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**Southwestern
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Kaibab National Forest

Vegetation and Fire Specialist Report

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Forest Plan Revision FEIS

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Introduction

This report evaluates and discloses the potential environmental consequences on the vegetation and fire (ecosystems) resource that may result with the adoption of a revised land management plan (Revised Plan). It examines, in detail, four different alternatives for revising the 1988 Kaibab National Forest land management plan, as amended (Plan).

Healthy, resilient landscapes have greater capacity to survive natural disturbances and large scale threats to ecological sustainability, especially under changing and uncertain future environmental conditions, such as those driven by climate change and increasing human uses (FSM 2020).

Fire has long played a role in shaping the vegetation of the Kaibab National Forest. The resiliency of much of the forest is dependent upon fire as a frequent disturbance process; the structure and function of vegetation are closely intertwined with the role of fire. Hence, they are examined together in this report.

Relevant Laws, Regulations, and Policy that Apply

The authority for restoring National Forest System lands derives from many laws enacted by Congress that define the purpose of national forests and grasslands. Forest Service Manual 2020 – Ecological Restoration and Resilience, summarizes the principal statutes that govern management and restoration, and provides an overview of each statute.

The Laws include:

- Organic Administration Act of 1897 (16 U.S.C. 475, 551)
- Weeks Law of 1911, as amended (16 U.S.C. 515, 552)
- Knutsen-Vandenberg Act of 1930 (16 U.S.C. at 576b)
- Anderson-Mansfield Reforestation and Revegetation Joint Resolution Act of 1949 (16 U.S.C. 581j and 581j(note))
- Granger-Thye Act of 1950 (16 U.S.C. at 580g-h)
- Surfaces Resources Act of 1955 (30 U.S.C. 611-614)
- Sikes Act (Fish and Wildlife Conservation) of September 15, 1960 (16 U.S.C. at 670g)
- Multiple-Use Sustained Yield Act of 1960 (16 U.S.C. 528-531)
- Wilderness Act of 1964 (16 U.S.C. §§ 1131 et seq.)
- Wild and Scenic Rivers Act (82 Stat. 906, as amended, 16 U.S.C. 1271 (note), 1271-1287)
- National Environmental Policy Act (NEPA) of 1969 (16 U.S.C. 4321 et seq.)
- Endangered Species Act of 1973 (P.L. 93-205, 87 Stat. 884; 16 U.S.C. 1531-1544, as amended)
- Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, as amended by National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1600-1614, 472a)
- Clean Water Act of 1977 (33 U.S.C. 1251, 1254, 1323, 1324, 1329, 1342, 1344; 91 Stat. 1566)
- Clean Air Act, as amended 1977 and 1990 (42 U.S.C. 7401, 7418, 7470, 7472, 7474, 7475, 7491, 7506, 7602)
- North American Wetland Conservation Act of 1989 (16 U.S.C. 4401 (note), 4401-4413, 16 U.S.C. 669b (note))
- Healthy Forests Restoration Act (HFRA) of 2003 (16 U.S.C. at 1611-6591)
- Stewardship End Result Contracting Projects (16 U.S.C. 2104 (note))
- Tribal Forest Protection Act of 2004 (P.L. 108-278, 118 Stat. 868; 25 U.S.C. 3115a)

Principal Executive Orders relevant to ecological restoration are listed below:

- Executive Order 11514: Protection and enhancement of environmental quality (35 FR 4247, March 7, 1970).
- Executive Order 11644: Use of off-road vehicles on the public lands (37 FR 2877, February 9, 1972).
- Executive Order 11988: Floodplain management (42 FR 26951, May 25, 1977).
- Executive Order 11990: Protection of wetlands (42 FR 26961, May 25, 1977).
- Executive Order 13112; Invasive Species (64 FR 6183, February 8, 1999).

Forest Service Manual 2020 itself also establishes further policy aimed to reestablish and retain ecological resilience of National Forest System lands.

The "Federal Wildland Fire Policy" is the principle document guiding fire management on Federal lands. The Policy was developed in 1995, and was further evaluated, and updated in the 2001 "Review and Update of the Federal Wildland Fire Management Policy." The "Guidance for Implementation of Federal Wildland Fire Management Policy," 2009, is the accompanying document that guides implementation of the Policy.

