Kaibab National Forest:

An Evaluation of Terrestrial Ecosystems (Ecological Units, Soil Composition, Structure and Processes) that Affect Ecosystem Diversity and Contribute to Ecological Sustainability

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Table of Contents

I. Introduction-Background 1
A. Purpose and Objective of Analysis 1
B. Scales, Terrestrial Ecosystems and Ecological Units Used in Analysis 2
II. The Ecological Niche of the Forest in the Southwestern Region 4
A. Geographic Extent of the Forest in the Southwestern Region 4
1. Ecological Division and Provinces 4
2. Ecological Sections 4
3. Ecological Subsections: 7
Ecological Contributions Findings: 8
Potential Natural Vegetation Types (PNVTS) 9
The Ecological Niche of the Forest Summary 11
III. Current and Historic Conditions, Niche, Disturbances and Processes, Departures, Trends/Projected Future, Risks, Ecological Need for Change 12
Resource Characteristic by PNVT: Soil Condition (Soil Loss) 12
Resource Characteristic by PNVT: Soil Productivity, Organic Matter and Microbiotic Crusts 20
Soil Condition - Trend Tables and Ecological Need for Change by PNVT 29
Cottonwood Willow, Riparian Forest PNVTs (at the Forest-scale) 29
Desert Communities PNVT (at the Forest-scale) 32
Gambel Oak Shrubland PNVT (at the Forest scale) (Occupies less than 0.5% of Forest extent) 34
Great Basin/Colorado Plateau Grasslands and Steppe (at the Forest-scale) 36
Mixed Conifer and Spruce-Fir PNVTs (at the Forest scale) 38
Montane/Subalpine Grassland PNVT (at the Forest-scale) 41
Pinyon-Juniper Woodland PNVT (at the Forest-scale) 45
Ponderosa Pine PNVT (at the Forest scale) 48
Sagebrush Shrubland PNVT (at the Forest-scale) 52
Semi-Desert Grassland PNVT (at the Forest-scale) 55
Wetland/Cienega PNVT (at the Forest-scale) 57
References: 63
Appendix A TES and PNVT Crosswalk for the Kaibab National 64
Appendix B TES Ecological Unit Acreage by PNVT 68

I. Introduction-Background

In 2006, the Kaibab National Forest is embarking on Forest Plan revision. With implementation of the 2005 Forest Planning Rule, The Forest Service is charged with developing management plans that create a framework for contributing to economic, social and ecological sustainability on National Forests and Grasslands. The planning rule and directives defines ecological sustainability as providing for the diversity of plant and animal communities using a multi-scale approach that evaluates and provides guidance for ecosystem and species management. The primary focus for assessing ecological sustainability in the current Rule is to provide for ecosystem diversity which contributes to a diversity of native plant and animal species.

A. Purpose and Objective of Analysis

The purpose of this analysis is to evaluate terrestrial ecosystems (ecological units) and soil resource characteristics most important in assessing ecosystem diversity from broad scales to finer scales below the Forest. This analysis focuses on CER Phase 1, Need for Change Evaluation for terrestrial ecosystem diversity and describes the ecological niche of the Forest at several scales (broader to finer) in order to evaluate the contributions to ecological sustainability that may occur at those scales.

The analysis includes an evaluation of ecological units (from broad to fine scales), soil resource current and historic conditions (estimated), disturbances and processes, trends and projected future conditions. Trends, departures between historic and current conditions and projected future conditions are analyzed in a tabular format (Table 9) towards the end of this analysis and is entitled **Soil Trend Analysis of the Kaibab National Forest.** Table 11 summarizes departure, trend and ecological need for change by PNVT and is located after several tables presenting conditions and trends for each PNVT.

Appendix A lists the ecological unit PNVT crosswalk from recent inventory called the Terrestrial Ecosystem Survey (TES) for the Kaibab National Forests, 2/9/2007. Appendix B lists TES map unit acreage by PNVT.

The evaluation of ecosystem risks with the objective of identifying specific ecological needs for changes in the Forest Plan is analyzed under separate risk assessment documents aggregated by PNVT and included in the final Ecosystem Sustainability report. The Ecosystem Sustainability report summarizes this analysis and includes some additional information gathered after this analysis was competed.

Species diversity and economic and social sustainability will also be analyzed in separate documents and interwoven in the Ecosystem Sustainability report. **The overall purpose in this phase of Forest Plan revision is to determine and summarize the ecosystem characteristics needing change**. A list of recommended specific needs for change and rationale will be provided (at some

phase) and may include eliminating, modifying, or adding to current plan direction.

B. Scales, Terrestrial Ecosystems and Ecological Units Used in Analysis

Selecting Appropriate Scales

According to the 2005 planning rule, the national direction and regional guidance for implementing the rule, we are required to evaluate ecological sustainability at different scales. The first part of this analysis describes the terrestrial ecological niche of the Forest at broader scales in order to evaluate the contributions towards ecological sustainability that may occur. The second part of the analysis is finer in scale and describes individual soil resources most likely to affect ecosystem diversity and ecological sustainability.

Scales Relevant to Analysis That Extend Beyond Forest Boundaries

According to national direction (Chapter 40 of FSH 1909.12) and Regional guidance from within the ecological sustainability working group report, our broad-scale analysis should extend beyond Forest boundaries in order to understand the environmental context and ecological niche of the Forest and the opportunities and limitations of the Forest to contribute to the sustainability of ecological systems.

National direction recommends using the province or section levels of the National Hierarchy of Ecological Units for this purpose (Ecological Subregions of the United States: Section Descriptions, July, 1994, McNab et. al).

The second part of the broad-scale analysis uses subsection mapping (Ecological Subregions: Sections and Subsections for the Conterminous United States) and provides further insights into the ecological niche of the Forest.

Within Forest System boundaries, data is available at scales finer than subsections. The Generalized Terrestrial Ecosystem Survey (GTES) provides seamless coverage and descriptive information of terrestrial ecological units at the landscape level within the boundaries of the Forest.

Even finer analysis is performed at the Forest-level scale and below using identified Potential Natural Vegetation Types (PNVT) derived from aggregated Forest Terrestrial Ecosystem Survey (TES) Ecological Units on the Forest and Southwest Regap analysis for areas and analysis outside of the Forest. The PNVTs are ecological unit based biophysical settings and depict the potential vegetation type that would dominate a site under natural disturbance regimes and biological processes (Ecological & Biological Diversity of the Coconino National Forest, Chapter 8, The Nature Conservancy, 2006)

PNVT descriptions can be found in the following Nature Conservancy reference, Southwest Forest Assessment Project (TNC 2006), pages 2-24 through 2-28.

The published TES identifies the potential plant community (PPC) and is based on documented reference sites Forest and Region-wide under contemporary disturbance. TES map units were aggregated into PNVT's for areas within the Forest. Within the Forest, the PPC, and therefore the PNVT indicates site potential and classified according to the late successional vegetation species that would be expected to occupy the site in the absence of major disturbance (Triepke, May, 2007 and derived from 'Southwest Forest Assessment Project' (TNC 2006), Appendix 2-BTNC,. Similar to *biophysical settings* conceptualized in the Interagency Fire Regime Condition Class Guidebook (v1.2, 2005), PNVTs combine potential vegetation and historic fire regime to form ecosystem classes useful for landscape assessment:

PNVT = PNV + Historic Fire Regime

The PPC does not represent desired vegetative conditions but serves as a capability sideboard to identify vegetation composition, diversity and vegetative ground cover that could exist. Soil resource characteristics are evaluated and analyzed by PNVT at the Forest level and throughout the PNVT extent to indicate the ecosystem contribution the Forest has towards and ecological sustainability. Appendix A depicts the crosswalk used between TES PPC's and the corresponding PNVT on the Coconino, Kaibab and Apache-Sitgreaves National Forests.

The TES Ecological Units (and soils) are derived from the Forest Ecological Unit Inventory, The Terrestrial Ecosystems Survey (TES) of the Kaibab National Forest, 1991. The TES is the result of the systematic analysis, mapping, classification and interpretation of terrestrial ecosystems also known as ecological types delineated and numbered in ecological units. It is the only seamless mapping of vegetation and soils available across the Forest that includes field visited, validated and correlated sites with a stringent Regional and National protocol stemming from decades of work. Major field work for the TES was completed during the period of 1979 through 1986. Soil names and descriptions were approved in 1992. Map units are identified by numbers ranging from 3 to 683.

It is important to realize that differences in ecosystem properties including soil and vegetation can occur within short distances. The TES was mapped at a scale of 1:24,000 across the landscape. Generally, small vegetation types smaller than about 10 to 40 acres were not mapped and are included in larger TES map units

Individual map units were based on data collected across the Forest and may or may not represent landscape existing conditions and potential plant community as depicted in the TES. Overall accuracy of mapping and information provided by the TES is considered reliable at the ecological unit or landscape level.

II. The Ecological Niche of the Forest in the Southwestern Region

A. Geographic Extent of the Forest in the Southwestern Region

1. Ecological Division and Provinces

The entire Forest is contained within the Tropical/Subtropical Steppe Division and Tropical/Subtropical Desert Division. Most of the Forest including Northern portions are contained within the Colorado Plateau Semi-Desert Province. A small portion of the Forest is contained in the American Semi-Desert and Desert Province. All other portions of the Forest dominated by coniferous forest are contained within the Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province.

2. Ecological Sections

The Forest is contained entirely within five sections (illustrated in Table 1):

1. Section 313A: Grand Canyon
2. Section 313C: Tonto Transition and
3. Section 313D: Painted Desert
4. Section 322A: Mojave Desert
5. Section M313A: White Mountains - San Francisco Peaks - Mogollon Rim

Table 1. The Sections of the Kaibab National Forest

Section	Section Name	Kaibab's Square Miles in each Section	Total Square Miles in Range	Kaibab's Percent of Section Area
313 A	Grand Canyon	1025	30,598	3.3%
313C	Tonto Transition	24.5	11,799	0.2%
313D	Painted Desert	516.5	13,952	3.7%
322A	Mojave Desert	64	51,947	0.1%
M313A	White Mountains - San Francisco Peaks - Mogollon Rim	871	21,028	4.1%
Total		2501		

A description of the Provinces and Sections of the Coconino National Forest taken from McNab, et al (2005) follows:

Province 313:- Colorado Plateau Semi-Desert

This Province has five sections located in parts of Arizona, New Mexico, Utah and Colorado with an area of about 75,300 square miles. Only three sections (described below) occur on the Forest. Climate is warm or hot summers and mild or cold winters at higher elevations. Annual precipitation ranges from about 6 – 25 inches and elevations range from about 4000 to 8000 feet. Geomorphology consists of plains, hills, plateaus, canyons and mountains. Vegetation is dominated by grama and galleta grass at lower elevations, pinyon-juniper at higher elevations or Great Basin sagebrush in Northern areas and chaparral and lesser areas of ponderosa pine.

Section 313A: Grand Canyon

As the name implies, this section is located in northwestern Arizona along the Grand Canyon and dominates the North Kaibab and Tusayan Ranger Districts. A little less than half of the Forest is contained within this section. However, only 3.3% of the total aerial extent of this ecological unit (section) occurs on the Kaibab Forest so the ecosystem diversity on the Forest only contributes a small proportion towards ecological sustainability of this section. Precipitation ranges from about 6 – 14 inches and elevations ranges from about 4200 – 7900 feet. Geomorphology includes canyons, cliffs, mesa and buttes. Lithology is dominated by sedimentary rocks including sandstones and shales. Soil taxa include Entisols and Aridisols (desert soils), with mesic and frigid soil temperature regimes and aridic soil moisture regimes. Dominant vegetation consists of pinyon-juniper at higher elevations and great basin sagebrush at lower elevations or in valley plains. Major disturbances include grazing, drought and wind.

Section 313C: Tonto Transition

This section is located in central and northwest central Arizona and in southern portions of the Coconino National Forest along the Mogollon Rim. This section occupies the lowest extent on the Forest and only .2% of the total aerial extent of this ecological unit (section) lies in the Forest so the ecosystem diversity on the Forest only contributes a very small proportion towards ecological sustainability of this section. Precipitation ranges from about 10 – 25 inches and elevations range from about 3000 – 7400 feet. Geomorphology includes mountains, hills, plains and escarpments. Lithology is dominated by volcanic rocks with lesser amounts of sedimentary and metavolcanic rocks. Soil taxa include Ustochrepts, Ustorthents, Haplustalfs, Argiustolls, Argiborolls, Ustifluvents, with ustic soil moisture regimes and thermic, mesic and a few frigid soil temperature regimes. Vegetation consists of interior chaparral including Turbinella oak and pinyon-juniper on elevations higher than about 4200 feet, and ponderosa pine at the highest elevations. Fire climaxes occur on steep, chaparral dominated slopes. Disturbances include fire; grazing and droughts have been increasingly common.

Section 313D: Painted Desert

This section is located on the Colorado Plateau in northeastern central Arizona and northeastern portions of the Forest. About 3.7% of the total aerial extent of this section lies in the Forest so the ecosystem diversity on the Forest contributes a small proportion of the overall ecological sustainability of this section. Precipitation ranges from 8 – 20 inches and elevations range from about 4000 – 7000 feet. Geomorphology includes hills, plains, canyons and plateaus. Lithology is dominated by sedimentary rocks. Soil taxa include Ustochrepts, Calciustolls, Haplustalfs, Argiustolls, with ustic soil moisture

regimes and mesic soil temperature regimes. Vegetations consists grama and galleta grass at lower elevations and pinyon-juniper on elevations. Disturbances include flash floods, droughts and grazing.

American Semi-Desert and Desert Province

This province extends from southeastern California through western Arizona and includes the Mojave Desert section found on the Kaibab Forest.

Section 322A: Mojave Desert

This section lies in northwest Arizona within the Mojave Desert and in the extreme western portion of the Forest. This section occupies the second lowest aerial extent of the Forest and only contributes .1% over this sections range. Consequently, ecosystem diversity on the Forest contributes an insignificant proportion and role of the overall ecological sustainability of this section. Precipitation ranges from 3 – 10 inches and elevations range from -300 – 11,000 feet throughout its range. The Forest is located within the higher elevation and precipitation range. Geomorphology includes plains and isolated mountains. Lithology is dominated by sedimentary, granitic and alluvial deposits. Soils include Aridisols and Entisols with thermic soil temperature regimes and aridic soil moisture regimes. Dominant vegetation includes creosotebush, greasewood and basin sagebrush.

Province M313: Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow

This Province is located on the Colorado Plateau and Basin and Range physiographic province. It has two sections located in parts of Arizona, New Mexico with an area of about 50,200 square miles. Only one section (described below) occurs on the Forest. Climate is warm summers and cold winters. Annual precipitation ranges from about 12 - 35 inches and elevations range from about 6000 to 12,600 feet. Geomorphology consists of plains, hills, escarpments and mountains. Vegetation is dominated by ponderosa pine, Gambel Oak, and White fire and Douglas fir at higher elevations or on north aspects.

