Forests	762,415 (5.7%)	14,228 (2.3%)	1.9%
Sagebrush Shrubland	22,137 (0.2%)	0 (0.0%)	0%
Montane / Subalpine Grassland	170,547 (1.3%)	39,828 (6.5%)	23.4%
Colorado Plateau / Great Basin Grassland	1,780,569 (13.3%)	40,419 (6.6%)	2.3%
Spruce Fir Forest	126,034 (0.9%)	144 (<0.1%)	0.1%
Semi-Desert Grassland	759,763 (5.7%)	0 (0.0%)	0%
Desert Communities	49,275 (0.4%)	0 (0.0%)	0%
Gambel Oak Shrubland	1,433 (<0.1%)	1,433 (0.2%)	100%
Wetland/Cienega	15,161 (0.1%)	871 (0.1%)	5.7%
Cottonwood Willow Riparian Forest	5,093 (<0.1%)	0 (0.0%)	0%
Other	2,228,339 (16.6%)	12,907 (2.1%)	0.6%
Total Area:	13,406,736 (100.0%)	614,446 (100.0%)	4.6%

Note: Light (yellow) shading indicates a disproportionately high abundance; dark (green) shading indicates a potential ecological reservoir/refuge; no shading indicates low abundance on-Forest and little potential for reservoir/refuge status.

Additional Ecological Attributes

The cinder cones scattered across the Williams Ranger District has a range of elevation and aspects that create a diversity of habitat patches in what would otherwise be a large contiguous ponderosa pine forest. Aspen occurs in small patches, scattered through the Ponderosa Pine and Mixed Conifer Forest PNVTs. Recently there has been decline in vigor of aspen stands on the District due to a combination of stressors, including insects, disease, herbivory, frost and drought events. The District has three Mexican spotted owl protected activity centers, Arizona bugbane habitat, and the proposed Garland Prairie Natural Research Area. The Williams Ranger District is also known for its trophy-sized elk.

Current Conditions and Trends of PNVTs by Section and Forest

Ecoregional Sections

Departure from reference conditions by PNVT within the key Sections is shown in Table 6, which also summarizes the "Importance of the Planning Unit to the Surrounding Landscape". All shaded cells indicate PNVTs that are important to defining the Forest's spatial niche. An evaluation of overall PNVT departure by PNVT within Sections identifies potential contributions for species reservoirs or refuges. This is based on the classification of vegetation structure within PNVTs as "typical" or "atypical" relative to reference conditions, and the risk of a negative outcome from disturbance by identified threats (see Appendix 2 and KNF 2008f).

Departures generally represent departures in vegetation structure and a similar departure in fire regime. The exceptions are Cottonwood Willow Riparian Forest PNVT, where flooding is the primary disturbance agent, and Desert Communities where fire has played little, if any historic role.

Table 6 – Departure / Risk of a Negative Outcome of PNVTs in key ecoregional Sections. Low (L)- structure likely to be fairly typical of reference period and/or negative outcomes from disturbance not expected; Medium (M)- structure somewhat atypical, at least across 1/3 - 2/3 of the affected area and some negative outcomes expected from disturbances; High (H)- most structure highly atypical with highly negative outcomes expected from disturbances.

PNVT	Grand Canyon	Painted Desert	SFP-WM-MR	Notes
Pinyon Juniper Woodland	M	**M**	**M**	Assumes most of this PNVT is PJ/Grass - as is 2/3 of the KNF.
Ponderosa Pine	**H**	**M**	H	
Mixed Conifer Forests	**H**	-	H	Assumes most of this PNVT is Dry MC - as is > 80% of KNF.
Sagebrush Shrubland	L	**M**	-	
Montane / Subalpine Grassland	L	L	L	
Colorado Plateau / Great Basin Grassland	-	H	M	
Spruce Fir Forest	L	-	L	
Semi-desert Grasslands	L	-	-	
Desert Communities	M	-	-	
Gambel Oak Shrubland	L	-	L	
Wetland / Cienega	H	-	L	
Cottonwood Willow Riparian Forest	H	-	-	Departure considered "H" based on assumptions that this PNVT is dominated by invasive species and the disturbance regime (flooding) is altered by off-Forest impoundments.

Note: Cells with light (yellow) shading indicate PNVTs that have a high abundance on the Forest. Those that are highly abundant on the Forest, and highly (H) or moderately (M) departed from reference conditions across the Section are **shaded and bolded**. Dark (green) shaded cells indicate potential opportunities for the Forest to provide a reservoir role or refuge for species within the Sections. No shading indicates PNVTs with low (L) departure and/or minimal representation on the Forest. A dash (-) indicates a PNVT does not occur on the Forest in the Section.

Forest-wide Preview

Table 7 provides a preview of key findings from the following Ecosystem Diversity section, "Reference and Current Conditions, Future Trends and Risks by PNVT" (also called the "temporal niche" analysis). The current departure from reference conditions and the projected trend towards or away from reference conditions on the KNF is presented here for comparison to the Section-wide information. The details that informed this summary are discussed in the PNVT descriptions presented in the next Ecosystem Diversity chapter. Both the Section-wide and Forest-wide findings are considered together at the end of this report, in the Ecological Need for Change chapter.

Table 7 – Summary of Kaibab National Forest ecological sustainability of PNVT risk assessments including departure from reference conditions and projected future trends

PNVT	Departure from Reference Condition	Projected Future Trend Under Current Management
Pinyon Juniper Woodland	Moderate	Static to Away
Ponderosa Pine	High	Static
Dry Mixed Conifer	High	Away
Sagebrush Shrubland	Moderate	Away
Montane / Subalpine Grassland	Moderate	Away
Colorado Plateau / Great Basin Grassland	Moderate	Away
Spruce Fir Forest	High	Static
Semi-Desert Grassland	Low	Away
Desert Communities	Moderate	Away
Gambel Oak Shrubland	High	Away
Wetland/Cienega	Low	Slowly Away
Cottonwood Willow Riparian Forest	High	Away

Context of Aquatic Systems within Watersheds

The analysis of Aquatic systems used watersheds, rather than ecoregional Sections, to evaluate the Forest's contribution to aquatic ecosystem diversity in the surrounding landscape. The Forest contains portions of eight 4th code watersheds (subbasins), containing an average of 15 percent of the watersheds and no more than 35 percent of any one watershed. The Forest makes up more than 10 percent of four 4th code watersheds (shaded yellow; Table 8). The KNF contains very little surface water, unlike most other Forests in the Southwest Region. In fact, only one natural free-flowing stream persists on the entire Forest; North Canyon Creek, on the NKRD in the Lower Colorado-Marble Canyon subbasin. North Canyon Creek flows above-ground for only about 1.5 miles, and is isolated from any other larger surface water sources. The creek provides habitat for rare species on the Forest, and has played a role in recovering the threatened Apache trout (KNF 2008c; KNF 2008g). The limited extent and isolation of this creek makes it

extremely vulnerable to uncharacteristic disturbances, especially because the PNVTs in the creek's watershed are departed from reference conditions (i.e., Spruce-fir, Mixed Conifer, and Ponderosa Pine forests).

Table 8 – Total subbasin (4th code watershed) area, miles of perennial streams, and percent of each on-Forest.

Subbasin Name (4th Code Watershed)	Sub-basin Area (mi^2)	Area on-Forest (mi^2)	Forest % of Sub-basin	Perennial Stream Miles in Subbasin	Perennial Stream Miles on Forest	% of Perennial Miles on-Forest Within Subbasin
Kanab	1,710	596	34.9%	69.8	0.0	0.0%
Lower Colorado-Marble Canyon	1,467	360	24.5%	67.2	1.5	2.2%
Havasu Canyon	2,933	607	20.7%	13.9	0.0	0.0%
Upper Verde	2,507	425	17.0%	78.5	0.0	0.0%
Lower Little Colorado	2,393	204	8.5%	5.0	0.0	0.0%
Big Chino-Williamson Valley	2,153	178	8.2%	11.9	0.0	0.0%
Paria	382	10	2.6%	25.1	0.0	0.0%
Grand Canyon	2,551	58	2.3%	69.2	0.0	0.0%
Total	**16,096**	**2,438**	**15.1%**	**340.6**	**1.5**	**0.5%**

Note: Shading indicates the KNF contains more than 10% of the subbasin.

Because natural streams and ponds are limited on the KNF, springs and seeps play an important role in providing water for wildlife and rare plants. The Mogollon Rim and the Kaibab Plateau have the highest density of springs in Arizona (pers. comm., Lawrence Stevens, Museum of Northern Arizona). There are approximately 709 springs and seeps in all 4th code watersheds connected to the Forest, and the KNF contains about 129 (18%) of these. Not all seeps and springs have been mapped or evaluated for ecological condition, but some are known to be in good condition, while others have been degraded or modified by use (KNF 2008b).

Precisely because the KNF is a relatively dry national forest in an arid region, the few aquatic resources on the Forest are extremely precious to the ecological diversity of the greater landscape, and warrant particular attention in Forest management decisions.

II. ECOSYSTEM DIVERSITY

The following section describes the ecological assessment and provides Forest-wide overviews of the current conditions, departures from reference conditions, and future trends of the Forest's contribution to the ecological sustainability of each PNVT. Information is presented regarding vegetative composition and structure, disturbance processes, invasive species, and insect/disease status. Fire regime condition class, soil class, aquatics, and airsheds are also evaluated. Detailed information supporting the conclusions is contained in the specialist reports for soils (KNF 2008a), air (Fitch and Truman 2007), water resources (KNF 2008b), vegetation and fire (KNF 2008f), insects and diseases (Lynch et al. 2008), and invasive plants (KNF 2007).

A. Terrestrial Systems

Potential Natural Vegetation Types

Most of the PNVTs on the Kaibab National Forest are adapted to fire as a primary disturbance agent; fire is a necessary process to maintain ecological sustainability. For this reason, the discussion of the ecological diversity and sustainability of the vegetation on the KNF also includes a discussion of the role of fire in ecological sustainability.

Methods

The ecological sustainability risk assessment for each PNVT on the KNF was made by first comparing current conditions to historic, or 'reference', conditions. Then, trends towards or away from reference conditions and potential future conditions were identified and considered in the context of their associated risk.

The term 'reference condition' refers to the ecological conditions that existed prior to European settlement. The reference period used in this analysis was between 1000 and 1880 AD. Reference conditions are assumed to be the most ecologically sustainable conditions; high departures and continuing trends away from these conditions are indicators of increased risk of unsustainable and undesirable conditions.

Each PNVT was described by the developmental structural states that range from a young herbaceous state to an older state, and often include a mix of species. The proportion of the developmental states that occur on the land when the natural disturbance processes and native species are in place is used to describe the historic range of variation for a PNVT.

Reference condition descriptions for each PNVT originated from one or a combination of three sources: (1) Southwest Forest Assessment Project information developed by The Nature Conservancy for the Forest Service (TNC-SWFAP; TNC 2006); (2) Landscape Fire and Resource Management Planning Tools Project data (LANDFIRE 2001); (3) Fire Regime Condition Class Interagency Handbook Reference Conditions (FRCC; NIFCG 2008). In a few cases, where a direct model was not available, surrogates were used (e.g., for the Gambel oak shrubland PNVT, the Madrean pine oak model was used). See the Vegetation and Fire Ecological Need for Change report (KNF 2008f) for details. The distributions of PNVTs on the KNF were identified using information from the Terrestrial Ecosystem Survey report (USDA Forest Service 1991). This report includes field-validated soil type descriptions that were used to predict associated vegetation Forest-wide. Outside the KNF boundaries, Southwest Gap Analysis Project data (SWReGAP 2006) were used to map PNVT composition (see Lowry et al. 2005).

Current conditions were described at the Forest level and the Section level. On the KNF, current conditions for each PNVT were based on the Forest Service Southwestern Region's Mid-Scale

Existing Vegetation Mapping program data (FS Mid-Scale Data; Mellin et al. 2008). Satellite imagery, soils and vegetation inventory data, aerial photography, and other existing base-level maps informed the development of the FS Mid-Scale Data. Mid-scale describes existing vegetation at a scale of 1:100,000 in terms of dominance type (tree, shrub, or grass), dominant species, size class, and canopy cover (Mellin et al. 2008). The percent departure from reference conditions was computed for each modeled PNVT. Departures from 0 to 33 percent were rated Low; departures 34 to 66 percent were rated Moderate, and departures >66 percent were rated as High. At the Section level, similar information was used to describe current conditions (personal communication, Jack Triepke, USFS Southwest Regional Office). Some inconsistencies exist between Forest and Section analyses because Section analyses used only regionally available data (e.g., SWReGAP 2006, LANDFIRE 2001), and less explicitly defined developmental states.

The Vegetation Dynamics Development Tool (VDDT; ESSA Technologies Ltd. 2007) was used to model future conditions and trends towards or away from reference conditions on the Forest, given current management practices. The vegetation models developed by TNC-SWFAP were used in VDDT runs for several of the PNVTs on the Forest. For other PNVTs, specialists from the Regional Office and from the Northern Arizona Forests developed or adapted models for use in VDDT. Some PNVTs were not modeled. Vegetation trend analyses were not conducted at the Section level. The sources for reference conditions, current conditions, and models used for future trends are summarized in Table 9.

Table 9 – Summary of data sources and models for PNVT reference conditions, current conditions, and future trends on the Kaibab National Forest

PNVT	Source for Reference Condition Descriptions & Models[1]	Current Condition Source Data for Percentages	Model Used to Identify Future Trend[2]
Pinyon Juniper Woodland	LANDFIRE	Mid-Scale Vegetation Data	KNF VDDT
Ponderosa Pine	TNC-SWFAP	Mid-Scale Vegetation Data	TNC VDDT, R-3 VDDT, KNF VDDT
Dry Mixed Conifer	TNC-SWFAP	Mid-Scale Vegetation Data	TNC VDDT
Sagebrush Shrubland	LANDFIRE	Mid-Scale Vegetation Data	None
Montane / Subalpine Grassland	LANDFIRE	Mid-Scale Vegetation Data	None
Colorado Plateau / Great Basin Grassland	LANDFIRE	Mid-Scale Vegetation Data	None
Spruce Fir Forest	TNC-SWFAP	Mid-Scale Vegetation Data	TNC VDDT
Semi-Desert Grassland	TNC-SWFAP	Mid-Scale Vegetation Data	TNC VDDT
Desert Communities	LANDFIRE	Mid-Scale Vegetation Data	KNF VDDT
Gambel Oak Shrubland	TNC-SWFAP	Mid-Scale Vegetation Data	None
Wetland/Cienega	FRCC Handbook	Mid-Scale Vegetation Data	None
Cottonwood Willow Riparian Forest	LANDFIRE	Mid-Scale Vegetation Data	None

[1] LANDFIRE- LANDFIRE (2001); TNC-SWFAP- The Nature Conservancy Southwest Forest Assessment Project (TNC 2006); FRCC- Fire Regime Condition Class Interagency Handbook (NIFCG 2008).
[2] VDDT- Vegetation Dynamics Development Tool (ESSA Technologies Ltd. 2007); KNF- Kaibab National Forest staff; R-3- Forest Service Region 3 staff, TNC- The Nature Conservancy (TNC 2006).

Reference Conditions, Current Conditions, Trends, and Risks by PNVT

This section contains brief descriptions of each PNVT, its reference condition, current condition, projected future condition under current management, and an assessment of ecological risk. Details may be found in the Kaibab National Forest Vegetation and Fire Ecological Need for Change Report (KNF 2008f).

Pinyon Juniper Woodlands

Introduction - The Pinyon-Juniper (PJ) Woodland PNVT covers about 638,000 acres and occurs on all three ranger districts (Figure 5). Of all PNVTs, it covers the greatest amount of area on the Forest, and can be broken down into 3 distinct sub-types: PJ-grassland, PJ-shrubland, and persistent PJ woodland. PJ-grasslands exist in areas with deeper soils. In other areas, PJ-shrublands with Gambel oak or sagebrush are dominant. Pockets of persistent PJ Woodlands with an understory of needle litter exist on sites with very poor soils.

Figure 5 – Pinyon Juniper Woodland (dark shade)

Reference Conditions – PJ-grasslands are open woodlands with a grassy understory, a few shrubs, and a fire return interval of less than 25 years. PJ-shrublands have a mosaic of different age-class patches, generally less than 100 acres in size (Huffman et al. 2006), with a fire return interval of approximately 46 years. Persistent woodlands are a mosaic of patches within the PJ matrix where poorer soils exist. The historic fire return interval on these sites was greater than 250 years, and when fires burned they had stand replacing fire effects.

Current Conditions – Currently, the woodlands exhibit greater canopy closure and less structural diversity than during the reference period. Compared to reference conditions, a variety of structural stages are under-represented, including early development stages with grass and tree seedlings, mid-development stages with grass or shrubs and low (<20%) tree cover, and old woodland (>180 yrs) with grass or shrubs and high (>45%) tree cover. Other stages are over-represented (creating too much homogeneity) including mid- and late-development stages with moderate (20-45%) tree cover. A common early practice to increase forage production involved "pushing" large tracts of pinyon and juniper trees over with bulldozers. Many of these areas are now considered to be in an uncharacteristic state of development.

Large wildland fires have become more common in this PNVT recently. Most fires were started by lightning. Since 1996, approximately 33,700 acres (5% of the PNVT) has experienced stand replacing fire. Several fires have been managed for resource benefits and have burned about 6,800 acres, half of which was stand replacement fire. The area burned by the Bridger Fire in 1996 (37,000 acres) has had three to five fires a year that burned about 50 to 500 acres each. The entire burned area has the potential to re-burn. Although infrequent stand replacing fires are typical of persistent PJ woodland, that sub-type historically occurred only as a minor component of the greater PJ matrix. Areas that were historically PJ-grassland or PJ-shrubland with relatively low tree cover typically experienced low- or mixed-severity fires. Stand replacing fires in these areas, which are now denser than they used to be, represent a departure from reference conditions.

Two extensive mortality events occurred in this type recently, first in 1996 and again in 2004. Both coincided with very dry years within a longer period of drought. Some insect outbreaks accompanied the second event. The net effect resulted in more open canopy cover in affected areas, and shifted species composition towards a more juniper-dominated woodland. Many pinyon pines died, creating high fuel loads, and could now predispose these areas to severe fires. The mortality events on the KNF may have been part of more widespread mortality that concentrated in marginal pinyon sites (Greenwood et al. 2008), and/or occurred in woodland-invaded grasslands.

Increased bark beetle activity may occur in pinyon-juniper woodlands during droughts, with the timing and severity of the damage being dependent upon host species, insect species, drought severity, and length of drought conditions. Other disturbance agents impact mortality events, including dwarf mistletoe infestations, and native defoliating agents such as sawflies, but damage from these agents is typically local rather than widespread (Lynch et al. 2008).

Invasive plants occur on about 4 percent of the PNVT. The most common is cheatgrass, although other species including Scotch thistle, Dalmatian toadflax, diffuse knapweed, yellow starthistle, Malta starthistle, bull thistle, and Russian knapweed have been found. Cheatgrass in particular presents a complex threat to PJ woodlands. It can establish easily after a fire and subsequently shorten the fire return interval, thereby encouraging more cheatgrass establishment, and eliminating native plants.

Regular livestock grazing occurs in most of the PNVT with the exception of the Kanab Creek and Saddle Mountain Wildernesses. This PNVT also provides winter range for native ungulates. Some range improvement projects that generated large amounts of fresh pinyon slash have resulted in localized pinyon bark beetle outbreaks. Some recreational and traditional uses occur, including pine nut gathering, fuelwood and ceremonial wood gathering. About 1,000 acres of PJ woodland are thinned annually to improve understory production. Very little prescribed burning has been implemented in this PNVT.

Projected Trends –Under the current disturbance regimes and management, after 20 years the woodlands would become younger (about 20% versus the historic condition of 10%) and denser than the reference conditions (46% versus the historic 30%). The trend would continue through year 100 and then stabilize. Future PJ woodlands would lack the desired amount of open late-development woodlands. The younger woodlands would be the result of stand replacing fire over larger areas than occurred during the reference conditions. The VDDT model used for the analysis did not include an invaded state. It is likely that under the current management scenario that the area invaded by cheatgrass would increase, shortening the fire return interval.

Threats/Risk Assessment Results – The primary threat to this PNVT is the lack of characteristic fire disturbance. This is especially true in the PJ-grassland, but may also apply to some PJ-shrubland. Uncharacteristically severe fire disturbance under current conditions may result in

negative effects to structure and species composition, potentially leading to shifts in invasive plants that shorten the fire return interval.

In recent years, there has been an increase in the size and severity of drought and bark beetle-related pinyon pine die-off. Extreme levels of mortality occurred during the 2001-2003 outbreak, killing 37 to 41 percent of the pinyon across the Forest. The die-off was 100 times as large (two orders of magnitude) as any previously recorded outbreak in northern Arizona. Factors contributing to the size and severity of the recent outbreak include higher tree densities with larger tree diameter, drought, and warm temperatures (Lynch et al. 2008).

Increased tree density, canopy cover, and the associated loss of understory plant cover and diversity are the primary characteristics that are departed, especially in the PJ-grasslands.

Condition Synopsis – In general on the KNF, PJ woodlands are moderately departed from reference conditions. Under current management, these woodlands will either exist in a static departed state, or trend away from reference conditions. Across each of the three ecoregional Sections, this PNVT is also considered moderately departed from reference conditions.

Figure 6 – Ponderosa Pine Forest (dark shade)

Ponderosa Pine Forest

Introduction - The ponderosa pine forest PNVT covers about 541,000 acres, and occurs on all three ranger districts (Figure 6). Aspen occurs in patches within the ponderosa pine forest on the WRD and is a common over- and understory component on the on the NKRD. Tree harvesting has occurred using selection, shelterwood, and sanitation harvest types.

Reference Conditions - There is no evidence of large (>500 acres) stand replacing fires during the reference period (Lang and Stewart 1910, Fulé et al. 2003c). Large (>500 acres) stand replacing fires started occurring on the forest in the 1960s. Historic conditions were open-canopied, uneven-aged interspersed clumps and groups of different aged trees. Fires primarily occurred as non-lethal surface fires with occasional group torching. The fire return interval was less than 25 years.

Current Conditions – Forest Service policy prior to 2000 was to fully suppress all wildland fires. Since 1995, about 20,000 acres (3.7 % of the PNVT) have burned with stand replacing fire. In areas greater than 100 acres that were not planted, seedlings have yet to re-establish, even in the older burn areas. Artificial regeneration has been partially successful at elevations less than 8,700 feet when the original objective of 500 seedlings per acre is used. However, field visits to the Summit, Willis, and Bridger-Knoll burn areas have shown that these areas have successfully regenerated to at least historic levels.

Since 2000, some naturally ignited wildland fires have been managed for resource benefits. These fires have ranged in size from ¼ acre to several thousand acres. Fuel reduction treatments including prescribed fire and thinning have been implemented on about 20,000 acres per year.

The ponderosa pine forests on the Kaibab are much denser than historic conditions, with 79 percent of the stands in a “closed” state (>32% canopy cover). Historically there were spaces between clumps of trees that are now either smaller or nonexistent. Only 19 percent of the PNVT is currently in the historic condition, which was all a mature to old forest with various-sized patches of young regenerating forest. The remaining portions are younger and denser than historic conditions, which supports large stand replacing fire.

Bark beetle outbreaks are becoming more frequent and extensive in pine trees. A combination of insects, disease, herbivory, frost and drought events are combining to cause decline and mortality in aspen. (Binkley et al. 2006, Lynch et al. 2008)

Invasive weeds like cheatgrass and bull thistle occupy up to 1 percent of this PNVT, mostly along roads. Areas with large wildland fires can have extensive populations of invasive weeds (KNF 2007).

Managed livestock grazing under permit occurs, with controlled numbers, timing, location, duration, and frequency. Unmanaged herbivory (i.e., herbivory that managers do not control by timing, location, duration, or frequency) occurs by deer, elk, antelope and bison. Developed recreation includes the use of trails, roads, campgrounds, overlooks, and special use permits. Dispersed recreation is popular and includes camping, bird watching, and some cross country travel (both on foot and on ATV). Rock quarries and utility corridors exist in this PNVT. The road system is well developed.

Projected Trends - Under current management practices, little change in the future is expected, with the proportion of the forest in each developmental stage moving slightly further away from reference conditions and then stabilizing after 100 years. At the current rate of natural and human disturbance the ponderosa pine forest will have a greater proportion of the forest in dense young states. Fine-scale stand diversity will likely decline, and result in more homogeneous stand structure. However, the differences between large forest patches (>100 acres) will likely increase, due to stand replacing fire, encroachment of fire intolerant tree species, and a continued buildup of live and dead fuels.

Threats/Risk Assessment Results - The primary threat to this PNVT is the lack of characteristic fire disturbance. Canopy cover is denser and more continuous throughout the PNVT. When fires occur under current conditions, they are more likely to result in a negative outcome, resulting in further departure from reference conditions. For this reason, uncharacteristic fire and drought are considered secondary threats. There is a moderate risk of insect/disease outbreaks, which are also a function of density. The amount and arrangement of the developmental stages, and increased tree density/canopy cover are the primary characteristics that are departed; trees are denser and younger than reference conditions.

Although not a general threat to the PNVT, the decline or loss of aspen on the WRD and across the White Mountains – San Francisco Peaks – Mogollon Rim Section is a concern. With the combined effects of elk browsing, insects, disease, severe weather events, and lack of fire disturbance, aspen is expected to substantially decline on the WRD in the near future.

Condition Synopsis – In general on the KNF, ponderosa pine forests are highly departed from reference conditions. Under current management, these forests will remain highly departed from reference conditions. Given current analysis methods, trends of further departure would not be detected, unless stand replacing fires reset the developmental stage. Across each of the three ecoregional Sections, this PNVT is also considered highly departed from reference conditions.

Mixed Conifer Forests

Introduction - Mixed Conifer Forests (Dry Mixed Conifer and Mixed Conifer with Aspen PNVTs) occur on approximately 128,000 acres on the WRD and NKRD (Figure 7). These stands are generally on the north slopes of cinder cones on the WRD and at higher elevations on the NKRD. Aspen occurs in patches on the WRD and as a near co-dominant species in some places on the NKRD. Some tree harvesting has occurred on the NKRD, and on Bill Williams Mountain on the WRD. Selection, shelterwood and sanitation harvest types have been used.

Reference Conditions - Fire history studies conducted on the Kaibab Plateau found virtually the same fire return interval in the two Mixed Conifer Forest PNVTs and no evidence of stand replacing fire greater than 100 acres in either. (Fulé et al. 2003c). Vankat (2004) found no evidence of stand replacing fire in patches larger than 240 acres, with the mean patch size of 15 acres. Wolf and Mast (1998) report fire return intervals of 4.9 to 10.3 years in mixed conifer prior to 1870. Similar to the Ponderosa Pine PNVT, the reference condition at the100-acre scale was an open (canopy cover <32%), uneven aged stand. At smaller scales, it contained a mix of different size classes and development stages.