The Implementation Guide provides the terminology related to fire used in this report. Wildland fire is a term describing any non-structure fire that occurs in the wildland. Wildland fires are categorized in two distinct types:

- Wildfires are unplanned ignitions, including escaped prescribed fires, which are declared wildfires. Wildfires may be ignited by natural causes, namely lightning, or human caused. Under the current Implementation Guide, some sort of suppression action is taken on all human caused wildfires.

- Prescribed fires are planned management ignitions.

The Implementation Guide states that fire, as a critical natural process, will be integrated into the land management plan. It also states that wildland fire, including prescribed fires and naturally caused wildfires, "will be used to protect, maintain, and enhance resources and, as nearly as possible, be allowed to function in its natural ecological role as a disturbance factor in the ecosystem." (USDA and others 2009)

Description of Affected Environment (Existing Condition)

Vegetation

Three major vegetation types dominate the landscape. Pinyon-juniper woodlands cover 40 percent of the Forest, and are found at lower elevations. As elevation increases, pinyon juniper transitions to ponderosa pine forests which cover 35 percent of the Forest. At higher elevations, mixed conifer forest predominates on the crest of the Kaibab Plateau on the North Kaibab Ranger District, and the tops of Kendrick, Sitgreaves, and Bill Williams peaks on the Williams Ranger District. Mixed conifer forests cover 8 percent of the KNF. Due to the range of elevation and soil types on the Forest, there is a wide diversity of other vegetation types including spruce-fir, grasslands, sagebrush shrublands, Gambel oak shrublands, and desert communities. Riparian and wetland vegetation is present in small but important areas.

Table 1 – Potential Natural Vegetation Types (PNVT) that occur on the Kaibab National Forest. Acreage and percent are expressed by Forest and Ranger District (North Kaibab- NKRD, Tusayan- TRD, Williams - WRD).

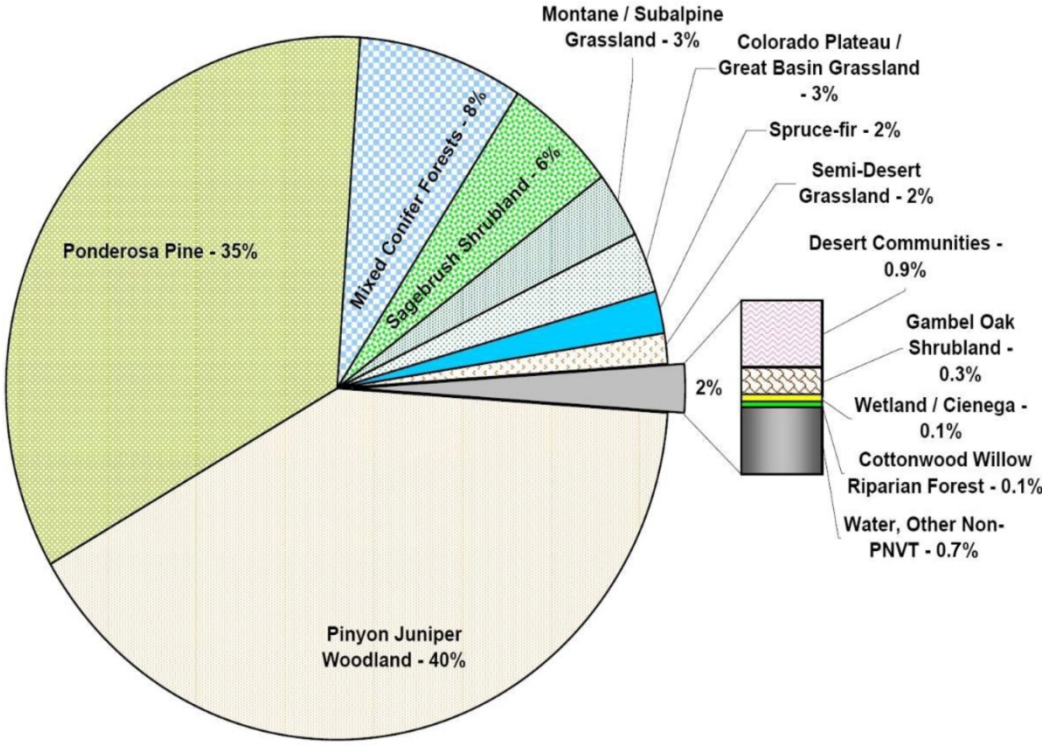
PNVT	Acres on Forest[1]	Percent of Forest	Acres on NKRD[2]	Percent of NKRD	Acres on TRD	Percent of TRD	Acres on WRD	Percent of WRD
Pinyon/ juniper communities	629,199	40.4%	247,062	37.7%	186,943	57.2%	195,194	12.5%
Ponderosa pine	541,159	34.7%	156,121	23.9%	103,248	31.6%	281,790	18.1%
Mixed conifer forests	127,854	8.2%	113,662	17.4%	0.0	0.0%	14,193	0.9%
Sagebrush shrublands	88,646	5.7%	57,735	8.8%	30,910	9.5%	1	0.0%
Montane/ subalpine grasslands	40,760	2.6%	6,479	1.0%	2,184	0.7%	32,097	2.1%
Colorado Plateau/Great Basin Grasslands	44,198	2.8%	69	0.0%	3,740	1.1%	40,389	2.6%
Spruce-fir forests	29,119	1.9%	28,974	4.4%	0.0	0.0%	145	0.0%
Semi-desert grasslands	24,970	1.6%	24,965	3.8%	0.0	0.0%	5	0.0%
Desert communities	13,742	0.9%	13,742	2.1%	0.0	0.0%	0	0.0%
Gambel oak shrublands	5,368	0.3%	3,939	0.6%	0.0	0.0%	1,429	0.1%
Wetland/ cienega	1,478	0.1%	612	0.1%	0.0	0.0%	866	0.1%
Cottonwood-willow riparian forest	1,196	0.1%	1,196	0.2%	0.0	0.0%	0	0.0%
Water, urban, agriculture, and other PNVTs	11,314	0.7%	1	0.0%	0.0	0.0%	11,312	0.7%
Totals:	**1,559,003**	**100%**	**654,557**	**100%**	**327,025**	**100%**	**577,421**	**37%**