Section M313A: White Mountains-San Francisco Peaks-Mogollon Rim

As the name implies, this section is located on the Colorado Plateau and extends from the White Mountains to the San Francisco Peaks and Mogollon Rim in central and east-central Arizona. This section occupies the second greatest extent on the Forest. About 4.1% of the total aerial extent of this section lies in the Forest so the ecosystem diversity on the Forest only contributes a small but important proportion of the overall ecological sustainability of the section. Precipitation ranges from 20 - 32 inches and elevations range from about 6000 to 12,600 feet and includes the highest Peak in Arizona, Humphrey's Peak. Geomorphology includes mountains, plains and hills. Lithology is dominated by volcanic and sedimentary rocks. Soil taxa include Alfisols and Inceptisols with udic soil moisture regimes and frigid or cryic soil temperature regimes. Vegetation is dominated by ponderosa pine, Gambel Oak, and White fire and Douglas fir at higher elevations or on north aspects. Disturbances include fire, forestry and grazing. Droughts have been increasingly common.

3. Ecological Subsections:

Subsections of the Forest have been mapped and provide further insight into the ecological niche of the Forest. Subsections are finer in scale than the sections described above and are nested within the sections. Table 2 provides aerial extent of each Subsection within the Forest and compares it to the total range of the Subsection useful in analysis of Forest contribution towards ecological sustainability

Table 2. Subsections of the Kaibab National Forest

Subsection	Subsection Name	Kaibab NF (square miles)	Subsection (square miles)	Percent of Subsection	Percent Of Forest
313Ag	Kaibab Uplift	97.7	234.4	41.7%	3.9%
313Ah	Shinarump Steppe	.2	2522.3	< .1%	< .1%
313Ak	Cold Desert-Great Basin Sagebrush	4.2	1531.0	.3%	.2%
313Ao	Grand Canyon Shrub-Woodland	118.1	2353.4	5.0%	4.7%
313Ap	Vermillion Cliffs Woodland	267.0	3136.1	8.5%	10.7%
313Ar	Kaibab Plateau Montane Conifer Forest	310.7	340.0	91.4%	12.4%
313As	Kaibab Plateau Spruce-Fire Forest	227.0	302.3	75.1%	9.1%
313Cb	Chino High Plains Grassland	.1	566.2	< .1%	< .1%
313Cd	Mazatzal Mountains Woodland	24.4	4247.2	.60%	.90%
313De	Kaibab Woodland	362.6	1067.3	34.0%0	14.5%
313Df	Kaibab Coniferous Forest	154.0	197.2	78.1%	6.2%
322Aw	Aubrey High Plains Grassland	64.4	2065.1	3.2%	2.6%
M313Ak	Coconino Plateau Woodland	511.1	2516.3	20.3%	20.4%
M313Al	Coconino Plateau Coniferous Forest	359.8	3084.2	11.7%	14.4%
Totals		2501.3			100%

Total acres on the Kaibab National Forest calculated in this GIS coverage are 1,600,885 or 2501 square miles.

Ecological Contributions Findings:

Sections:

Section 313A: (Grand Canyon) Only 3.3% of the total aerial extent of this ecological unit (section) occurs on the Kaibab Forest so the ecosystem diversity on the Forest only contributes a small proportion towards ecological sustainability of this section.

Section 313 C: (Tonto Transition) Only .2% of the total aerial extent of this ecological unit (section) lies in the Forest so the ecosystem diversity on the Forest only contributes a very small proportion towards ecological sustainability of this section.

313D: (Painted Desert) About 3.7% of the total aerial extent of this section lies in the Forest so the ecosystem diversity on the Forest contributes a small proportion of the overall ecological sustainability of this section.

222A: (Mojave Desert) Only .1% over this sections range lies within the Forest. Consequently, ecosystem diversity on the Forest contributes an insignificant proportion and role of the overall ecological sustainability of this section.

M313A: (White Mountains-San Francisco Peaks-Mogollon Rim) About 4.1% of the total aerial extent of this section lies in the Forest so the ecosystem diversity on the Forest only contributes a small but important proportion of the overall ecological sustainability of the section.

Subsections:

Subsection M313Ak (Coconino Plateau Woodland) occurs over the greatest extent (20%) of the Forest and throughout the range of the Subsection (20%). The ability of the Forest to make an appreciable contribution towards ecological sustainability of this ecological type (Subsection) is significant and important. Current ecosystem diversity conditions on the Forest do play a large role in overall ecological sustainability of this Subsection.

Similarly, Subsections 313De and M313Al cover substantial portions of the Forest and about 15% of the total extent of each Subsection. The ability of the Forest to make an appreciable contribution towards ecological sustainability of this ecological type (Subsection) is important. Current ecosystem diversity conditions on the Forest do play a large role in overall ecological sustainability of this Subsection.

Subsections 313Ar (Kaibab Plateau Montane Conifer Forest) and 313As (Kaibab Plateau Spruce-Fire Forest) cover relatively small portions of the Forest but more than 75% of their total extent occurs on the Forest. Even though it doesn't occupy a large portion of Forest acreage, the acres it does occupy contribute a large portion towards the Subsections; ecological sustainability. Therefore, the Forest contributes a very significant role in sustaining these ecological types. Current ecosystem diversity conditions on the Forest play a very large role in overall ecological sustainability of these Subsections.

Conversely, Subsections 313Ah, 313Ak, 313Cb and 313Cd cover less than 1% of the Forest and less than 1% of the total extent of each Subsection. The Forest plays a very minor role in contributing towards ecological sustainability. Current ecosystem diversity

conditions on the Forest, trend and land management play a very small large role in overall ecological sustainability of these Subsections.

Forest areas contained within all other Subsections (see Table 2) contribute less than 15% both on the Forest and through the range of the Subsection towards ecological sustainability of that Subsection. Therefore, the Forest contributes a minor role in sustaining these ecological types. Current ecosystem diversity conditions on the Forest play a minor role in overall ecological sustainability of these Subsections.

The documentation and Subsection descriptions are an incomplete work in progress and only exist in draft form. For this reason, in the CER, Phase 1 on the Forest, our analysis provides the ecological descriptive information used in the Province and Section levels (above) of the National hierarchy and includes the acreage figures provided at all levels (Province, Section and Subsection) for comparative analysis of Forest contributions towards ecological sustainability

Potential Natural Vegetation Types (PNVTS)

Of the 14 rows in Table 3, the Forest contains parts of 12 PNVTs. (See footnote about Interior Chaparral. Water is not a PNVT.) As mentioned earlier, these PNVTs are derived from TES ecological units and were aggregated to spatially display the PNVTs AZ ReGAP was used to map PNVTs outside Forest boundaries.

Table 3 displays PNVT acreage and relative percent both on the Forest and throughout the pertinent (Subsection) extent of each PNVT. The pertinent "PNVT Subsection Extent" includes the PNVT area that intersects any portion of the Forest and is generally limited to the PNVT area within the ecological Subsection. Some PNVT's may not be completely nested within any given Subsection. This area of PNVT extent does not include other disconnected PNVT polygons that may exist outside the immediate Subsection. The PNVT Subsection extent was chosen for analysis because management can directly influence ecological sustainability of connected PNVTs far easier than disconnected similar PNVTs. PNVT extent within the Forest and contributions toward ecological sustainability can be derived from Table 3 analysis.

Table 3. Forest PNVTs and Extent

PNVT	Forest		PNVT Subsection Extent	
	%	Acres	%	PNVT Acres
Cottonwood Willow Riparian Forest	0.1	1,201	0.7	169,014
Desert Communities	0.9	13,747	0.1	13,023,517
Gambel Oak Shrubland	0.3	5,478	100.0	5,478
Great Basin/Colorado Plateau Grassland and Steppe	3.0	47,657	0.3	18,726,671
Interior Chaparral	0.0	5[1]	0.0	2,406,541
Mixed Conifer Forest	8.1	128,040	13.8	926,727
Montane / Subalpine Grassland	3.6	56,112	27.3	205,695
Pinyon Juniper Woodland	40.6	642,299	4.6	13,949,328

[1] This PNVT does not appear within the area managed under the Kaibab NF Plan in the Midscale Vegetation map. It is not discussed further in this report.

Ponderosa Pine Forest	34.7	548,036	9.5	5,779,686
Sagebrush Shrubland	5.1	80,501	3.7	2,157,365
Semi-Desert Grassland	1.6	25,184	0.8	2,971,885
Spruce Fir Forest	1.8	29,127	14.1	206,425
Water	0.0	484	0.1	449,716
Wetland / Cienega	0.2	2,738	16.2	16,948
Total	**100.0**	**1,580,610**		**60,994,997**

PNVT Niche and Contributions towards Ecological Sustainability: Analysis of Table 3 shows that there are 14 PNVTs located in parts of the Forest and occupy an extent ranging from about less than 1% to 100%. In addition, only one PNVT is totally contained within the Forest (Gambel Oak Shrubland) but only covers .3% of the Forest because acreage is limited at 5478.

Pinyon-Juniper Woodlands and Ponderosa Pine Forests occupy the largest extent in the Forest while Wetland/Cienega, Riparian Forests, Spruce-Fir Forests, Gambel Oak Shrublands, Semidesert Grasslands and Desert Communities PNVTs are the least extensive on the Forest. Providing favorable conditions of ecosystem diversity in Pinyon-Juniper Woodlands and Ponderosa Pine Forest will sustain a large portion of the Forest ecology including habitat and those species that depend on the habitat for their survival. The least extensive PNVTs on the forest may be some of the most important areas to focus conserving or improving ecosystem diversity for overall plant and animal habitat since acreage is limited.

Mixed Conifer PNVTs include many areas of aspen dominated stands which probably should have been identified within the Aspen Forest and Woodland PNVT listed in Table 3.

Similarly, Great Basin Grasslands, Mixed Conifer, Montane/Subalpine Grasslands and Sagebrush Shrublands cover minor portions of the Forest (all less than 9%). These PNVTs on the forest may be some of the more important areas to focus conserving or improving ecosystem diversity for overall plant and animal habitat since acreage is limited.

Furthermore, comparing PNVT extent on the forest to Subsection PNVT extent, one can conclude that the Forest contribution towards ecological sustainability ranges from less than 1% to 100%. Therefore, the ability of the Forest to make contributions towards ecological sustainability is variable and is extremely limited in low percentages of extent and high in areas of greater PNVT extent. Consequently, current ecosystem diversity conditions on the Forest can play a small to large role in overall ecological sustainability of a given PNVT. The Forest can play a major role in contributing towards ecological sustainability in the Gambel Oak Shrublands, Mountain/Subalpine Grasslands followed by Wetland/Cienega/,Spruce-Fir and Mixed Conifer PNVTs.

*Worthy of note is an issue brought up by Forest Planner Bruce Higgins. Bruce notes that TES map units 623 and 624 (more than 81,000 acres on the North Kaibab RD) were mapped as Mixed Conifer potential. His on-site follow-up (including some notable Scientists - (Fule cited in TNC 2006, Allen and others 2002) believe the PPC is actually Ponderosa Pine. It will be important for the veg group to carry this information forward in their analysis to properly define the veg type and return fire interval for Forest

Planning and future treatment implications. Similarly, the TES mapped some sparsely covered ponderosa pine Grassland sites as Ponderosa Pine PPCs near the Coconino NF boundary and should be revisited. Jack Triepke recommends handling these site-specific issues in CER Phase 2.

A. Kinds of Soils (Structure).

This information is already provided in the Section and Subsection description above.

The Natural Resource Conservation Service maintains Soil Survey information and a State soils map (STASGO). However, this map does not provide detailed soil information necessary to analyze soil loss, productivity or condition and consequently has not been used in this analysis.

B. Acres and Distribution of Soil (Composition) Within the Forest

Appendix B displays TES ecological units by PNVT and Forest acreage extent.

The Ecological Niche of the Forest Summary

As described above, the ecological niche of the Forest lies within five Sections, 14 Subsections and 12 PNVTs extending through six life zones from desert (hot, dry) to Spruce-Fir (cold, moist). A wide range in elevations occur from about 3100 to 9200 feet producing climatic conditions within each section and subsection that create favorable conditions for ecosystem diversity. From analysis of Table 1 and Table 2, we can understand the ability of the Kaibab National Forest to contribute towards ecological sustainability in the broader scale of the southwestern Region of the United States. While the Forest does not contribute a high percentage of area towards ecological sustainability at the Province and Section level, it is apparent that for some Subsections and PNVTs, the Forest contains appreciable land area that contributes towards ecological sustainability as described above.

III. Current and Historic Conditions, Niche, Disturbances and Processes, Departures, Trends/Projected Future, Risks, Ecological Need for Change

The following soil resource characteristics will be individually analyzed; soil loss soil condition, soil productivity and organic matter. Microbiotic crusts will be analyzed qualitatively. Extent of hydric soils (Wetlands/Cienega PNVT) and Montane/Subalpine Grassland soils are displayed in Table 3 above and conditions described below.

Table 11 (towards end of document) is a trend analysis and details soil ecological characteristics departure between historic and current conditions and summarizes projected future trend by PNVT.

Table 12 (following trend analysis) summarizes departure, projected future trend and ecological need for change.

Resource Characteristic by PNVT: Soil Condition (Soil Loss)

Current conditions:

PNVT and Planning Unit: The TES identified soil condition by ecological map unit and is primarily based on Forest-wide on-site soil erosion as modeled by the Universal Soil Loss Equation (USLE).

Soil condition classes used for Soil Loss Soil Condition are Satisfactory, Unsatisfactory and Unsuited. Satisfactory soil conditions signify that current erosion is less than the soil tolerable (T) threshold. Threshold values vary by soil type and roughly equate to the point where annual soil renewability or soil productivity is sustained. Erosion rates higher than T cause a loss of soil surface horizons and soil productivity. Conversely, erosion rates less than T allow for the soil to naturally regenerate enough and do not cause a loss of soil productivity. Satisfactory soil conditions signify that low levels of erosion is occurring and is less than T and therefore represent maintenance of soil productivity. Unsatisfactory soil conditions signify a high level of erosion is occurring and is more than T and therefore represents continued loss of soil and productivity. Unsuited soil conditions are those soil types that are inherently unstable.

Table 4 displays Forest soil condition (based on soil loss by PNVT) acreage and relative extent and percent contributions throughout the PNVT Subsection extent

Canopy Cover Relationships:

Observations made (Steinke, Fleishman on the Kaibab and Coconino National Forest (1990 – 2006) and analyzed in the Anderson Mesa Landscape Scale Assessment (2004) indicate as Pinyon-Juniper canopy cover approaches and exceeds about 40%, herbaceous understory and litter is reduced resulting in high amounts of bare soil, accelerated soil erosion, loss of surface organic matter and soil productivity.