Current Conditions – The trees in this PNVT are younger and denser than during the reference period. About 5 percent of the area exists in a mature uneven-aged state and only 23 percent of the area is comprised of uneven aged groups. The other 72 percent of the PNVT has a canopy closure greater than 30 percent.

Figure 7 – Mixed Conifer Forest (dark shade)

Recent management has focused on moving towards desired conditions. The prescriptions have primarily thinned small trees around or under older trees. In some cases, group selection cuts have removed patches of large trees to promote regeneration within a larger uneven-aged area.

Wildland fires within the Mixed Conifer Forest PNVTs have been suppressed. Large (> 500 acres) stand replacing fires on the forest first started occurring in the 1960s. Since 1995, over 11,000 acres (9% of the PNVT) have burned with stand replacing wildfire.

Outbreaks of western spruce budworm, Douglas fir beetle, or fir engraver have occurred on about a 15 year interval, since 1950. Prior to 1950, outbreaks were less frequent. Spruce budworm

attacks stressed trees after periods of increased moisture and fir beetle or fir engraver seek out weakened trees during droughts (Lynch et al. 2007).

Invasive weeds like cheatgrass and bull thistle occupy up to 1 percent of this PNVT, mostly along roads. Areas with large wildland fires can have extensive populations of invasive weeds.

Managed livestock grazing occurs in the PNVT under permit. The numbers, timing, and amount of grass/shrub utilization are managed. Unmanaged herbivory by elk, deer, and bison also occurs. Motorized and non-motorized recreation, organized and dispersed camping occur. There are rock quarries and utility corridors within this PNVT.

Projected Trends – VDDT model results indicate a continuing departure from reference conditions. With the current incidence of stand replacing fire, more than 10 percent of the forest will be in a "stand initiation" state with grasses and seedlings), while 45 to 55 percent of the forest will be in dense forest states. The remaining forest (~40%) would be in an uncharacteristic state that does not easily regenerate after fires due to long seed-dispersal distances for shade-intolerant pine, increases in soil temperatures and decreases in soil moisture. These uncharacteristic states promote the current frequency of stand replacing fire.

Threats/Risk Assessment Results - The primary threat to this PNVT is the lack of characteristic fire disturbance. Canopy cover is denser and more continuous across all developmental stages. When fires occur under current conditions, they carry a significant risk of a negative outcome, further departing states and species composition. For this reason, uncharacteristic wildfire and drought are also considered secondary threats. The moderate threats of insects and disease are also a function of canopy cover, density, and species composition shifts.

Tree density and relative species abundance (i.e., more shade-tolerant spruce and fir species) are the primary characteristics that are departed. Older tree stages are also missing in some cases, but in others they are present but masked by the overabundance of younger trees.

Although not a general threat to the PNVT, the decline or loss of aspen on the WRD and across the White Mountains – San Francisco Peaks – Mogollon Rim Section is a concern. With the combined effects of elk browsing, insects, disease, severe weather events, and lack of fire disturbance, aspen is expected to substantially decline on the WRD in the near future.

Condition Synopsis – In general on the KNF, mixed conifer forests are highly departed from reference conditions. Under current management, these forests will trend even further away from reference conditions. Across the two ecoregional Sections that contain mixed conifer forest (Grand Canyon and White Mtns. – San Francisco Peaks – Mogollon Rim Sections), this PNVT is also considered highly departed from reference conditions.

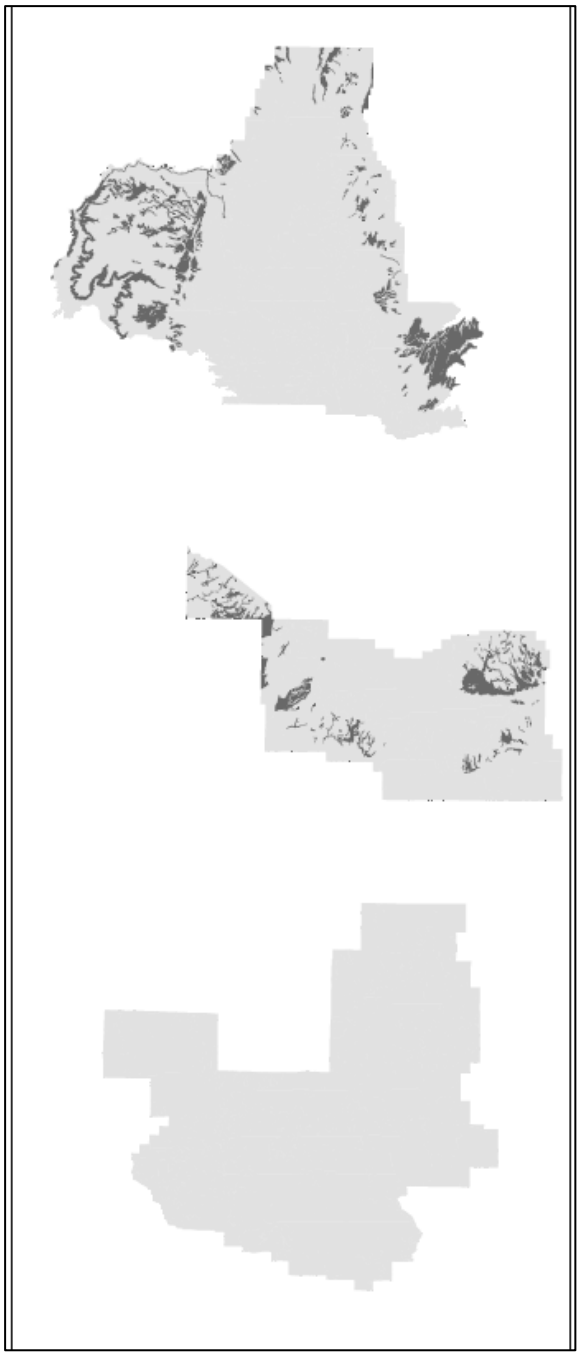

Figure 8 – Sagebrush Shrubland (dark shade)

Sagebrush Shrublands

Introduction - The Sagebrush Shrubland PNVT covers about 88,700 acres on the NKRD and TRD (Figure 8). It occurs mostly in drainage bottoms, but also on slopes near the Upper Basin (TRD), on a broad flat plain above Marble Canyon, and on Little Mountain (NKRD).

Reference Conditions – This PNVT was historically dominated by mature grasses and shrubs. A young grass/sagebrush state and a older, more closed state of shrubs with an herbaceous understory also occurred, each covering about 20 percent of the area. Grasses and forbs were abundant. The historic fire return interval was ~120 years, and had mixed severity fire effects. About one third of the PNVT burned every 100 to 240 years with stand replacing fire.

Current Conditions - Wildland fires have recently occurred in this PNVT. Most have been less than 10 acres, but the 1996 Bridger-Knoll fire was very big (37,000 acres). All of these fires were suppressed. A few areas in this PNVT have received mowing treatments to increase forage production, and some areas have undergone type-conversions to grasslands on both districts. Sagebrush been has been re-established in some areas with planting. Regrowth and re-establishment responses vary, partly due to the sagebrush subspecies present.

A type-conversion to crested wheatgrass has occurred across about 13 percent of the sagebrush shrublands on the Forest. In the rest of the PNVT, it is more mature and closed than during the reference period. Approximately 7 percent of the area is a late-seral mix of herbaceous and shrub vegetation with encroaching pinyon and juniper, which makes up more than 10 percent of the canopy.

Invasive plants occur on more than 7,000 acres of this PNVT (20%). Cheatgrass is the most common; thistles and Dalmatian toadflax are also present. Cheatgrass readily expands in recently burned areas if not mitigated.

Projected Trends – Increases in canopy density of shrub species and encroaching tree species are expected to continue under the current natural and management disturbances. At the current rate of mixed severity fire, the entire PNVT would burn every 2,500 years. At the current rate of stand replacing fires, the entire PNVT would burn every 1,425 years. Occurrence of invasive plant species is expected to increase, especially following fire.

Threats/Risk Assessment Results - The primary threats to this PNVT are the combination of lack of fire disturbance, limited nutrient cycling, and closed shrub states with juniper encroachment, which create large areas susceptible to stand-replacing fires. Further departures are predicted under the current management and disturbances.

Elk herbivory on rare native shrubs in the TRD is a concern. Fires occurring under current conditions may lead to negative outcomes for species composition, by impairing shrub establishment and development. Increased invasive plant cover after wildfire is also considered a risk.

Condition Synopsis – In general on the KNF, sagebrush shrublands are moderately departed from reference conditions. Under current management, these shrublands will trend further away from reference conditions. Across the Painted Desert Section this PNVT is also considered moderately departed from reference conditions, but in the Grand Canyon Section it shows only low departure from reference conditions.

Montane / Subalpine Grasslands

Introduction - There are approximately 40,900 acres of this PNVT on the Forest, and it occurs on all three Districts (Figure 9). The PNVT refers to two types of high-elevation grasslands, with montane grasslands (e.g., Government Prairie on the WRD) occurring at slightly lower elevations than subalpine grasslands (e.g., De Motte Park on the NKRD). Both types of grasslands range from small patches (<10 acres) to large areas covering hundreds or thousands of acres. Smaller patches are sometimes circular, around small sinkhole features; or long and narrow, associated with valley bottoms.

Reference Conditions – Historically, this PNVT was dominated by grasses and forbs, with minimal tree canopy cover (<9%). The fire return interval was approximately 35 years, but was probably highly influenced by the fire cycle of adjacent forest types. For example, montane grasslands surrounded by ponderosa pine likely experienced a shorter fire return interval than subalpine grasslands surrounded by spruce-fir forest. Fires may have regularly burned across montane grasslands (e.g., Johnson 1998), but perhaps only burned the edges of subalpine grasslands. Cold soil temperatures and/or high soil moisture are also thought to play a role in maintaining some of these grasslands (TNC 2006).

Current Conditions - Wildland fires have occurred recently in this PNVT, but are frequently suppressed. Wildfires have started within the PNVT, and in adjacent PNVTs later spreading into the grasslands. The 2006 Warm Fire (NKRD) mostly burned around subalpine grasslands and did not burn invading conifers. Since 2003, several fires have been managed for resource benefits on the TRD, and have spread through or around the Montane Grasslands.

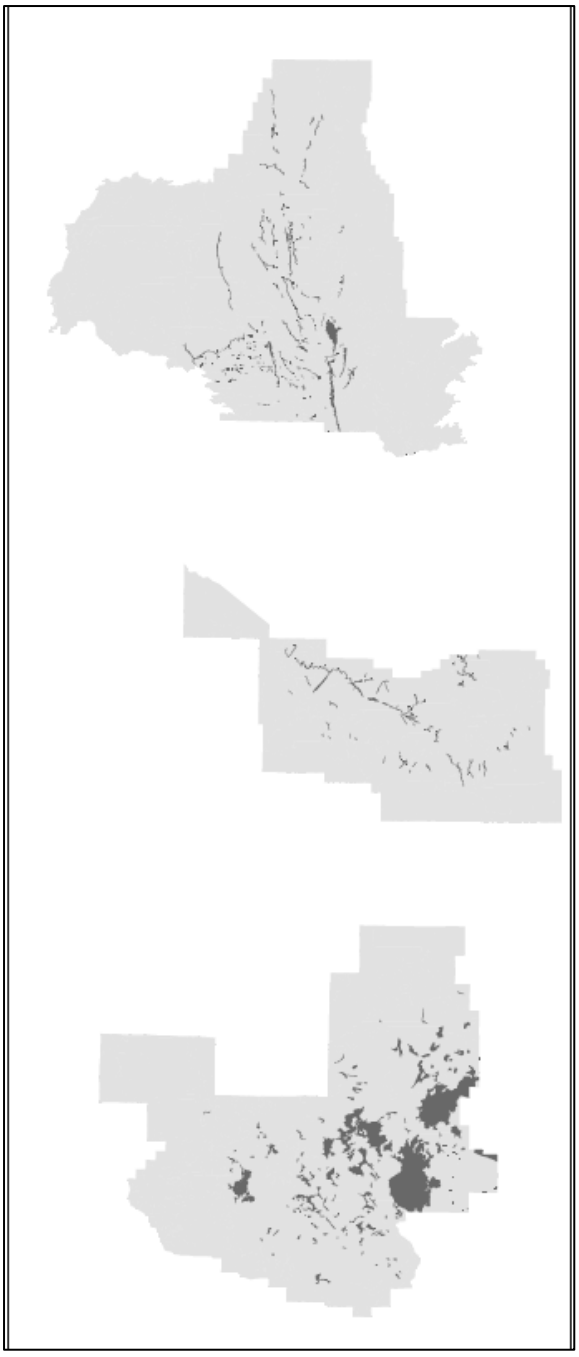

Figure 9 – Montane / Subalpine Grassland (dark shade)

Montane and subalpine grasslands are being invaded by conifers on at least 8 percent of this PNVT. On the Kaibab Plateau, conifer encroachment was estimated to occur at an average rate of 12 to 16 feet per decade, and faster during wet periods (Moore and Huffman 2004). Many narrower meadows surrounded by ponderosa pine have a high numbers of invading pine seedlings within them. Garland Prairie has young conifer encroachment that extends at least one-quarter mile into the PNVT. Although fire is thought to be the driving force to maintaining montane grasslands (and perhaps to a lesser extent, subalpine grasslands), fires burning in treed

areas of the grasslands may burn hotter and damage soils, slowing the return to near pre-fire cover conditions. Down logs burning during a wildfire tend to damage soils under and near the logs. These conditions could predispose the affected areas to hosting invasive weeds.

Invasive plants have infested approximately 1 percent of the PNVT. Species include (but are not limited to) Dalmatian toadflax and cheatgrass (KNF 2007). There are no known changes to montane or subalpine grasslands as the result of insect outbreaks.

During early periods of European settlement, sheep and cattle were grazed extensively in many montane and subalpine grasslands, possibly altering species composition at that time towards less palatable herbaceous plants and woody species (TNC 2006). Currently, livestock graze under permit during the summer, and meadows are not generally grazed until after the spring cool season growing period. Antelope, deer, elk (WRD and TRD, primarily), and sometimes bison (NKRD only) graze in the meadows.

Roads and trails exist within this PNVT, although efforts have been made to close many roads. Off-road vehicle travel is prohibited in this PNVT but does occur. Flowers and seeds are collected from meadows.

Projected Trends - Conifer encroachment is expected to continue under the current disturbance frequencies. The PNVT will continue to depart from reference conditions.

Threats/Risk Assessment Results - The primary threat to this PNVT is the lack of fire disturbance and limiting nutrient cycling. Closed shrub states are becoming more common; pine and juniper are encroaching in montane grasslands, while spruce and fir are encroaching in subalpine grasslands. In the narrower valleys, tree invasion is bringing about a rapid departure. Fires occurring under current conditions may result in negative effects to species composition due to the potential for invasive plant establishment, but it is not currently considered a high risk. Inappropriate livestock grazing and excessive wildlife herbivory may also negatively impact localized areas in this PNVT. Continued departures are expected under the current disturbances and management.

Condition Synopsis – In general on the KNF, montane and subalpine grasslands are moderately departed from reference conditions. Under current management, these grasslands will trend further away from reference conditions. Across all three ecoregional Sections this PNVT is considered minimally departed from reference conditions.

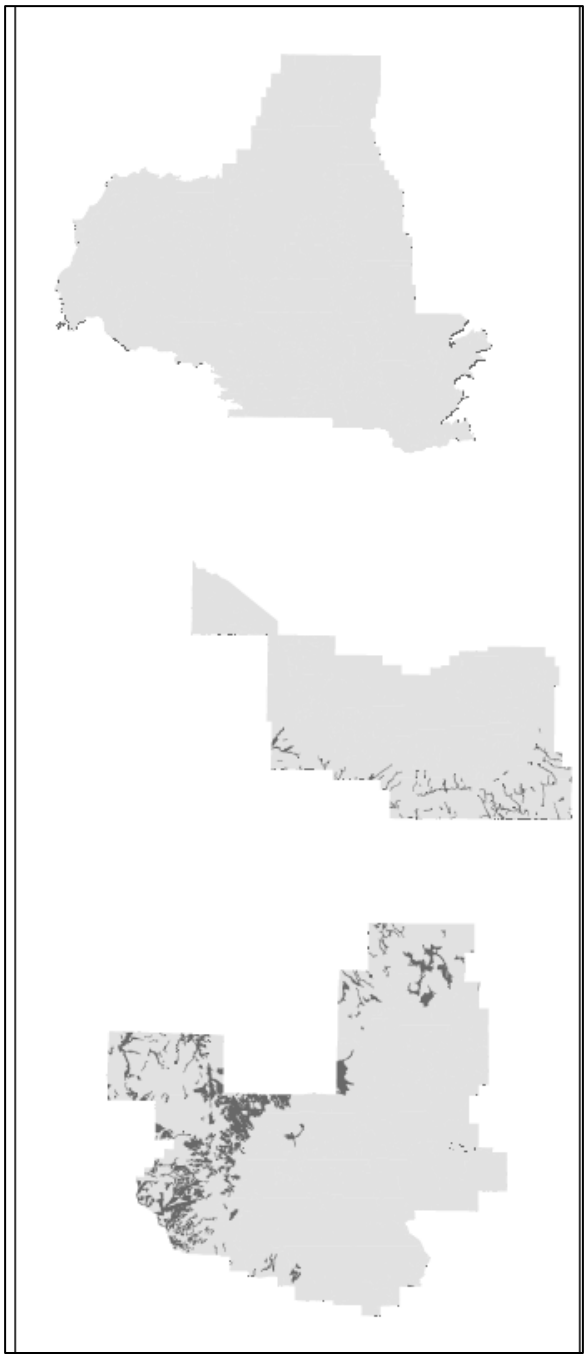

Figure 10 – Colorado Plateau / Great Basin Grasslands (dark shade)

Colorado Plateau / Great Basin Grasslands

Introduction - There are about 44,300 acres of Colorado Plateau / Great Basin grasslands within TRD and WRD (Figure 10). Grasslands are located in drainage bottoms and are surrounded by sagebrush or pinyon-juniper. In some cases ponderosa pine will border Colorado Plateau / Great Basin grasslands on a north facing aspect.

Reference Conditions – Historically, this PNVT was dominated by grasses and forbs, with minimal tree canopy cover (<9%). The fire return interval was less than 35 years. Post-fire cover was less than pre-fire conditions, but returned close to pre-fire conditions within a few years (Johnson 1998).

Current Conditions - Wildland fires occur in this PNVT but they are infrequent and have generally been less than 10 acres in size. Tree encroachment and an increase in the shrub component are contributing to higher fuel loads and the potential for uncharacteristic states containing invasive plants. Fires burning under current conditions burn hotter, damage soils, predispose the area to invasion by non native plants, and may shorten the fire return interval.

Invasive plants like cheatgrass occur in less than 1 percent of the PNVT. There are no known changes to Great Basin Grassland states as the result of insect outbreaks.

Livestock grazing is managed under permit; native ungulates (antelope, deer, and elk) also use the grasslands. Balancing livestock and wildlife needs so that damage to the resource does not occur can be difficult in some areas. Roads exist in this PNVT. Little recreation use occurs.

Projected Trends - Grasslands will continue to depart from reference conditions. Shrub cover will become greater, and tree encroachment will continue.

Threats/Risk Assessment Results - The primary threats to this PNVT are the lack of fire disturbance and limiting nutrient cycling. Closed shrub states are becoming more common and juniper is encroaching. Fires occurring under current conditions may result in negative effects to species composition due to the potential for invasive plant establishment, but it is not currently considered a high risk. Inappropriate livestock grazing and excessive wildlife herbivory may also negatively impact localized areas in this PNVT.

Condition Synopsis – In general on the KNF, Colorado Plateau / Great Basin grasslands are moderately departed from reference conditions. Under current management, these grasslands will trend further away from reference conditions. Across in the two ecoregional Sections where this PNVT occurs on the Forest (Painted Desert and White Mountains – San Francisco Peaks – Mogollon Rim) it is also considered moderately departed from reference conditions.

Spruce-Fir Forest

Introduction - There are approximately 29,100 acres of this PNVT on the Forest, mostly on the NKRD (Figure 11). A few acres exist on the William Ranger District in Kendrick Mountain Wilderness Area. It occurs in patches that are generally surrounded by Mixed Conifer Forests, Ponderosa Pine or Montane / Subalpine Grassland PNVTs.

Reference Conditions – Spruce-fir forests on the Kaibab Plateau exhibited a high degree of diversity, maintained by mixed-severity fires (i.e., low- and high-intensity fires in close proximity). From a study on the Kaibab Plateau, Fulé et al. (2003b) reported that the estimated fire return interval in the spruce-fir forest type (2 to 32 years) was longer than that of ponderosa or mixed conifer forests, but shorter than intervals recorded for other high-elevation forests in the Southwest. A pattern of numerous small fires and few large fires characterized this PNVT on the Kaibab Plateau (Lang and Stewart 1910, Fulé et al. 2003b, Vankat 2004). Insects, disease, and drought also contributed to sub-stand mortality and regeneration. Fulé et al. (2003b) state that the pattern of severe burning in their study site on the Kaibab Plateau did not appear to be stable over the spatial and temporal scale of their study. This suggests that spruce-fir on the Kaibab Plateau had a structure that was highly variable of over time and space.

Current Conditions – Current tree density and canopy cover are substantially greater than during the reference period (Fulé et al. 2003a, Fulé et al. 2003b). Average stand age is also younger, due to the number of young trees that have persisted in the absence of characteristic disturbances. Wildland fires occur in this PNVT although most are suppressed at less than one/tenth acre.

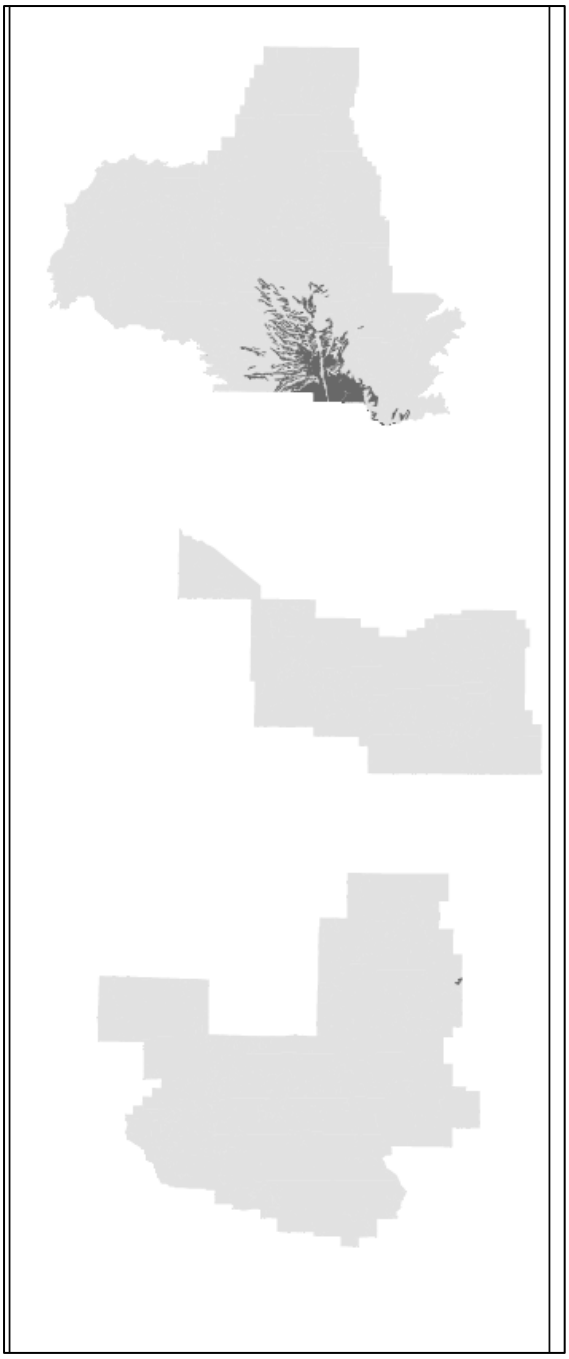

Figure 11 – Spruce-Fir Forest (dark shade)

Spruce beetles are present on the KNF, but widespread outbreaks have not occurred across large areas on the Forest. However, insect outbreaks are a possibility. Just northwest of the KNF in Utah, some parts of the Dixie National Forest have been impacted heavily by spruce budworm outbreaks and entire populations of spruce have died. Western tent caterpillar outbreaks and frost events are causing mortality in the aspen. The insect/disease threat is Low to Moderate (Lynch et al. 2007). Invasive plants like Dalmatian toadflax and bull thistle are found on less than 0.1 percent of the area (KNF 2007).

Livestock graze under permit during the summer. Mule deer and occasionally bison graze in this PNVT. Some fuel wood gathering occurs. Developed and dispersed recreation occurs, mostly in the form of hunting and dispersed camping.

Projected Trends - Modeling indicates a rapid shift from mid-aged closed-canopy forest to an older closed-canopy state. Because this appears to be an artifact of the model, the two states are evaluated together. In 50 years, little change is expected from the current condition, with 75 percent of the area in a mature closed canopy states, versus the reference condition of 34 percent. Under current management and disturbances, a return to the reference condition of a multi-age, mature open-canopy forest, would not be expected.

Threats/Risk Assessment Results - The primary threat to this PNVT is the lack of characteristic fire disturbance. While generally counter-intuitive for this PNVT across the Southwest Region, local peer-reviewed research (Fulé et al. 2003a and 2003b) showed that historically the spruce-fir PNVT was significantly influenced by fires in adjacent PNVTs (e.g., Ponderosa Pine and Mixed Conifer). Much of the current Spruce-fir PNVT may actually have been a Mixed Conifer PNVT in the past. In present mapping efforts, the role of fire disturbance may not have been appropriately accounted for in the delineation of the Spruce-fir PNVT. Since fire exclusion in the late 1800's, a species shift away from aspen, ponderosa pine and Douglas-fir, and a shift toward Engelmann spruce and corkbark fir has been documented (Fulé et al. 2003a). As a result, canopy cover is denser and more continuous across developmental states.

Tree density and species relative abundance are the primary characteristics that are departed. Older tree states may also be missing in some areas. In other areas, the older tree components are present but masked by a high density of younger trees.

When fires occur under current conditions, they carry a significant risk of a negative outcome (i.e., broad-scale stand replacing fire), further departing states and species composition. For this reason, wildfire and drought are considered secondary threats for this PNVT.

Condition Synopsis – In general on the KNF, spruce-fir forests are highly departed from reference conditions. Under current management, the condition of these forests will continue in a static trend departed from reference conditions. Across the two ecoregional Sections where this PNVT occurs (Grand Canyon and White Mountains – San Francisco Peaks – Mogollon Rim), it is considered minimally departed from reference conditions.