[1]Acreages exclude private lands within the Forest Boundary.

[2]NKRD = North Kaibab Ranger District, TRD = Tusayan Ranger District, and WRD = Williams Ranger District

*Acreages exclude private lands within the Forest boundary.

Figure 1 – Percent of Kaibab National Forest in each Potential Natural Vegetation Type 7 (PNVT).



Fire

Most of the vegetation on the Forest is adapted to the recurrent wildland fires started by lightning from spring and summer thunderstorms. In these vegetation communities, frequent, low-intensity fire plays a vital a role in maintaining ecosystem health. In the 1800s, intensive grazing by domestic livestock removed the grasses that previously carried low intensity surface fires. Early settlers suppressed fires to protect their livelihood and homes. As a result, the condition and structure of most of northern Arizona's forests, woodlands, shrublands, and grasslands have changed. Fuels, in the form of dead woody material, continued to build up because when fires were started, they were usually extinguished quickly.

With a significantly reduced understory and no fire, conifer seedlings survived at unprecedented rates. In ponderosa pine, frequent fire mixed conifer, and grassland vegetation communities, conifer seedlings invaded forest openings, and encroached into grasslands and savannahs. Many large, old trees were harvested for lumber. Today the Kaibab National Forest contains uncharacteristically dense forests with many more young trees than were present historically. The forested types are deficient in grasses, forbs, and shrubs due to tree competition and shading from the denser canopy; they are at high risk for uncharacteristic wildfires due to the accumulated buildup of live and dead woody material, increased crown bulk density, and increased canopy continuity. Grasslands have decreased in size due to conifer encroachment from the edges.

The probability and occurrence of large uncharacteristic, stand-replacing fires continues to increase. These fires cause high tree mortality, degrade watersheds, sterilize soils, and threaten homes and communities. While the average number of fire starts has been stable over the past 30 years, there has been a dramatic increase in the total number of acres burned by uncharacteristic high severity wildfire across the Kaibab National Forest, particularly since 1996 (Figures 2 and 3).

Figure 2: Chart depicting the number of fires per year from 1970 through 2010. The ten year moving average number of starts is around 200 per year.