Table 4. Forest Soil Condition (Soil Loss) by PNVT

PNVT	Soil Loss Soil Condition						Forest PNVT Total		PNVT Subsection Extent
	Satisfactory		Unsatisfactory		Unsuited				
	%	Acres	%	Acres	%	Acres	% in PNVT	Acres	% Contribution
Cottonwood Willow Riparian Forest	100.0	1,201					**0.1**	**1,201**	0.7
Desert Communities			100.0	13,747			**0.9**	**13,747**	0.1
Gambel Oak Shrubland	100.0	5,478					**0.3**	**5,478**	100
Great Basin/Colorado Plateau Grassland and Steppe	100.0	47,657					**3.0**	**47,657**	0.3
Mixed Conifer Forest	96.8	123,986	3.2	4,055			**8.1**	**128,040**	13.8
Montane / Subalpine Grassland	98.3	55,151	1.7	961			**3.6**	**56,112**	27.3
Pinyon Juniper Woodland	66.9	429,652	20.7	133,272	12.4	79,375	**40.6**	**642,299**	4.6
Ponderosa Pine Forest	84.8	464,992	13.2	72,323	2.0	10,722	**34.7**	**548,036**	9.5
Sagebrush Shrubland	85.4	68,767			14.6	11,734	**5.1**	**80,501**	3.7
Semi-Desert Grassland	60.3	15,190	39.7	9,994			**1.6**	**25,184**	0.8
Spruce Fir Forest	100.0	29,127					**1.8**	**29,127**	14.1
Water or Urban							**0.0**	**484**	0.1
Wetland / Cienega	100.0	2,738					**0.2**	**2,738**	16.2
Total		**1,243,939**		**234,351**		**101,836**	**100.0**	**1,580,610**	

Context/Niche: Analysis of Table 4 reveals that about 1,244,000 acres or 79% of the Forest is in satisfactory soil loss condition. About 234,000 acres or 15% is in unsatisfactory condition and about 102,000 acres or 6% is in unsuited condition. The greatest areas of satisfactory soil loss conditions are found in the Ponderosa Pine forest PNVT. More than 84% of the Ponderosa Pine Forest, Mixed Conifer, Spruce-Fire, Sagebrush Shrubland, Great Basin Grassland and Steppe, Wetland/Cienega, and Riparian Forest PNVTs are in satisfactory soil loss condition. This indicates that on-site soil loss is within threshold limits and is not reducing the ability of the soil to maintain long-term soil productivity.

Conversely, the greatest areas of unsatisfactory soil conditions are found in the Pinyon-Juniper Woodland PNVT but only amounts to about 21% of the Forest aerial extent of this PNVT. All of the Desert Communities PNVT is in unsatisfactory soil conditions putting this type at risk of loss of soil productivity and reducing it's ability to provide favorable conditions of ecosystem diversity and sustain those species that rely on it's habitat for survival.

Further analysis shows that significant portions (about 40%) of the Semidesert Grasslands and fairly large acreages of the Ponderosa Pine PNVT (72,000 acres or 13%) are in unsatisfactory soil condition. Soil erosion may be occurring beyond its threshold and the soil is at risk of not maintaining long-term soil productivity.

Considerable portions of the Pinyon-Juniper and Sagebrush Shrubland PNVTs are in unsuited condition due to inherently erodible soils.

Maintaining satisfactory soil loss condition (currently about 79% of Forest) is important in maintaining long-term soil productivity which is key to sustaining ecosystem diversity. Unsatisfactory soil loss conditions (15% of Forest) have resulted in the reduced ability of the soil to grow plants and sustain productive, diverse vegetation. **Unsatisfactory soils have reduced ability to provide favorable conditions of ecosystem diversity and sustain those species that rely on its habitat for survival.**

Fortunately, Forest PNVTs that contribute most towards Subsection PNVT sustainability (Gambel Oak Shrubland, Montane/Subalpine Grasslands, Mixed Conifer, Pinyon-Juniper Woodlands, Wetland/Cienega) are generally in satisfactory condition. The Ponderosa Pine PNVT also contributes appreciable acres toward ecological sustainability and is generally in satisfactory soil loss condition. These PNVTs contribute significant acres towards ecological sustainability and should be managed to maintain satisfactory soil conditions. However, as mentioned above, there are numerous PNVTs within the Forest that have unsatisfactory soil conditions and risk a loss of ecosystem diversity if not improved.

Wind Erosion:

Wind erosion is not quantified for any PNVT because it has not been modeled by TES map unit. However, wind erosion is common and a large part of overall erosion on bare soil surface textures including sands, loamy fine sands sandy loam, clays and calcareous soils. These soil surfaces have a high Wind Erodibility Group (National Soils Handbook, 1983) and when left unprotected by vegetative ground cover contribute to overall erosion and loss of soil productivity.

Soils in Pinyon-Juniper, Great Basin Grasslands, Montane Meadows, Semidesert Grasslands and Desert PNVTs generally have more bare soil that conifer dominated PNVTs and consequently at greatest risk of accelerated high wind erosion. Topographic sites that experience high winds (such as Anderson Mesa) and soils with recent high burn severity are particularly susceptible to soil loss as a result of wind erosion (personal observations, Rory Steinke, 1990 – 2006). Maintaining a protective vegetative ground cover is essential in reducing wind erosion and maintaining on-site soil productivity.

Historic Conditions and Reference Dynamics:

No quantitative data exists to measure historical soil loss. However, some qualitative and quantitative inferences can be made and estimated providing insight into historic soil loss condition primarily using knowledge about present disturbances and their effect on erosional processes. Additional qualitative statements made include reports from GTES, 1991 and Dahms, 1997). Historic conditions analyzed here generally estimate Pre-European settlement conditions unless otherwise noted.

Context/Niche:

Prior to European settlement, Native Americans routinely burned areas to prepare for planting and harvesting of native crops and harvested woodlands for timber and fuelwood (Dahms, 1997) so there were likely areas with soils in less than satisfactory condition or reduced soil productivity. Dahms also reports that local areas of pinyon-juniper were devastated for timber and fuelwood harvesting, miles of canals diverted water in Desert communities and Cottonwood-Willow riparian communities had miles of lush riparian vegetation, and associated spring-fed cienegas. Historic soil conditions probably had local, but overall minor areas of impaired or unsatisfactory soils and somewhat dewatered streams but cannot be accurately predicted or quantified in this analysis.

Historically (pre-European settlement) and without anthropogenic (man-caused) disturbances, soil loss (and consequently soil loss condition) would probably have been below threshold values (and therefore in satisfactory soil loss condition) where not unsuited (inherently unstable). Since there were no political boundaries historically, soil loss would have been similar on similar soils throughout the range of the PNVT both within and outside of the Forest.

Herbivory (ungulate grazing) has been observed to reduce effective vegetative ground cover (vegetative basal area and litter) and contribute to causing accelerated (soil loss above threshold limits) erosion (GTES, 1991 and personal observations). Previous to 1935, there is little documentation of range condition on public lands (GTES, 1991). However, one can surmise that domestic livestock grazing was not present historically (before European settlement) and therefore did not cause accelerated erosion. Those soils identified as unsuited are inherently unstable soils and would have had natural erosion above tolerable (thresholds) regardless of natural or anthropogenic disturbances.

Natural flood disturbance would have had limited affect on the extent of soil loss only causing accelerated erosion adjacent to stream channels or floodplains. Drought may have reduced the amount of protective vegetative ground covers resulting in accelerated erosion. It is not known to what degree Native American agricultural practices, including burning and cultivation may have had on soil loss but it is probable that when soils with

high erosion hazard where burned and farmed, accelerated erosion resulted from storm events.

It is important to recognize that effective vegetative ground cover is essential (as indicated by satisfactory soil loss condition) to protect against accelerated erosion and sustain soil productivity.

Summary: Currently, about 79% of the soils (1,244,000 acres) are in satisfactory soil loss condition while about 15% (234,000 acres) are unsatisfactory and slightly more than 6% (102,000 acres) are unsuited or inherently unstable. Most areas that are currently in unsatisfactory soil loss condition would probably have historically been in satisfactory soil loss condition for a combined total of about 94% of the Forest (1,478,000 acres) in satisfactory soil loss condition. About 6% of the Forest (102,000 acres) would have been unsuited or inherently unstable historically. Table 5 displays this information.

Table 5. Estimated Historic vs. Current Soil Loss Condition Percentages on KNF

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

Disturbances and Processes: The following is a list and analysis of current and historic disturbances that occur on the Forest affecting all identified soil resource characteristics including soil loss, soil productivity and organic matter.

Current:

1. Herbivory: Cattle grazing occurs throughout most PNVTs. High levels of ungulate grazing (both livestock and elk) has been observed to reduce effective vegetative ground cover (in Pinyon-Juniper Woodland and dryer PNVTs) and contribute to accelerated erosion, soil compaction (GTES, 1991) and declined soil productivity (especially during periods of drought). It has been observed that Pinyon-Juniper Woodlands with more than about 40% canopy cover and under sustained grazing have sparse herbaceous understories, a lot of bare soil, sheet erosion and unsatisfactory soil conditions. High levels of elk grazing are largely uncontrolled and have been observed in Montane/Subalpine Grasslands, Great Basin Colorado Plateau Grasslands and Steppe and aspen dominated areas within Mixed Conifer PNVTs and have resulted in similar adverse effects on the soil and in some cases contributed to a shift in grass species composition to less protective soil stabilizing species. Elk grazing in many areas regenerated with young aspen has caused a decline in aspen regeneration resulting in an absence of younger aged aspen outside of fenced areas. This has resulted in many decadent, single aged aspen stands with almost no recruitment of young aspen.
2. Drought: The Forest has experienced several years of drought (roughly since about 1999) with occasional normal levels of seasonal moisture. Reduced

precipitation results in reduced vegetative growth, reduced surface organic matter and productivity and ineffective vegetative ground cover putting the soil at risk of accelerated erosion and compaction during storm events and subsequent loss of soil productivity. As vegetation dries out, there is increased risk of wildfire spread and subsequent accelerated erosion and watershed degradation.

3. Flooding: Flooding affects the Riparian Forest's and Wetland PNVTs as well as unmapped streamcourses throughout all PNVTs. Flooding may cause localized soil loss in the stream channel, streambanks and floodplains if not well protected with vegetative ground cover. Frequent flooding is a natural process and disturbance within these PNVTs. Flash flooding can occur in perennial, intermittent and ephemeral streams in all PNVTs), especially in large watersheds where short duration, high intensity storms occur. It is important to maintain native vegetation described in the Potential Plant Community of the TES to provide channel stability, functional riparian areas and good water quality for wildlife and aquatic species.
4. Fire Regime (fuel loading or buildup): With the exclusion of wildfire through out most PNVTs in the last 70 years, fuel loading has increased in woodland and forest PNVTs resulting in high risk of accelerated erosion, loss of soil and vegetative productivity, and sediment transport to connected streams following wildfires in areas with moderate and high erosion hazard on the Forest. High levels of sediment can reduce fishery and aquatic habitat and those species that rely on it for their survival. Wildfire frequency, severity and Fire Regime Condition Class (FRCC) by PNVT can be found in the Vegetation and Fire Section of the CER Phase 1 Report. Over 63% of the Forest (with high proportions in Pinyon-Juniper and Ponderosa Pine PNVTs) is in FRCC III (highly departed vegetation compared to PNVT) and poses risk to watershed degradation following wildfires.
5. Erosion Hazard: Erosion hazard might better be analyzed as a soil characteristic but will be analyzed here as part of the process of erosion. The process of soil water and wind erosion is variable and dependant on many soil factors including disturbance. Once disturbance causes the protective vegetative layer to be removed, the soil is susceptible to erosion and can occur above tolerable limits on soil with moderate or severe erosion hazards. Erosion hazard is the probability of soil loss resulting from the complete removal of vegetation and litter (TES Handbook, 1984). A rating of slight indicated that removal of vegetation will not cause soil loss above the threshold. A rating of moderate indicates that rates of soil loss will result in lowering of site productivity. A rating of severe indicates that rates of soil loss have a high probability of lowering site productivity. Areas that have excessive fuel loadings (about 63% of the Forest has FRCC 3) on soils with moderate or severe erosion hazard pose a risk of appreciable watershed degradation following wildfires. Current erosion hazard is equal to historic erosion hazard because it compares tolerable soil loss to potential soil loss (soil loss occurring when the vegetative ground cover is removed. Table 6 shows erosion hazard by PNVT.

6. Prescribed Burning Including Fire-Use and Mechanical Fuels Treatments: Prescribed burning and Fire-Use is a useful tool to reduce hazardous fuel accumulations when fuel moisture conditions do not detrimentally heat the soil causing organic matter to mineralize altering soil function. Mechanical treatments to thin excessive fuels remove minor areas of Forest litter and may compact soil when wet. Following prescribed BMP's can successfully mitigate detrimental effects to the soil.
7. Timber Harvesting: Use of heavy machinery to skid logs and on landings removes protective Forest litter and may compact the soil when wet. Following prescribed BMP's can successfully mitigate detrimental effects to the soil.

Table 6. Erosion Hazard by PNVT						
PNVT	Erosion Hazard					
	Slight		Moderate		Severe	
	%	Acres	%	Acres	%	Acres
Cottonwood Willow Riparian Forest			100.0	1,201		
Desert Communities					100.0	13,747
Gambel Oak Shrubland					100.0	5,478
Great Basin/Colorado Plateau Grassland and Steppe	100.0	47,657				
Mixed Conifer Forest	1.6	2,050	38.9	49,853	59.5	76,138
Montane / Subalpine Grassland	93.7	52,581	4.3	2,432	2.0	1,099
Pinyon Juniper Woodland	33.1	212,419	43.0	275,913	24.0	153,967
Ponderosa Pine Forest	68.1	373,142	16.0	87,596	15.9	87,298
Sagebrush Shrubland	50.0	40,248	35.4	28,519	14.6	11,734
Semi-Desert Grassland	48.6	12,248	11.7	2,942	39.7	9,994
Spruce Fir Forest	7.6	2,218	29.3	8,534	63.1	18,376
Water or Urban						
Wetland / Cienega	100.0	2,738				
Total		**745,301**		**456,990**		**377,835**

Analysis of Table 6 reveals that the following PNVTs have appreciable areas of severe erosion hazard, all Desert Communities, Gambel Oak Shrubland, Mixed Conifer, and Spruce-Fir. Where disturbances or lack of disturbances (lack of fire) has caused high fuel loadings, canopy covers and high departures from natural conditions (FRCC 3), there is high risk of watershed degradation following wildfires on soils with severe or moderate erosion hazard. Other PNVTs have fewer areas of soils with severe or moderate erosion hazard but where they do exist, wildfire could have similar negative consequences on the watershed including soil productivity, ecosystem diversity and sustainability and sediment delivery or flooding. Soils with moderate and high erosion hazard should be draped over FRCC's to determine areas most at risk of watershed degradation following wildfires.

Historic: The following is a list and analysis of historic disturbances that may have occurred on the Forest affecting soil characteristics and ecosystem diversity.