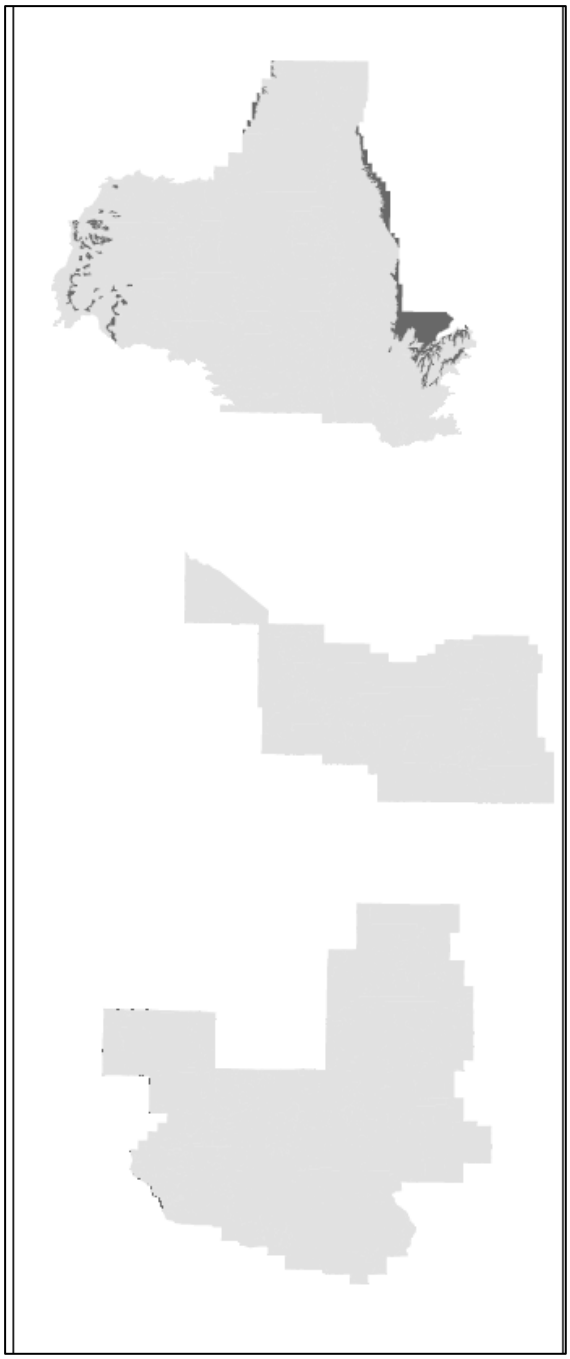

Figure 12 – Semi-Desert Grasslands (dark shade)

Semi-Desert Grasslands

Introduction - The Semi-Desert Grassland PNVT covers about 25,000 acres on the NKRD (Figure 12). It is located on the east side of the District along House Rock Valley, and on the west side near Kanab Canyon. A portion of the PNVT that occurs on the flat slopes of House Rock Valley near the Buffalo Ranch may actually be a Black Sagebrush PNVT. The Nature Conservancy classified the Buffalo Ranch area as being altered, and not restorable to grassland with natural processes (TNC 2006).

Reference Conditions - This PNVT consisted of grasses with shrub density of less than 10 percent. Approximately 20 percent of the PNVT was in a young grass state recovering from fire, and approximately 80 percent of the PNVT was mature grass with some shrubs. Fire maintained this open structure with a fire return interval of 2.5 to 10 years.

Current Conditions - Few wildland fires are known to have occurred within this PNVT since 1950. Only one was larger than 10 acres. The amount of semi-desert grassland in an open mature grass/shrub state is overstated because of the recent lack of fire. The majority of the PNVT has a closed shrub overstory. The PNVT is more mature and less diverse than during the reference period.

Establishment of pinyon, juniper and sagebrush within these grasslands is occurring. Invasive weed surveys have not been completed, but invasive species are thought to occupy less than 0.1 percent of the area and consist of mostly of cheatgrass.

Managed livestock grazing occurs within the northern portion of this PNVT during the winter months. Unmanaged herbivory occurs in the southern portion of the PNVT by bison and mule deer. Motorized and non-motorized recreation occurs. Some dispersed camping occurs.

Projected Trends - The PNVT will continue to depart from reference conditions under the current disturbance frequencies. Vegetation models show that under the current disturbances, after 100 years, the majority of the PNVT would consist of a closed shrub structure with few grasses. Invasive grasses would spread, shortening the fire return interval.

Threats/Risk Assessment Results -

The primary threat to this PNVT is the lack of characteristic fire disturbance and limited nutrient cycling. Closed shrub states are becoming more common; pine and juniper also are encroaching. Under the current disturbances and management, continued departures are expected due to tree encroachment and increased fuel loading. Fires occurring under current conditions may result in negative effects to species composition, due to the potential for invasive plant establishment, but it is not currently considered a high risk. Contributing to this is a potential threat from bison herbivory.

Condition Synopsis – In general on the KNF, semi-desert grasslands are minimally departed from reference conditions. Under current management, the condition of these grasslands will trend away from reference conditions. Across the Grand Canyon Section where this PNVT occurs on the Forest, it is also considered minimally departed from reference conditions.

Desert Communities

Introduction - This PNVT consists of about 13,800 acres on the NKRD in Kanab Creek and Jumpup Creek (Figure 13). It is within the Kanab Creek Wilderness Area. This PNVT surrounds the Cottonwood Willow Riparian Forest PNVT. Unlike most of the Forest, fire did not play a historic role in this PNVT.

Reference Conditions - Extensive grasses with a shrub cover less than 30 percent. The primary disturbance may have been from arthropods.

Current Conditions - Only 10 wildland fires have occurred in the PNVT since the 1950s, and none exceeded 10 acres in size. The Jump Fire started on the edge of the PNVT in 1996 and burned several thousand acres north of the PNVT.

This PNVT has an extensive closed shrub overstory, probably encouraged by past grazing. The area has not been grazed by livestock since 1998, except for occasional unauthorized use. Effects of current wildlife herbivory are unknown.

The PNVT has not been inventoried for invasive species (KNF 2007). Cheatgrass may occupy the PNVT at a similar rate as the Semi-Desert Grasslands or the Sagebrush Shrubland PNVTs, which is estimated to be about 15 percent.

The area receives some dispersed recreation use. Trail maintenance occurs on an annual basis.

Projected Trends - An increase in invasive species is expected to gradually shorten the fire return interval, creating a feedback loop that would continue to increase their presence.

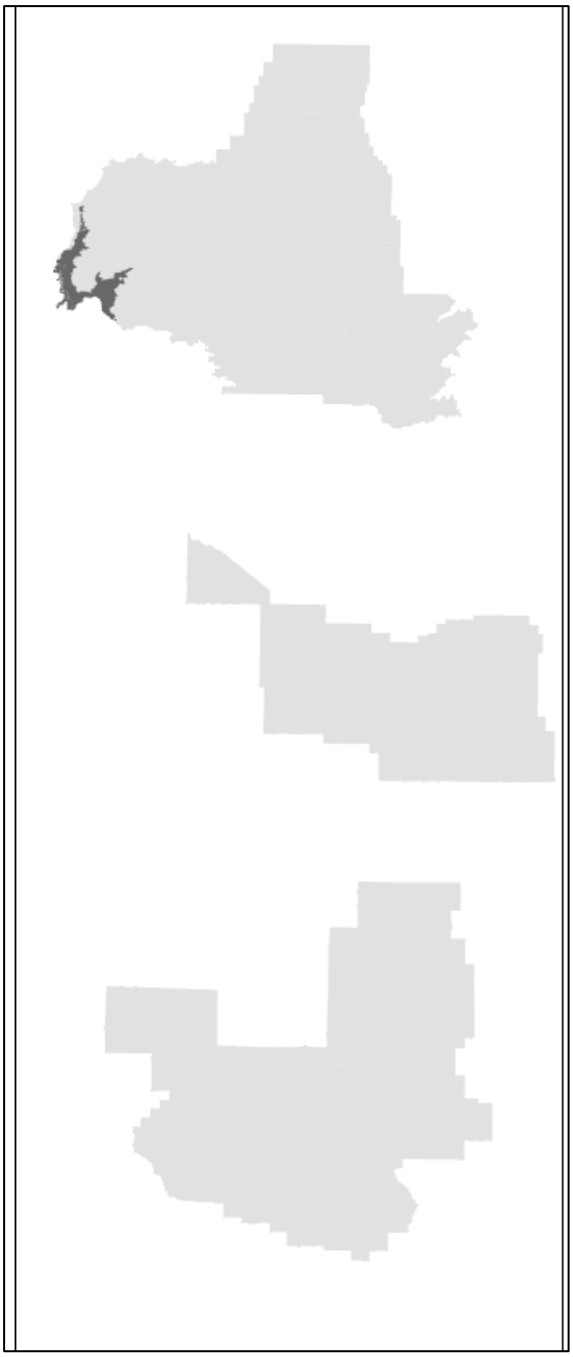

Figure 13 – Desert Communities (dark shade)

Threats/Risk Assessment Results - The primary threat to this PNVT is invasive species, which shorten the fire return interval and change species composition. Secondarily, closed shrub states are becoming more common and juniper also is encroaching, increases the risk of uncharacteristic fire disturbance. This could further reduce native plant diversity and structure, increasing invasive plant cover and erosion.

Condition Synopsis – In general on the KNF, desert communities are moderately departed from reference conditions. Under current management, the condition of these communities will trend away from reference conditions. Across the Grand Canyon Section where this PNVT occurs on the Forest, it is also considered moderately departed from reference conditions.

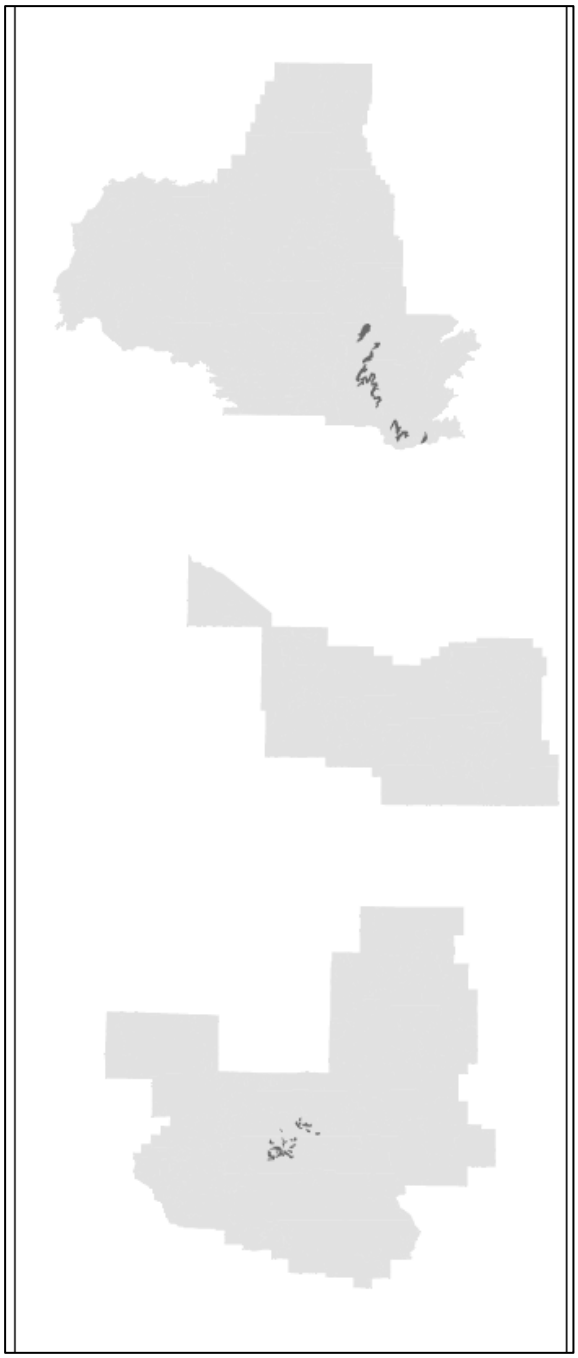

Figure 14 – Gambel Oak Shrublands (dark shade)

Gambel Oak Shrublands

Introduction - This PNVT occurs in patches totaling approximately 5,400 acres of the NKRD and WRD (Figure 14).

Reference Conditions - The majority of the PNVT would support an understory of grass and forbs. Younger shrubs would have little dead woody material and a historic fire return interval was less than 25 years.

Current Conditions - The PNVT consists entirely of older plants with a high dead woody component. Fire spreads easily. In areas with thick shrubs, there is little grass cover. The PNVT is departed from reference conditions.

Projected Trends - The PNVT will continue to depart from reference conditions.

Threats/Risk Assessment Results - The primary threat to the Gambel Oak Shrubland PNVT is the combination of lack of fire disturbance, leading to an increase in closed tree/shrub states. Encroaching conifers make larger areas susceptible to single stand-replacing events. Drought could raise the risk of a stand replacing event. Under current conditions, fire disturbance could lead to some negative outcomes for soils and increased invasive plants. Continuing departures are anticipated.

Condition Synopsis – In general on the KNF, Gambel oak shrublands are highly departed from reference conditions. Under current management, the condition of these shrublands will trend even further away from reference conditions. Across the two Sections where this PNVT occurs on the Forest (Grand Canyon and White Mountains – San Francisco Peaks – Mogollon Rim), it is considered minimally departed from reference conditions.

Wetland / Cienega

Introduction - There are approximately 1,500 acres of Wetland / Cienega on the forest, split between the NKRD and WRD (Figure 15). Most of the PNVT on the NKRD (e.g., Demotte Park) is likely to actually be the Montane / Subalpine Grassland PNVT because most the area lacks the water component described in the PNVT. Half of the PNVT is associated with small lakes (e.g., Franks, Crane, Round, Grassy, Holden, Fay, Coleman, Scholz, Moritz, Raymond) that are less than ten acres in size. The largest single area is an ephemeral lake on the WRD, Davenport Lake.

Reference Conditions - This PNVT is historically experienced a fire return interval of less than 35 years, but was likely dependent on the fire regime of adjacent PNVTs. Post fire cover is less than pre-fire conditions, but returns close to pre-fire conditions within a few years (Johnson 1998).

Current Conditions - Wildland fires of limited extent occur in this PNVT, originating in adjacent PNVTs. Most fires within this PNVT have been suppressed. The 2006 Warm Fire on the NKRD mostly burned around the Crane Lake and did not burn invading conifers.

Wet meadows are being invaded by conifer species. Several narrower meadows surrounded by forest have many tree seedlings and are rapidly departing from historic conditions.

There are no known changes to Wetland/ Cienega states as the result of insect outbreaks. Invasive plants have become established in this PNVT at approximately the same rate as in the Montane / Subalpine Grasslands PNVT, less than 1 percent or about 15 acres.

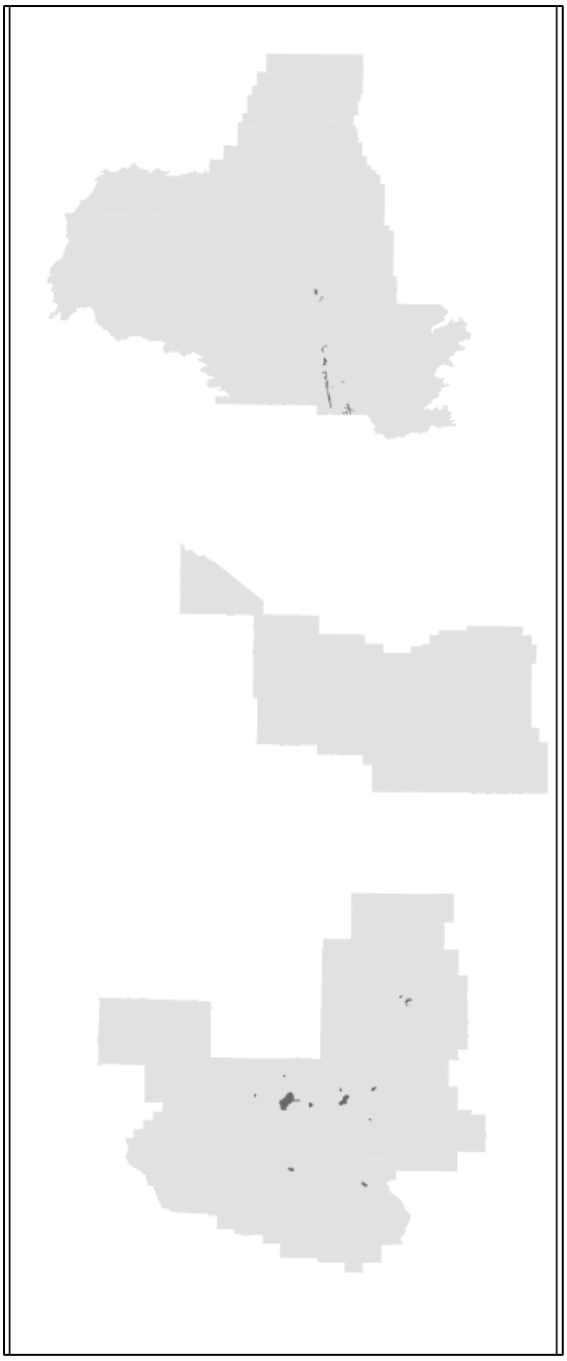

Figure 15 – Wetland / Cienega (dark shade)

Livestock graze under permit during the summer, and generally do not enter the meadows until after the spring cool season growing period and soils are dry. Deer, elk, antelope and sometimes bison (NKRD only) graze in the meadows.

Roads and trails exist within this PNVT, although successful efforts have been made to close unnecessary roads. Off-road vehicle travel is prohibited in this PNVT but does occur. Flowers and seeds are collected from meadows

Projected Trends – Overall, the PNVT is near reference conditions, but trending away. There are no young grasses and about 7 percent of the PNVT has encroaching conifers. Under the current management and disturbances, the trend away from reference conditions is expected to slowly continue.

Threats/Risk Assessment Results - The primary threat to this PNVT is the lack of characteristic fire disturbance and limiting nutrient cycling. Adjacent forest species are encroaching. Contributing to this is a secondary threat from drought. Tree encroachment and tree density of adjacent PNVTs serve to lower water input and flow in this system. A slow departure is estimated overall, but is rapid on the NKRD because of the linear shape of the meadows. Fire disturbance under current conditions may lead to some negative outcomes for species composition toward invasive plants and is deemed a moderate risk at present.

Condition Synopsis – In general on the KNF, wetlands and cienegas are minimally departed from reference conditions. Under current management, the condition of these areas will trend slowly away from reference conditions. Across the White Mountains – San Francisco Peaks – Mogollon Rim Section this PNVT is also considered minimally departed from reference conditions, but in the Grand Canyon Section it is considered moderately departed from reference conditions.

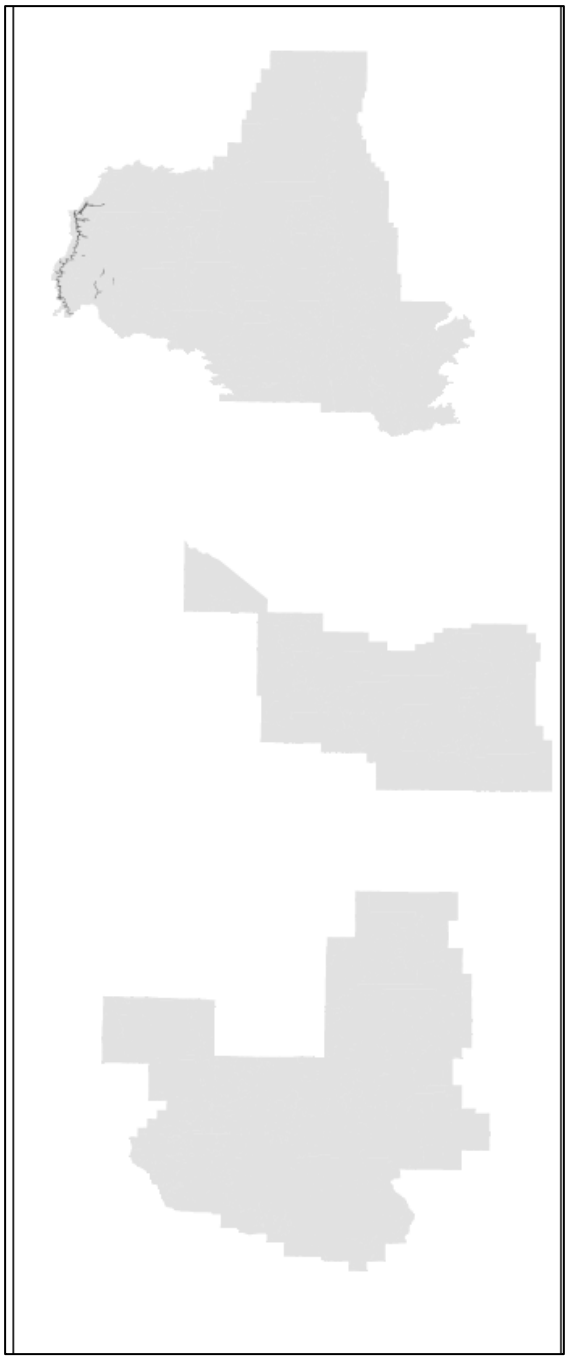

Figure 16 – Cottonwood-Willow Riparian Forest (dark shade)

Cottonwood-Willow Riparian Forest

Introduction - This PNVT covers about 1,200 acres and only occurs the in Kanab Creek Wilderness on the NKRD (Figure 16). It extends from the confluence of Kanab Creek and Slide Creek on the north to Grand Canyon National Park on the south. Side canyons to the east that have intermittent water flow contribute to about 25 percent of the PNVT area. Unlike most of the Forest, fire has played a very limited role in this PNVT.

Reference Conditions - The reference condition for this PNVT is 55 percent mid-aged to mature cottonwood and willow trees, 25 percent in younger trees and 20 percent in grass, shrubs and tree sprouts. The primary disturbance agent in this PNVT is flooding, which in the springtime raises the water table and creates seedbeds for tree and shrub seed germination. Human-caused fire and other activities may have had some influence on structure but the effect is unknown. The adjacent PNVT is primarily Desert Communities, which has a very long or absent fire return interval.

Current Conditions - Upstream impoundments and diversions in Kanab Creek have greatly reduced flooding disturbance since the early 1900s. The stream is now highly intermittent. A majority of the PNVT is in an uncharacteristic state due to the absence of large old trees and the invasion of tamarisk and Russian olive (KNF 2007). Within Kanab Creek, there are only 5 to 10 large cottonwoods per mile of stream, and willows almost only occur in side drainages. There is little or no herbaceous cover.

The area was grazed by livestock during the winter months until 1998. Current unauthorized livestock grazing occurs occasionally.

Minor trail maintenance activities occur.

Projected Trends - Tamarisk will continue to spread and reduce the presence of cottonwood and willows. The departure away from reference conditions will continue.

This PNVT is at high risk of further departures due to the invasion of tamarisk, and to a lesser degree, Russian olive. Kanab Creek extends to the south through Grand Canyon National Park until it joins the Colorado River. The portion of this PNVT that is in Grand Canyon National Park has the same threat.

The PNVT is also at high risk due to the lack of year round water flow and flooding disturbance. This is the result of water impoundments that occur more than 20 miles upstream, and the increased presence of juniper and tamarisk in and near Kanab Creek and its tributaries.

While cottonwood and willow species reestablish following spring floods, tamarisk may be better adapted to post-disturbance environments, post flood or fire, than native species. Tamarisk appears to be more tolerant of both droughts and floods than native willows. The ability of tamarisk to tolerate high levels of soil salinity may also favor it in the post-fire environment, as soil salinity tends to increase after fire. Tamarisk may increase fire frequency and is likely to persist following fire and expand its dominance with repeated burning of low-elevation riparian plant communities. It also raises the salinity of the soil surface to a range that is toxic to native cottonwoods.

Many sites along southwestern river systems are characterized by tamarisk communities with halophytic, fire-tolerant shrubs (e.g. big saltbush and arrowweed) as co-dominants, with only senescent individuals of the historically dominant cottonwood and willow remaining. It has been suggested that cottonwood is nearing localized extinction on many riverine systems of the desert Southwest

Threats/Risk Assessment Results - The primary threats to this PNVT are water diversions and impoundments and are not within Forest Service control. The threats that are within Forest Service control are posed by non-native species, particularly tamarisk. Accidental human-caused fires in existing cottonwood and willow groves also pose a potential threat.

Condition Synopsis – In general on the KNF, cottonwood-willow riparian forests are highly departed from reference conditions. Under current management, the condition of these riparian forests will trend even further away from reference conditions. Across the Grand Canyon Section where this PNVT occurs on the Forest, it is also considered highly departed from reference conditions.

Fire Regime Condition Class

While fire disturbance is key to most of the vegetation successional states used in the previous section, this analysis looks specifically at the fire regime departures from reference conditions in each PNVT. Natural 'fire regime' refers to the role fire played in a vegetation type during the reference period. Fires regimes are classified by the frequency and severity of fires that occurred prior to Euro-American settlement. The standard fire regime classification system, based on fire return interval and fire severity, is displayed in Table 10 (NIFCG 2008).

Table 10 – Standard fire regime groups and descriptions (excerpted from NIFCG 2008)

Fire Regime	Approximate Return Interval	Severity	Severity Description
I	0 - 35 years	Low / Mixed	Generally low severity fires replacing less than 25% of the dominant overstory vegetation; can include mixed severity fires that replace up to 75% of the overstory.
II	0 - 35 years	Replacement	High severity fires replacing greater than 75% of the dominant overstory vegetation. Includes fire-adapted grasslands.
III	35 - 200 years	Mixed / Low	Generally mixed severity fires; can also include low severity fires.
IV	35 - 200 years	Replacement	High severity fires.
V	200+ years	Replacement / Any Severity	Generally high severity; can include any severity type in this frequency range.

Another classification system, Fire Regime Condition Class (FRCC), refers to a relative measure that describes the degree of departure from the reference period's fire regime and vegetation condition class (Table 11; NIFCG 2008). Departures from reference conditions result in changes to species composition, stand age, canopy closure, fuel loading, fire frequency and severity. Other disturbances, such as management (e.g., mechanical thinning), intensive grazing, insect and disease epidemics, invasive species, and drought can also affect condition class (Schmidt et al. 2002). Each class indicates the degree of departure from historic conditions and possible changes to key ecosystem components according to the following characteristics: vegetation characteristics (i.e., species composition, structural stage, stand age, canopy closure, and mosaic pattern); fuel composition; and fire frequency, severity, and pattern.

Table 11 – Fire Regime Condition Class and descriptions (excerpted from NIFCG 2008)

Fire Regime Condition Class	Class Description	Ecological Consequences
FRCC 1	Conditions are within the historic range of variability. (<33% departure)	Effects of wildfire and other disturbances are similar to those that occurred historically. Composition and structure of vegetation and fuels are similar to the natural and historic regime. The risk of losing key ecosystem components is low (e.g. native species, large trees, and soil).
FRCC 2	Moderate departure (33 - 66%) from historic conditions.	The effects of wildfire and other disturbances are not similar to those that occurred historically. Composition and structure of vegetation, and fuels are not like the natural and historic regime. The risk of losing key ecosystem components is moderate.
FRCC 3	High departure (>66%) from historic conditions.	The risk of losing key ecosystem components is high.

Methods

Fire Regime Condition Class was determined for the nine PNVTs for which fire is a primary or contributing disturbance factor. LANDFIRE Rapid Assessment data was used to conduct the FRCC analysis on the Forest (LANDFIRE Rapid Assessment Fire Regimes Layer 2001, LANDFIRE Rapid Assessment Reference Condition Models 2001). LANDFIRE computes the FRCC using the departure of vegetation characteristics from historic conditions to interpolate missed fire return intervals and expected fire severity.