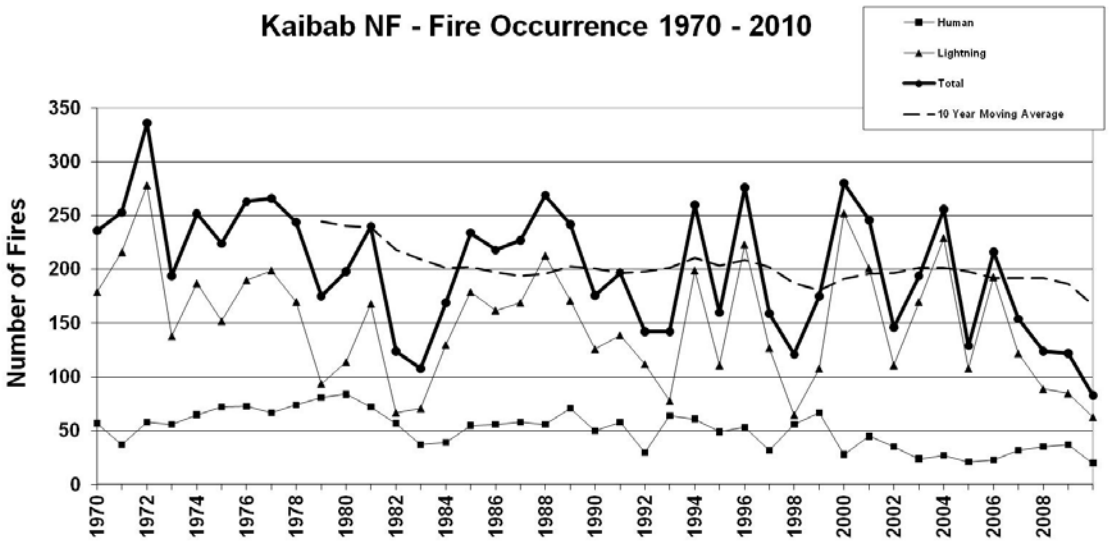


Figure 3: Chart depicting the number of acres burned by wildfires from 1970 through 2010. This does not include acres from fires that were managed to achieve resource objectives, but only fires that were actively suppressed. Notice that while the number of starts in Figure 2 remained fairly static, dramatic spikes in the number of acres burned begin to appear in 1996. The 10 year moving average of number of acres burned increases to 5,000 acres a year or more.

This indicates that the fuel conditions, particularly in forested vegetation types, have increased so that they support increasingly extreme fire behavior resulting in more severe fire effects. This trend may be accentuated with changes to climate. Extreme fire behavior and the resulting severity is uncharacteristic, and well outside the historic range of variability.

Forest-wide Current Condition and Trends

Table 2 provides a summary of key findings from the Ecological Sustainability Report (KNF 2008a). The current departure from reference conditions and the projected trend towards or away from reference conditions on the Kaibab is presented here for each vegetation community. Note that the trend for ponderosa pine is static. This is reflects what percentage of the vegetation type is departed, rather than how far vegetative structure and function is departed from reference conditions. The trend is static because nearly all of the type is not in reference conditions, and there is very little of the type that is currently in reference conditions that could become departed in the future.

Table 2 – Conditions, trends, and primary departures for each PNVT on the Kaibab National Forest

PNVT	Acres on Forest	Departure from Reference Condition	Projected Future Trend Under Current Management	Primary Departures
Pinyon Juniper Woodland	629,199	Moderate	Static to Away	Increased tree density, reduced understory cover and diversity, insect/drought-related die-off, and invasion of exotic plant species.
Ponderosa Pine	541,159	High	Static	Increased tree density, reduced understory, increased risk of uncharacteristic, high severity fire, decline of aspen.
Frequent Fire and Mesic Mixed Conifer	127,854	High	Away	Increased tree density, species shifts toward more shade tolerant species, increased risk of uncharacteristic, high severity fire.
Sagebrush Shrubland	88,646	Moderate	Away	Lack of characteristic fire disturbance, limited nutrient cycling, closed shrub states, tree encroachment.

PNVT	Acres on Forest	Departure from Reference Condition	Projected Future Trend Under Current Management	Primary Departures
Montane / Subalpine Grassland	40,760	Moderate	Away	Lack of characteristic fire disturbance, limited nutrient cycling, closed shrub states, tree encroachment.
Colorado Plateau / Great Basin Grassland	44,198	Moderate	Away	Lack of characteristic fire disturbance, limited nutrient cycling, closed shrub states, tree encroachment.
Spruce Fir Forest	29,119	High	Static	Increased tree density, species shifts toward more shade tolerant species, and increased fuel continuity.
Semi-Desert Grassland	24,970	Low	Away	Lack of characteristic fire disturbance, limited nutrient cycling, closed shrub states, tree encroachment.
Desert Communities	13,742	Moderate	Away	Invasion of exotic plant species, closed shrub states, tree encroachment.
Gambel Oak Shrubland	5,368	High	Away	Lack of fire disturbance, conifer encroachment.
Wetland/Cienega	1,478	Low	Slowly Away	Lack of characteristic fire disturbance, limited nutrient cycling, reduced water input, woodland tree species encroachment.
Cottonwood Willow Riparian Forest	1,196	High	Away	Upstream water diversions and impoundments, tamarisk, and exotic plant species invasion.