1. Herbivory: Very little range condition data is available before 1935 (GTES, 1991). However the GTES shows that from 1902 – 1987 that as more livestock numbers and acres were grazed, range condition (and therefore soil condition) declined and as fewer number and acres were grazed, range condition and trend improved. One can surmise that domestic livestock grazing was not present historically (before European settlement) and therefore did not cause accelerated erosion. Merriam elk did exist but are believed to occur in relatively low populations and therefore did not appreciably affect soil loss. Buffalo were known to graze and were reported to denude grass in some areas.

2. Drought: Cyclic drought patterns are known to have occurred throughout the last few centuries as evidenced through tree ring studies. The worst drought on record

occurred in 1892-1893 when 50 -75 % of range animals perished or shipped to market (GTES, 1991). The first assessments of range condition were made by untrained observers (late 1800's). These explorers contained optimistic assessments of large amounts of forage, but equally ominous warnings of areas denuded of grass by buffalo and drought (GTES, 1991). The most common explanation of decline in range condition in 1935 was drought. However, Chapline challenges this by pointing out despite the recent dry cycle of 5 – 20 years before 1935, fenced and conservatively grazed areas are invariably better than excessively stocked areas and therefore, drought does not stop at fence lines and cause poor range condition (U.S. Senate, 1936, pp. 161 - 162). Other studies suggest periods of drought are believed to have contributed to cause higher levels of soil loss than periods of normal or above moisture due to reduced effective vegetative ground cover soil protection during periods of drought estimated to have caused greater soil loss during storms.

3. Flooding: Similar to current condition disturbances described above except it is likely streambanks were better vegetated providing for grater streambank stability and less soil erosion and sediment delivery.
4. Fire Regime (fuel loading or buildup): It is likely fuel build-ups were much lower in Woodland and Forest PNVTs and consequently did not pose as high a risk to accelerated soil loss and sediment delivery. FRCC"s were probably not highly departed from their PNVT.
5. Erosion Hazard: Current erosion hazard is equal to historic erosion hazard.
6. Prior to European settlement, Native Americans routinely burned areas to prepare for planting and harvesting of native crops and harvested woodlands for timber and fuelwood (some local, minor areas of pinyon-juniper were devastated, Dahms, 1997) so there were likely areas with soils in less than satisfactory condition.

Resource Characteristic by PNVT: Soil Productivity, Organic Matter and Microbiotic Crusts

Current conditions:

PNVT and Planning Unit: The TES classified soils according to Soil Taxonomy. Understanding and interpreting soil classification provides useful information into soil productivity, soil organic matter and the relative differences between soils on the Forest.

Production potential based on soil-climate relationships are provided by TES mapping units and estimate potential forage productivity on-site. These figures can be found in the TES and along with the soil type are used to guide the PNVT productivity comparisons in this analysis. This section will provide estimated comparisons of soil productivity by PNVT that might be useful in directing future management of desired conditions.

Estimated current and historic surface litter organic matter will be displayed in Table 8.

Context/Niche: Maintenance of vegetative ground cover is essential to maintain soil organic matter and soil productivity on all soils. Surface vegetative ground cover biodegrades into organic matter essential in soil nutrient cycling.

As mentioned in the soil condition analysis above, maintaining the protective vegetative ground cover is also essential to keep erosion below threshold levels especially on soils with moderate and high erosion hazard (see Table 6).

Coarse-Woody Material:

Coarse-woody material (>3 inches diameter) is variable across ponderosa pine vegetation types but has been observed to be low in many areas (Steinke 1990 – 2006). Hazardous fuel treatments (including pile burning) leaving less than about 5 - 10 tons/acre on the forest floor (7 – 14 tons/acre for ponderosa pine/Arizona fescue) decrease nutrient cycling function and long-term soil productivity (Graham, 1994). WUI treatment objectives aim to reduce fuel build up around homes and the associated wildfire risk to life and property. Small WUI "doughnuts" created around communities that leave less than the 5 - 10 tons/acre of coarse woody material probably don't reduce overall soil nutrient cycling and productivity substantially. However, hazardous fuel treatments in areas outside of WUI interfaces should strive to maintain at least 10 – 15 tons/acre of coarse woody material.

Table 7 compares estimated current and historic soil productivity by PNVT. Departures between current, historic and potential productivity are listed in bold by PNVT. Bolded PNVTs with associated departures have the greatest need for change in management to restore or improve forage or soil productivity.

PNVTs rated as high have soils that are capable of producing the greatest amount of forage under conditions of the PNVT. PNVTs rated as moderate have soils that are capable of producing moderate amounts of forage under condition of the PNVT and those PNVTs rated as low have soils capable of producing low amounts of forage under conditions of the PNVT. Forage is those species palatable to ungulates. The categories used are based on an analysis of the thickness of the surface organic matter (A horizon), soil texture, depth to bedrock and known disturbances. Categories uses are qualitative estimates based on the Forest Soil Scientists expertise.

Current soil productivity analyzes and combines current soil organic matter and current forage production and includes current disturbances believed to decrease the soil productivity. Potential Soil Productivity is an estimate of soil productivity (organic matter and forage potential) without disturbances and may be useful in estimating historic soil productivity. Some soils in unsatisfactory soil condition (identified in Table 4) may be long-term or near irreversibly disturbed and may not be able to revert back to the historic soil productivity levels displayed in Table 7.

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Table 7. Estimated Soil Productivity by PNVT with Notable Departures of Current from Historic and Potential Bolded.					
PNVT	**Current Soil Organic Matter**	**Current Forage Production**	**Current Soil Productivity**	**Potential Forage Production**	**Potential (Historic) Soil Productivity**
Cottonwood Willow Riparian Forest	Low	Low	Low	Low	Low
Desert Communities	Low	**Very Low**	**Very Low**	Low	Low
Gambel Oak Shrubland	Moderate - High	Moderate	Moderate	Moderate	Moderate
Great Basin/Colorado Plateau Grassland and Steppe	Moderate - High	**Moderate**	***Moderate**	Moderate - High	Moderate - High
Mixed Conifer Forest	Moderate	Low	Moderate	Low	Moderate
Montane / Subalpine Grassland	High	**Low – Moderate**	**Moderate - High**	High	High
Pinyon Juniper Woodland	Low - Moderate	**Low**	**Low - Moderate**	Moderate	Moderate
Ponderosa Pine Forest	Low - Moderate	**Low – Moderate**	**Low - Moderate**	Moderate	Moderate
Sagebrush Shrubland	Low - Moderate	**Low**	**Low**	Low - Moderate	Low - Moderate
Semi-Desert Grassland	Low	**Very Low**	**Very Low - Low**	Low	Low
Spruce Fir Forest	Moderate	Low	Moderate	Low	Moderate
Water or Urban	NA	NA	NA	NA	NA
Wetland / Cienega	High	Moderate	High	High	High

Table 8. Current and Potential (PNVT) Surface Organic Matter (Litter)			
PNVT	Current Surface Organic Matter (Litter)r	Potential (PNVT) Surface Organic Matter (Litter)	Difference or Departures
Cottonwood Willow Riparian Forest	Low	Moderate	**Notable**
Desert Communities	Very Low	Low	**Notable**
Gambel Oak Shrubland	Moderate	Moderate	
Great Basin/Colorado Plateau Grassland and Steppe	Low	Moderate	**Notable**
Mixed Conifer Forest	High	High	
Montane / Subalpine Grassland	Low - Moderate	Moderate	**Notable**
Pinyon Juniper Woodland	Low	Moderate	**Notable**
Ponderosa Pine Forest	High	High	
Sagebrush Shrubland	Low	Moderate	**Notable**
Semi-Desert Grassland	Low	Moderate	**Notable**
Spruce Fir Forest	High	High	
Water or Urban	NA	NA	
Wetland / Cienega	Moderate	High	**Notable**

Table 8 serves to compare existing vegetative ground cover (litter or duff greater than about ½ inch) to potential vegetative ground cover and may serve as a sideboard in setting desired condition. Categories described are qualitative estimates based on TES data obtained during the TES. Historic conditions may approximate those conditions under the PPC in the absence of sustained, recurrent or episodic fire. Bolded PNVTs have a notable difference in organic matter levels between current conditions and conditions under potential. Bolded PNVTs have the greatest need for change in management to improve organic matter and soil productivity.

Summary: The most productive soils (currently and historically) are those soils within the Wetland/Cienega and Montane/Subalpine PNVTs followed by the Great Basin/Colorado Plateau Grasslands. These PNVTs have soils with high amounts of organic matter and are capable of producing the greatest amount of forage under conditions of the PNVT. It appears as though current surface organic matter (litter) and forage productivity is moderate offering some opportunity for improved soil and forage production towards high.

Conversely, the least productive soils and soils with the lowest amount of organic matter and forage productivity are located in the Desert Communities, Semi-Desert Grasslands and Cottonwood Willow Riparian Forest PNVTs. These PNVTs can not be expected to produce high amounts of forage.

Pinyon-Juniper Woodlands currently have low to moderate soil productivity (organic matter and forage production) but have the potential to become moderately productive and produce moderate amounts of forage. It has been observed that as canopy cover approaches 40%, understory productivity becomes increasingly sparse and soil conditions

become impaired and exhibit sheet erosion. These PNVTs are good candidates for mechanical thinning, lop and scatter to increase surface organic matter, and improved grazing.

Ponderosa Pine, Mixed Conifer and Spruce-Fir PNVTs generally have moderate amounts of organic matter in the soil (and moderate soil productivity) and have low to moderate amounts of forage productivity both currently, historically and in the Potential Plant Community. Similar to Pinyon-Juniper Woodlands, as Ponderosa Pine canopy covers increase, there is a noticeable amount of decrease in the understory and subsequently, forage productivity decreases (personal observations and GTES, 1991). Under conditions of the PNVT, these soils and associated PNVTs can be expected to produce moderate amounts of forage. These vegetation types have high amounts of surface organic matter (litter) that may be built up to a thickness that prevents herbaceous regeneration and also may provide fuel for a total ground fire spread. High amounts of duff built up and dispersed evenly across the soil may carry wildfire across the entire stand and may contribute to stand replacing fires posing a risk to the watershed in terms of degraded effects.

Overstocked pinyon-juniper woodlands and ponderosa pine forests have decreased herbaceous productivity due to tree competition for soil nutrients. As canopies are treated (thinned or burned) or with insect and drought outbreaks, herbaceous understory and forage production increases (Abela, 2004, Korb, Springer, 2003).

The Great Basin Grassland and Steppe PNVT is rated as moderate current soil productivity because soil loss condition is satisfactory. However, it is very probable that many of these soils are impaired and either lacking surface litter or slightly compacted and therefore may be better placed in Low – Moderate soil productivity due to herbivory and grazing disturbance. However, no refined soil condition field data exists on the Forest.

Both internal soil organic matter and surface litter organic matter contribute to maintenance of soil productivity and contribute to sustaining ecosystem diversity and those species that depend on the habitat for their survival.

<u>Historic Conditions and Reference Dynamics:</u>

Very little data exists to measure historical soil productivity and organic matter. However, some qualitative and quantitative inferences can be made and estimated providing insight into historic conditions primarily using knowledge about present disturbances and their effect on organic matter and productivity. Historic conditions analyzed here generally estimate Pre-European settlement conditions unless otherwise noted.

Context/Niche: Historic soil productivity can be estimated from an understanding of soil taxonomy, disturbances, erosion processes and from productivity potential referenced in the TES. The published TES identifies the herbaceous production potentials under the PPC and is based on documented reference sites Forest and Region-wide. In part, soils are classified based on their current levels of soil organic matter. The most productive soils listed above are believed to have had equal to or more organic matter and

productivity historically because they were not subject to equal amounts of disturbances seen over the last century.

Since the TES identified reference sites (sites with least disturbance), historic soil organic matter and productivity can be inferred and is estimated in Table 7 and Table 8 under the column **Potential (Historic) Soil Productivity and Potential (PNVT) Surface Organic Matter (Litter)** respectively.

Dahms reports in (An Assessment of Forest Ecosystem Health in the Southwest, 1997) that prior to 1848, pinyon-juniper woodlands that are now dense, were open diverse assemblages of trees, shrubs, grasses, and forbs and have encroached onto adjacent grasslands. In the historic period, native use of woodlands for timber and fuelwood had a significant effect (Dahms, 1997). Dahms also reports ponderosa pine forest types were open, park-like and with vigorous and abundant herbaceous understory or a mosaic of clumped trees and grasses.

Disturbances and Processes: Current and historic disturbances and processes are similar to those described in the Soil Loss Condition portion above.

Microbiotic Crusts:

Current Condition:

Microbiotic (biological) crusts have not been quantified in any detail. However, a qualitative summary may be useful in describing existing conditions and the ecological role of crusts and disturbance effects to define and risks and ecological need for change.

Microbiotic crusts are the community of organisms living at the surface of soils. Major component are cyanobacteria, green algae, microfungi, mosses, liverworts and lichens (www.soilcrust.org). Biological soil crusts are commonly found in semiarid and arid environments and have been observed in coarse textured soils predominantly in Pinyon-Juniper Woodlands, Semidesert Grasslands and Desert Communities on the Forest and to a limited extent in other PNVTs dryer than Pinyon-Juniper Woodlands. Most areas where crusts have been observed currently cover less than 5% of the soil surface.

Crusts play an important ecological role in the environment (USGS Canyonlands Research Station, 2006). Because they are concentrated in the top 1 to 4 mm of soil, they primarily affect processes that occur at the land surface or soil-air interface. These include soil stability and erosion, atmospheric nitrogen-fixation, nutrient contributions to plants, soil-plant-water relations, infiltration, seedling germination, and plant growth.

Fungi, both free-living and as a part of lichens, contribute to soil stability and water infiltration by binding soil particles with hyphae. Lichens and mosses assist in soil stability by binding particles with rhizines/rhizoids, increasing resistance to wind and water erosion. The increased surface topography of some crusts, along with increased aggregate stability, further improves resistance to wind and water erosion

Disturbances:

Crusts are well adapted to severe growing conditions, but poorly adapted to compressional disturbances. Domestic livestock and elk grazing, and more recently, recreational activities (hiking, biking, and off-road driving) can place a toll on the integrity of the crusts. Disruption of the crusts brings decreased organism diversity, soil

nutrients, stability (and increased soil loss), and decreased organic matter and soil productivity. Studies of trampling disturbance have noted that losses of moss cover, lichen cover, and cyanobacterial presence can be severe (1/10, 1/3, and 1/2 respectively), runoff can increase by half, and the rate of soil loss can increase six times without apparent damage to vegetation. Ungulate grazing in PNVTs where crusts are present or believed to be present, poses an unquantifiable risk to soil productivity and ecosystem diversity and those species that depend on its habitat for their survival.

Historic Conditions:

Historical information is limited and has not been quantified. However, reference sites that are undisturbed from livestock grazing impacts in nearby Grand Canyon National Park in Pinyon-Juniper Woodlands show coarse-textured sandy loam soils have high amounts of microbiotic crusts (structure similar to Forest crusts) in tree interspaces and ranges from about 5 – 40% of the total soil surface (personal observations by R. Steinke, 2005). It is not known what the composition was on Forest PNVTs so no detailed inferences can be made.