Forestwide Overview

Across all fire-adapted PNVTs found on the Forest, about 4 percent of the acres are in FRCC 1, 33 percent of the acres are in FRCC 2, and 63 percent are in FRCC 3. This means that over half of the KNF is highly departed from reference conditions. The vegetative structure has changed enough to shift many acres out of their historic range of variability. Table 12 shows the departure of each of the PNVTs found on the Forest as determined by the LANDFIRE model (LANDFIRE Rapid Assessment Reference Condition Models 2001). The last column generalizes the degree of departure based on percent of acres in each FRCC. If the majority of acres fell in FRCC2 the departure was rated as Moderate. If the majority of acres were in FRCC3 the departure was rated as High.

Table 12 – Fire regime group, current fire regime condition class (FRCC) by percent of each PNVT, and overall departure from historic fire conditions on the Forest

PNVT	LANDFIRE Acres of PNVT on Forest	Fire Regime Group	% of PNVT in FRCC 1	% of PNVT in FRCC 2	% of PNVT in FRCC 3	Departure from Historic Condition
Pinyon Juniper Woodland	638,321	I, IV, V	2%	16%	81%	High
Ponderosa Pine	541,010	I	6%	35%	59%	High
Mixed Conifer	127,718	I	2%	88%	10%	Moderate
Sagebrush Shrublands	79,862	III	2%	27%	71%	High
Montane / Subalpine Grassland	40,855	II / III	1%	62%	37%	Moderate
Colorado Plateau / Great Basin Grassland	44,199	II	0%	29%	71%	High
Spruce Fir Forest	29,142	III, IV	0%	100%	0%	Moderate
Semi-desert Grasslands	25,043	II	1%	35%	64%	High
Gambel Oak Shrublands	5,366	III	0%	72%	28%	Moderate
Totals	1,531,516		4%	33%	63%	

The departure from historic conditions is reflected and substantiated by Kaibab National Forest fire records. In the last several decades, the average number of both human and lightning caused wildfires has remained stable (Figure 17). The Kaibab averages about 200 fire starts per year.

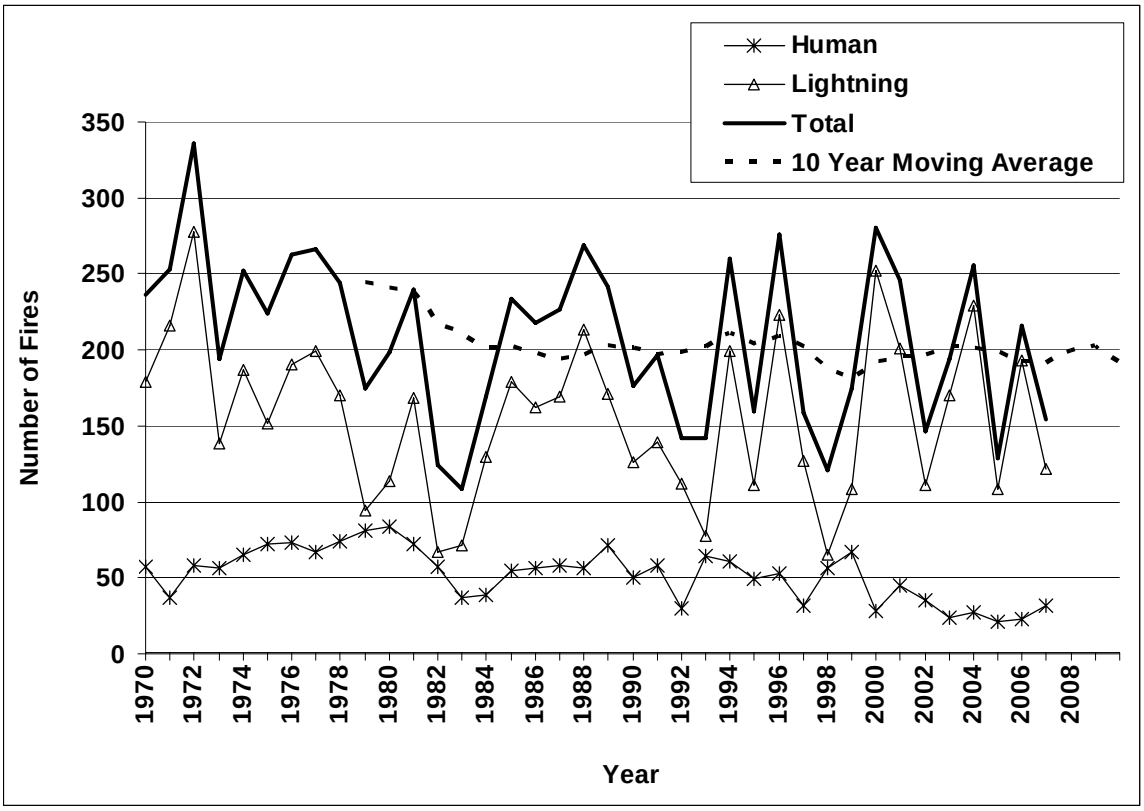

Figure 17 - Fire occurrence by cause, total, and 10-year average on the Kaibab National Forest, 1970 to 2007

While the average number of starts has been stable, there has been a dramatic increase in the total number of acres burned by uncharacteristic wildfire across the Kaibab National Forest, particularly since 1995 (Figure 18). This is indicates that the fuel conditions across most PNVTs have increased so that they support increasingly extreme fire behavior resulting in more severe fire effects, and are highly departed from reference conditions. Extreme fire behavior and the resulting severity is uncharacteristic, and well outside the historic range of variability. The Bridger Knoll Fire in 1996, the Pumpkin Fire and Outlet Fire in 2000, and the Warm Fire in 2006 all burned the thousands of acres in a short period. They sustained crown fires and resulted in overstory mortality across large areas, where historically there were frequent low intensity, or mixed-severity fires.

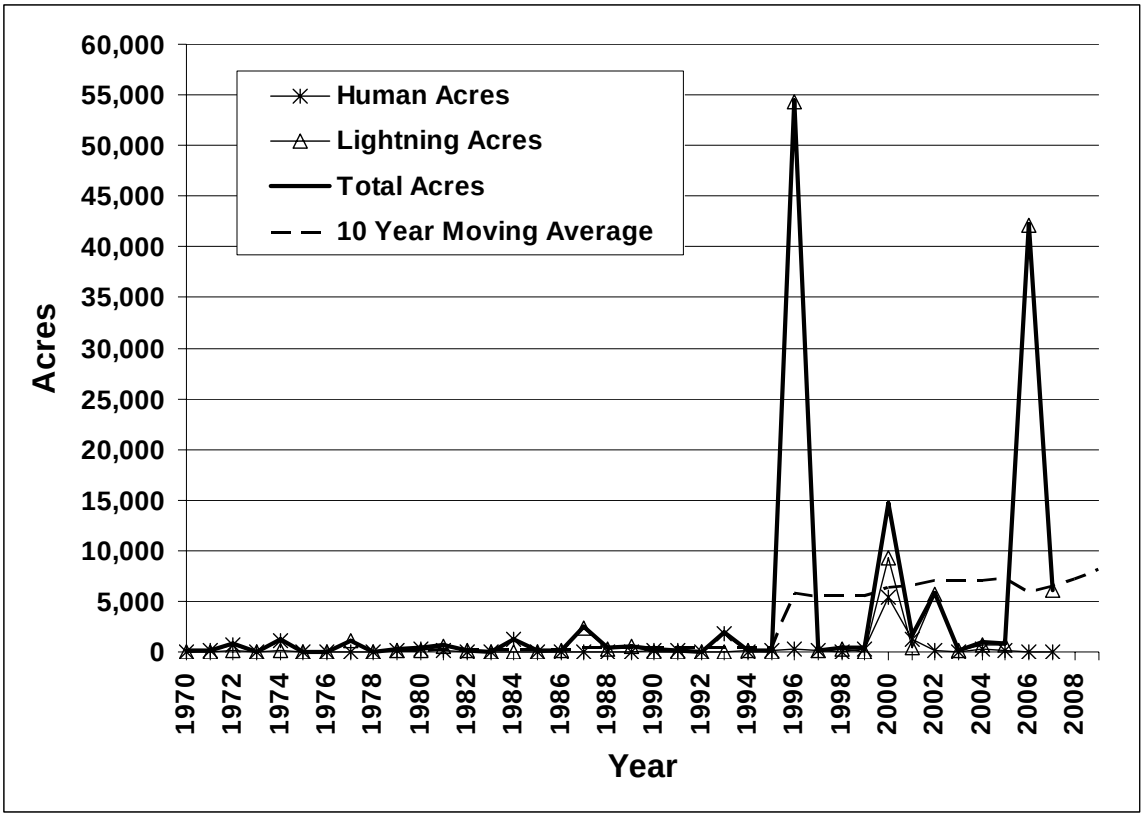

Figure 18 - Acres burned with stand replacing wildfire on the Kaibab National Forest (by cause, total, and 10-year average), 1970 to 2007. Does not include acres from wildfires managed for resource benefit.

Soils

Departure of soils from reference conditions were analyzed in terms of soil condition and soil productivity. The full analysis can be found in the soils specialist report (KNF 2008a).

Soil Condition: Methods

Soil condition is based on three soil functions including 1) the ability of the soil to resist erosion, 2) the ability of the soil to infiltrate water and 3) the ability of the soil to recycle nutrients. Soil condition provides an overall picture of soil health vital in sustaining ecosystems. The Terrestrial Ecosystem Survey (TES) of the Kaibab National Forest was used as the basis for determining current soil condition (USDA Forest Service 1991). The TES identified soil condition by ecological map unit and predicted soil loss.

Departures in soil condition were identified as low, moderate, or high and are based on acre differences between current and historic soil condition by PNVT. The following definitions of soil condition were used in the analysis:

Satisfactory: Indicators signify that soil function is being sustained and soil is functioning properly and normally. The ability of the soil to maintain resource values and sustain outputs is high.

Unsatisfactory: Indicators signify that a loss of soil function has occurred. Degradation of vital soil functions result in the inability of the soil to maintain resource values, sustain outputs or recover from impacts. Unsatisfactory soils are candidates for improved management practices or restoration designed to recover soil functions.

Inherently Unstable: These soils are naturally erodible; instability is inherent in the soil type. These soils erode faster than they are renewed but are functioning properly and normally.

Impaired: Indicators signify a reduction in soil function. This class falls between Satisfactory and Unsatisfactory. The ability of the soil to function properly and normally has been reduced and/or there exists an increased vulnerability to degradation. An impaired category indicates a need to determine the cause and degree of decline in soil functions. Changes in land management practices or other preventative measures may be appropriate.

Soil Condition: Forestwide Overview

Historic soil conditions are inferred based on TES ecological site identifications and descriptions. Historic soil conditions are assumed to have been dominated by satisfactory soil conditions (Table 13). About 94 percent of the Forest had satisfactory soil condition. About 6 percent of the Forest had inherently unstable soils that naturally erode faster than they are renewed. Severe disturbances were rare during the reference period. Historic fire regimes maintained most of the Ponderosa Pine, Mixed Conifer Forests and Pinyon-Juniper PNVTs in open stands (10 to 30% canopy cover) that did not support high intensity fires (KNF 2008f). Open stands generally have more herbaceous and vegetative ground cover which would support satisfactory soil conditions. There were no roads, off-highway vehicle use, livestock grazing, Rocky Mountain elk grazing, logging, or motorized recreation.

Soil Condition: Current Condition and Projected Trends

Human disturbances encountered in the last 100 – 125 years are believed to have caused impacts resulting in a degraded soil condition. Approximately 15 percent of the Forest currently exists in an unsatisfactory condition class (Table 13).

Table 13 - Comparison of estimated historic vs. current refined soil conditions on the KNF

Soil Condition Class	Historic Percent	Current Percent	Difference between Historic and Current
Satisfactory	94	79	-15%
Unsatisfactory	Low	15	+15%
Inherently Unstable	6	6	0%

Differences between historic and current soil condition (departures) are reflected by the occurrence of unsatisfactory soil states. Approximately 15 percent of the soils on the Forest are departed (percent unsatisfactory multiplied by acres). Two of the 12 PNVTs have moderate or high departure between historic and current soil conditions (darker shading, Table 14). Although not highly departed across the Forest, Pinyon-Juniper Woodland and Ponderosa Pine Forest PNVTs contain relatively large areas of unsatisfactory watershed condition; about 134,000 and 73,000 acres, respectively (lighter shading, Table 14). These conditions indicate a reduction or loss in soil function and the possibility that they may not be able to sustain ecological functions and soil productivity. The projected soil condition trend (relative to reference conditions) by PNVT is shown in the Condition Trend column.

Table 14 – Soil condition class percentage and condition trend by PNVT

PNVT	Percent Satisfactory	Percent Unsatisfactory	Inherently Unstable	Condition Trend
Pinyon Juniper Woodland	67	21	12	Towards for Treated Acres Static to Away for Untreated
Ponderosa Pine Forest	85	13	2	Towards
Mixed Conifer Forests	97	3	_	Static
Sagebrush Shrubland	85	_	15	Static
Montane / Subalpine Grassland	98	2	_	Static
Great Basin/Colorado Plateau Grassland	100	_	_	Static
Spruce Fir Forest	100	_	_	Static
Semi-Desert Grassland	60	40	_	Slowly Towards
Desert Communities	_	100	_	Slowly Towards
Gambel Oak Shrubland	100	_	_	Static
Wetland / Cienega	100	_	_	Static
Cottonwood Willow Riparian Forest	100	_	_	Static

Note: Darker shading indicates PNVTs with moderate (33% - 66%) or high (> 66%) departures. Lighter shading indicates PNVTs with large acreages in a departed state.

The moderately to highly departed Semi-Desert Grasslands and Desert Communities PNVTs are trending slowly toward recovery while Pinyon Juniper Woodlands are probably slowly departing overall. Ponderosa Pine Forest, with a low overall departure is also trending toward restoration in places where it is departed.

Soil Productivity: Methods

Current and historic soil productivity was determined by evaluating soil organic matter, litter cover, and estimated forage production estimates. In addition, coarse-woody material was analyzed for the Ponderosa Pine PNVT. Terrestrial Ecosystem Survey data (USDA Forest Service 1991) was used to estimate historic conditions for forage and litter production as well as current litter cover. Forage Maximum was used to describe forage production reference values. These values were compared against estimated current forage values from years of personal field observations (Steinke 2007). Organic matter thickness was derived from thickness of the organic surface horizon through soil classification (KNF 2008a). These data figured into a qualitative assessment of current soil productivity departure from historic soil productivity.

Soil Productivity: Forestwide Overview

The most productive soils are those within Montane/Subalpine Grasslands and Wetland Cienega PNVTs followed by the Great Basin Grasslands. These PNVTs have soils with high amounts of organic matter that are capable of producing the greatest amount of forage under historic conditions of the PNVT. Current forage productivity, however, appears to be low to moderate. As a result, there may be opportunities to improve forage production.

Soils in the Desert Communities PNVT are the least productive have the lowest amount of organic matter. Low productivity PNVTs cannot be expected to produce a lot of forage. They have low levels of organic matter at the surface due to dry climate or having been recently developed. This was also true during the reference period.

The Pinyon-Juniper Woodland and Ponderosa Pine PNVTs currently have low to moderate soil productivity (organic matter and forage production) but were more productive and produced more forage historically because there was lower canopy cover. If canopy cover is reduced through management or natural disturbance, herbaceous understory and forage production would be expected to increase.

Soil Productivity: Current Conditions and Projected Trends

Table 15 lists reference condition productivity, current condition productivity, and projected future trends of current conditions to reference conditions by PNVT. Shaded rows represent PNVTs with a departed condition or a trend away from reference conditions.

Table 15 –Findings of the qualitative assessment of soil productivity*, including the level of departure from historic to current conditions, projected future trends given current management practices, and special considerations in each PNVT.

PNVT	Historic Soil Productivity	Current Soil Productivity	Departure	Projected Future Trend	Special Considerations
Pinyon Juniper Woodland	Moderate	Low to Moderate	Low to Moderate	Static, Away, and Towards	Static to Away for untreated areas Towards for treated areas Nutrient cycling reduced with canopy cover >40%.
Ponderosa Pine Forest	Moderate	Low to Moderate	Low to Moderate	Static, Away, and Towards	Static to Away for untreated areas Towards for treated areas Nutrient cycling reduced with canopy cover >40%.
Mixed Conifer Forest	Moderate	Moderate	Low	Static	None
Sagebrush Shrubland	Low to Moderate	Low	Low to Moderate	Static to Slowly Towards	None
Montane / Subalpine Grassland	High	Moderate to High	Low to Moderate	Static to Towards	Static for areas unfenced from ungulates Towards for areas fenced from ungulates
Great Basin / Colorado Plateau Grassland	Moderate to High	Moderate	Low to Moderate	Static	None
Spruce Fir Forest	Moderate	Moderate	Low	Static	None
Semi-desert Grassland	Low	Very Low To Low	Low to Moderate	Static to Slowly Towards	Improvements would take many years because of the dry climate
Desert Communities	Low	Very Low	Low to Moderate	Static to Slowly Towards	Improvements would take many years because of the dry climate
Gambel Oak Shrubland	Moderate	Moderate	Low	Static	None
Wetland / Cienega	High	High	Low	Static to Towards	Static for areas unfenced from livestock Towards for areas fenced from livestock
Cottonwood Willow Riparian Forest	Low	Low	Low	Static	None

*Productivity: High = soils capable of producing the greatest amount of forage, Moderate = soils capable of producing moderate amounts of forage, and Low = soils capable of producing relatively low amounts of forage.

B. Aquatic Systems

Aquatic systems include those water resource characteristics identified as important in assessing water resource ecosystem diversity. The Forest contains portions of eight 4th code watersheds and 22 smaller, nested, 5th code watersheds. The Forest contribution to broad-scale ecological sustainability was conducted using large 4th code watersheds, and threats to aquatic systems on the Forest were assessed using smaller 5th code watersheds.

Reference conditions for aquatic characteristics are unknown unless indicated otherwise. The majority of data, except for groundwater and stream flow yield, came from the National Hydrography Dataset (NHD; USGS 2008). Wetland and riparian condition and extent comes from Forest-specific, on-site data collected in 1990. Water quality data was obtained from the Arizona Department of Environmental Quality (ADEQ; ADEQ 2008).

Threats to watersheds were identified by classifying the risk of adverse outcomes from uncharacteristic disturbances, specifically wildfire occurring in departed PNVTs. The Vegetation and Fire Need for Change Report (KNF 2008f) documents the process of assigning risk by composition-structure class within PNVTs. These were disaggregated by watershed for analysis. Relative ratings between watersheds are documented in Appendix 2 of this report.

Historic and Current Conditions

Watersheds: The Forest contains portions of eight 4th code watersheds, containing an average of 15 percent of the watersheds and no more than 35 percent of any one watershed. The Forest makes up more than 10 percent of four 4th code watersheds (Table 8). Forest threats to these sub-basins are further assessed. Watershed conditions are believed to have been satisfactory during the reference period.

Currently, watershed conditions on the Forest are generally satisfactory. Unsatisfactory soil conditions within these watersheds have contributed to a decline in some areas, particularly in the desert and pinyon-juniper communities. Past livestock grazing and the lack of fire have contributed to these downward trends. Currently, vegetation departures from historic conditions pose risks to a number of watersheds from the threat of large fires and the increase in fuels in these watersheds. Fires occurring in areas with high fuel loadings burn with high intensities, damage soils, remove ground cover, and deliver large sediment loads to stream channels. Table 16 displays the relative risks to the 4th and 5th code watersheds. Dark shading indicates higher risk and light shading indicates moderate risk. A relative scale of risk was devised to compare the watersheds across the Forest, and within sub-basins (Appendix 2). The level of risk in the 4th code watersheds is high, moderate, or low relative to the overall vegetation condition on the Forest; level of risk in the 5th code watersheds is high, moderate, or low relative to the condition of its 4th code watershed.

Table 16 – Fourth- and 5th-code watersheds and relative risk on the KNF

Watershed Name	Acres of Unchar. Disturbance Risk				Relative Risk
4th, 5th	H	M	L	Total	
Grama Canyon-Kanab Creek	1,271	3,024	16,872	21,168	Low
Hack Canyon		224	158	382	Low
Jumpup Canyon-Kanab Creek	29,908	9,795	73,669	113,372	Low
Lower Johnson Wash	13,109	609	17,223	30,941	Moderate
Snake Gulch	76,583	13,487	69,782	159,852	High
White Sage Wash	15,780	4,641	27,368	47,788	Low
Kanab	**136,650**	**31,780**	**205,072**	**373,502**	**Low**
Bright Angel Creek-Lower Colorado River	29	_	22	51	High
House Rock Wash	21,506	24,181	54,630	100,317	High
North Canyon Wash	20,013	1,646	31,967	53,626	High
Shinumo Wash-Lower Colorado River	6,333	2,142	33,485	41,960	Low
Tatahatso Wash-Lower Colorado River	1,287	738	14,976	17,001	Low
Lower Colorado - Marble Canyon	**49,167**	**28,707**	**135,081**	**212,956**	**Low**
Cataract Creek	52,112	5,207	22,417	79,736	High
Heather Wash	34,929	3,293	73,187	111,409	Low
Middle Havasu Creek	6		581	586	Low
Miller Wash	11,993	2,790	20,883	35,665	Low
Red Horse Wash	42,237	5,037	57,651	104,925	Moderate
Spring Valley Wash	35,903	1,292	28,388	65,583	High
Havasu Canyon	**177,180**	**17,619**	**203,107**	**397,905**	**Moderate**
Grindstone Wash-Upper Verde River	2,954	0	953	3,908	High
Hell Canyon	61,966	8,811	35,836	106,613	High
Sycamore Creek	106,518	2,578	20,621	129,717	High
Upper Verde	**171,439**	**11,389**	**57,410**	**240,238**	**High**
Lee Canyon-Lower Little Colorado River	12,184	1,645	39,266	53,095	Low
Lower Cedar Wash-Tappan Wash	12,618	13,624	26,800	53,042	High
Upper Cedar Wash	10,499	2,062	12,490	25,051	High
Lower Little Colorado	35,301	17,331	78,555	131,187	Lower
Ash Fork Draw-Jumbo Tank	22,392	9,460	29,281	61,134	High
Lower Partridge Creek	665	212	1,639	2,516	Low
Upper Partridge Creek	17,076	4,644	30,605	52,325	Low
Big Chino - Williamson Valley	40,133	14,317	61,526	115,975	Moderate
Lower Buckskin Gulch	603	9	5,640	6,251	Low
Paria	603	9	5,640	6,251	Low
Shinumo Creek-Lower Colorado River	1,602	176	334	2,112	High
Tapeats Creek-Lower Colorado River	20,743	406	7,783	28,931	High
Grand Canyon	22,344	582	8,117	31,043	High
Grand Totals	**632,817**	**121,733**	**754,507**	**1,509,057**	

Note: See text and Appendix 2 for High, Moderate, and Low risk descriptions. Bold indicates 4th-code watersheds where the KNF contains >10 % of that watershed's area.

Perennial Streams: North Canyon Creek and Kanab Creek are the only known historic perennial streams on the Forest. North Canyon Creek is part of North Canyon Wash, located in the Lower Colorado-Marble Canyon 4th code watershed (Table 16). Depending on precipitation, North Canyon Creek historically ran from one to six miles above at the surface before going underground. North Canyon Creek makes up only about 2 percent of the perennial stream distance in this watershed, while the Forest area makes up almost 25 percent of the watershed. Historically, Kanab Creek was perennial, and 29 percent of the stream distance was within the Forest, nearly proportional to the 35 percent of Forest land area that is in the subbasin.

Currently, North Canyon Creek in the North Canyon Wash 5th code watershed is believed to be at or near historic water flow conditions. Correspondingly, riparian conditions are thought be similar to historic conditions with a diversity of riparian species. North Canyon Creek stream is classified in good condition and is not diverted. Some log structures were installed by the federal Civilian Conservation Corps for fish habitat in the late 1930's, however the creek has not been substantially altered, and is not considered departed from reference conditions.

Kanab Creek, which lies in the Grama Canyon and Jumpup Canyon 5th code watersheds, have off-forest/upstream diversions that have converted it to an ephemeral stream. The natural flooding disturbance has been greatly reduced. Kanab Creek is now dominated by tamarisk, which is crowding out the native willow and cottonwood community. Livestock grazing was a factor in this area but livestock have been excluded from grazing since 1996. Occasional unauthorized use continues.

Seeps, Springs, Reservoirs and Stock Tanks: Arizona has the second highest density of springs in the United States. The Mogollon Rim (WRD) and the Kaibab Plateau (NKRD) have the highest density of springs in Arizona (pers. comm., Lawrence Stevens, Museum of Northern Arizona). According to the NHD data, there are 709 springs and seeps in all Forest connected 4th code watersheds. The KNF contains 129 springs and seeps or about 18 percent of the total. The historic extent and flow of springs and seeps are unknown, but are presumed to be at least equal to the current extent. There are no springs on the Forest that flow more than 0.2 miles. Field observations indicate that the extent and flow of springs and seeps fluctuate depending on precipitation. During the reference period, constructed reservoirs were not common.

A substantial number of the springs are known to be developed which probably occurred after the Homestead Act of 1862. These developments removed water from the site and reduce riparian vegetation extent. Several springs have been documented to be at risk or are nonfunctional riparian areas due to ungulate grazing and recreational impacts. These impacts are believed to be minor in the larger Forest context. Springs and seeps may have reduced flows from increased transpiration associated with high tree density and continuous forest canopies, or from being located adjacent to existing wells. Currently, the KNF is conducting an inventory of the majority of seeps and springs, collecting information on vegetation, flow rates, and likely impact sources.

There are 492 reservoirs and stock tank claims on the Forest, and 3,281 in the 4th code watersheds according to the Arizona Department of Water Resources (2008). This represents 15 percent of the structures, roughly equivalent to the land area in the sub-basins affected. The Forest reservoir and stock tanks were mostly built between 1930 and 1980. These impoundments have reduced flows volume and duration of water flowing through some of the ephemeral and intermittent streams on the Forest. However, due to the short duration that these stream channels had water historically, a reduction in riparian vegetation has not been seen. The reservoirs and stock tanks have increased perennial water availability on the Forest for livestock and wildlife as well a corresponding increase in riparian vegetation surrounding them.

Water Quality: Historically, water quality was very good except immediately following large fires, drought or extreme flood events. Most of the time, streams, lakes and wetlands would have met current water quality standards.

North Canyon Creek is the only stream on the Kaibab. Because it is very short ADEQ does not monitor it. The Forest makes no known contribution of negative impacts to ADEQ-monitored streams on or off the Forest.