The departures of ponderosa pine, frequent fire mixed conifer, the aspen component of those vegetation types, and the grasslands are the focus of this report. The Forest has a limited capacity, in the anticipated 10 -15 year lifespan of the Revised Plan to reverse trends in all vegetation types, and move them all towards desired conditions. Limitations are imposed by

limited and fluctuating funding, current lack of a market for small diameter biomass to offset cost of treatments, and length of time required to accomplish and approve planning for treatments. Acknowledgement of limited capacity necessitated the development of Priority Needs for Change to focus efforts during the planning period. Objectives in the Revised Plan alternatives are designed to address these Priority Needs for Change. Further discussion on how the Priority Needs for Change were developed is given in the next section of this report: Revision Topics Addressed.

The full description of the desired condition for ponderosa pine, frequent fire mixed conifer, aspen, and montane subalpine grasslands can be found in the Kaibab National Forest Proposed Land Management Plan. The desired conditions are the same for all developed alternatives.

The current conditions and trends for ponderosa pine, frequent fire mixed conifer, and montane/subalpine, Great Basin, and semi-desert grasslands are described below. More information on current condition and trends in these, and other vegetation types, can be found in the Kaibab's Ecological Sustainability Report (KNF 2009), and in the Vegetation and Fire Ecological Need for Change report (Kaibab 2008d).

Ponderosa Pine

The ponderosa pine vegetation community generally occurs at elevations ranging from 6,200 to 8,200 feet, and covers about 540,000 acres of the Forest. It occurs extensively on all three Districts. The dominant species in this system is ponderosa pine (*Pinus ponderosa*) and makes up about 80 percent of the overstory. Other trees, such as Gambel oak (*Quecus gambelii*), Douglas-fir (*Pseudotsuga menziesii*), pinyon pine (*Pinus edulis*), and juniper (*Juniperus* spp.) may be present. Aspen (*Populus tremuloides*) may occur in patches, or as a nearly co-dominant species as on the North Kaibab. This vegetation community is adapted to drought during the growing season, and has evolved several mechanisms adapted to frequent, low intensity surface fires.

Canopy cover is far denser and more continuous across developmental states than desired conditions, and fuel loads have accumulated on the forest floor. The primary threat is uncharacteristic, high severity wildfire. Insect epidemics and drought represent secondary threats. When wildfires occur under current, more dense conditions, they are more likely to kill many of the large and old trees, moving the vegetation structure further from desired conditions. The time it would take to grow and restore the vegetation to desired conditions after such a fire, rather than from current condition, would be greatly increased. There is a moderate risk of insect and/or disease outbreaks, which is also a function of increased tree density, and is exacerbated by drought.

Frequent Fire (Dry) Mixed Conifer

Frequent fire (dry) mixed conifer vegetation communities are found between 7,200 and 9,500 feet. Ponderosa pine dominates, making up approximately 57 to 80 percent (Fulé and others 2003) of the overstory. Other species present are Douglas fir, white fir (*Abies concolor*), and aspen. Aspen may be present either in patches, or as a nearly co-dominant species. Frequent fire mixed conifer occurs on the North Kaibab Ranger District, and on the north facing aspects of Bill Williams, Sitgreaves, and Kendrick mountains, and other north facing cinder cones and canyon walls on the Williams District. The pre-settlement fire regime in dry mixed conifer is similar to that of ponderosa pine (Fulé and others 2003). At the highest elevations of the Kaibab Plateau, dry mixed conifer is intermingled with mesic (wet) mixed conifer and spruce-fir with mixed severity fire regimes. Even here, large stand replacing fires are uncharacteristic; the historic size

of stand replacing fires on the Kaibab Plateau is less than 240 acres, with a median size of 15 acres (Vankat 2004).