Table 9. Soil Trend Analysis of the Kaibab National Forest

	Terrestrial Ecological Unit Extent			
	Province	**Sections**	**Subsections**	**PNVT**
Historic Condition	CO Plateau Semi-Desert, American Semi-Desert and Desert, AZ-NM Mtns. Semi-Desert –Open Woodland – Coniferous Forest – Alpine Meadow	313A, 313C, 313D, 322A,M313A	14 (see Soil report section II A, Table 2 for list and acreage and relative %)	12 (see Soil report, Table 3 for list)
Current Condition	CO Plateau Semi-Desert, AZ-NM Mtns. Semi-Desert –Open Woodland – Coniferous Forest – Alpine Meadow	313A, 313C, 313D, 322A,M313A	14	12
Projected Future Condition & Trends	CO Plateau Semi-Desert, AZ-NM Mtns. Semi-Desert –Open Woodland – Coniferous Forest – Alpine Meadow – **Static**	313A, 313C, 313D, 322A,M313A - **Static**	14 - **Static**	12 - **Static**
Interpretation and Analysis	Ecological unit (geographic extent) does not change over time because polygons are static representations of ecological units. Soil and water resource structure, composition, function and processes may change over time and are analyzed by PNVT, Forest or watershed in Tables 2 and 3			

	below.
Risks	Extent static and no risks to change extent

Comparison of small areas (large scale) to large areas (small scale) has been analyzed in Section II (**The Ecological Niche of the Forest in the Southwestern Region)**of the Terrestrial/Soils report and compares PNVT (as aggregated by TES map unit) terrestrial and soil characteristics to Sections and Subsections geographic extent and characteristics.

Table 10. Forest-Wide (Average of all PNVTs) Scale Soil Conditions

	Ecosystem or Resource Characteristic		
	TES Soil Loss Condition	**Refined Soil Condition**	**[2]Soil Productivity/ Surface Litter/ Forage Production**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report): 94% satisfactory Low - unsatisfactory 6% unsuited (inherently unstable)	No refined soil condition available on Forest.	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report, Table 9) Varies by PNVT. See analysis tables below by PNVT.
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	79% satisfactory 15% unsatisfactory 6% unsuited (inherently unstable)	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition.	Varies by PNVT. See analysis tables below by PNVT.
Projected Future Condition (PFC) & Trends	Slight upward improvement under current management overall but varies by PNVT. See tables below for details by PNVT. **Slightly upward.**	NA	Varies by PNVT. See analysis tables below by PNVT.

[2] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Interpretation and Analysis	Small overall gap in soil loss condition forest-wide. There is currently about 15% more soils in unsatisfactory condition compared to historic condition that current Forest Plan management could improve. Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probably that there are additional acres in less than satisfactory condition.	NA	Varies by PNVT. See analysis tables below by PNVT.
Risks	Varies by PNVT. See tables below for detailed analysis by PNVT.		
Reversible?	Varies by PNVT. See tables below for detailed analysis by PNVT.		
Opportunities?	Varies by PNVT. See tables below for detailed analysis by PNVT.		
Ecological Need for Change	Varies by PNVT. See tables below for detailed analysis by PNVT.		

Soil Condition - Trend Tables and Ecological Need for Change by PNVT

Cottonwood Willow, Riparian Forest PNVTs (at the Forest-scale)

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[3]Refined Soil Condition**	**[4]Soil Productivity/ Surface Litter/ Forage Production Others**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report): >99% satisfactory <1% unsatisfactory <1% unsuited (Inherently Unstable)	No assessment made or available.	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report, Table 9): Low overall soil productivity Moderate litter Low forage production

[3]Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[4] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[3]Refined Soil Condition**	**[4]Soil Productivity/ Surface Litter/ Forage Production Others**
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	>99% satisfactory <1% unsatisfactory <1% unsuited (Inherently Unstable)	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. However, the KNF Riparian Survey, 1990) lists most stream, riparian acres in fair condition. It is probable that there are additional acres in less than satisfactory condition, especially reduced nutrient cycling, (litter and vegetative species diversity and composition). Plan language is adequate for establishment of road or disturbed area/riparian area filter strips.	Low overall soil productivity Low litter cover Low forage production
Projected Future Condition (PFC) & Trends	Similar to current and historic conditions. >99% satisfactory <1% unsatisfactory <1% unsuited (Inherently Unstable). **Static**	Where Forest Plan guidelines are met: Litter and species diversity to improve in less than satisfactory areas fairly rapidly since riparian areas are resilient and rapid in recovery. Future conditions should approximate historic conditions implementing current Plan allowable use and Range FSH direction. Where Forest Plan guidelines are not met, PFC to remain static since herbaceous vegetation may be over-utilized. **Static to Upward**	Litter cover and forage production should improve slightly when current Plan utilization guidelines are met. Where current grazing of herbaceous component exceeds plan direction, litter and forage productivity will not improve. Low overall soil productivity Low - moderate litter cover Low forage production **Static to Upward**

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[3]Refined Soil Condition**	**[4]Soil Productivity/ Surface Litter/ Forage Production Others**
Interpretation and Analysis	Accelerated soil erosion is not occurring due to flat slopes preventing accelerated soil erosion and current Forest management leaving adequate protective vegetative ground cover.	Moderate gap between historic and current condition. Future litter and vegetation conditions (nutrient cycling function) should improve and approach historic under current Plan grazing guidelines as long as allowable use levels in Forest Plan are met. It is not known how much current utilization by livestock and elk exceeds Forest Plan allowable use guidelines riparian area wide, but where it does, it has contributed to less than satisfactory soil conditions. FSH offers additional adaptive management strategy. Following Plan direction with BMP implementation should reduce Forest management impacts and maintain or improve soil condition somewhat.	Moderate gap between historic and current litter and forage productivity. Future litter and forage production should improve and approach historic under current Plan grazing guidelines as long as allowable use levels in Forest Plan are met.

Desert Communities PNVT (at the Forest-scale)

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[5]Refined Soil Condition**	**[6]Soil Productivity/ Surface Litter/ Forage Production Others**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report): >95% satisfactory <5%unsatisfactory <1% unsuited (inherently unstable)	No assessment made or available.	Low overall soil productivity Low litter Low forage production
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	<5% satisfactory 95% unsatisfactory <1% unsuited (inherently unstable)	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition.	Very low overall soil productivity Very low litter Very low forage production
Projected Future Condition (PFC) & Trends	Unsatisfactory soil conditions slowly improve and with time come closer to historic conditions given normal or above years of precipitation. **Slow Upward trend**	Unknown because not assessed quantitatively.	Productivity should slowly improve and with time come closer to historic conditions given normal or above years of precipitation. **Slow Upward trend or static with continued drought.**

[5] Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[6] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[5]Refined Soil Condition**	**[6]Soil Productivity/ Surface Litter/ Forage Production Others**
Interpretation and Analysis	Large gap between historic and current conditions and smaller gap between historic and PFC. Current Forest Plan direction for grazing management should, over time improve protective litter cover and species diversity, composition and production all of which should reduce accelerated erosion. Recovery of Desert vegetation will require several years of time because of limited precipitation and is dependant on years of normal or above precipitation and management following Plan utilization guidelines	Limited soil condition improvement in the short-term (< 10 years). Overall soil condition (mainly impaired and unsatisfactory soil nutrient cycling functions) to slowly improve and are expected to improve in the longer term (> 10 years). Personal observations of recovery (litter and plant diversity) in exclosures reveal improvement is slow and requires more than about 5 - 10 years (Steinke, 2006)	Gap between historic and current conditions and smaller gap between historic and PFC. Current Forest Plan direction for grazing management should, over time improve protective litter cover and forage production or remain static with continued drought. Recovery of Desert vegetation will require years of time because of limited precipitation and are dependant on years of normal or above precipitation and management following Plan utilization guidelines.

Gambel Oak Shrubland PNVT (at the Forest scale) (Occupies less than 0.5% of Forest extent)

Ecosystem or Resource Characteristic				
	TES Soil Loss Condition	**[7]Refined Soil Condition**	**[8]Soil Productivity/ Surface Litter/ Forage Production**	**Others**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report): Gambel Oak: >95% satisfactory <1% unsatisfactory <1% Unsuited (Inherently Unstable)	No assessment made or available.	Largely unknown but inferred and estimated to be the following (See Section III Historic Conditions in Terrestrial Ecological Sustainability Report, Table 9): Low-Moderate overall soil productivity Moderate surface litter Low –Moderate forage production.	
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	Gambel Oak: >95% satisfactory <1% unsatisfactory <1% Unsuited (Inherently Unstable) Current litter cover is adequate to protect soil from accelerated erosion.	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition.	Low-Moderate overall soil productivity Moderate surface litter Low - Moderate forage production.	

[7] Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[8] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic				
	TES Soil Loss Condition	**[7]Refined Soil Condition**	**[8]Soil Productivity/ Surface Litter/ Forage Production**	**Others**
Projected Future Condition (PFC) & Trends	Similar to Historic and Current conditions. **Static**	Unknown	Similar to historic and current conditions under current Forest Plan management. **Static**	
Interpretation and Analysis	No gap between historic, current and PFC since management of Gambel oak currently leaves adequate surface litter to prevent soil erosion above threshold and management of inherently unstable soils in chaparral cannot change erosion above natural thresholds.		Almost no gap between historic, current and PFC in overall soil and forage productivity.	

Great Basin/Colorado Plateau Grasslands and Steppe (at the Forest-scale)

Ecosystem or Resource Characteristic				
	TES Soil Loss Condition	**[9]Refined Soil Condition**	**[10]Soil Productivity/ Surface Litter/ Forage Production**	**Others**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report). >95% satisfactory < 5% unsatisfactory <1% unsuited	No assessment made or available.	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report, Table 9). Moderate to high overall soil productivity Moderate surface litter Moderate to high forage production	
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	>95% satisfactory <5% unsatisfactory <1% unsuited (inherently unstable) Vegetative ground cover is generally lower than PPC but not enough to erode above threshold (KNF TES, 1991).	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition.	Moderate overall soil productivity Low – moderate surface litter Moderate forage production	

[9] Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[10] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic				
	TES Soil Loss Condition	**[9]Refined Soil Condition**	**[10]Soil Productivity/ Surface Litter/ Forage Production**	**Others**
Projected Future Condition (PFC) & Trends	The vast majority of soil loss below threshold and therefore satisfactory. **Static**	Soil condition moves towards historic conditions with normal precipitation. As vegetation and litter improve (within 5 – 10 years), nutrient cycling function improves and any thin, compacted soil surfaces become more blocky and granular (may take longer than 5 – 10 years since compacted surfaces require more time to improve (personal observations, Steinke, 1990 -2006). **Slow, upward Trend**	Soil productivity (including surface litter and forage production) moves towards historic conditions with normal or above precipitation. As vegetation and litter improve (within 5 – 10 years), soil organic matter and soil and forage productivity improves. **Slow, upward Trend**	
Interpretation and Analysis	Very little gap between, historic, current and PFC. Current grazing strategies projected to maintain and improve vegetation and litter to stabilize soil. Thinning encroached pinyon-juniper or ponderosa pine will improve vegetative ground cover and reduce soil loss. Restricting cross-country OHV access will reduce erosion.	PFC trend to slowly improve under current Plan grazing direction. Elk grazing causes local additional disturbance and forage utilization but current adaptive management grazing strategy (Forest Plan and FSH, Chapter 90) direction (when followed) is adequate to protect or improve soil resources. Thinning encroached pinyon-juniper or ponderosa pine will improve vegetative ground cover and reduce soil loss. Restricting cross-country OHV access will reduce erosion. Following Plan direction with BMP implementation should reduce Forest management impacts and maintain or improve soil condition.	Gap between historic and current conditions. PFC trend to slowly improve under current Plan grazing direction and drought management policy. Elk grazing causes local additional forage utilization but current adaptive management grazing strategy (Forest Plan and FSH, Chapter 90) direction (when followed) is adequate to maintain or enhance surface litter, soil organics and improve forage production . Thinning encroached pinyon-juniper or ponderosa pine will improve vegetative ground cover and forage productivity.	

Mixed Conifer and Spruce-Fir PNVTs (at the Forest scale)

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[11]Refined Soil Condition**	**[12]Soil Productivity/ Surface Litter/ Forage Production Others**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report): >96% satisfactory <4% unsatisfactory <1% Unsuited (Inherently Unstable)	No assessment made or available.	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report, Table 9): Moderate overall soil productivity High surface litter Low forage production. Naturally high canopy covers prevent high herbaceous forage productivity.

[11] Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[12] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[11]Refined Soil Condition**	**[12]Soil Productivity/ Surface Litter/ Forage Production Others**
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	>96% satisfactory <4% unsatisfactory <1% Unsuited (Inherently Unstable) Current litter cover is adequate to protect soil for accelerated erosion.	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. Current litter cover is adequate to protect soil for accelerated erosion and provides organic matter to maintain soil infiltration function and productivity.	Moderate overall soil productivity High surface litter Low forage production. Naturally high canopy covers prevent high herbaceous forage productivity. Some areas mapped as Mixed Conifer PNVT near Jacob Lake have less than 10% regenerating fir species under high ponderosa pine canopies. These systems developed under suppressed fire regimes and probably should be identified as Ponderosa Pine PNVTs with fire disturbances included (Allen et al 2002, TNC 2006).
Projected Future Condition (PFC) & Trends	>96% satisfactory <4% unsatisfactory <1% Unsuited (Inherently Unstable) **Static**	Similar to current and historic conditions. **Static**	Similar to historic and current conditions under current Forest Plan management. **Static**

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[11]Refined Soil Condition**	**[12]Soil Productivity/ Surface Litter/ Forage Production Others**
Interpretation and Analysis	No large gap between historic, current and PFC since management of mixed conifer and spruce-fir forests currently leave adequate surface litter to prevent soil erosion above threshold.	No gap between historic, current and PFC since management of mixed conifer and spruce-fir forests currently leave adequate surface litter to maintain soil functions. Sustained drought may pose substantial risk to local watershed and soil functions in the event of wildfire.	Almost no gap between historic, current and PFC in overall soil productivity.