The only water body on the Forest that has been classified by ADEQ into an EPA water quality category (EPA 2008a) is Whitehorse Lake, a constructed impoundment. Sampling has been conducted periodically from 1993 to 2006. In 1998, Whitehorse Lake was considered an "Impaired Water" for exceeding the turbidity standard for Aquatic and Coldwater Fisheries designated use (ADEQ 2008). From 1997-2000, the lake exceeded standards in dissolved oxygen, pH, and turbidity standards. In 2002, the lake exceeded standards in dissolved oxygen standard. ADEQ classified the lake as Category 5 for high pH, fish kills in 1994, excessive ammonia and turbidity. In 2006, ADEQ placed Whitehorse Lake into an improved class, Category 2 "Attaining Some Uses" where it remains.

Large fires, drought or extreme flood events will likely continue to affect water quality. Typically, these events adversely affect soil and water conditions for short periods and recover quickly. The sub-basin risk is primarily determined by the potential for sediment delivery to ephemeral systems, should a large fire occur.

Ground Water: Ground water on the Forest is deep within the regional aquifers at an average depth of 1,200 feet. Historically, this aquifer was charged with surface precipitation at the higher altitudes and in areas with heavily fractured rock.

In recent years, there have been increased demands for groundwater. Water use in Flagstaff and Colorado Plateau municipalities increased about 30 percent from the mid-1980's to the mid-1990's (Bills et al. 2000). No data were found on groundwater use for cities and private wells within or near the Forest. The effect of Forest and adjacent private well pumping to seep, spring or down stream water flow is possible, but no effects have been documented.

Wetlands: The extent of historic wetlands on the Forest is largely unknown. They are believed to have been similar to current condition, which is 88 wetlands, totaling 494 acres. Of these, 31 are in poor condition, 45 are in fair condition, and 12 are in good condition. The primary causes of poor conditions are livestock and native ungulate use, and recreational impacts. About 17 wetlands have been modified to capture more water. Several of these wetlands have been excluded from livestock grazing in the last 10 years, which has improved conditions. However, precipitation amount and timing is the primarily factor affecting wetland riparian size and condition and associated riparian vegetation.

Projected Future Condition and Trends

Watershed: Watershed conditions on the Forest are expected to remain in satisfactory condition (Table 17). Unsatisfactory soil conditions within these watersheds, particularly for desert and pinyon-juniper communities, are expected to remain static or continue to improve with improved livestock grazing management and canopy reduction treatments in the pinyon-juniper PNVTs. The risk of heavy sediment load delivery from uncharacteristic fires is expected to increase over time as PNVTs continue to depart from reference conditions (Table 16).

Departures and trends for aquatic ecological characteristics for the 4th code watersheds, including stream flow and groundwater yield, seeps, springs and stock pond extent are displayed in Table 17. Trends show the anticipated trajectory under current management, towards or away from reference conditions, or static (no change). Unknown means no data is available for the indicated aquatic characteristic.

Table 17 - Departures between reference and current conditions and projected trends by aquatic characteristic at the 4th code watershed scale.

4th Code Watershed	Groundwater Yield	Stream flow Yield	Seeps & Springs Departure*	Stock Pond Departure*	Overall Watershed Departure / Trend
Kanab	Unknown	None on Forest	L to H	H (no stock ponds historically)	Low / Static
Lower Colorado-Marble Canyon			L		
Havasu Canyon					
Upper Verde			L to H		
Lower Little Colorado			L		
Big Chino-Williamson Valley					
Paria					
Grand Canyon					

*Departure: Low = less than 33% of the area is in fair or poor condition, M = 34-66% of the area is in fair or poor condition, and H = 67-100% of the area is in fair or poor condition (based on riparian, wetland, and water quality data; KNF 2008b).

Perennial Streams: North Canyon Creek is expected to remain at or near historic conditions for water flow and riparian vegetation. However, the high risk of uncharacteristic fire and potential for soil erosion and sedimentation is expected to continue to increase.

Due to the high and increasing demand for water in its upper watershed, Kanab Creek is will likely remain an intermittent stream. Tamarisk could be treated in the future with beetles and/or herbicides to restore the native cottonwood and willow community.

Seeps, Springs, Reservoirs, and Stock tanks: Springs and seeps are expected to continue to flow at rates similar to historic levels. Developed springs will continue to be used near levels used during the homestead era. Riparian vegetation is expected to improve around springs that are excluded from livestock grazing. Where livestock grazing continues at the springs, riparian conditions will remain static. Where forest canopies are reduced in watersheds above springs, flows are expected to increase. Where wells are located in watershed above springs on Forest or private lands, it is likely that spring flow would decrease.

The number and size of reservoirs and stock tanks will likely remain near current levels. These impoundments will continue to reduce some flows volume and duration running through

ephemeral and intermittent streams on the Forest. The reservoirs and stock tanks will continue to increase perennial water on the forest for livestock and wildlife as well as increasing riparian vegetation surrounding them. Overall aquatic sustainability is not affected because the stock tanks are typically small and widely scattered.

Water Quality: Overall water quality condition for streams, lakes and wetlands reflects watershed conditions and will likely continue to be in good and static condition except immediately following large fires, drought or extreme flood events. Historically, under favorable climatic conditions, good and static water quality conditions usually return quickly after disturbance.

Whitehorse Lake will continue to be monitored by ADEQ and is likely to continue to improve with improvements to recreation management on this artificial impoundment.

Ground Water: Ground water use by cities and private wells on and off-Forest will likely increase with demand, possibly affecting seep, spring or down stream water flow off the Forest and in some localized areas on the Forest. This is most likely in the Upper Verde and Havasu subbasins.

Wetlands: Wetland conditions will continue to improve on wetlands that are excluded by livestock grazing and have reduced recreational impacts. Wetlands that are not excluded from livestock grazing or recreational impacts will continue to remain in static condition. Precipitation will continue to determine how fast these wetlands improve, the size of the wetlands and what riparian vegetation grows at each site.

Table 18 summarizes departure and trends for aquatic ecological characteristics by 4^{th} and 5^{th} code watershed. Trend projects ecological trajectory under current management. Trend is either towards or away from reference conditions or static (no change). 'None' means that the aquatic characteristic is not present in the watershed and 'Unknown' means that data is lacking regarding the status of the aquatic characteristic.

Table 18 - Departure from reference conditions, projected trends and ecological need for change by aquatic characteristic by 4th and 5th code watershed on forest.

4th Code Watershed	5th Code Watershed	Water Quality Departure* and Trend	Riparian Condition Departure* / Trend		Aquatic Char. of Greatest Concern
			Stream	Wetland	
Kanab	Kanab Creek	Not applicable / no surface water body present or monitored	H / Static for invasive species and no perennial water	H / Static for unfenced areas; towards for fenced or deferred grazing	Stream and wetland condition
Lower Colorado – Marble Canyon	House Rock Wash		Not applicable / no identified riparian area	Not applicable / no identified wetlands present.	None
	North Canyon Wash		L / Static	H / Static for unfenced areas; towards for fenced or deferred grazing.	Stream and Wetland Condition
	Shinumo Wash		Not applicable / no identified riparian area	Not applicable / no identified wetlands present.	None
	Tatahatso Wash				
	Bright Angel Creek				
Havasu Canyon	Cataract / Spring Valley			H / Static for unfenced areas; towards for fenced or deferred grazing	Wetland condition
	Red Horse Wash			Not applicable/no identified wetlands present.	None
Upper Verde	Hell Canyon – Grindstone Wash			H / Static for unfenced areas; towards for fenced or deferred grazing	Wetland condition
	Sycamore	L / Slightly Variable but generally Static, not historic			Wetland condition. Monitor water quality
Lower Little Colorado	Cedar Wash	Not applicable / no surface water body present or monitored		Not applicable / no identified wetlands present.	None
	Lee Canyon				
Big Chino – Williamson. Valley	Ash Fork Draw Jumbo Tank				
	Heather Wash				
	Partridge Creek				
Paria	Lower Buckskin Gulch				
Grand Canyon	Shinumo Creek				
	Tapeats Creek				

*Departure: L = less than 33% of the area is in fair or poor condition. M = 34-66% of the area in fair or poor condition, and H = 67-100% of the area is in fair or poor condition (based on riparian, wetland, and water quality data; KNF 2008b).

Threats/Risk Assessment Results

The PNVTs in the Lower Colorado – Marble Canyon watershed are departed from reference conditions, and at considerable risk of uncharacteristic wildfire. There is an opportunity to reduce this watershed risk to North Canyon Creek by reducing tree density. Because a large portion of the affected watershed is in the Saddle Mountain Wilderness Area and is on steep slopes, the challenges of reducing tree density and canopy closure while protecting the associated fishery are substantial.

An opportunity to restore riparian vegetation around some seeps and springs exists by instituting further control of livestock grazing. Some areas receive heavy use by elk (and perhaps bison), which may be addressed by different management strategies to alleviate or mitigate impacts.

Currently, vegetation departures from historic conditions pose risks to a number of watersheds from the threat of large fires and the increase in fuels in these watersheds (Table 16). Fires occurring in areas with high fuel loadings burn with high intensities, damage soils, remove ground cover, and deliver large sediment loads to stream channels.

C. Atmospheric Systems

Airsheds

Clean air free of contaminants is needed to promote ecological sustainability, just as it is for human health. Air contaminants are measured relative to their affect on human health and human aesthetics rather than in relation to vegetation and wildlife tolerance. However, the same air quality indices can be used as an indicator of the relative cleanliness or contamination of an airshed. The Kaibab National Forest falls within two airsheds as designated by the Arizona Department of Environmental Quality (ADEQ): the Colorado River Airshed and the Verde River Airshed (ADEQ 2008).

The Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for specific pollutants which, if emitted in significant quantities may pose a danger to public health and welfare (EPA 2008b). Table 19 describes the pollutant sources that are at least partly under Forest Service control. In Arizona, pollutants are monitored by the ADEQ, and sources for each of the NAAQS pollutants have been identified in Arizona (ADEQ 2008). Further information about the atmospheric systems analysis can be found in the specialist report for air resources (Fitch and Truman 2007).

Table 19 - Pollutants, pollutant sources, and sources under Forest Service control

Pollutant	Pollutant Source	Sources under control and authority of the Forest
Carbon monoxide	Motor vehicles, wood-burning stove, fireplaces, wildland fires, prescribed fires, manufacturing	Prescribed fires conducted by the Forest, Suppression of wildland fires on Kaibab NF.
Lead	Metal processing, waste incinerators, utilities, manufacturing	N/A
Nitrogen dioxide	Motor vehicles, electric utilities, other industrial, commercial, residential operations that burn fuels, wildland fires, prescribed fires.	Suppression of wildland fires on Kaibab NF. Prescribed fires conducted by the Forest.
Ozone	Motor vehicle exhaust, industrial emissions, gasoline vapors, chemical solvents, natural sources.	N/A
Particulate matter	Dust, smoke from wood burning stoves, fireplaces, wildland fires, prescribed fires, other emissions	Prescribed fires conducted by the Forest, Suppression of wildland fires on Kaibab NF.
Sulfur dioxide	Burning fossil fuels including coal, gasoline and diesel.	N/A

Reference Conditions

Lightning caused wildfires were common and widespread prior to European settlement. Northern Arizona has one of the highest incidences of lightning-caused fires in the country. The Kaibab National Forest has almost 840,000 acres of vegetation with a frequent natural fire return interval,

less than 35 years. This translates to a conservative estimate of about 48,000 acres burning annually under historic conditions. Approximately 40,350 acres burned with low to mixed severity fire effect and about 7,000 acres burning in high severity conditions.

Current Conditions

The EPA Air Quality Index for Coconino County for the past 10 years shows air quality in Coconino County is rated as Good for 252 to 313 day our of the year (Table 20). Very few days reached the thresholds for Unhealthy for Sensitive Groups. Values for Maricopa County containing the greater Phoenix area are shown for comparison (EPA 2008b).

Table 20 – EPA Air Quality Index for Coconino County for 1998 - 2007 (number of days)

County	Year	Good	Moderate	Unhealthy for Sensitive	Unhealthy	Hazardous
Coconino County	1998	292	73	0	0	0
	1999	282	78	5	0	0
	2000	288	76	2	0	0
	2001	313	52	0	0	0
	2002	252	98	12	0	0
	2003	275	87	2	0	0
	2004	297	67	2	0	0
	2005	300	61	4	0	0
	2006	279	85	1	0	0
	2007	276	83	1	0	0
Maricopa County	2007	64	266	33	1	1

Of the NAAQS pollutants, those existing in measurable levels in Coconino County are ozone and small particulate matter (i.e., PM2.5 and PM10). Measurable amounts of ozone are present most of the year though rarely at elevated levels. Measurable amounts of particulates were only detected a few days each year.

Ozone is an unstable gas composed of three oxygen atoms, and is formed when hydro carbons and nitrogen oxides react chemically with sunlight (Fitch and Truman 2007). Possible impacts of elevated levels of ozone on forested species include reduced growth and seed production and increased susceptibility to insects and disease. Long-term ozone stress may lead to changes in species composition and biodiversity. Ponderosa pine and aspen are species that are sensitive to ozone when present at elevated levels (FIA 2008).

Particulate matter is tiny bits of solids or semi-solids in the air measuring 0.1 to 10 micrometers in diameter. Particles larger than 10 micrometers tend to settle out of the air, but those smaller remain airborne can cause respiratory problems. (Fitch and Truman 2007)

Emissions that are under the control and authority of the Forest are from wildland fires and prescribed fires. Currently emissions are considered within the historic range of variation. About

200 wildland fires occur annually on the Forest. The 10 year average for number of acres burned by unwanted wildfires is about 6,000 acres per year. The average number of acres treated by managing natural starts through wildland fire use continues to increase. Since average number of acres burned per year since 2003 is 7,900 acres. Since 2005 the Forest has treated over 10,000 acres per year with prescribed fire. While the number of acres burned per year does fluctuate due weather and fuel conditions, the current number of acres burned per year comes to around 23,900 acres. This is well below the low estimate reference condition of 40,350 acres.

Projected Future Trends and Conditions

While air quality in Northern Arizona is considered to have a low level of impairment, Arizona has a variety of pollutant sources not present historically, and air quality is trending slowly away from reference conditions. The number of days per year that prescribed burning takes place is likely to stay the same or increase. Over time, as prescribed burning continues, and shifts from initial entry burns to maintenance burns, the reduced fuel load will result in lower emissions per acre when burned. Since ADEQ limits the total acres burned per day in any airshed, daily emissions do not accumulate to exceed Air Quality Standards.

Most of the Kaibab National Forest is departed from its historic fire frequency. By not burning periodically, accumulated fuels contribute to a greater amount of emissions when large uncharacteristic wildfires occur. Management activities addressing ecosystem risks brought about by lack of characteristic fire are likely to increase atmospheric particulates over time, but are unlikely to adversely affect ecological sustainability of the frequent fire systems that dominate the Forest and surrounding lands. Limits to the frequency and extent of burning imposed by regulation, human health and esthetic concerns are likely to limit management activities that affect air quality before any potential long-term adverse ecological effects might occur.

Overall, Coconino County has very clean air. Particulate emissions from Forest management activities are regulated by ADEQ. Uncharacteristic wildfire is the primary threat to air quality on the forest, but does not have adverse ecological implications and has relatively short term effects.

There has been an increase in ozone levels, but the source is off-Forest and can not be affected by management activities within Forest Service control.

III. SPECIES DIVERSITY

Species diversity is linked to maintenance and enhancement of desired ecosystems. The Species Diversity Analysis Process, in conjunction with the Ecosystem Diversity Analysis Process, strives to promote ecological sustainability across the planning area by developing Forest Plan components that protect or enhance species diversity where existing plan direction does not sufficiently protect or enhance individual species, groups of species, or habitats (FSH 1909.12 Ch. 40, FSM 1921.74b and 1921.77c). The Species Diversity Analysis Process will be used to identify the need for change in the existing Forest Plan, evaluate plan options, and evaluate the proposed plan.

This section of the ESR is supported by the KNF Species Diversity Report (KNF 2008c), and an Microsoft ACCESS database holds background data gathered on each species considered in the analysis process. The database is meant to function as a "living document" that can be supplemented as new information comes available. The KNF Species Diversity Report and database are on file at the KNF Supervisor's Office in Williams, Arizona.

Species Lists

Rather than considering the relationships between ecosystem diversity components and all plant and animal species (and subspecies) in the plan area, the Species Diversity Analysis Process uses explicit criteria to identify a select number of species (and subspecies) considered to be of concern or interest in the plan area. This list of select species serves as a model for species diversity in the plan area. The list was developed only for Forest Plan revision purposes, and does not confer special regulatory status on any species beyond existing state and federal status.

Development of the initial species diversity list was an iterative process that followed national direction (FSH 1909.12, Chap. 40, Sec. 43.2). Forest Service biologists and botanists gathered initial species information, and incorporated input from a species diversity focus group. The focus group included members from the Forest Service, U.S. Fish and Wildlife Service (FWS), Arizona Game and Fish Department, Grand Canyon Wildlands Council, National Park Service, Nature Conservancy, and others. The State Heritage Data Management System and Arizona Rare Plant Task Force were contracted for plant information, and the Museum of Northern Arizona was contracted for invertebrate information. An initial list of species and subspecies, including plants, macro-lichens, invertebrates, reptiles, amphibians, birds, and mammals, with population or habitat concerns in Arizona was developed using the following criteria:

Threatened and Endangered Species

Threatened and Endangered Species (T&E) include those that are federally listed under the Endangered Species Act (ESA). This list is maintained by the FWS, and can be found at the Arizona FWS Ecological Services website (www.fws.gov/southwest/es/arizona/), or the national FWS website (www.fws.gov/endangered).

Species of Concern

Species of Concern (SOC) include species for which management actions may be necessary to prevent listing under the ESA:

- Species identified as proposed or candidate species under ESA
- Species ranked G-1, G-2, or G-3 by NatureServe (www.natureserve.org)
- Subspecific taxa ranked T-1, T-2, or T-3 by NatureServe.
- Species that have been petitioned for federal listing and for which a positive "90-day finding" has been made.

- Species that have been recently delisted including those delisted within the past five years and other delisted species for which regulatory agency monitoring is still considered necessary.

Potential Species of Interest

Potential Species of Interest (SOI) include species for which management actions may be needed to achieve ecological or other multiple-use objectives. The list of SOI was developed in a more discretionary manner, and did not necessarily include species for which there was not significant local risk or high public interest. Potential SOI were identified as:

- Species ranked as S-1, S-2, N-1, or N-2 by NatureServe
- State listed threatened and endangered species
- Species identified as species of conservation concern in the Arizona State Comprehensive Wildlife Strategy
- Species on the FWS Birds of Conservation Concern National Priority List
- Species of regional or local conservation concern
- Species hunted or fished
- Other species of public interest

The resulting initial species diversity list included 1,835 species and subspecies.

Results of Screening

Using the following specific screening criteria, a portion of species from the initial list were not carried forward for further analysis in the planning process. Information about these species have been retained in the project record (i.e., Microsoft ACCESS database) should information become available that might warrant reconsideration in the future. The species carried forward in the planning process will be the focus of analysis and potential development of plan components.

Species Screened Out

If SOC or SOI from the initial list of 1,835 species met any of the following criteria they were removed from further consideration in the planning process (FSH 1909.12, CH 40, Sec. 43.22d):

- Species does not occur on the forest and there is no known habitat in the plan area.
- Species is secure in the plan area based on occurrence, distribution, available habitat, and response to natural disturbance and/or management.
- There is too little information to complete a reliable assessment (taxonomic uncertainty, habitat needs, population trend estimates).
- Species are not affected by any form of current or potential management or lack of management in the plan area.

The list of species screened out and the rationale for removing each from further consideration is available in the Species Diversity Report (KNF 2008c).

Species Carried Forward for Further Analysis

The screening process resulted in a list of 145 species to be carried forward in the Species Diversity Analysis Process, and included 26 birds, 1 fish, 8 reptiles and amphibians, 9 invertebrates, 19 mammals, and 82 plants to be carried forward for further analysis (Table 21). Of these, 3 were federally threatened or endangered species, 84 were SOC and 58 were SOI.

Table 21 - Species carried forward in the Species Diversity Analysis Process. Taxa: Bird (B), Fish (F), Reptile/Amphibian (R/A), Invertebrate (I), Mammal (M), Plant (P). Category: Threatened or Endangered under the Endangered Species Act (T or E); Species of Concern (SOC), or Species of Interest (SOI) as identified under the 2008 Planning Rule, FSH 1909.12

Scientific Name	Common Name	Taxa	Category
Accipiter gentilis	Northern goshawk	B	SOI
Amphispiza belli	Sage sparrow	B	SOI
Baeolophus ridgwayi	Juniper titmouse	B	SOI
Buteo regalis	Ferruginous hawk	B	SOI
Cardellina rubrifrons	Red-faced warbler	B	SOI
Coccothraustes vespertinus	Evening grosbeak	B	SOI
Contopus cooperi	Olive-sided flycatcher	B	SOI
Dendragapus obscurus	Dusky (blue) grouse	B	SOI
Dendroica graciae	Grace's warbler	B	SOI
Dendroica nigrescens	Black-throated gray warbler	B	SOI
Falco peregrinus anatum	American peregrine falcon	B	SOC
Gymnogyps californianus	California condor	B	T&E
Gymnorhinus cyanocephalus	Pinyon jay	B	SOI
Haliaeetus leucocephalus	Bald eagle	B	SOC
Melanerpes lewis	Lewis's woodpecker	B	SOI
Oporornis tolmiei	MacGillivray's warbler	B	SOI
Oreoscoptes montanus	Sage thrasher	B	SOI
Passerculus sandwichensis	Savannah sparrow	B	SOI
Pipilo chlorurus	Green-tailed towhee	B	SOI
Progne subis arboricola	Purple martin (Western)	B	SOI
Regulus satrapa	Golden-crowned kinglet	B	SOI
Sphyrapicus nuchalis	Red-naped sapsucker	B	SOI
Spizella breweri	Brewer's sparrow	B	SOI
Strix occidentalis lucida	Mexican Spotted Owl	B	T&E
Vermivora celata	Orange-crowned warbler	B	SOI
Vireo vicinior	Gray vireo	B	SOI
Oncorhynchus apache	Apache (Arizona) Trout	F	T&E
Bufo microscaphus	Arizona toad	R/A	SOI
Crotalus cerberus	Arizona black rattlesnake	R/A	SOI
Eumeces skiltonianus	Western skink	R/A	SOI
Hyla wrightorum	Arizona (mountain) treefrog	R/A	SOI
Lampropeltis pyromelana infralabialis	Utah Mountain Kingsnake	R/A	SOC
Lampropeltis triangulum	Milksnake	R/A	SOI
Rana pipiens	Northern leopard frog	R/A	SOI
Spea intermontana	Great basin spadefoot	R/A	SOI
Acrolophitus nevadensis	Nevada point-headed grasshopper	I	SOC

Scientific Name	Common Name	Taxa	Category
Aeshna persephone	Persephone's Darner	I	SOC
Callophrys sheridanii comstocki	Desert Green Hairstreak	I	SOC
Cicindela terricola kaibabensis	Kaibab Variable Tiger Beetle	I	SOI
Libellula nodisticta	Hoary skimmer	I	SOI
Papilio indra kaibabensis	Kaibab Indra Swallowtail	I	SOC
Piruna polingii	Four-spotted Skipperling	I	SOC
Speyeria nokomis	Nokomis Fritillary	I	SOC
Speyeria nokomis nokomis	Nokomis Fritillary	I	SOC
Antilocapra americana	Pronghorn	M	SOI
Corynorhinus townsendii pallescens	Pale Townsend's Big-Eared Bat	M	SOI
Cynomys gunnisoni	Gunnison's prairie dog	M	SOI
Dipodomys microps leucotis	House Rock Valley chisel-toothed kangaroo rat	M	SOI
Euderma maculatum	Spotted bat	M	SOI
Eumops perotis californicus	Greater Western Mastiff Bat	M	SOI
Idionycteris phyllotis	Allen's Lappet-Browed Bat	M	SOI
Microtus longicaudus	Long-tailed vole	M	SOI
Microtus mogollonensis navaho	Navajo Mogollon vole	M	SOI
Myotis auriculus	Southwestern myotis	M	SOI
Neotamias minimus consobrinus	Kaibab least chipmunk	M	SOI
Nyctinomops macrotis	Big free-tailed bat	M	SOI
Ovis canadensis nelsoni	Desert bighorn sheep	M	SOI
Sciurus aberti	Abert's Squirrel	M	SOI
Sciurus aberti kaibabensis	Kaibab tree squirrel	M	SOI
Sorex merriami	Merriam's Shrew	M	SOI
Sorex nanus	Dwarf shrew	M	SOI
Tamiasciurus hudsonicus	Red Squirrel	M	SOI
Thomomys talpoides kaibabensis	Kaibab northern pocket gopher	M	SOI
Actaea arizonica	Arizona Bugbane	P	SOC
Agave utahensis var. *kaibabensis*	Utah Century Plant	P	SOC
Agave utahensis var. *utahensis*	Utah Agave	P	SOC
Allium bigelovii	Bigelow's Onion	P	SOC
Aquilegia caerulea var. *pinetorum*	Columbine	P	SOC
Arenaria aberrans	Mt. Dellenbaugh Sandwort	P	SOC
Asclepias hallii	Hall's Milkweed	P	SOC
Asclepias quinquedentata	Slimpod milkweed	P	SOI
Astragalus amphioxys var. *modestus*	Alladin's slippers	P	SOC
Astragalus ampullarius	Gumbo Milkvetch	P	SOC
Astragalus cremnophylax var. *hevronii*	Hevron's Milkvetch	P	SOC
Astragalus cremnophylax var. *myriorraphis*	Cliff Milkvetch	P	SOC
Astragalus episcopus var. *lancearius*	Lancer Milkvetch	P	SOC