Montane/Subalpine Grassland PNVT (at the Forest-scale)

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[13]Refined Soil Condition**	**[14]Soil Productivity/ Surface Litter/ Forage Production**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report): >98% satisfactory <2% unsatisfactory	No assessment made or available.	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report, Table 9): High soil productivity Moderate surface litter High forage production

[13]Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[14] Soil productivity is a measure of soil organic matter and forage production (see page 24, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[13]Refined Soil Condition**	**[14]Soil Productivity/ Surface Litter/ Forage Production**
Current Condition (from CNF Terrestrial/Soils Ecological analysis, 12/2006)	98% satisfactory 2% unsatisfactory Litter cover is generally lower than PPC but not enough to erode above threshold (KNF TES, 1991).	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition, especially reduced nutrient cycling, (litter and vegetative species diversity and composition) and some sols may be compacted. Local, uncontrolled elk grazing routinely utilizes more than current Forest Plan direction allows even before cattle can be rotated in (per. Comm.. D. Brewer, 2007). Livestock grazing occurring in grasslands in combination with elk may exceed Plan utilization guidelines resulting in decreased soil functions (nutrient cycling and infiltration). It is not known which montane grasslands have high elk impacts but could be determined through conversations with Forest Scientists. Montane grasslands are not fenced from either cattle or elk. Some roads are located adjacent to and within montane grasslands and have additional associated recreation impacts. Litter and vegetative conditions tend to improve rather quickly following years of normal or above precipitation.	Moderate - high soil productivity Low - moderate surface litter Low - moderate forage production

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[13]Refined Soil Condition**	**[14]Soil Productivity/ Surface Litter/ Forage Production**
Projected Future Condition (PFC) & Trends	The vast majority of soil loss below threshold and therefore satisfactory. Similar to historic conditions because PNVT is located on flat slopes and erosive energy is limited. **Static**	Current Plan direction does not allow Forest elk herd management so projected condition would be similar to current where continued elk grazing coupled with cattle grazing occurs. Current grazing management utilizing deferred cattle grazing may show some improved conditions. Relatively rapid improvement of litter and vegetation diversity and productivity is expected where elk-livestock exclosures are built or elk herd controlled for those impacted montane grasslands. Slower improvement of soil structure and compacted soils is expected in these fenced or elk-free areas. Following Plan direction with BMP implementation should reduce Forest management impacts and maintain or improve soil condition somewhat. Restricted cross-country OHV travel and associated recreation use from Travel Management Rule will allow for some improvement overall. **Static – Slightly Upward Overall:** Annual precipitation has large effect at vegetation and litter recovery. **Static** where elk and livestock graze together because elk and livestock use is moderate to high. **Upward trend** for areas with elk and livestock are excluded but currently, only fencing would control elk grazing and is not economically feasible and requires normal years of precipitation. Removing encroaching trees is effective at improving forage production.	Likely similar to current conditions for those montane grasslands where continued elk grazing coupled with cattle grazing occur and slightly improved with Plan utilization levels followed and improved with elk fencing. Soil productivity (soil organic matter) high because surface soil organic layer is not eroding (no erosion above threshold identified under current conditions in Soil report). Forage (including species composition, diversity and productivity and litter production low to moderate for areas accessible to elk and livestock. **Static** for unfenced areas (almost all areas fall in this class) with elk/livestock use is moderate to high. **Upward** for elk/cattle fenced grasslands. **Slight upward trend** for montane grasslands with rotation based on Plan directed allowable use or deferred to no livestock gazing

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[13]Refined Soil Condition**	**[14]Soil Productivity/ Surface Litter/ Forage Production**
Interpretation and Analysis	Data shows gap between historic, current and PFC. Accelerated soil erosion is limited due to flat slopes.	PFC trend is variable (ranges from static to upward) depending level of utilization. Removing encroaching trees is effective at improving forage production. Forest Plan does not direct cooperative elk herd management with State Game and Fish and Plan direction can not manage elk herd. Current Plan emphasizes wildlife and livestock grazing but livestock grazing must be managed under a specified allowable use but has been difficult and ineffective in many areas. Current management allows but has not fenced montane grasslands because it would require many miles of fencing and would be very costly.	Gap between Historic and current productivity conditions. PFC trend is variable (ranges from static to upward) depending on level of utilization. Interpretation and analysis similar to refined soil condition statements.

Pinyon-Juniper Woodland PNVT (at the Forest-scale)

Ecosystem or Resource Characteristic				
	TES Soil Loss Condition	**[15]Refined Soil Condition**	**[16]Soil Productivity/ Surface Litter/ Forage Production**	**(Microbiotic Crusts)**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report) 83% satisfactory <1% unsatisfactory 17% inherently unstable	No assessment made or available.	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report) Overall moderate productivity. Moderate surface litter. Moderate forage production.	Present in small quantities on coarse-textured soils.

[15] Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[16] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic				
	TES Soil Loss Condition	**[15]Refined Soil Condition**	**[16]Soil Productivity/ Surface Litter/ Forage Production**	**(Microbiotic Crusts)**
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	67% satisfactory 21% unsatisfactory 12% inherently unstable Many areas of overstocked pinyon-juniper trees have been thinned. Many areas remain untreated with canopy covers exceeding PPC predictions (per. Comm.. with D. Brewer, 2007) resulting in reduced vegetative ground cover and increased susceptibility to erosion.	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition, especially reduced nutrient cycling, (litter and vegetative species diversity and composition).	Overall low-moderate productivity. Low-surface litter. Low forage production.	Very limited in quantity on coarse-textured soils.
Projected Future Condition & Trends	Overall soil conditions to remain the same or decline where overstocked PJ stands (**generally > 40% canopy cover**) are not treated (thinned). **Static to downward trend for untreated acres.** **Upward trend for treated acres.**	Overall soil condition to remain the same or decline where overstocked PJ stands are not treated (thinned). **Static to downward trend for untreated, overstocked acres.** **Upward trend for treated acres**.	Overall soil, litter and forage productivity to remain the same or decline in untreated (unthinned), overstocked areas and improve in treated areas. **Static to downward trend in untreated areas. Upward trend for treated areas**.	Very limited in quantity on coarse-textured soils. **Static to slow upward trend.**

Ecosystem or Resource Characteristic				
	TES Soil Loss Condition	**[15]Refined Soil Condition**	**[16]Soil Productivity/ Surface Litter/ Forage Production**	**(Microbiotic Crusts)**
Interpretation and Analysis	Gap between historic, current and PFC soil loss. High PJ canopy covers require thinning to improve soil condition. Current management does not treat adequate acres to recover soil conditions Forest-wide. Improved grazing, and restricted cross-country OHV impacts and implementation of BMP's help reduce soil loss. Without substantial PJ thinning, soil loss will increase. % of unsatisfactory soils would decrease and % of sat soils would approach historic conditions with accelerated PJ thinning in overstocked stands.	Large gap between historic, current and PFC soil conditions. High PJ canopy covers (greater than about 40%) require thinning to improve soil condition. Current management does not treat adequate acres to recover soil conditions. Following Plan direction resulting in improved grazing, and restricted cross-country OHV impacts and implementation of BMP's help improve soil condition. Without substantial PJ thinning, soil loss will increase and, soil nutrient cycling functions will decrease. % of unsatisfactory and impaired soils would decrease and % of sat soils would approach historic conditions with accelerated PJ thinning. Sustained drought may pose substantial risk to local watershed and soil functions in the event of wildfire.	Large gap in productivity conditions in untreated areas. Current management will not treat the majority of overstocked woodlands within 20 years. Current cattle grazing strategies should improve herbaceous understory somewhat but not enough to improve overall productivity (including forage production) in overstocked areas. Productivity in properly stocked PJ areas should improve slowly. Improved grazing would allow microbiotic crusts to recolonize but very slowly.	

Projected Future Condition Rationale: (For Ponderosa Pine and Pinyon-Juniper PNVTs**),** treatment results in upward trend while no treatment results in static to downward trend in soil and forage productivity.

Reducing tree canopy and density (through thinning or burning) has been demonstrated to increase the herbaceous layer in both total cover and species richness (Korb and Springer 2004). Thinning and burning in theses PNVTs result in increased ground flora biomass (Abella, 2004). Both these statements support the identified projected future trend in ponderosa pine forests. Personal observations indicate dense ponderosa pine forests have lower herbaceous understories.

Historical Conditions (also described in more detail in Terrestrial and Water Sustainability report, Steinke, 2006): Prior to European settlement, Native Americans routinely burned areas to prepare for planting and harvesting of native crops and harvested woodlands for timber and fuelwood (Dahms, 1997) so there were likely areas with soils in less than satisfactory condition or reduced soil productivity. Dahms also reports that local areas of pinyon-juniper were devastated for timber and fuelwood harvesting, miles of canals diverted water in Desert communities and Cottonwood-Willow riparian communities had miles of lush riparian vegetation, and associated spring-fed cienegas. Historic soil conditions probably had local, but overall minor areas of impaired or unsatisfactory soils and somewhat dewatered streams but cannot be accurately predicted or quantified in this analysis.

Ponderosa Pine PNVT (at the Forest scale)

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[17]Refined Soil Condition**	**[18]Soil Productivity/ Surface Litter/ Forage Production**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report) >95% satisfactory <5% unsatisfactory 2% inherently unstable	No assessment made or available.	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report, Table 9) Overall moderate productivity. High surface litter. Moderate forage production.

[17] Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[18] Soil productivity is a measure of soil organic matter (litter) and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[17]Refined Soil Condition**	**[18]Soil Productivity/ Surface Litter/ Forage Production**
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	85% satisfactory 13% unsatisfactory 2% inherently unstable Current litter cover is adequate in most areas to protect soil from accelerated erosion. Current grazing and silviculture treatments maintain and improve protective vegetative ground cover overall with BMP implementation.	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition, especially reduced nutrient cycling, (litter and vegetative species diversity and composition). Many areas have tree high canopy covers restricting herbaceous understory production and have created the potential for crown-carrying wildfire resulting in high burn severity impacts to watershed.	Overall low-moderate productivity. High surface litter Low – moderate forage production (majority is probably low) Many areas have very high canopy covers limiting herbaceous understory production. Other areas have lower tree canopy cover and moderate forage production.

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[17]Refined Soil Condition**	**[18]Soil Productivity/ Surface Litter/ Forage Production**
Projected Future Condition (PFC) & Trends	Approaches historic condition under current management **Upward trend.**	Similar to current conditions for untreated, high canopy cover ponderosa pine forests. Soil conditions in treated areas should improve rather rapidly. **Static** (untreated) to **upward** (treated areas) trend.	Similar to current conditions in tree stands with high canopy covers and untreated. Areas with low tree canopy cover or treated areas will have moderate forage production and approach historic conditions. Current Plan direction for silvicultural treatments, thinning and prescribed fires will reduce the canopy cover and allow increased herbaceous understory growth and forage productivity. Untreated areas to remain the same of further reduced forage productivity. **Static to downward for untreated. Upward for treated areas**.

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[17]Refined Soil Condition**	**[18]Soil Productivity/ Surface Litter/ Forage Production**
Interpretation and Analysis	No large gap between historic, current and PFC since management of ponderosa pine forests currently leave adequate surface litter to prevent soil erosion above threshold. Following Plan direction with BMP implementation should reduce Forest management impacts and maintain or improve soil condition somewhat.	No large gap between historic, current and PFC since management of ponderosa pine forests currently leave adequate surface litter to prevent soil erosion above threshold. Areas with high tree canopy cover have reduced herbaceous understories). Sustained drought may pose substantial risk to local watershed and soil functions in the event of wildfire and high tree canopy covers may carry crown fires resulting in high burn severity impacts to watershed. Following Plan direction with BMP implementation should reduce Forest management impacts and maintain or improve soil condition somewhat.	Small gap between historic, current and PFC in overall soil productivity. Larger gap between historic forage production, current and PFC due to high canopy covers. Treated (thinning or burning) areas trend upward, and untreated trend downward. Could improve coarse woody material.
Risks	(tickler) High degrading wildfire risk on FRCC 3's may cause moderate and severe burn severity resulting in watershed degradation.		

Projected Future Condition Rationale: (For Ponderosa Pine and Pinyon-Juniper PNVTs**),** treatment results in upward trend while no treatment results in static to downward trend in soil and forage productivity.

Reducing tree canopy and density (through thinning or burning) has been demonstrated to increase the herbaceous layer in both total cover and species richness (Korb and Springer 2004). Thinning and burning in these PNVTs result in increased ground flora biomass (Abella, 2004). Both these statements support the identified projected future trend in ponderosa pine forests. Personal observations indicate dense ponderosa pine forests have lower herbaceous understories.

Historical Conditions (also described in more detail in Terrestrial and Water Sustainability report, Steinke, 2006): Prior to European settlement, Native Americans routinely burned areas to prepare for planting and harvesting of native crops and harvested woodlands for timber and fuelwood (Dahms, 1997) so there were likely areas with soils in less than satisfactory condition or reduced soil productivity. Dahms also reports that local areas of pinyon-juniper were devastated for timber and fuelwood harvesting, miles of canals diverted water in Desert communities and Cottonwood-Willow riparian communities had miles of lush riparian vegetation, and associated spring-fed cienegas. Historic soil conditions probably had local, but overall minor areas of impaired or unsat soils and somewhat dewatered streams but cannot be accurately predicted or quantified in this analysis

Sagebrush Shrubland PNVT (at the Forest-scale)

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[19]Refined Soil Condition**	**[20]Soil Productivity/ Surface Litter/ Forage Production**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report) 85% satisfactory <1% unsatisfactory 15% inherently unstable	No assessment made or available.	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report) Overall low to moderate productivity. Moderate surface litter. Low to Moderate forage production.

[19] Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[20] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[19]Refined Soil Condition**	**[20]Soil Productivity/ Surface Litter/ Forage Production**
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	85% satisfactory <1% unsatisfactory 15% inherently unstable Some steep, inherently unstable soils may have grazing access on lower slopes with negative impacts to protective vegetative ground cover but is probably limited in extent.	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition.	Overall low-moderate productivity. Low-moderate surface litter. Low forage production.
Projected Future Condition & Trends	Overall soil condition to remain the same. **Static**	Unknown.	Productivity should slowly improve and under current management with time come closer to historic conditions given normal or above years of precipitation. **Slow Upward trend**.

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[19]Refined Soil Condition**	**[20]Soil Productivity/ Surface Litter/ Forage Production**
Interpretation and Analysis	No gap between historic, current and PFC since management currently leaves adequate surface litter to prevent soil erosion above threshold and management of inherently unstable soils cannot change erosion above natural thresholds. Care should be taken not to graze steep, inherently unstable soils.	Sustained drought may pose substantial risk to local watershed and soil functions in the event of wildfire.	Small gap between historic, current and PFC litter and forage production. Current grazing strategies restricted cross-country OHV travel removal of encroaching trees and shrubs should slowly improve litter cover, soil organics and forage production or remain close to static with continued drought. Vegetation recovery is rather slow because of limited precipitation in this PNVT and is dependant on years of normal or above precipitation and management following Plan utilization guidelines

Semi-Desert Grassland PNVT (at the Forest-scale)

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[21]Refined Soil Condition**	**[22]Soil Productivity/ Surface Litter/ Forage Production**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report). >95% satisfactory <5% unsatisfactory <1% unsuited (inherently unstable)	No assessment made or available.	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report, Table 9) Low soil productivity Moderate litter Low forage production
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	60% satisfactory 40% unsatisfactory <1% unsuited (inherently unstable)	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition.	Very Low –Low soil productivity Low litter and organic matter Very low - Low forage production
Projected Future Condition (PFC) & Trends	Unsatisfactory soil conditions slowly improve and with time come closer to historic conditions given normal or above years of precipitation. **Slow Upward trend**	Unknown because not assessed quantitatively.	Productivity should slowly improve and with time come closer to historic conditions given normal or above years of precipitation. **Slow Upward trend**.

[21] Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[22] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[21]Refined Soil Condition**	**[22]Soil Productivity/ Surface Litter/ Forage Production**
Interpretation and Analysis	Large gap between historic and current conditions and smaller gap between historic and PFC. Current Forest Plan direction for grazing management should, over time improve protective litter cover and species diversity, composition and production all of which should reduce accelerated erosion. Current thinning of invading trees and shrubs assists in vegetation and soil recovery. Recovery of Semi-desert vegetation will require years of time (less than desert PNVT) because of limited precipitation and is dependant on years of normal or above precipitation and management following Plan utilization guidelines	Current grazing strategies and restricted cross-country OHV travel should slowly improve soil nutrient cycling functions or remain static with continued drought. Semi-desert vegetation and soil nutrient cycling recovery is slow due to limited precipitation. Compacted soils will require longer recovering. Following Plan direction with BMP implementation should reduce Forest management impacts and maintain or improve soil condition somewhat.	Gap between historic and current litter and forage production and smaller gap between historic and PFC. Current grazing strategies, restricted cross-country OHV travel removal of encroaching trees and shrubs should slowly improve litter cover, soil organics and forage production or remain close to static with continued drought. Semi-desert vegetation recovery is rather slow (predicted to take more than 5 years under current management, Steinke, 2007) because of limited precipitation and is dependant on years of normal or above precipitation and management following Plan utilization guidelines

Wetland/Cienega PNVT (at the Forest-scale)

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[23]Refined Soil Condition**	**[24]Soil Productivity/ Surface Litter/ Forage Production Others**
Historic Condition	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report): >99% satisfactory <1% unsatisfactory 0% unsuited (inherently unstable)	No assessment made or available.)	Largely unknown but inferred and estimated to be the following (see Section III Historic Conditions in Terrestrial Ecological Sustainability Report, Table 9): High soil productivity High surface litter High forage production

[23]Refined soil condition class was not assessed Forest-wide. Statements made are predicted based on findings made in similar PNVTs and soils on the CNF. Refined soil condition is an evaluation of 3 soil functions, (soil stability, soil hydrology/infiltration and soil nutrient cycling (FSH2509.18).
[24] Soil productivity is a measure of soil organic matter and forage production (see page 20, Terrestrial Ecological Sustainability report 12/13/2006).

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[23]Refined Soil Condition**	**[24]Soil Productivity/ Surface Litter/ Forage Production Others**
Current Condition (from KNF Terrestrial/Soils Ecological analysis, 12/2006)	>99% satisfactory <1% unsatisfactory 0% unsuited (inherently unstable)	Other soil functions including soil hydrology and nutrient cycling are not assessed because Forest has not collected information. It is probable that there are additional acres in less than satisfactory condition, especially reduced nutrient cycling, (litter and vegetative species diversity and composition) and some soils may be compacted as observed on similar soils on the CNF (R. Steinke, 1990 – 2007 and Anderson Mesa Landscape Assessment, Soil Specialist Report, 2004). **Most wetland in fair or poor condition in 1990.** However, the KNF Riparian Survey, 1990, reports most wetlands were in **fair or poor condition in 1990** with associated livestock impacts. More up to date information is not available on wetland condition except several of the wettest areas have since been fenced (per. Comm. D. Brewer, 2007). However, up to 50% of these fenced wetlands have fence maintenance concerns and are not functional today and therefore are grazed (per. Comm.. B. Higgins,2007). Currently, livestock only have access to about 50% of Forest wetlands but fences are intended to restrict almost all livestock access and grazing activity. Where elk grazing occurs, elk may routinely utilize more than current Forest Plan direction allows even before cattle may have access. Litter and vegetative conditions tend to rapidly improve following years of normal or above	Moderate - High soil productivity Moderate surface litter Moderate forage production

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[23]Refined Soil Condition**	**[24]Soil Productivity/ Surface Litter/ Forage Production Others**
Projected Future Condition (PFC) & Trends	Similar to historic and current conditions because wetlands are located on flat slopes with high amounts of protective vegetative ground cover so do not erode above thresholds. >99% satisfactory <1% unsatisfactory 0% unsuited (inherently unstable) **Static Trend**	Wetlands are all fenced and fences are maintained, or have restricted livestock access. Rapid improvement of litter and vegetation diversity and productivity where fences are maintained. Slower improvement of soil structure and compacted soils in these fenced areas. The Plan option of deferred cattle grazing may show some improved conditions where utilization guidelines are met. Current Plan direction does not allow Forest elk herd management so projected condition would be static for those wetlands where elk grazing occurs. Restricted cross-country OHV travel will allow for some improvement overall. Following Plan direction with BMP implementation should reduce Forest management impacts and maintain or improve soil condition somewhat. Plan language is adequate for establishment of road or disturbed area/riparian area filter strip but many roads do not have adequate filter strips adjacent to wetlands and roads located adjacent to wetlands provide additional impacts to wetland from recreational use. Travel Management should resolve this. Following Plan direction with BMP implementation should reduce Forest management impacts and maintain or improve soil condition somewhat. **Static** for those areas without elk and livestock fencing (almost all wetlands fall in this class) or with moderate to high use or where roads located	Soil productivity (soil organic matter) high because surface soil organic layer is not eroding (no erosion above threshold identified under current conditions in Soil report). Forage (including species composition, diversity and productivity and litter production moderate in unfenced areas accessible to livestock and elk. **Static** for unfenced or un-maintained fenced wetlands (about half) with livestock/elk access and moderate to high use. **Upward** for fenced and properly maintained fenced wetlands where no elk utilization occurs. **Slight upward trend** for wetlands with management option of deferred to no livestock gazing or when waters for wildlife and livestock are built

Ecosystem or Resource Characteristic			
	TES Soil Loss Condition	**[23]Refined Soil Condition**	**[24]Soil Productivity/ Surface Litter/ Forage Production Others**
Interpretation and Analysis	No gap between historic, current and PFC. Accelerated soil erosion is not occurring due to flat slopes and current Forest Plan direction and management leaving adequate protective vegetative ground cover.	Gap between current and PFC conditions largely due to fence maintenance issues. PFC trend is variable (ranges from static to upward) depending on fence maintenance, elk utilization and management option to graze wetlands with low to moderate utilization guidelines. Forest Plan does not direct cooperative elk herd management with State Game and Fish and Plan direction can not manage elk herd.	Gap between Historic and current productivity conditions. PFC trend is variable (ranges from static to upward) depending on fence maintenance and with low to moderate utilization guidelines. Interpretation and analysis similar to refined soil condition statements.

Table 11. Soil Departure Trend and Ecological Need for Change (Towards = trend is towards reference; Away = away from reference; Static = no trend; H=highly departed; M= moderately departed; L=low departure.)			
PNVT/system	**Soil condition**	**Soil productivity**	**Ecological Need for Change?**
Cottonwood Willow Riparian Forest	L-Static	L-Static	No
Desert Communities	L-Towards	L- Static to Very slowly Towards (would take many years to improve due to climate)	No
Gambel Oak Shrubland	L-Static	L-Static	No
Great Basin/Colorado Plateau Grassland and Steppe	L-Static	L-Towards	No
Mixed Conifer Forest	L-Static	L-Static	No
Montane / Subalpine Grassland	L-Static	M-Static (unfenced) To Towards (fenced)	Yes[25]
Pinyon Juniper Woodland	H- Static to downward trend for untreated acres. Upward trend for treated acres.	M- Static to downward trend for untreated acres. Upward trend for treated acres.	Yes[26]
Ponderosa Pine Forest	L-Towards	L- Static to downward trend for untreated acres. Upward trend for treated acres	Yes[27]
Sagebrush Shrubland	L-Static	L-Slowly towards	No
Semi-Desert Grassland	M-Slowly towards	L-Slowly towards	No
Spruce Fir Forest	L-Static	L-Static	No
Wetland / Cienega	L-Static	L-Static (unfenced) To Towards (fenced)	Yes[28]

[25] Adjusted from indicated trend based upon refined soil conditions. See PNVT analysis, "Refined Soil Conditions" column.
[26] Observations, Table 9 (refined soil condition) and preliminary analysis (Report in progress, Steinke, 2008) of the Ponderosa Pine, and Pinyon –Juniper Woodland PNVTs indicate nutrient cycling is reduced over a substantial portion of areas where canopy cover is higher than about 40%. These PNVT's have an ecological need for change.
[27] Observations Table 9 (refined soil condition) and preliminary analysis of the Ponderosa Pine, and Pinyon –Juniper Woodland PNVTs indicate nutrient cycling is reduced over a substantial portion of areas where canopy cover is higher than about 40%. Mixed Conifer PNVT's may be similar. These PNVT's have an ecological need for change.
[28] Adjusted from indicated trend based upon refined soil conditions. See PNVT analysis, "Refined Soil Conditions" column.

Table 11 summarizes departure, projected future trend and ecological need for change for soil condition and soil productivity. Shaded rows represent PNVTs with an ecological need for change.

PNVT departure for soil condition was assessed as Low (0 – 33%), Moderate (34 – 66%) or High (> 66%) and is the difference between current percent soil conditions in unsatisfactory condition and reference condition assumed to be satisfactory.

Departure categories for soil productivity described are qualitative and based on productivity differences between reference and current conditions from TES data obtained during the TES. Where departures only vary by 2 classes in a 6-class system (very low, through high) Moderate is used. Where departure varies by more than two classes, high is used.

Some PNVTs showing a "Low" departure also show a trend toward restoration. This simply reflects the difference in resolution between the three-class and six-class systems used.

Observations indicate Montane Subalpine Grasslands and Wetland PNVT's may have impaired soil conditions not reflected in the TES soil condition rating but are included in the trend analysis in Table 11 under refined soil conditions.

References:

Allen, C. D., M. Savage, D. A. Falk, K. F. Suckling, T. W. Swetnam, T. Schulke, P. B. Stacey, P. Morgan, M. Hoffman, and J. T. Klingel. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: a broad perspective. Ecological Applications 12:1418-1433.

TNC - The Nature Conservancy. 2006. Historical Range of Variation and State and Transition Modeling of Historic and Current Landscape Conditions for Potential Natural Vegetation Types of the Southwest. Southwest Forest Assessment Project. The Nature Conservancy. 21 Chapters. Available online at www.azconservation.org.

USDA Forest Service. 1994. Managing Coarse Woody Debris in Forests of the Rocky Mountains, Intermountain Research Station. 16 pages.

USDA Forest Service. 1991. Terrestrial Ecosystems Survey of the Kaibab National Forest. Southwestern Region. 319 pp.

USDA Forest Service, 1991. General Ecosystem Survey. Southwestern Region. 188 pp.

USDA Forest Service. 1984. Terrestrial Ecosystems Survey (TES) Handbook

USDA, Natural Resource Conservation Service, 1993. National Soil Survey Handbook, 655 pages.

USDA Forest Service, 1997. An Assessment of Forest Ecosystem Health in the Southwest, General Technical Report RM-GTR-295. Rocky Mountain Forest and Experimental Range Station.

USGS Canyonlands Research Station. 2006. www.soilcrust.org. SW Biological Science Center. Moab, Utah

Appendix A TES and PNVT Crosswalk for the Kaibab National

TES Map Units To PNVT		
Map Unit	**Veg Type**	**PNVT**
0015	Pofr2-Barren	Cottonwood Willow Riparian Forest
0153	Barren-Cora/Hija	Desert Communities
0150	Barren-Cora/Hija	Desert Communities
0615	Abco/Psmeg/Pipos/Quga	Dry Mixed Conifer
0312	Psmeg-Barren	Dry Mixed Conifer
0322	Psmeg	Dry Mixed Conifer
0624	Abco/Psmeg/Pipos/Quga	Dry Mixed Conifer
0623	Abco/Psmeg/Pipos/Quga	Dry Mixed Conifer
0622	Pipos/Quga/Potr5/Abco	Dry Mixed Conifer
0618	Pipos/Quga/Potr5/Abco	Dry Mixed Conifer
0625	Psmeg-Barren	Dry Mixed Conifer
0614	Abco/Psmeg/Pipos/Quga	Dry Mixed Conifer
0613	Abco/Psmeg/Pipos/Quga	Dry Mixed Conifer
0612	Pipos/Quga/Potr5/Abco	Dry Mixed Conifer
0606	Pien/Pipos/Potr5	Dry Mixed Conifer
0605	Pien/Pipos/Potr5	Dry Mixed Conifer
0604	Pien/Pipos/Potr5	Dry Mixed Conifer
0603	Pien/Pipos/Potr5	Dry Mixed Conifer
0540	Psmeg/Pipos/Jude2/Qutu2-Barren	Dry Mixed Conifer
0619	Pipos/Quga/Potr5/Abco	Dry Mixed Conifer
0659	Abco/Psmeg/Pipos/Quga	Dry Mixed Conifer
0302	Abco/Psmeg/Pipos/Quga	Dry Mixed Conifer
0658	Abco/Psmeg/Pipos/Quga	Dry Mixed Conifer
0660	Quga/Rone	Gambel Oak Shrubland
0156	Quga/Rone-Barren	Gambel Oak Shrubland
0514	Chna2/Hija/Pied	Great Basin Grassland
0007	Agsm/Pied	Great Basin Grassland
0542	Chna2/Bogr2/Pied	Great Basin Grassland
0041	Agsm/Pied	Great Basin Grassland
0036	Chna2/Agsm/Pied	Great Basin Grassland
0003	Atca2/Agsm/Pied	Great Basin Grassland
0006	Popr/Fear2	Montane / Subalpine Grassland
0513	Fear2/Mumo	Montane / Subalpine Grassland
0037	Popr/CAREX/Fear2	Montane / Subalpine Grassland
0440	Fear2/Mumo	Montane / Subalpine Grassland
0011	Popr/Mumo	Montane / Subalpine Grassland
0009	Popr/Agsm/Pipos	Montane / Subalpine Grassland
0645	Feov/Bran/Mumo	Montane / Subalpine Grassland