Scientific Name	Common Name	Taxa	Category
Astragalus humistratus var. *tenerrimus*	Groundcover milkvetch	P	SOC
Astragalus lentiginosus var. *oropedii*	Freckled milkvetch	P	SOC
Astragalus lentiginosus var. *vitreus*	Freckled milkvetch	P	SOC
Astragalus pinonis var. *atwoodii*	A Milkvetch	P	SOC
Astragalus rusbyi	Rusby's Milkvetch	P	SOC
Astragalus subcinereus	Silver Milkvetch	P	SOC
Astragalus titanophilus	Limestone Milkvetch	P	SOC
Astragalus troglodytus	Creeping Milkvetch	P	SOC
Botrychium echo	Reflected Moonwort	P	SOC
Camissonia gouldii	Diamond Valley Suncup	P	SOC
Carex oreocharis	A Sedge	P	SOC
Castilleja kaibabensis	Kaibab Indian-paintbrush	P	SOC
Chrysothamnus molestus	Disturbed (Tusayan) rabbitbrush	P	SOC
Cirsium rothrockii	Rose-color Thistle	P	SOC
Clematis hirsutissima var. *hirsutissima*	Hairy clematis	P	SOI
Cleome lutea var. *jonesii*	Jones' Spider-flower	P	SOC
Cordylanthus wrightii ssp. *kaibabensis*	Wright's Bird's-beak	P	SOC
Cryptantha abata	Dent-nut Cat's-eye	P	SOC
Cystopteris utahensis	Utah Bladder Fern	P	SOC
Draba asprella var. *asprella*	Rough Whitlow-grass	P	SOC
Draba asprella var. *kaibabensis*	Rough Whitlow-grass	P	SOC
Draba asprella var. *stelligera*	Rough Whitlow-grass	P	SOC
Draba rectifructa	Mountain Whitlow-grass	P	SOC
Erigeron saxatilis	Cliff Fleabane	P	SOC
Eriogonum corymbosum var. *glutinosum*	Wild Buckwheat	P	SOC
Eriogonum darrovii	Darrow's Buckwheat	P	SOC
Eriogonum ericifolium var. *pulchrum*	Yavapai wild buckwheat	P	SOC
Eriogonum jonesii	Jones' Wild Buckwheat	P	SOC
Eriogonum mortonianum	Morton Wild Buckwheat	P	SOC
Eriogonum thompsoniae var. *atwoodii*	Atwood's Wild Buckwheat	P	SOC
Escobaria vivipara var. *kaibabensis*	Spinystar	P	SOC
Gaillardia parryi	Parry's Blanket-flower	P	SOC
Hedeoma diffusa	Flagstaff Pennyroyal	P	SOC
Helianthus arizonensis	Arizona sunflower	P	SOI
Heuchera novomexicana	New Mexico Alum-root	P	SOC
Ivesia arizonica	Arizona Whitefeather	P	SOC
Ivesia arizonica var. *arizonica*	Arizona Whitefeather	P	SOC
Lepidium montanum var. *glabrum*	Mountain Pepperweed	P	SOC
Lesquerella arizonica	Arizona Bladderpod	P	SOC
Lesquerella kaibabensis	Kaibab Bladder-pod	P	SOC
Lotus mearnsii var. *mearnsii*	Mearns lotus	P	SOC

Scientific Name	Common Name	Taxa	Category
Macromeria viridiflora var. *viridiflora*	Giant-trumpets	P	SOC
Mertensia macdougalii	Macdougal's Bluebells	P	SOC
Moneses uniflora	Wood nymph	P	SOI
Myosurus nitidus	Western Mouse-tail	P	SOC
Nuphar lutea	Pond lily	P	SOI
Pediocactus paradinei	Park Pincushion-cactus	P	SOC
Pediocactus peeblesianus var. *fickeiseniae*	Fickeisen Hedgehog-cactus	P	SOC
Pediomelum mephiticum	Skunk-top Scurfpea	P	SOC
Penstemon caespitosus var. *desertipicti*	Mat Penstemon	P	SOC
Penstemon laevis	Southwestern Beardtongue	P	SOC
Penstemon nudiflorus	Flagstaff Beardtongue	P	SOC
Penstemon pseudoputus	Kaibab Beardtongue	P	SOC
Penstemon rydbergii	Rydberg's penstemon	P	SOI
Perityle congesta	Compacted Rock Daisy	P	SOC
Perityle gracilis	Grass-like Rockdaisy	P	SOC
Phacelia serrata	Serrate Phacelia	P	SOC
Phemeranthus validulus	Western Flame-flower	P	SOC
Phlox amabilis	Arizona Phlox	P	SOC
Potentilla crinita var. *lemmonii*	Bearded Cinquefoil	P	SOC
Ranunculus oreogenes	Oregon Buttercup	P	SOC
Rosa stellata ssp. *abyssa*	Grand Canyon Rose	P	SOC
Salix bebbiana	Bebb's willow	P	SOI
Shepherdia rotundifolia	Roundleaf Buffaloberry	P	SOC
Sporobolus interruptus	Black Dropseed	P	SOC
Stachys rothrockii	Rothrock's Hedge-nettle	P	SOC
Thelypodiopsis ambigua var. *ambigua*	Long Valley tumblemustard	P	SOC
Thelypteris puberula	Showy maidenfern	P	SOI
Triteleia lemmoniae	Oak Creek Triteleia	P	SOC

Habitat Associations and Initial Species Groups

Two types of basic life history data were initially used to group species to be carried forward in the Species Diversity Analysis Process; aquatic or terrestrial habitat associations, and biotic or abiotic habitat components. Species were grouped first by habitat association, which was represented by either water or the 15 broadly defined terrestrial vegetation types historically present in the planning area (i.e. 'PNVT'; see discussion in the Terrestrial Systems section). Species were secondarily grouped by habitat components not specifically addressed by broad habitat associations. Finally, species not addressed in the two previous groups were addressed separately.

Species Associated with Ecosystem Diversity Characteristics of Terrestrial Vegetation or Aquatic Systems:

Table 22 shows the number of species with major habitat associations (i.e. PNVT or Water). Figure 19 shows these same species broken down by category and habitat association. A

detailed listing by species can be found in the Species Diversity Report (KNF 2008c). Numerous species were associated with more than one PNVT. Three species (Pale Townsend's big-eared bat, American peregrine falcon, and California condor), were so wide ranging among habitat types that they could not be assigned a particular habitat association.

Table 22 - Total number of species associated with each habitat type

Habitat Association	Total Species
Pinyon-Juniper Woodland	48
Ponderosa Pine Forest	56
Dry Mixed Conifer Forest	16
Mixed Conifer with Aspen	19
Sagebrush Shrubland	20
Montane / Subalpine Grassland	18
Great Basin Grassland	16
Spruce Fir Forest	10
Semi-desert Grassland	10
Desert Communities	12
Gambel Oak Shrubland	2
Wetland / Cienega	11
Cottonwood-Willow Riparian Forest	3
Water	9

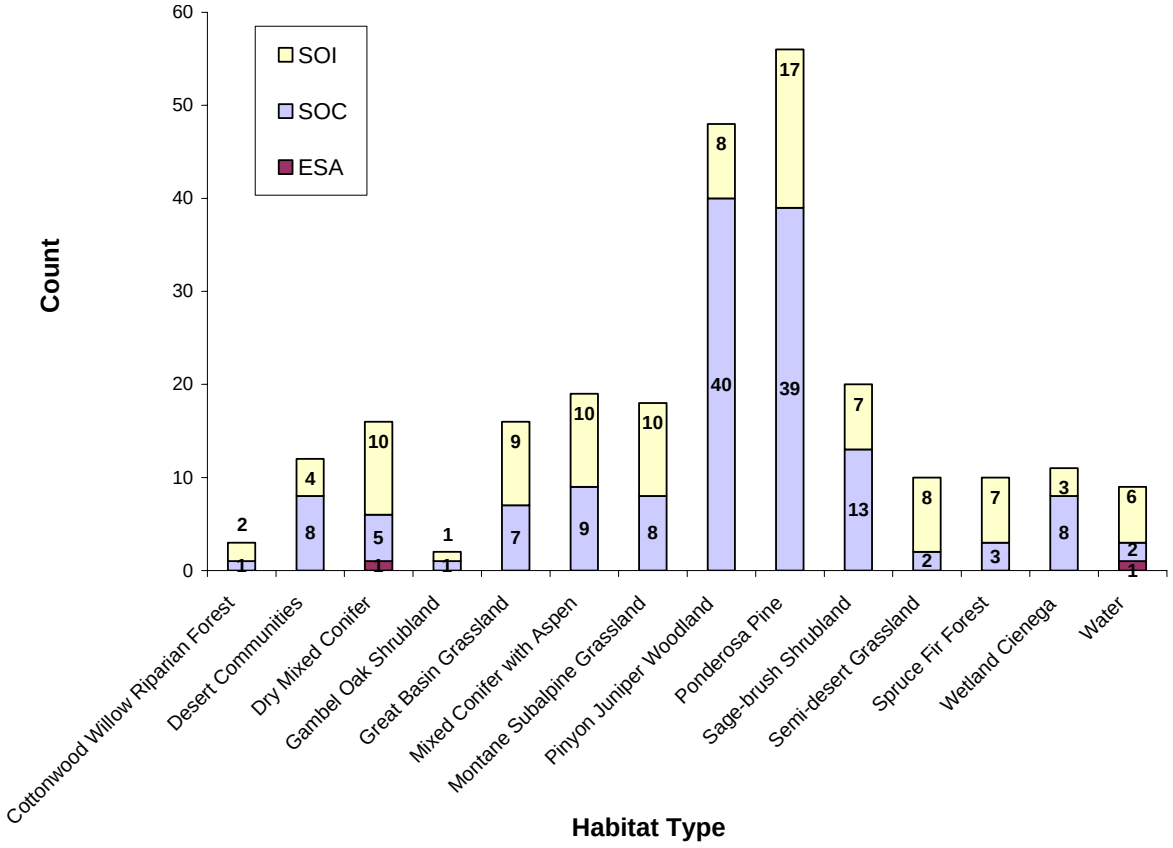

Figure 19 - Proportion of species by category and habitat association. ESA: federally threatened or endangered species; SOC: species-of-concern; SOI: species-of-interest.

Species Grouped by Habitat Component

Plants were grouped solely by habitat associations (i.e., PNVT and Water). Non-plant species were secondarily grouped by related habitat components (Table 23).

Table 23 - Species associated with specific related habitat components

Habitat Components	Species Common Name
Trees: cavities, snags, downed logs, litter/debris, tree species (i.e., oak, aspen), tree size class, tree height, sap-producing hardwoods.	Red-naped sapsucker, Western skink, Dusky (blue) grouse, Grace's warbler, Mexican spotted owl, Utah Mountain kingsnake, Navajo Mogollon vole, Purple martin (Western), Olive-sided flycatcher, Pale Townsend's big-eared bat, Allen's lappet-browed bat, Juniper titmouse, Lewis's woodpecker, Red-faced warbler, Southwestern myotis, Northern goshawk, Bald eagle, Evening grosbeak
Forest: open/closed canopy, forest clearings, degree of canopy layering, tree dispersion (i.e., clumps and groups)	Dusky (blue) grouse, Olive-sided flycatcher, Juniper titmouse, Lewis's woodpecker, Northern goshawk, Abert's squirrel, Pinyon jay, Golden-crowned kinglet, Black-throated gray warbler, Spotted bat, Red-faced warbler, Green-tailed towhee, Dwarf shrew, Evening grosbeak, Arizona (mountain) treefrog.
Understory: available forage (Eriogonum), low shrubs, ferns, grasses for nesting.	Desert green hairstreak, Dusky (blue) grouse
Shrubland: shrub height and density, herbaceous component.	Pronghorn, House Rock Valley chisel-toothed kangaroo rat, Sage sparrow
Wetland/Water: cattle tanks, ephemeral pools, seeps, springs, emergent vegetation, marsh/wetland edges	Persephone's darner, Arizona toad, Arizona (mountain) treefrog, Hoary skimmer, Four-spotted skipperling, Nokomis fritillary, Nokomis fritillary ssp. nokomis, Navajo Mogollon vole
Grassland: subalpine meadows, moist meadows, open grasslands	Greater western mastiff bat, Pronghorn, Gunnison's prairie dog, Long- tailed vole, Ferruginous hawk, Big free-tailed bat, Four-spotted skipperling, Nokomis fritillary, Gray vireo, Kaibab Variable Tiger Beetle, Spotted bat
Rock and Other Abiotic: burrows, canyons, cliffs crevices, talus, mines, empty buildings	Milksnake, Mexican spotted owl, Southwestern myotis, Pale Townsend's big-eared bat, American peregrine falcon, Allen's lappet-browed bat, Spotted bat, Greater western mastiff bat, Purple martin (Western), Big free-tailed bat, House Rock Valley chisel-toothed kangaroo rat, Western skink, Utah Mountain kingsnake, Dwarf shrew, Arizona black rattlesnake

Other Species

The California condor is the only species not associated with a particular habitat in the plan area, nor addressed by the habitat component groups specified above. For this species, food resources (i.e., carcasses) are the critical limiting factor.

Species with Limited Distributions:

A species (or subspecies) was considered to have a *Restricted Distribution* if it is limited in extent within the Southwest; a species was considered to be a *Narrow Endemic* if it has extremely limited distribution and/or habitat within and near the planning unit. Due to their limited distribution and potential susceptibility to perturbation, these species may require additional management considerations. These definitions are subjective, and meant to concentrate attention

on those species that could be pushed towards extinction by one large event (e.g., one large uncharacteristic fire), and species that the KNF manages nearly all its known range. There were 73 species for which restricted distribution was considered an additional issue contributing to the severity of the risk. Of these, 47 were narrow endemics (Table 24).

Table 24 - Species with restricted distributions and whether they are considered narrow endemics within or near the planning unit

Scientific Name	Common Name	Narrow Endemic
Actaea arizonica	Arizona Bugbane	YES
Aeshna Persephone	Persephone's Darner	No
Agave utahensis var. *kaibabensis*	Utah Century Plant	YES
Agave utahensis var. *utahensis*	Utah Agave	No
Aquilegia caerulea var. *pinetorum*	Columbine	No
Arenaria aberrans	Mt. Dellenbaugh Sandwort	YES
Astragalus amphioxys var. *modestus*	Alladin's slippers	No
Astragalus ampullarius	Gumbo Milkvetch	No
Astragalus cremnophylax var. *hevronii*	Hevron's Milkvetch	YES
Astragalus cremnophylax var. *myriorraphis*	Cliff Milkvetch	YES
Astragalus episcopus var. *lancearius*	Lancer Milkvetch	No
Astragalus humistratus var. *tenerrimus*	Groundcover milkvetch	YES
Astragalus lentiginosus var. *oropedii*	Freckled milkvetch	YES
Astragalus lentiginosus var. *vitreus*	Freckled milkvetch	No
Astragalus pinonis var. *atwoodii*	A Milkvetch	YES
Astragalus rusbyi	Rusby's Milkvetch	YES
Astragalus subcinereus	Silver Milkvetch	No
Astragalus titanophilus	Limestone Milkvetch	No
Astragalus troglodytus	Creeping Milkvetch	No
Camissonia gouldii	Diamond Valley Suncup	No
Castilleja kaibabensis	Kaibab Indian-paintbrush	YES
Chrysothamnus molestus	Disturbed (Tusayan) rabbitbrush	YES
Cicindela terricola kaibabensis	Kaibab Variable Tiger Beetle	YES
Cleome lutea var. *jonesii*	Jones' Spider-flower	YES
Cordylanthus wrightii ssp. *Kaibabensis*	Wright's Bird's-beak	YES
Crotalus Cerberus	Arizona black rattlesnake	No
Cryptantha abata	Dent-nut Cat's-eye	No

Scientific Name	Common Name	Narrow Endemic
Dipodomys microps leucotis	House Rock Valley chisel-toothed kangaroo rat	YES
Draba asprella var. *asprella*	Rough Whitlow-grass	YES
Draba asprella var. *kaibabensis*	Rough Whitlow-grass	YES
Draba asprella var. *stelligera*	Rough Whitlow-grass	YES
Erigeron saxatilis	Cliff Fleabane	YES
Eriogonum corymbosum var. *glutinosum*	Wild Buckwheat	No
Eriogonum darrovii	Darrow's Buckwheat	No
Eriogonum ericifolium var. *pulchrum*	Yavapai wild buckwheat	YES
Eriogonum jonesii	Jones' Wild Buckwheat	YES
Eriogonum mortonianum	Morton Wild Buckwheat	YES
Eriogonum thompsoniae var. *atwoodii*	Atwood's Wild Buckwheat	YES
Escobaria vivipara var. *kaibabensis*	Spinystar	YES
Gaillardia parryi	Parry's Blanket-flower	YES
Gymnogyps californianus	California condor	No
Hedeoma diffusa	Flagstaff Pennyroyal	YES
Helianthus arizonensis	Arizona sunflower	No
Heuchera novomexicana	New Mexico Alum-root	No
Lampropeltis pyromelana infralabialis	Utah Mountain Kingsnake	No
Lepidium montanum var. *glabrum*	Mountain Pepperweed	YES
Lesquerella arizonica	Arizona Bladderpod	No
Lesquerella kaibabensis	Kaibab Bladder-pod	YES
Lotus mearnsii var. *mearnsii*	Mearns lotus	YES
Mertensia macdougalii	Macdougal's Bluebells	No
Myosurus nitidus	Western Mouse-tail	No
Neotamias minimus consobrinus	Kaibab least chipmunk	YES
Oncorhynchus apache	Apache (Arizona) Trout	No
Papilio indra kaibabensis	Kaibab Indra Swallowtail	YES
Pediocactus paradinei	Park Pincushion-cactus	YES
Pediocactus peeblesianus var. *fickeiseniae*	Fickeisen Hedgehog-cactus	YES
Pediomelum mephiticum	Skunk-top Scurfpea	No
Penstemon caespitosus var. *desertipicti*	Mat Penstemon	No

Scientific Name	Common Name	Narrow Endemic
Penstemon nudiflorus	Flagstaff Beardtongue	YES
Penstemon pseudoputus	Kaibab Beardtongue	YES
Perityle congesta	Compacted Rock Daisy	YES
Phacelia serrata	Serrate Phacelia	YES
Phlox amabilis	Arizona Phlox	YES
Potentilla crinita var. *lemmonii*	Bearded Cinquefoil	YES
Ranunculus oreogenes	Oregon Buttercup	No
Rosa stellata ssp. *Abyssa*	Grand Canyon Rose	YES
Sciurus aberti kaibabensis	Kaibab tree squirrel	YES
Shepherdia rotundifolia	Roundleaf Buffaloberry	YES
Sporobolus interruptus	Black Dropseed	YES
Phemeranthus validulus	Western Flame-flower	YES
Thelypodiopsis ambigua var. *ambigua*	Long Valley tumblemustard	YES
Thomomys talpoides kaibabensis	Kaibab northern pocket gopher	YES
Triteleia lemmoniae	Oak Creek Triteleia	YES

IV. INTEGRATION AND RISK ASSESSMENT

The Ecosystem Diversity Risk Assessment first determined the threats to composition, structure and processes that create or sustain the various vegetation types found on the Forest. The projected trends for each PNVT in comparison to its reference condition and potential threats that may influence that projected trend were used to determine whether these threats pose a risk to ecosystem diversity. This analysis is documented in the Vegetation and Fire Ecological Need for Change report (KNF 2008f). The assessment then identifies relationships between the vegetation, soil, aquatic, and air resources, and determines which threats are under agency authority to address.

The Species Diversity Risk assessment first identified threats to species and/or their habitat that were the same as the threats to composition, structure, and processes that create or sustain the vegetation types and aquatic features of the Forest (i.e. threats to ecosystem diversity characteristics). Next, specific threats to species habitat components were considered, using a more fine-scale approach than that used in the terrestrial and aquatic ecosystem sections. Finally, species threats not associated with physical habitat components were identified.

A. Ecosystem Diversity Risk Assessment

Terrestrial Systems

Vegetation composition and structure has departed from reference conditions in all twelve PNVTs on the Forest. Terrestrial vegetation systems also greatly influence soil and aquatic conditions.

Pinyon-Juniper Woodlands

Under current management and disturbance regimes, pinyon-juniper woodlands are becoming younger and denser than the historic conditions due to changes in wildfire occurrence. Bark beetle outbreaks, especially associated with droughts may increase, lowering pinyon presence. Increased tree density and the associated loss of understory plant cover and diversity are the primary characteristics that are departed from reference conditions, especially in pinyon-juniper grasslands. In pinyon-juniper shrublands, the continuous distribution of high tree density across the landscape represents a departure from reference conditions. Lowering tree densities to within historic patterns could reverse or mitigate the threats. Uncharacteristic wildfire effects represent a significant threat, particularly when combined with secondary threats of uncharacteristic insect/drought related die-off and invasive plants.

Ponderosa Pine Forest, Mixed Conifer Forest

In both of these PNVTs, canopy cover is denser and more continuous across developmental states than reference conditions. When fires occur under current conditions, they are more likely to result in the negative outcome of further departure from reference conditions. Even though the trend of Ponderosa Pine is static, this extremely departed PNVT does not show further departure given the analysis methods used. The amount and arrangement of the developmental states and increased tree density/canopy cover are the primary characteristics that are departed; they are denser and younger than reference conditions. The primary threat to these PNVTs is the lack of fire disturbance. Wildfire and drought represent secondary threats to these PNVTs. There is a moderate risk of insect and/or disease outbreaks, which are also a function of density. Although not a general threat to the PNVT, the decline or loss of aspen on the WRD and across the White Mountains – San Francisco Peaks – Mogollon Rim Section is a concern. With the combined effects of elk browsing, insects, disease, severe weather events, and lack of fire disturbance, aspen is expected to substantially decline on the WRD in the near future.

Sagebrush Shrubland

The primary threats to the Sagebrush Shrubland PNVT are the combination of lack of characteristic fire disturbance, limited nutrient cycling, and closed-canopy shrub states with juniper encroachment, which create large areas susceptible to stand-replacing events. Further departure from reference conditions are predicted under the current management and disturbances. Severe elk pressure on native shrubs, particularly sensitive species on the TRD, has been documented. Bison herbivory may pose a secondary threat on the NKRD. Fires occurring under current conditions may lead to negative outcomes for native species composition. Increased invasive plant cover after wildfire is considered a moderate risk.

Montane / Subalpine Grassland, Great Basin Grassland, and Semi-Desert Grassland

The primary threats to these PNVTs are the lack of characteristic fire disturbance and limited nutrient cycling. Closed shrub states are becoming more common; conifers are also are encroaching. Under the current disturbances and management, continued departures are expected. Uncharacteristic fires occurring under current conditions may result in negative effects to species composition, due to the potential for invasive plant invasion, but it is not currently considered a high risk. Excessive ungulate pressure may also play a substantial role in some areas.

Spruce-Fir Forest

The primary threat to the Spruce-Fir Forest PNVT is the lack of characteristic fire disturbance. Much of the spruce-fir PNVT may actually be ponderosa pine or mixed conifer forest, because the role of fire disturbance may not have been appropriately accounted for in the delineation of the PNVT. Since fire exclusion, there has been a species shift away from aspen, ponderosa pine and Douglas-fir and toward Engelmann spruce and corkbark fir. Canopy cover is denser and more continuous across developmental states. Tree density and species relative abundance are the primary characteristics that are departed. Older tree states may also be missing in some areas. Other areas contain the older tree components, but are difficult to discern due to the dominance of the younger trees. When fires occur under current conditions, they carry a significant risk of a negative outcome, further departing states and species composition from reference conditions. For this reason, wildfire and drought are considered secondary threats to this PNVT.

Desert Communities

The primary threat to the Desert Communities PNVT is the invasion of exotic plant species, which shortens the fire return interval and changes species composition. Secondarily, closed shrub states are becoming more common, and junipers are encroaching, increasing the risk of uncharacteristic fire disturbance. This could further reduce native plant diversity and structure, increasing invasive plant cover and erosion.

Gambel Oak Shrubland

The primary threat to the Gambel Oak Shrubland PNVT is the lack of characteristic fire disturbance, leading to an increase in closed tree/shrub states. Encroaching conifers make larger areas susceptible to single stand-replacing events. Drought could raise the risk of a stand replacing event. Under current conditions, fire disturbance could lead to some negative outcomes for soils and increased invasive plants. Continuing departure from reference conditions are anticipated, given current management practices.

Wetland / Cienega

The primary threats to the Wetland / Cienega PNVT are the lack of characteristic fire disturbance, limited nutrient cycling, and reduced water input. Trees from the adjacent forests and woodlands are encroaching. Tree encroachment and high tree density of adjacent PNVTs serve to lower the

water table and reduce water flow in this system. Contributing to this problem is the secondary threat of drought. A slow departure from reference conditions is estimated overall, but is rapid on the NKRD because of the linear shape of the wetland patches. Fire disturbance under current conditions may lead to some negative outcomes for species composition toward invasive plants and is deemed a moderate risk.

Cottonwood-Willow Riparian Forest

The primary threats to the Cottonwood-Willow Riparian Forest PNVT are off-Forest water diversions and impoundments, which are not within Forest Service control. Secondary threats that are within Forest Service control are those posed by non-native plants. Several management techniques to control non-native plants exist, including mechanical, chemical, and biological methods.

Soils Condition and Productivity

Over the past several decades, soil conditions have improved with changes to livestock grazing management and thinning that reduces dense tree cover. The majority (79%) of soils on the KNF are in satisfactory condition. Approximately 15 percent of Forest soils in the Pinyon-Juniper Woodland, Ponderosa Pine, Semi-Desert Grassland and Desert Communities PNVTs have unsatisfactory soil conditions. In areas where overstory canopy reduction treatments have occurred, soil conditions have improved are now trending toward reference conditions, albeit slowly in Semi-desert Grasslands, and Desert Communities.

Soil productivity is moderately departed with mixed trends (i.e., away, static, and towards reference conditions) in Pinyon Juniper Woodland and Ponderosa Pine Forests. Historically, these soils were more productive and produced more forage because tree canopy coverage was lower. Soil productivity in other PNVTs is minimally or moderately departed and either static or trending towards reference conditions. Where canopy cover is reduced through management activities or characteristic disturbances, herbaceous understory and forage production would be expected to increase, thereby improving soil productivity. Soil conditions would likely continue to improve as additional beneficial effect of projects implemented to achieve vegetation objectives, such as grassland restoration and fuel reductions.

Short-term, but severe erosion events after uncharacteristic fires in forest and woodland PNVTs are fairly common and expected to continue and increase under current management. Over time, uncharacteristic fire events could lead to permanent losses in soil productivity. Activities that reduce the risk of uncharacteristic fire also reduce the likelihood of these erosion events taking place. Under current management the general trend indicates that uncharacteristic fire events will become more common.

Aquatic Systems

The Kaibab contains at least 10 percent of four 4th code watersheds: Kanab Creek, Lower Colorado-Marble Canyon, Havasu Canyon and Upper Verde. These were evaluated for potential downstream effects. Watersheds with high departures from reference condition and a static trend or are trending away from reference conditions are of concern and are listed in Table 25. Departures are the result of past livestock management, disruption of the historic fire return interval, impoundments, and invasive species, that have affected water quality and/or riparian and wetland conditions.

Table 25 – Watersheds with significant departures of aquatic characteristics

4th Code Watershed	5th Code Watershed
Kanab Creek	All
Lower Colorado-Marble Canyon	North Canyon Wash
Havasu Canyon	Cataract Creek
	Spring Valley Wash
Upper Verde	Hell Canyon-Grindstone Wash
	Sycamore Creek

The primary risk to these watersheds is uncharacteristic fire. As a result, watersheds containing departed PNVTs are at risk. Table 26 summarizes this information, derived from the aquatic section of this report. There is a higher risk of erosion and sedimentation following an uncharacteristic fire in these 5th code watersheds and a downstream risk of sedimentation. Risks to the ecological integrity of North Canyon Creek are a particular concern, because this is a unique water feature on the KNF that provides habitat for rare species. If the North Canyon Wash watershed experiences a severe fire and/or erosion event, the stream biota would not be replenished naturally because there are no adjacent steams.