TES Map Units To PNVT		
Map Unit	**Veg Type**	**PNVT**
0518	Fear2/Mumo	Montane / Subalpine Grassland
0643	Feov/Bran/Mumo	Montane / Subalpine Grassland
0642	Feov/Bran/Mumo	Montane / Subalpine Grassland
0005	Popr/Feov/Bran	Montane / Subalpine Grassland
0630	Fear2/Mumo	Montane / Subalpine Grassland
0655	Feov/Dain/Mumo	Montane / Subalpine Grassland
0264	Pied/Juos/Artr2/Stco4-Barren	Pinyon Juniper Woodland
0523	Pied/Jude2/Qutu2/Arpu5-Barren	Pinyon Juniper Woodland
0496	Pied/Jumo	Pinyon Juniper Woodland
0495	Pied/Jumo	Pinyon Juniper Woodland
0476	Pied/Jumo	Pinyon Juniper Woodland
0272	Pied/Juos/Quga/Artr2	Pinyon Juniper Woodland
0273	Pied/Juos/Quga/Artr2	Pinyon Juniper Woodland
0277	Pied/Jumo/Stco4	Pinyon Juniper Woodland
0274	Pied/Juos/Artr2/Stco4-Pied/Juos/Artr2-Barren	Pinyon Juniper Woodland
0288	Pied/Jumo	Pinyon Juniper Woodland
0263	Pied/Juos/Artr2/Stco4	Pinyon Juniper Woodland
0592	Pied/Jumo/Stco4	Pinyon Juniper Woodland
0281	Pied/Juos/Artr2	Pinyon Juniper Woodland
0287	Pied/Jumo/Quga/Stco4	Pinyon Juniper Woodland
0296	Pied/Jumo/Stco4-Barren	Pinyon Juniper Woodland
0591	Atca2/Stco4/Bogr2/Pied	Pinyon Juniper Woodland
0165	Pied/Jumo	Pinyon Juniper Woodland
0166	Pied/Jumo	Pinyon Juniper Woodland
0167	Pied/Jumo	Pinyon Juniper Woodland
0589	Pied/Jumo-Barren	Pinyon Juniper Woodland
0261	Pied/Quga/Artr2/Stco4-Barren	Pinyon Juniper Woodland
0250	Pied/Juos/Artr2/Stco4	Pinyon Juniper Woodland
0599	Pied/Bogr2	Pinyon Juniper Woodland
0032	Pied/Juos/Artr2	Pinyon Juniper Woodland
0162	Pied/Jumo	Pinyon Juniper Woodland
0172	Pied/Jumo/Stco4	Pinyon Juniper Woodland
0295	Pied/Jumo/Stco4-Barren	Pinyon Juniper Woodland
0587	Pied/Jumo	Pinyon Juniper Woodland
0586	Pied/Jumo	Pinyon Juniper Woodland
0677	Atca2/Stco4/Agcr/Pied	Pinyon Juniper Woodland
0251	Pied/Juos/Artr2/Stco4-Barren	Pinyon Juniper Woodland
0252	Pied/Juos/Artr2/Stco4-Barren	Pinyon Juniper Woodland
0257	Pied/Juos/Quga/Artr2	Pinyon Juniper Woodland
0543	Pied/Jumo	Pinyon Juniper Woodland
0541	Pied/Jude2/Qutu2/Arpu5-Barren	Pinyon Juniper Woodland
0260	Pied/Quga/Artr2/Stco4	Pinyon Juniper Woodland

TES Map Units To PNVT		
Map Unit	**Veg Type**	**PNVT**
0644	Pied/Juos/Artr2-Pied/Juos/Artr2/Stco4	Pinyon Juniper Woodland
0294	Pipos/Quga	Ponderosa Pine
0010	Pipos/Quga	Ponderosa Pine
0290	Pipos/Quga	Ponderosa Pine
0293	Pipos/Quga	Ponderosa Pine
0291	Pipos/Quga	Ponderosa Pine
0284	Pipos/Pied/Quga/Artr2	Ponderosa Pine
0283	Pipos/Pied/Quga/Artr2	Ponderosa Pine
0282	Pipos/Pied/Quga/Artr2	Ponderosa Pine
0275	Pipos/Pied/Quga/Artr2	Ponderosa Pine
0402	Pipos/Quga	Ponderosa Pine
0271	Pipos-Barren	Ponderosa Pine
0266	Pipos/Quga-Barren	Ponderosa Pine
0265	Pipos/Quga	Ponderosa Pine
0276	Pipos/Pied/Quga/Artr2-Barren	Ponderosa Pine
0620	Pipos/Quga	Ponderosa Pine
0507	Chna2/Fear2/Bogr2	Ponderosa Pine
0519	Pipos/Quga	Ponderosa Pine
0525	Pipos/Quga-Barren	Ponderosa Pine
0537	Pipos/Quga	Ponderosa Pine
0539	Pipos/Quga-Barren	Ponderosa Pine
0563	Pipos/Pied/Quga	Ponderosa Pine
0431	Pipos/Pied/Quga	Ponderosa Pine
0297	Pipos/Pied/Quga/Artr2	Ponderosa Pine
0565	Pipos/Pied/Quga	Ponderosa Pine
0326	Pipos/Pied/Quga	Ponderosa Pine
0621	Pipos-Barren	Ponderosa Pine
0631	Pipos/Quga	Ponderosa Pine
0648	Pipos/Pied/Quga-Barren	Ponderosa Pine
0649	Pipos/Pied/Quga	Ponderosa Pine
0681	Pipos-Barren	Ponderosa Pine
0564	Pipos/Pied/Quga-Barren	Ponderosa Pine
0311	Pipos/Pied/Quga	Ponderosa Pine
0407	Pipos/Quga	Ponderosa Pine
0300	Pipos/Quga	Ponderosa Pine
0299	Pipos/Pied/Quga/Artr2	Ponderosa Pine
0298	Pipos/Pied/Quga/Artr2	Ponderosa Pine
0304	Pipos/Quga	Ponderosa Pine
0310	Pipos/Quga	Ponderosa Pine
0320	Pipos	Ponderosa Pine
0324	Pipos/Quga	Ponderosa Pine
0325	Pipos/Quga	Ponderosa Pine

TES Map Units To PNVT		
Map Unit	**Veg Type**	**PNVT**
0401	Pipos/Quga	Ponderosa Pine
0405	Pipos/Pied/Quga	Ponderosa Pine
0406	Pipos/Pied/Quga	Ponderosa Pine
0305	Pipos/Pied/Quga	Ponderosa Pine
0682	Artr2/Agcr/Quga	Sagebrush Shrubland
0683	Artr2/Stco4/Agcr/Quga	Sagebrush Shrubland
0154	Artr2/Bogr2-Barren	Sagebrush Shrubland
0634	Artr2/Agcr/Stco4/Pied	Sagebrush Shrubland
0673	Artr2/Agcr/Quga	Sagebrush Shrubland
0672	Artr2/Agcr/Quga	Sagebrush Shrubland
0004	Artr2/Bogr2/Stco4	Sagebrush Shrubland
0017	Artr2/Bogr2/Pied	Sagebrush Shrubland
0023	Artr2/Bogr2/Pied	Sagebrush Shrubland
0632	Artr2/Bogr2/Stco4	Sagebrush Shrubland
0279	Artr2/Agcr/Stco4/Pied	Sagebrush Shrubland
0255	Atca2/Stco4/Bogr2/Pied	Sagebrush Shrubland
0217	Artr2/Bogr2	Sagebrush Shrubland
0636	Atca2/Bogr2/Eula5	Semi-desert Grasslands
0637	Atca2/Bogr2/Eula5	Semi-desert Grasslands
0633	Atca2/Bogr2/Eula5-Barren	Semi-desert Grasslands
0151	Cora/Hija-Barren	Semi-desert Grasslands
0626	Pien/Abla/Abco/Psmeg	Spruce Fir Forest
0627	Pien/Abla/Abco/Psmeg-Barren	Spruce Fir Forest
0628	Pien/Abla/Abco/Psmeg	Spruce Fir Forest
0303	Pien	Spruce Fir Forest
0641	Pien/Abla/Abco/Psmeg	Spruce Fir Forest
0629	Pien/Abla/Abco/Psmeg	Spruce Fir Forest
0998	Water	Water
0020	CARE/ELEO/Pola4/Alge	Wetland/Cienega
0035	CAREX/JUNCUS-CAREX/Popr/Deca5	Wetland/Cienega

Appendix B TES Ecological Unit Acreage by PNVT

Map Unit Symbol	Cottonwood Willow Riparian Forest	Desert Communities	Dry Mixed Conifer	Gambel Oak Shrubland	Great Basin Grassland	Montane / Subalpine Grassland	Pinyon Juniper Woodland	Ponderosa Pine	Sagebrush Shrubland	Semi-desert Grasslands	Spruce Fir Forest	Wetland/Cienega	Total
0003					3,755								**3,755**
0004									790				**790**
0005						3,001							**3,001**
0006						5,890							**5,890**
0007					3,308								**3,308**
0009						2,860							**2,860**
0010								5,725					**5,725**
0011						1,149							**1,149**
0015	1,202												**1,202**
0017									2,011				**2,011**
0020												870	**870**
0023									9,463				**9,463**
0032							4,020						**4,020**
0035												612	**612**
0036					2,740								**2,740**
0037						1,242							**1,242**
0041					1,538								**1,538**
0150		6,816											**6,816**
0151										2,939			**2,939**
0153		6,945											**6,945**
0154									11,731				**11,731**

Map Unit Symbol	Cottonwood Willow Riparian Forest	Desert Communities	Dry Mixed Conifer	Gambel Oak Shrubland	Great Basin Grassland	Montane / Subalpine Grassland	Pinyon Juniper Woodland	Ponderosa Pine	Sagebrush Shrubland	Semi-desert Grasslands	Spruce Fir Forest	Wetland/Cienega	Total
0156				3,936									**3,936**
0162							3,327						**3,327**
0165							4,069						**4,069**
0166							4,239						**4,239**
0167							2,598						**2,598**
0172							3,796						**3,796**
0217									558				**558**
0250							29,227						**29,227**
0251							34,814						**34,814**
0252							71,912						**71,912**
0255									8,860				**8,860**
0257							2,087						**2,087**
0260							53,492						**53,492**
0261							4,791						**4,791**
0263							58,887						**58,887**
0264							30,747						**30,747**
0265								10,735					**10,735**
0266								1,314					**1,314**
0271								9,722					**9,722**
0272							25,942						**25,942**
0273							23,504						**23,504**
0274							7,694						**7,694**
0275								44,344					**44,344**
0276								2,964					**2,964**
0277							25,480						**25,480**

Map Unit Symbol	Cottonwood Willow Riparian Forest	Desert Communities	Dry Mixed Conifer	Gambel Oak Shrubland	Great Basin Grassland	Montane / Subalpine Grassland	Pinyon Juniper Woodland	Ponderosa Pine	Sagebrush Shrubland	Semi-desert Grasslands	Spruce Fir Forest	Wetland/Cienega	Total
0279									615				**615**
0281							8,701						**8,701**
0282								1,015					**1,015**
0283								18,723					**18,723**
0284								1,707					**1,707**
0287							33,235						**33,235**
0288							7,191						**7,191**
0290								17,601					**17,601**
0291								2,951					**2,951**
0293								58,825					**58,825**
0294								48,316					**48,316**
0295							8,398						**8,398**
0296							1,742						**1,742**
0297								10,367					**10,367**
0298								11,350					**11,350**
0299								2,521					**2,521**
0300								5,122					**5,122**
0302			3,893										**3,893**
0303											145		**145**
0304								1,453					**1,453**
0305								1,255					**1,255**
0310								5,916					**5,916**
0311								1,859					**1,859**
0312			1,373										**1,373**
0320								1,750					**1,750**

Map Unit Symbol	Cottonwood Willow Riparian Forest	Desert Communities	Dry Mixed Conifer	Gambel Oak Shrubland	Great Basin Grassland	Montane / Subalpine Grassland	Pinyon Juniper Woodland	Ponderosa Pine	Sagebrush Shrubland	Semi-desert Grasslands	Spruce Fir Forest	Wetland/Cienega	Total
0322			4,710										**4,710**
0324								12,671					**12,671**
0325								8,929					**8,929**
0326								1,519					**1,519**
0401								31,154					**31,154**
0402								13,914					**13,914**
0405								8,588					**8,588**
0406								7,960					**7,960**
0407								2,517					**2,517**
0431								932					**932**
0440						830							**830**
0476							1,260						**1,260**
0495							18,171						**18,171**
0496							14,604						**14,604**
0507								27,974					**27,974**
0513						19,061							**19,061**
0514					29,305								**29,305**
0518						4,005							**4,005**
0519								31,683					**31,683**
0523							8,429						**8,429**
0525								13,036					**13,036**
0537								50,166					**50,166**
0539								2,646					**2,646**
0540			2,669										**2,669**
0541							5,732						**5,732**

Map Unit Symbol	Cottonwood Willow Riparian Forest	Desert Communities	Dry Mixed Conifer	Gambel Oak Shrubland	Great Basin Grassland	Montane / Subalpine Grassland	Pinyon Juniper Woodland	Ponderosa Pine	Sagebrush Shrubland	Semi-desert Grasslands	Spruce Fir Forest	Wetland/Cienega	Total
0542					3,523								**3,523**
0543							27,910						**27,910**
0563								20,632					**20,632**
0564								8,315					**8,315**
0565								5,896					**5,896**
0586							15,317						**15,317**
0587							19,306						**19,306**
0589							14,860						**14,860**
0591							7,920						**7,920**
0592							14,059						**14,059**
0599							14,260						**14,260**
0603			2,134										**2,134**
0604			1,170										**1,170**
0605			1,406										**1,406**
0606			616										**616**
0612			544										**544**
0613			2,034										**2,034**
0614			2,964										**2,964**
0615			130										**130**
0618			227										**227**
0619			7,623										**7,623**
0620								4,900					**4,900**
0621								6,912					**6,912**
0622			2,684										**2,684**
0623			34,277										**34,277**

Map Unit Symbol	Cottonwood Willow Riparian Forest	Desert Communities	Dry Mixed Conifer	Gambel Oak Shrubland	Great Basin Grassland	Montane / Subalpine Grassland	Pinyon Juniper Woodland	Ponderosa Pine	Sagebrush Shrubland	Semi-desert Grasslands	Spruce Fir Forest	Wetland/Cienega	Total
0624			46,908										**46,908**
0625			11,061										**11,061**
0626											15,965		**15,965**
0627											2,274		**2,274**
0628											1,438		**1,438**
0629											773		**773**
0630						1,059							**1,059**
0631								3,043					**3,043**
0632									14,067				**14,067**
0633										9,949			**9,949**
0634									15,059				**15,059**
0636										5,991			**5,991**
0637										6,160			**6,160**
0641											8,552		**8,552**
0642						675							**675**
0643						137							**137**
0644							5,200						**5,200**
0645						89							**89**
0648								1,243					**1,243**
0649								2,122					**2,122**
0655						826							**826**
0658			415										**415**
0659			900										**900**
0660				1,431									**1,431**
0672									8,553				**8,553**

Map Unit Symbol	Cottonwood Willow Riparian Forest	Desert Communities	Dry Mixed Conifer	Gambel Oak Shrubland	Great Basin Grassland	Montane / Subalpine Grassland	Pinyon Juniper Woodland	Ponderosa Pine	Sagebrush Shrubland	Semi-desert Grasslands	Spruce Fir Forest	Wetland/Cienega	Total
0673									4,261				**4,261**
0677							12,580						**12,580**
0681								2,707					**2,707**
0682									3,575				**3,575**
0683									9,182				**9,182**
Total	**1,202**	**13,761**	**127,739**	**5,367**	**44,170**	**40,824**	**629,503**	**534,990**	**88,724**	**25,038**	**29,146**	**1,482**	**1,541,944**