Table 26 - Fourth code and substantial 5th code watersheds with moderate or high risk of watershed damage from disturbance to departed PNVTs

4th Code Watershed	5th Code Watershed	Relative Risk from Disturbance in Departed PNVT
Kanab Creek	Lower Johnson Wash	Moderate
	Snake Gulch	High
Lower Colorado-Marble Canyon	House Rock Wash	High
	North Canyon Wash	
Havasu Canyon	Cataract Creek	High
	Red Horse Wash	Moderate
	Spring Valley Wash	High
Upper Verde	Grindstone Wash-Upper Verde River	High
	Hell Canyon	
	Sycamore Creek	
Lower Little Colorado	Lower Cedar Wash-Tappan Wash	High
	Upper Cedar Wash	
Big Chino-Williamson Valley	Ash Fork Draw-Jumbo Tank	High
Grand Canyon	Shinumo Creek-Lower Colorado River	High
	Tapeats Creek-Lower Colorado River	

Water quality and quantity from natural sources on the Forest are not significantly departed from reference conditions, nor are they expected to change due to current management. The Forest makes no surface water contribution off the Forest and the groundwater contribution is unknown.

The Kaibab Plateau (NKRD) and the Mogollon Rim (WRD) have some of the highest densities of seeps and springs in the Arizona. Observations have shown that about half of these are currently being impacted by grazing livestock and other ungulates. Artificial water sources have greatly increased water availability for wildlife and livestock, with a stable (flat) trend. Riparian vegetation is probably greater than its historic extent due to the presence of artificial waters.

Airsheds

There are no known air quality problems known to have adverse effects on the Forest's ecosystems, plants or animals. Monitoring of ground-level ozone in both the Grand Canyon National Park and in Flagstaff has recorded a few days in the past year when levels exceeded standards set for human health. The long-term trend of ozone concentrations is unknown. The primary source of ground-level ozone in the Forest airsheds appears to be southern California (Diem 2004) and is beyond the management control and authority of the Forest.

Management activities implemented to restore fire-adapted ecosystems are likely to increase atmospheric particulates over time, but are unlikely to adversely affect ecological sustainability of the frequent fire systems that dominate the Forest and surrounding lands. Regulation of managed burning to protect human health and esthetics limit management activities affecting air quality maintain lower particulate levels than occurred historically.

Threats to Ecosystem Diversity Subject to Agency Authority

Identified threats were analyzed to determine: 1) whether or not the threat is under the Forest Service's control and ability to influence through management; 2) whether or not the threat would be likely to affect ecosystem structure, composition, or processes; and 3) the potential consequences of a negative outcome. Only those threats under the authority of the Forest Service and ability to manage were carried further in the risk assessment. Each was evaluated for its reversibility potential with management. Table 27 lists potential threats with a determination of whether they are within Forest Service control and authority to address.

Although climate change was not formally analyzed as an risk to ecological and species diversity, we recognize that climate change exists and that future management actions may need to be responsive as new data becomes available. In general, most climate modelers agree that the Southwest is trending toward prolonged drought and more intense disturbance events. General changes in vegetation patterns could affect overall distribution and range of flora as well as fauna. Changing ecological conditions could provide opportunities for invasion by non-native species with potential subsequent negative impacts on various taxa. Cumulatively, these factors could likely impact biodiversity, but the extent is uncertain. (See Periman 2008 and references therein).

Table 27 - Potential threats to the ecosystem diversity of the Forest

Threat	Agency Control	Agency Authority
Fire Suppression, Fire Use, Lack of Fire	Yes	Yes
Wildfire and Uncharacteristic Wildland Fire Effects	No	Yes – Decision to suppress under authority and control
Managed Grazing	Yes	Yes
Unmanaged herbivory by wildlife	No	Maybe – Can mitigate in very limited areas w/ fence exclosures or jackstraw cuts.
Invasive plants	No	Yes
Motorized recreation, Off highway vehicle use and Non-motorized dispersed recreation	Yes	Yes through TMR and Forest Orders
Regeneration Cutting, Thinning and Fuelwood Cutting. Forest Product gathering.	Yes	Yes
Insect/disease	No	Yes - FS can manage stand density/resiliency.
Illegal wood cutting	No	Yes
Drought	No	Yes - FS can manage vegetation density and structure.
Climate Change	No	No - Distinguished from drought by long time frame. Effect may shift, increase, decrease or eliminate PNVT from Forest.
Roads	No	Yes
Minerals (uranium, quarries)	No – locatable; Yes – common	Yes
Developed Recreation	Yes	Yes
Dams/impoundments	No - Private lands; Yes - National Forest	Yes
Water withdrawal (wells)	No – Private lands; Yes – National Forest	No – Private lands; Yes – National Forest
Solid waste dumping	No	Yes
Herbicides	Yes	Yes

B. Species Risk Assessment

Species carried forward for further analysis were assigned to two risk assessment groups: 1) species threatened by risks to ecosystem diversity characteristics (i.e., threats to composition, structure, and processes that affect vegetation, soil, and aquatic conditions in the plan area), and 2) species facing threats in addition to risks to ecosystem diversity characteristics.

Species Associated with Threats to Ecosystem Diversity Characteristics

Information about each species was reviewed, and a determination made as to whether the threats to the terrestrial and aquatic Ecosystem Diversity Characteristics may also affect the species. In general, it was assumed that those species associated with PNVTs or water sources departed and not trending toward reference conditions were at risk (Table 28). Many species were associated with more than one PNVT. All PNVTs analyzed in the Terrestrial Systems section are departed from reference conditions, suggesting that the associated species' habitat needs are not being met and therefore not sustainable under current management.

Water sources (seeps, springs, streams, ponds, reservoirs, tanks) exhibit various conditions by watershed. Most watersheds in the planning area show low departure from reference conditions, but some individual water sources are departed (see Aquatic Systems section). The KNF Fish Species Diversity Report discusses habitat threats for fish on the Forest (KNF 2008g)

Table 28 – Species associated with terrestrial or aquatic ecosystem diversity characteristics at risk

Habitat (PNVT/Water)	Taxa and Species Common Name
Pinyon-Juniper Woodland	Birds: Juniper titmouse, Black-throated gray warbler, Pinyon jay, Gray vireo
	Reptiles & Amphibians: Arizona black rattlesnake, Western skink, Utah Mountain kingsnake, Great Basin spadefoot
	Invertebrates: Desert green hairstreak, Kaibab Indra swallowtail
	Mammals: Big free-tailed bat
	Plants: Utah century plant, Hall's milkweed, Alladin's slippers, Gumbo milkvetch, Cliff milkvetch, Lancer milkvetch, Freckled milkvetch (var. *oropedii*), Freckled milkvetch (var. *vitreus*) , A milkvetch (*Astragalus pinonis* var. *atwoodi*), Silver milkvetch, Creeping milkvetch, Diamond Valley suncup, Disturbed (Tusayan) rabbitbrush, Jones' spider-flower, Wright's bird's-beak, Dent-nut cat's-eye, Utah bladder fern, Rough whitlow-grass (var. *kaibabensis*), Wild buckwheat, Yavapai wild buckwheat, Jones' wild buckwheat, Spinystar, Parry's blanket-flower, Arizona sunflower, Mountain pepperweed, Arizona bladderpod, Park pincushion-cactus, Mat penstemon, Southwestern beardtongue, Flagstaff beardtongue, Grass-like rockdaisy, Western flame-flower, Arizona phlox, Grand Canyon rose, Roundleaf buffaloberry, Rothrock's hedge-nettle, Long Valley tumblemustard

Habitat (PNVT/Water)	Taxa and Species Common Name
Ponderosa Pine Forest	Birds: Northern goshawk, Olive- sided flycatcher, Grace's warbler, Bald eagle, Lewis's woodpecker, MacGillivray's warbler, Purple martin (Western)
	Reptiles & Amphibians: Arizona black rattlesnake, Western skink, Arizona (mountain) treefrog, Utah Mountain kingsnake
	Invertebrates: Persephone's darner, Nokomis fritillary, Nokomis fritillary ssp. nokomis, Nevada point-headed grasshopper
	Mammals: Allen's lappet-browed bat, Southwestern myotis, Abert's squirrel, Kaibab tree squirrel, Merriam's shrew
	Plants: Slimpod milkweed, Groundcover milkvetch, Freckled milkvetch (var. *oropedii*), Rusby's milkvetch, Silver milkvetch, Creeping milkvetch, Rose-color thistle, Hairy clematis, Wright's bird's-beak, Dent-nut cat's-eye, Utah bladder fern, Rough whitlow-grass (var. *asprella*), Rough whitlow-grass (var. *kaibabensis*), Rough whitlow-grass (var. *stelligera*), Cliff fleabane, Yavapai wild buckwheat, Flagstaff pennyroyal, Arizona whitefeather, Arizona whitefeather (var. *arizonica*), Arizona bladderpod, Giant-trumpets, Macdougal's bluebells, Wood nymph, Western Mouse-tail, Southwestern beardtongue, Flagstaff beardtongue, Kaibab beardtongue, Compacted rock daisy, Serrate phacelia, Western flame-flower, Arizona phlox, Bearded cinquefoil, Oregon buttercup, Black dropseed, Rothrock's hedge-nettle, Oak Creek triteleia
Dry Mixed Conifer Forest	Birds: Northern goshawk, Red-faced warbler, Evening grosbeak, Olive-sided flycatcher, MacGillivray's warbler, Green-tailed towhee, Mexican spotted owl, Orange-crowned warbler
	Invertebrates: Kaibab Indra swallowtail, Nokomis fritillary, Nokomis fritillary ssp. Nokomis
	Mammals: Allen's lappet-browed bat, Southwestern myotis, Merriam's shrew
	Plants: Cliff milkvetch, Silver milkvetch
Sagebrush Shrubland	Birds: Sage sparrow, Sage thrasher, Brewer's sparrow
	Reptiles & Amphibians: Great Basin spadefoot
	Invertebrates: Desert green hairstreak
	Mammals: Pronghorn, Spotted bat, Big free-tailed bat
	Plants: Alladin's slippers, Lancer milkvetch, Freckled milkvetch (var. *vitreus*), Disturbed (Tusayan) rabbitbrush, Wright's bird's-beak, Dent-nut cat's-eye, Jones' wild buckwheat, Morton wild buckwheat, Atwood's wild buckwheat, Park pincushion-cactus, Fickeisen hedgehog-cactus, Grand Canyon rose

Habitat (PNVT/Water)	Taxa and Species Common Name
Montane/Subalpine Grassland	Birds: Savannah sparrow
	Invertebrates: Kaibab variable tiger beetle, Four-spotted skipperling
	Mammals: Spotted bat, Greater western mastiff bat, Long- tailed vole, Navajo Mogollon vole, Big free-tailed bat, Dwarf shrew, Kaibab northern pocket gopher
	Plants: Mt. Dellenbaugh sandwort, Reflected moonwort, A sedge (*Carex oreocharis*), Kaibab Indian-paintbrush, Kaibab bladder-pod, Kaibab beardtongue, Rydberg's penstemon, Black dropseed
Great Basin Grassland	Birds: Ferruginous hawk, Savannah sparrow
	Reptiles & Amphibians: Milksnake, Great Basin spadefoot
	Invertebrates: Kaibab Indra swallowtail
	Mammals: Pronghorn, Gunnison's prairie dog, House Rock Valley chisel-toothed kangaroo rat, Spotted bat, Navajo Mogollon vole
	Plants: Utah Agave, Freckled milkvetch (var. *vitreus*), Limestone Milk-vetch, Darrow's Buckwheat, Park Pincushion-cactus, Fickeisen Hedgehog-cactus
Spruce-Fir Forest	Birds: Olive-sided flycatcher, Dusky (blue) grouse, Golden-crowned kinglet
	Mammals: Kaibab least chipmunk, Red squirrel, Kaibab northern pocket gopher
	Plants: Columbine, Groundcover milkvetch, Reflected moonwort, Wood nymph,
Semi-Desert Grassland	Birds: Ferruginous hawk
	Reptiles & Amphibians: Arizona black rattlesnake, Milksnake
	Mammals: Pronghorn, Gunnison's prairie dog, House Rock Valley chisel-toothed kangaroo rat, Spotted bat
	Plants: Bigelow's onion, Mearns lotus, Skunk-top scurfpea
Desert Communities	Birds: Brewer's sparrow
	Mammals: House Rock Valley chisel-toothed kangaroo rat, Big free-tailed bat, Desert bighorn
	Plants: Utah century plant, Bigelow's onion, Gumbo milkvetch, Hevron's milkvetch, Mountain pepperweed, Mearns lotus, Skunk-top scurfpea, Long Valley tumblemustard
Gambel Oak Shrubland	Reptiles & Amphibians: Arizona black rattlesnake, Utah Mountain kingsnake

Habitat (PNVT/Water)	Taxa and Species Common Name
Wetland/Cienega	Birds: Bald eagle
	Reptiles & Amphibians: Arizona toad, Arizona (mountain) treefrog, Northern leopard frog, Great Basin spadefoot
	Invertebrates: Persephone's darner, Hoary skimmer, Four-spotted skipperling, Nokomis fritillary, Nokomis fritillary ssp. *nokomis*
	Plants: Pond lily, Bebb's willow
Cottonwood-Willow Riparian Forest	Reptiles & Amphibians: Arizona toad
	Plants: Jones' spider-flower, Showy maidenfern
Mixed Conifer w/ Aspen	Birds: Red-faced warbler, Evening grosbeak, Olive-sided flycatcher, Dusky (blue) grouse, MacGillivray's warbler, Golden-crowned kinglet, Red-naped sapsucker, Orange-crowned warbler
	Invertebrates: Nokomis fritillary, Nokomis fritillary ssp. *nokomis*
	Mammals: Southwestern myotis, Kaibab least chipmunk, Red squirrel, Kaibab northern pocket gopher
	Plants: Arizona Bugbane, Columbine, Rusby's milkvetch, Mountain whitlow-grass, Wood nymph
Water (seeps, springs, streams, ponds, reservoirs, tanks)	Birds: Bald eagle
	Fish: Apache (Arizona) trout
	Reptiles & Amphibians: Arizona toad, Arizona (mountain) treefrog, Northern leopard frog, Great Basin spadefoot
	Invertebrates: Persephone's darner, Hoary skimmer
	Plants: Pond lily

Species Facing Threats Not Associated with Ecosystem Diversity Characteristics

Additional management considerations may be necessary to adequately address threats that are not covered by landscape level management policies. Species with additional threats to their habitat which could not be accounted for by ecosystem diversity risks alone were categorized separately by related habitat features (Table 29, Figure 20). This included the fine-scale microhabitat components that species depend on within the broader context of their habitat.

Table 29 - Species affected by threats to habitat features in addition to risks to ecosystem diversity characteristics
Note: **Threats marked with an asterisk (*) may be localized, but the extent of impact** may **include the entire range of some narrow endemics, or significantly impact species of restricted distribution.**

Threats	Potential Outcome	Species Common Name
Threats to **tree features** include loss of snags, debris removal, uncharacteristic fire, wood collection.	Loss of roost and nest sites for bats and cavity nesting birds. Decreased foraging opportunities and reduced habitat for small mammals, snakes and birds. Can lead to widespread population declines within the plan area	Red-naped sapsucker, Western skink, Dusky (blue) grouse, Grace's warbler, Mexican spotted owl, Utah Mountain kingsnake, Navajo Mogollon vole, Purple martin (Western), Olive-sided flycatcher, Pale Townsend's big-eared bat, Allen's lappet-browed bat, Juniper titmouse, Lewis's woodpecker, Red-faced warbler, Southwestern myotis, Northern goshawk, Bald eagle, Evening grosbeak
Threats to **forest features** include uncharacteristic fire, loss of deciduous trees/shrubs, herbivory that removes canopy layering, fire suppression, and excessive overstory tree removal.	Direct loss of habitat, loss of nesting/roosting and foraging sites can lead to population declines within the plan area	Dusky (blue) grouse, Olive-sided flycatcher, Juniper titmouse, Lewis's woodpecker, Northern goshawk, Abert's squirrel, Pinyon jay, Golden-crowned kinglet, Black-throated gray warbler, Spotted bat, Red-faced warbler, Green-tailed towhee, Dwarf shrew, Evening grosbeak, Arizona (mountain) treefrog.
Threats to **understory features** include non-native grass invasion, overgrazing, fire regime,	Decrease in available forage and foraging sites	Desert green hairstreak, Dusky (blue) grouse
Threats to **shrubland features** include overgrazing, drought, woodland invasion.	Loss of habitat and decrease in available forage and nesting sites	Pronghorn, House Rock Valley, chisel-toothed kangaroo rat, Sage sparrow
Threats to **wetland/water features** include wetland drainage and spring capping, flood scouring, overgrazing near water.	Direct loss of habitat, loss of forage opportunities, decrease in reproductive sites	Persephone's darner, Arizona toad, Arizona (mountain) treefrog, Hoary skimmer, Four-spotted skipperling, Nokomis fritillary, Nokomis fritillary ssp. *nokomis,* Navajo Mogollon vole
Threats to **grassland features** include drying of moist meadows, too much bare ground, loss of forbs.	Loss of foraging opportunities/prey base	Greater western mastiff bat, Pronghorn, Gunnison's prairie dog, Long- tailed vole, Ferruginous hawk, Big free-tailed bat, Four-spotted skipperling, Nokomis fritillary, Gray vireo, Kaibab variable tiger beetle, Spotted bat
Threats to **rock and other abiotic features** include rock collection, cliff blasting, recreational rock climbing/caving, demolition of buildings used as roost sites	Loss of hibernacula suitability and nesting sites can lead to decreased reproductive status for snakes, bats, birds, and small mammal species	Milksnake, Mexican spotted owl, Southwestern myotis, Pale Townsend's big-eared bat, American peregrine falcon, Allen's lappet-browed bat, Spotted bat, Greater western mastiff bat, Purple martin (Western), Big free-tailed bat, House Rock Valley chisel-toothed kangaroo rat, Western skink, Utah Mountain kingsnake, Dwarf shrew, Arizona black rattlesnake

Threats	Potential Outcome	Species Common Name
* **Soil disturbance** such as activities of livestock, people, or machinery that result in compaction, churning, and/or erosion.	Can inhibit plant germination and/or growth and vigor.	Arizona bugbane, Bigelow's onion, Mt. Dellenbaugh sandwort, Slimpod milkweed, Gumbo milkvetch, Lancer milkvetch, Groundcover milkvetch, Freckled milkvetch var. oropedii, Rusby's milkvetch, Silver milkvetch, Creeping milkvetch, Reflected moonwort, Diamond Valley suncup, A sedge (*Carex oreocharis*), Rose-color thistle, Jones' spider-flower, Wright's bird's-beak, Dent-nut cat's-eye, Mountain whitlow-grass, Darrow's buckwheat, Yavapai wild buckwheat, Jones' wild buckwheat, Parry's blanket-flower, Arizona whitefeather, Arizona whitefeather var. *arizonica*, Kaibab bladder-pod, Macdougal's bluebells, Western mouse-tail, Pond lily, Park pincushion-cactus, Skunk-top scurfpea, Flagstaff beardtongue, Kaibab beardtongue, Rydberg's penstemon, Serrate phacelia, Western flame-flower, Arizona phlox, Bearded cinquefoil, Oregon buttercup, Black dropseed, Rothrock's hedge-nettle, Oak Creek triteleia
* **Livestock grazing**	Can exceed a species ability to regenerate and reproduce, encourage invasive species, and alter growing conditions.	Arizona bugbane, Bigelow's onion, Slimpod milkweed, Rusby's milkvetch, Reflected moonwort, A sedge (*Carex oreocharis*), Kaibab Indian-paintbrush, Disturbed (Tusayan) rabbitbrush, Hairy clematis, Wild buckwheat, Darrow's buckwheat, Southwestern beardtongue, Black dropseed
* **Excessive wildlife herbivory**	Can exceed a species ability to regenerate and reproduce, and alter growing conditions	A sedge (*Carex oreocharis*), Disturbed (Tusayan) rabbitbrush, Wild buckwheat, Southwestern beardtongue, Kaibab beardtongue, Bebb's willow
Removal of overstory (e.g., inappropriate timber removal, insect/disease mortality) is relevant to plants that need cool, shady site conditions.	Can inhibit plant reproduction and/or growth and vigor.	Arizona bugbane, Hairy clematis, Wood nymph
Dewatering or **channelization** lowers the water table.	Can inhibit plant reproduction and/or growth and vigor.	Bebb's willow

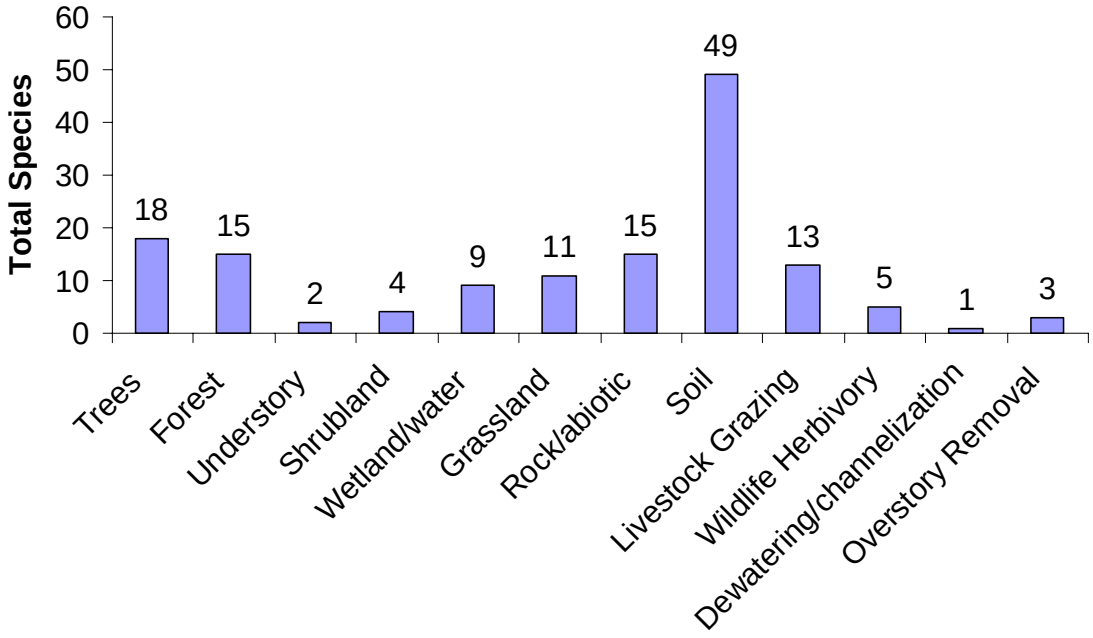

Figure 20 - Species affected by additional threats to specific habitat features

Some species face threats that are not related to ecosystem diversity characteristics or habitat features, and they are identified in Table 30, Figure 21). Some species that occur in the planning area face an additional threat simply by virtue of their relatively limited range-wide distribution. These species might be easily affected by localized and/or stochastic events, and were noted separately regardless of whether or not they were associated with habitat level threats (see Species Diversity section).

Table 30 - Species facing threats not tied to habitat features. Threats marked with an asterisk (*) can be localized, but the extent of impact can include the entire range of some narrow endemics, or significantly impact species of restricted distribution

Additional Threats Not Tied To Habitat Features	Potential Outcome	Species Common Name
Invasive Species Interactions	Competition for resources (food, space, water), and/or hybridizations can lead to direct mortality and decreases in populations within the planning area, loss of native species and changes in vegetation structure	Apache (Arizona) trout, Arizona (mountain) treefrog, Arizona toad, Arizona bugbane, Mt. Dellenbaugh sandwort, Gumbo milkvetch, Hevron's milkvetch, A milkvetch (Astragalus pinonis var. atwoodii), Silver milkvetch, Creeping milkvetch, Diamond Valley suncup, Dent-nut cat's-eye, Darrow's buckwheat, Kaibab bladder-pod, Macdougal's bluebells, Western mouse-tail, Fickeisen hedgehog-cactus, Skunk-top scurfpea, Southwestern beardtongue, Flagstaff beardtongue, Kaibab beardtongue, Serrate phacelia, Western flame-flower, Arizona phlox, Bearded cinquefoil, Oregon buttercup, Grand Canyon rose, Oak Creek triteleia
Poisoning/Pesticide Use	Direct mortality and local to widespread population declines	Pale Townsend's big-eared bat, Allen's lappet-browed bat, Big free-tailed bat, Gunnison's prairie dog, California condor
Disease	Direct mortality and local to widespread population declines	Northern leopard frog, Gunnison's prairie dog, Arizona (mountain) treefrog, Desert bighorn, Arizona toad
Cowbird parasitism	Decrease in nesting success, local population declines	Gray vireo
Development (housing, agriculture, roads, fences)	Local population declines, possible isolation of species and restrictions on species interactions	Gunnison's prairie dog, Pronghorn, Milksnake, Ferruginous hawk
* Crushing by livestock, people, or machinery; often associated with soil disturbance events.	Direct mortality, can lead to widespread population declines of narrow endemics	Arizona bugbane, Bigelow's onion, Mt. Dellenbaugh sandwort, Slimpod milkweed, Gumbo milkvetch, Lancer milkvetch, Diamond Valley suncup, Jones' spider-flower, Wright's bird's-beak, Dent-nut cat's-eye, Mountain whitlow-grass, Yavapai wild buckwheat, Jones' wild buckwheat, Parry's blanket-flower, Arizona whitefeather, Arizona whitefeather var. arizonica, Wood nymph, Pond lily, Park pincushion-cactus, Rydberg's penstemon, Serrate phacelia, Black dropseed, Rothrock's hedge-nettle

Additional Threats Not Tied To Habitat Features	Potential Outcome	Species Common Name
* Activities associated with infrastructure construction and maintenance (e.g., cliff blasting, road work).	Direct mortality, can lead to widespread population declines of narrow endemics	Gumbo milkvetch, Groundcover milkvetch, Cliff fleabane
Misidentification as a weed during weed eradication	Direct mortality	Arizona sunflower
Slash piles/burning in forest openings	Direct mortality	Western flame-flower
Uranium exploration/mining	Direct mortality and population decline	Grand Canyon rose

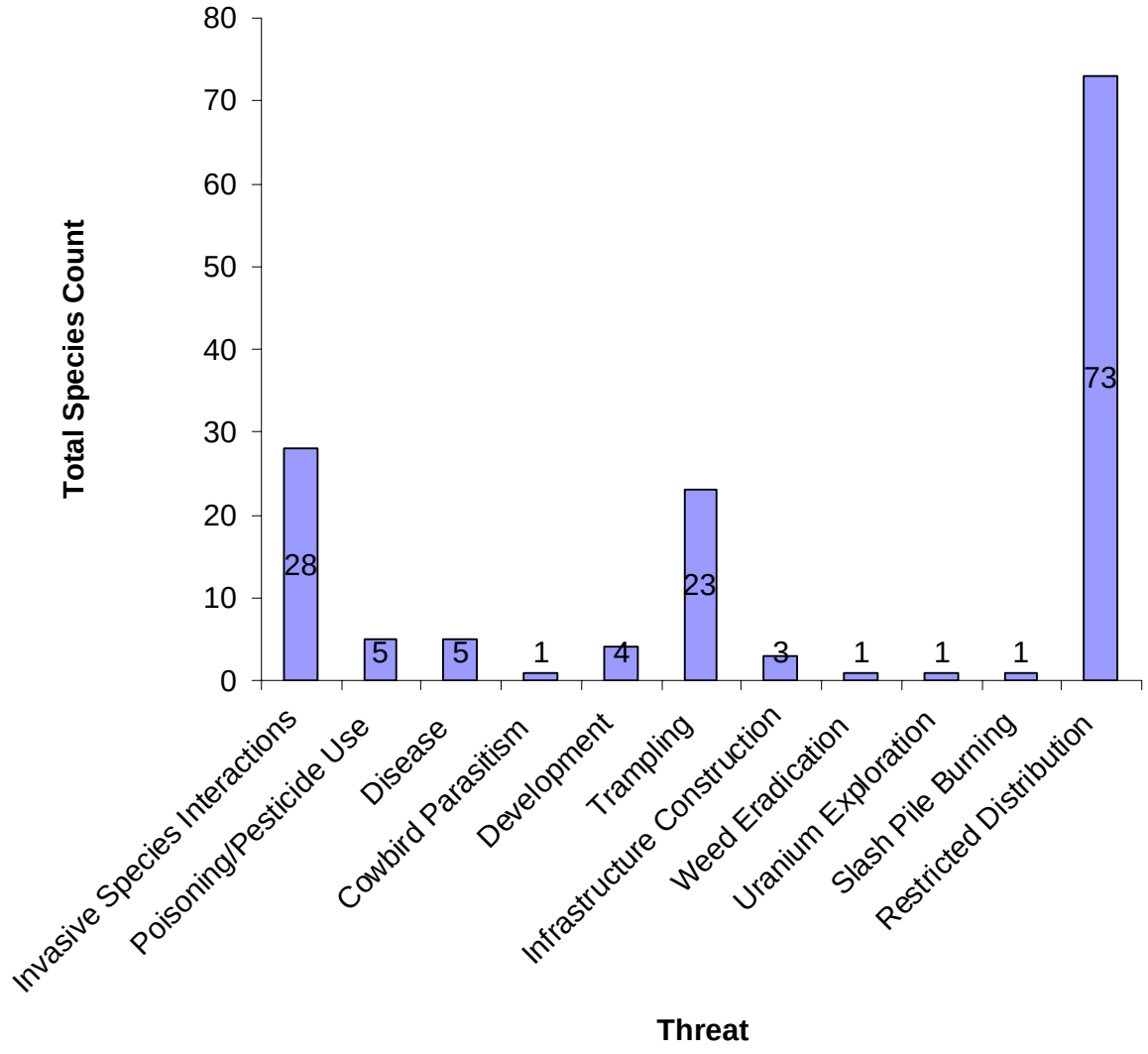

Figure 21 – Species potentially affected by additional threats not tied to habitat features

Summary of Major Findings from Species Risk Assessment

Of the 145 species identified as a model of species diversity on the KNF, 142 species are subject to factors that threaten terrestrial and aquatic ecosystem diversity characteristics. As the risks to ecosystem diversity characteristics mentioned above are managed, the species' habitat needs related to those ecosystem diversity characteristics will also be addressed. However, 96 species are subject to additional threats beyond identified risks to terrestrial and aquatic ecosystem diversity characteristics.

Some of these additional threats involve localized habitat features. The risk of these threats must be considered at the project level to manage for and maintain full ecosystem function across the Forest. While plant and wildlife species use broad-scale vegetation types and associated developmental states in a general sense, most species use fine-scale habitat components in a specialized way. For example, many primary- and secondary cavity nesting species depend on an adequate distribution of standing dead wood suitable for excavation. The narrow endemic plant, Arizona bugbane, is highly dependent on cool, shady microsite conditions in ponderosa pine forest. These fine-scale habitat needs are not specifically considered or addressed in broad-scale terrestrial or aquatic management plans, so it is necessary to develop desired conditions and evaluate habitat needs from the species' perspective. Desired conditions can be described in the Forest Plan, but the best way to evaluate these fine-scale habitat issues is at the project level. By using both broad-scale and fine-scale approaches to land management planning, the Forest can promote sustainable management of fully-functioning ecosystems.

Other additional threats that face some species are not related to specific habitat features. Some of these threats are directly within the agency's control and authority to manage, such as avoiding Arizona sunflowers during weed eradication activities, and avoiding Western flame-flowers during slash-pile burning activities. Some threats are not so much within agency control, but the KNF has the authority to mitigate the threats. For example, biological threats like disease or cowbird parasitism may be addressed by modifying livestock use, or restricting access in areas of high risk. The impacts of development, infrastructure, and non-renewable resource exploration/extraction activities may also be mitigated on a case-by-case basis. Desired conditions and acceptable mitigation strategies addressing threats not tied to habitat features can be described in the Forest Plan.

Species that may suffer especially severe consequences of unmanaged threats are the 73 "restricted distribution" plants and animals on the Forest. In areas where these species occur, or are likely to occur, special consideration must be paid to analyzing and managing the risk of localized threats at the project level.

V. ECOLOGICAL NEED FOR CHANGE

The state of ecological sustainability on the Forest is presented here as a distillation of ecosystem characteristics; including vegetation composition and structure within PNVTs, soil, water, air, species diversity, and the Forest's spatial niche in the greater landscape. Based on the analyses previously presented in this report, certain aspects of the current state of the Forest need some degree of change to address threats facing ecological sustainability on the Forest. This chapter highlights ecosystem characteristics in need of change on the Kaibab National Forest.

Summary and Recommendations of Ecosystem Characteristics Needing Change

Two key factors should be considered when identifying ecological needs for change: the current status and trend of an ecosystem, and the effects of management activities on that status and trend. The two tables in this section work together to combine these considerations; Table 31 summarizes the analysis of the Forest's terrestrial vegetation and natural aquatic ecosystems, Table 32 presents ecosystem information with species and Forest niche information. The greatest focus in identifying needs for change is on terrestrial vegetation because it is the primary factor that affects other ecosystem components on the Forest, and can be directly manipulated by management. However, other critical ecological issues to be considered during Forest Plan revision are also presented at the end of this section.

Table 31 includes the difference between historic and current conditions (departures), the trend of departures for the next 50 years, what characteristics are most important that make up the departures, what current or past activities have the most influence on those characteristics, what possible management responses may be considered to reverse adverse trends or departures, and additional particular notes.

Table 31 – Summary of ecosystem departure characteristics, contributing activities, and possible management responses

Ecosystem	Departure	Trend	Significant Departure Characteristics	Significant Contributing Activities	Possible Management Response	Notes
Pinyon Juniper Woodland	Moderate	Static to Away	Canopy densities higher which may increase bark beetle activity. More continuity of canopy. Invasive species.	Past fire suppression and past managed grazing.	Fire suppression when crown fire risk is moderate or high across large areas. Density reduction in characteristic patterns. Weed control.	This PNVT includes PJ-grassland, PJ-shrubland, and PJ-woodland. They may require separate management approaches.
Ponderosa Pine	High	Static	Canopy densities higher; an excess of young forest states.	Past fire suppression grazing and tree cutting practices. Current wildfires and drought.	Fire suppression when crown fire risk is moderate or high. Canopy density and fuels reduction in characteristic patterns. Regeneration in characteristic patterns. Retain most of the older trees.	Trend is "Stable" because it can not depart any further by the analyses used. However, uncharacteristic fires and other disturbances that kill many large or old trees will increase the time it would take to restore this PNVT. Elk may hinder aspen recovery within much of the WM-SFP-MR Section; mitigation is expensive but possible.
Mixed Conifer Forest	High	Away	Canopy densities higher. Species abundance shifts. An excess of young forest states.	Past fire suppression, grazing, and tree cutting practices.	Fire suppression when crown fire risk is moderate or high. Canopy density and fuels reduction in characteristic patterns and species composition. Regeneration in characteristic patterns and species composition. Retain most of the older trees.	Uncharacteristic fires and other disturbances that kill many large or old trees will increase the time it would take to restore this PNVT. Elk may hinder aspen recovery within much of the WM-SFP-MR Section; mitigation is expensive but possible.
Sagebrush Shrubland	Moderate	Away	Increasing shrub density/continuity and juniper encroachment. Loss of understory species abundance and species abundance shifts.	Past fire suppression, past and current unmanaged herbivory.	Reintroduce fire to reduce shrub density, recycle nutrients and control juniper encroachment. Other practices to control shrub density may be required first. Modified wildlife management (bison) and managed grazing practices may also be necessary first.	Response to fire depends on sage species – some species regenerate well after fire, and others do not. KNF likely has both types, but distribution on the Forest is unknown. Expected response and appropriate action should be determined before using fire to manage sagebrush shrublands.

Ecosystem	Departure	Trend	Significant Departure Characteristics	Significant Contributing Activities	Possible Management Response	Notes
Montane / Subalpine Grassland	Moderate	Away	Increasing shrub density; conifer encroachment.	Past fire suppression and past managed grazing. Current unmanaged herbivory may also be a threat.	Reintroduce fire to reduce shrub density, recycle nutrients and control juniper encroachment. Other practices to control shrub density may be required first. Modified grazing practices may be necessary first, but response may be limited by continued pressure from elk.	The percent of departure over time from tree encroachment into subalpine meadows may be higher in the Grand Canyon Section because of the linear shape of the PNVT here (relative to other sections). The role of fire in these subalpine meadows may be different and require a different management approach than that in montane grasslands on other parts of the Forest.
Colorado Plateau / Great Basin Grassland	Moderate	Away	Increasing shrub density and juniper encroachment.	Past fire suppression and past/current ungulate herbivory (managed & unmanaged).	Reintroduce fire to reduce shrub density, recycle nutrients and control juniper encroachment. Other practices to control shrub density may be required first. Modified grazing practices may be necessary first, but response may be limited by continued pressure from elk.	No other concerns regarding this PNVT were raised.
Spruce Fir Forest	High	Static	Canopy densities higher. More continuous dense canopy. Species abundance shifts. An excess of young forest states.	Past fire suppression, grazing and tree cutting practices.	Fire suppression when crown fire risk is high until canopy density and fuels reduction in characteristic patterns and species composition. Regeneration in characteristic patterns and species composition. Retain most older trees.	Much of this PNVT may have historically been Mixed Conifer forest. Since fire exclusion, a shift towards Engelmann spruce and corkbark fir has been documented.
Semi-Desert Grassland	Low	Away	Increasing shrub density and juniper encroachment.	Past fire suppression, past and current managed/unmanaged herbivory.	Reintroduce fire to reduce shrub density, recycle nutrients and control juniper encroachment. Other practices to control shrub density may be required first. Modified wildlife management (bison) and managed grazing practices may also be necessary first.	Approximately half of this PNVT is on the Buffalo Ranch and may not be subject to FS habitat management control under the existing MOU with the Arizona Game and Fish Department. A portion of land near the Buffalo Ranch may actually be a Black Sagebrush PNVT.

Ecosystem	Departure	Trend	Significant Departure Characteristics	Significant Contributing Activities	Possible Management Response	Notes
Desert Commun-ities	Moderate	Away	Increased invasive plants. Shorter fire return interval. Increased shrub/juniper canopy cover.	Past managed / unmanaged herbivory. Introduction of invasive plants.	Reduce density of junipers and shrubs. Control invasive plants. Keep fires as small as possible.	This PNVT is entirely within the Kanab Creek Wilderness.
Gambel Oak Shrubland	Low	Away	Canopy densities higher. More continuity of canopy. Invasive plants.	Past fire suppression. Introduction of invasive plants.	Reintroduce fire to reduce canopy density and break up continuity, recycle nutrients and control conifer encroachment. Other practices to control density may be required first.	No other concerns regarding this PNVT were raised.
Wetland / Cienega	Low	Slowly Away	Increased tree cover. Invasive plants. Shorter fire return interval. Decreased water flow (surface / sub-surface.)	Past fire suppression and past managed grazing. Current unmanaged herbivory may also be a threat, as is motorized recreation.	Reintroduce fire to reduce tree density/encroachment. Other practices to control tree density may be required first. Reduce tree density of adjacent PNVTs. Enforce closures to motorized vehicles and repair damage.	Drought especially compounds the effects of grazing and increased tree density in and around this PNVT.
Cottonwood Willow Riparian Forest	High	Away	Loss of flooding disturbance and perennial stream flow. Loss of tree structure and native species especially cottonwood and willow.	Upstream (off-Forest) impoundments-diversions. Introduction of non-native invasive trees/shrubs.	Control of invasive species. Keep fires as small as possible.	This PNVT is entirely within the Kanab Creek Wilderness. Tamarisk leaf beetle (*Diorhabda elongata*) may move into this PNVT within a few years and begin reducing tamarisk without Forest Service action.
Streams, Seeps & Springs	L to H	Static to Away	Degraded riparian and/or wetland conditions; invasive species; risk of uncharacteristic fire.	Past livestock use, current concentrated localized livestock / wildlife use, past fire suppression.	Control invasive species; fence out livestock and possibly elk; reduce tree density / encroachment in adjacent PNVTs with mechanical thinning and/or reintroduced fire.	Riparian and aquatic systems in arid landscapes are centers of high biological diversity (Sada 2008). Wildlife activity is more concentrated around open water sources than in the general landscape, and obligate aquatic and semi-aquatic species on the Forest are entirely dependent on the Forest's limited and scattered perennial water sources.

Table 32 combines key findings from the Forest's spatial niche analysis (Chapter I), ecosystem diversity analysis (Chapter II) and species diversity analyses (Chapter III). The first column identifies the ecosystem, and the next four columns refer to the departure and trend of that ecosystem in relation to reference conditions. The 'Species' column refers to the number of identified species associated with that ecosystem. The last two columns refer to the Forest's spatial niche, based on the discussion in Chapter I regarding the Ranger Districts in context of the ecoregional sections they occur in (refer to Figure 3, and Tables 3, 4, and 5). 'Districts w/ high abundance' refers to the number of Districts that contain a disproportionately high abundance of that PNVT (or seeps and springs) in their section. 'Reservoir/Refuge possibility' refers to the relative importance the Forest may have in providing a refuge from highly departed off-Forest conditions.

Table 32 – Summary of the state of ecosystems on the Forest addressed by PNVT and natural water (i.e., streams, seeps, and springs).

	Vegetation		Soil Condition-Productivity		Species	Niche	
Ecosystem	Departure	Trend	Departure	Trend	# of Species related	Districts w/ high abundance	Reservoir / Refuge possibility
Pinyon Juniper Woodland	M	Slowly Away	M*	Slowly Away	48	2	M
Ponderosa Pine	H	Static	M*	Slowly Away	56	2	H
Mixed Conifer Forests	H	Away	L	Static	26	1	H
Sagebrush Shrubland	M	Away	L	Slowly Toward	20	1	L
Montane / Subalpine Grassland	M	Away	M	Static	18	3	N/A
Colorado Plateau / Great Basin Grassland	M	Away	L	Slowly Toward	16	0	H, M
Spruce Fir Forest	H	Static	L	Static	10	1	L
Semi-Desert Grassland	L	Away	M	Slowly Toward	10	1	N/A
Desert Communities	M	Away	L	Slowly Toward	12	0	M
Gambel Oak Shrubland	L	Away	L	Static	2	2	N/A
Wetland/Cienega	L	Slowly Away	M	Static	11	1	L
Cottonwood Willow Riparian Forest	H	Away	L	Static	3	0	H
Streams, Seeps & Springs	Mixed site-specific departures; moderate departure overall				9	2	N/A

* Overall departure for these PNVTs is in the "Low" range, but large areas are departed on the Forest.

In relation to the three ecoregional sections, the Forest contains a relatively high abundance of 10 ecosystems in at least one District. Where the Forest does not have a high abundance of an ecosystem in at least one District, there are seven cases where the Forest may have an opportunity to provide a refuge or reservoir for species in the section because the larger landscape off-Forest exhibits a moderate to high departure from reference conditions.

Additional Issues

The following issues affect future ecological sustainability and resource management on the KNF, and will need consideration when the revised Forest Plan is being drafted:

- Proposed Forest Plan components should provide guidance that addresses broad-scale ecosystem concerns, as well as allow for fine-scale or project-level issues.

- Proposed Forest Plan components should note situations where current management is appropriate, but the rate of implementation is too low to alter the direction of trends.

- Thoughtful monitoring efforts are important for adapting management activities to conditions in the planning area. Proposed Forest Plan components should support monitoring and adaptive management efforts on the Forest, given the following considerations:

    - Adaptive management should enable the Forest to avoid large future revision efforts, but it requires more regular monitoring and evaluation, and will take up some of our capacity.

    - The Forest should determine the most efficient and effective means of measuring success in restoring fire-adapted ecosystems.

    - Habitat monitoring should target wildlife and sensitive plant management objectives, rather than relying on traditional forest and range monitoring practices that may not address specific habitat objectives.

    - Species monitoring has been employed on the KNF to a limited extent (e.g., bird surveys), but could be used more extensively and with greater influence in designing future projects.

- In light of the Forest's limited organizational resources, the following questions should be considered:

    - Are there opportunities to partner with others to address the needs for change effectively?

    - As progress is made with restoration, how much effort is needed to retain the gains made?

    - Are there proposed or ongoing projects that may be dropped because they do not address the needs for change?

Next Steps in the Forest Plan Revision Process

This ecological sustainability report and the social-economic sustainability report will be integrated to create a comprehensive evaluation report (CER). That comprehensive report, along with other information, including public, tribal and other agency comments, will be reviewed by the KNF leadership team to identify the needs for change that will be addressed in the process of revising the Forest Plan.

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APPENDIX 1 – VEGETATION DEPARTURE FROM REFERENCE CONDITIONS SECTION-WIDE

The graph below (Figure AP1) displays the results of the analysis of vegetation departure from reference conditions by PNVT for the three primary Sections the Forest overlaps. Data used in the analysis came from Southwest ReGAP (Lowry et al. 2005, SWReGAP 2006), Forest Service Mid-scale Vegetation data (see Mellin et al. 2008), and LANDFIRE project data (LANDFIRE 2001). The process for assigning risk by vegetation structure within each PNVT is documented in the Vegetation-Fire report (KNF 2008f). Essentially, the ratings consider the likelihood and consequences of uncharacteristic disturbances. This often assumes that a high risk (highly departed from reference conditions) will result in a highly negative outcome, but not always. For example, a highly uncharacteristic departure, such as tree invasion in a grassland PNVT, received an "M" or even an "L" in some cases because the consequence of a disturbance may be likely to restore at least some grassland structure and function, barring non-native species invasion.

This graph presents each PNVT across the three Sections, so a relative comparison of departure from reference conditions between Ranger Districts may be made when considering the Forest niche. Since >90 percent of each Ranger District of the Forest lies uniquely in one of these three Sections, the Sections may be compared directly to each of the Ranger Districts. The abbreviations in the graph for each Section are: GC – Grand Canyon; PD – Painted Desert; and WM – White Mountains-San Francisco Peaks-Mogollon Rim.

This graph indicates over 40 percent of the Pinyon-Juniper Woodland, Ponderosa Pine and Mixed Forest PNVTs are highly departed, in all three Sections. There are also significant percentages in departed states for Desert Communities and Wetland/Cienegas in one or two Sections. Desert Communities occur only on-Forest in the Grand Canyon Section. Wetland/Cienegas do not occur on-Forest in the Painted Desert Section.

Three instances merit specific discussion:

- Cottonwood Willow Riparian Forests are probably highly departed in all three Sections but the data used can not resolve this departure because the departure is due to invasive species and a disrupted disturbance regime.
- Spruce-fir Forest in the Grand Canyon Section has been demonstrated to have a frequent surface and mixed-severity fire regime. (Fulé et al. 2003b, Vankat 2004) This is probably due primarily to the small patch size of this PNVT and it's proximity to other PNVTs with frequent surface or mixed-severity fire regimes (Ponderosa Pine, Mixed Forests. The continuity of closed canopy forest that has developed across all of these PNVTs has created highly departed conditions that will now support much larger stand-replacing fires than any research or historic inventory has documented

Dry Mixed Conifer and Mixed Conifer with Aspen PNVTs are combined here into Mixed Conifer Forests. It is believed that the majority of the mixed type is a frequent fire type (Dry Mixed Conifer) across all three Sections. While this is known for the Grand Canyon Section, it is not verified for the other two. The departure ratings are based upon that assumption.

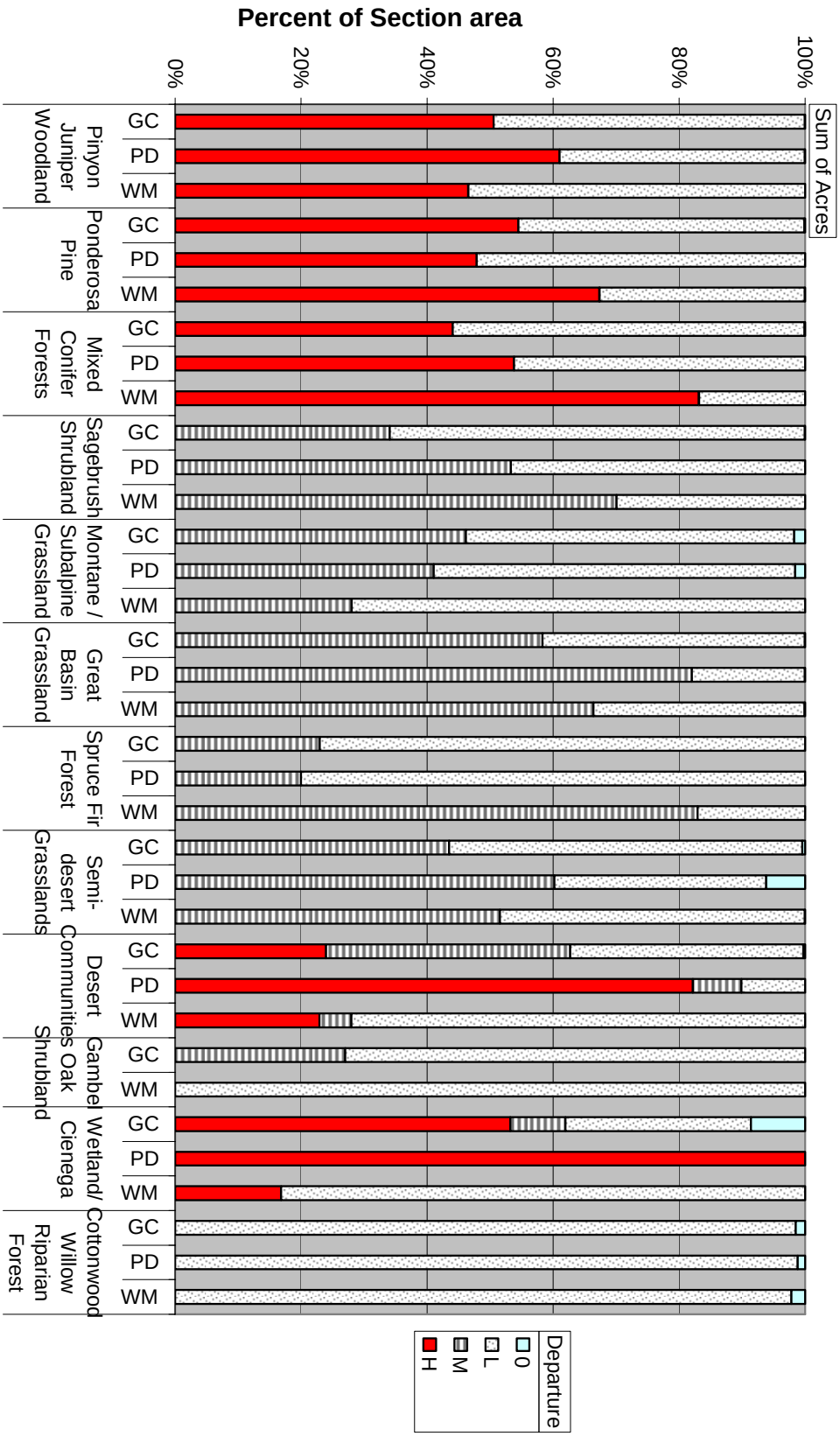

Figure AP1 – Summary of how much current vegetation conditions are departed from reference conditions (H-High, M-Medium, L-Low) across the Grand Canyon (GC), Painted Desert (PD), and White Mountains-San Francisco Peaks-Mogollon Rim (WM) Sections.

APPENDIX 2 – WATERSHED RISK RATING

PNVT and structure were assigned departures, as Shown in Appendix 1, Table 41 of the Vegetation and Fire Report (KNG 2008f). Risk of negative outcome values used are: 0 – unevaluated; L - low - structure likely to be fairly typical of reference period and/or negative outcomes from disturbance not expected; M - medium - structure somewhat atypical - at least across 1/3 - 2/3 of the affected area and some negative outcomes expected from disturbances; and, H - high - most structure highly atypical with highly negative outcomes expected from disturbances. The ratings consider the likelihood and consequences of uncharacteristic disturbances. This often assumes that a high risk (highly departed from reference) will result in a highly negative outcome, but not always. For example, a highly uncharacteristic departure (such as tree invasion in grassland PNVTs) received an "M" or even an "L" in some cases, because the consequence of a disturbance may be likely to restore at least some natural structure and function, barring non-native species invasion.

A risk score was used to put watershed on par with each other as follows:

> Score = (High acres * 2 + Moderate Acres - Low Acres) / Total Acres, but not less than 0 for the 4th code Watersheds (to avoid math problems).

Based upon a number of recent uncharacteristic events across much of this Forest, as well as the assessment that half the Forest is moderately to highly departed from reference states across PNVTs, an assumption of at least Moderate departure is used to construct the following ratings. Ratings do not consider threats that are not closely related to vegetation states and uncharacteristic disturbances likely as a result of those states.

4th code watersheds are rated relative to the overall Forest score (x) as follows:

> Higher: >1.33 * x
>
> Moderate: > .66 * x and <= 1.33 * x
>
> Lower: <= .66 * x

5th code watersheds are rated using their Score in the context of the 4th code rating as follows. Since many uncharacteristic fires and other potential disturbances operate at scales larger than 5th code watersheds, the context of the 4th code watershed is considered. Eg. Thresholds for higher ratings are lower for 5th code watersheds when they are in a higher risk 4th code watershed.

4th code rating =>	H	M	L
To receive a 5th code rating of:	The Score must be:		
H	>0.67 * x	>0.75 * x	>1.25 * x
M	(0.5 - 0.67) x	(0.67 - .75) x	(0.75 - 1.25) x
L	<0.5 * x	<0.67 * x	<0.75 * x

It is important to note these ratings have no intrinsic value beyond a relative score when comparing watershed risk. They are simple a way to help inform a discussion about where restoration work might most be needed within the context of this risk factor as one of many.

Errata

Kaibab National Forest Ecological Sustainability Report
Version 1.01, December 19, 2008

There is an error on page 12 under the section, “Terrestrial Systems: Context of the Ranger Districts within the Sections,” sub-section, “Williams Ranger District in Context of the White Mountains – San Francisco Peaks– Mogollon Rim Section, Additional Ecological Attributes”. The following phrase is incorrect, “The District has three Mexican spotted owl protected activity centers…”

The correct phrase is “The District has *six* Mexican spotted owl protected activity centers…” (emphasis added).

Corrected 30 March 2009