In the frequent fire mixed conifer vegetation type, canopy cover is denser and more continuous across developmental states than desired conditions. The primary threat is uncharacteristic, high severity wildfire. As with ponderosa pine, when fires occur under current conditions, they are more likely to result in high mortality of large and old trees, and further departure from desired conditions. Testimony of this risk can be seen in the fire effects of the Outlet and the Warm fires. The Outlet Fire in 2000, burned most of its 15,500 acres during the initial burning period pushed by high winds from the Grand Canyon National Park through Kaibab forest lands. The 40,500 acre Warm Fire, in 2006, exhibited plume dominated fire behavior and burned over 30,000 acres in one burning period in late June, as the fire transitioned from the ponderosa pine type into dry mixed conifer. The time it takes to grow and restore the vegetation to desired conditions after such a fire, rather than from current condition, is greatly increased. Insect or disease epidemics and drought represent secondary threats, which are also a function of increased tree density.

Aspen

Aspen is an important component of ponderosa pine, frequent fire mixed conifer, mesic mixed conifer, and spruce-fir communities, where biophysical conditions are suitable. The desired conditions for aspen within these communities shift from smaller, more permanent patches at lower elevations to larger, to more ephemeral patches at higher elevations. Aspen frequency and regeneration is rapidly declining and trending away from desired conditions due to increased conifer encroachment and dominance, drought, fire exclusion, and ungulate herbivory.

The decline and loss of the aspen component in the ponderosa pine vegetation type is of particular concern on the Williams Ranger District. The Tusayan Ranger District has only a few scattered aspen clones which are also of concern, particularly since they are so rare. With the combined effects of elk browsing, insects, disease, severe weather events, and lack of fire disturbance, aspen decline is expected to continue. Aspen appears to be much less departed on the North Kaibab Ranger District. On the North Kaibab Ranger District, following stand-replacing events (shelterwood seed cuts and high severity wildfires in ponderosa pine and frequent fire mixed conifer) aspen has expanded and regenerated in apparently uncharacteristically large patterns. On the North Kaibab, these responses probably enhance rather than threaten the aspen population over time.

Grasslands

Three primary grassland PNVTs appear on the Kaibab NF. Montane/subalpine grasslands on the forest range in elevation from below 7,200 feet to above 10,000 feet, and are found primarily on the North Kaibab and Williams Ranger Districts. They occupy about 40, 800 acres of the forest. Great Basin Grasslands are mostly found at the lowest elevations of the Williams and Tusayan Ranger Districts, and are surrounded by sagebrush or pinyon-juniper. They occupy 44,200 acres of the forest. Semidesert grasslands cover about 25,000 acres on the lower and west east side of the North Kaibab Ranger District.

These grasslands range from small patches less than 10 acres in size to large areas covering thousands of acres. They contain several plant associations with varying dominant grasses and herbaceous species. The reference fire regime for grasslands is typically driven by the fire regime of the surrounding forest type. Those adjacent to ponderosa pine or frequent fire mixed conifer have a high frequency fire return interval of less than 35 years. Those surrounded by wet mixed conifer and spruce-fir likely only burned at the edges (Johnson 1998), and far less frequently.

Grasslands are much less abundant than they were historically, which reduces the amount of available habitat for grassland associated species. The primary threats to this vegetation community are conifer encroachment, the lack of characteristic fire disturbance and limited nutrient cycling. The montane/subalpine grasslands on the North Kaibab Ranger District are long and narrow. As a result of their shape, encroachment from the edges is of particular concern, as they could transition from grassland to forested area at a rapid rate. Under the current disturbance regime and current rate of management, further departures are expected. Excessive ungulate pressure may also play a role in some areas.

Revision Topics Addressed in this Analysis

The Comprehensive Evaluation Report (CER) (Kaibab 2009) was prepared in April of 2009 to evaluate the needs for change in light of how management under the current Kaibab Forest Plan is affecting the current conditions and trends related to sustainability. This CER is based upon the Ecological Sustainability Report (Kaibab 2008a), and the Social and Economic Evaluation Report (Kaibab 2008b) which describe the social, economic, and ecological conditions and trends across the Forest.

An internal Management Review of this CER was conducted in December of 2008 to determine which needs for change issues would be carried forward into plan revision. The Forest Leadership Team identified four priority topics that focus the scope of the Kaibab's Plan revision. These topics reflect the priority needs and potential changes in program direction that are emphasized in the development of the Revised Forest Plan components. They are:

- Modify forest structure and species composition to restore or maintain sustainability and restore historic fire regimes.
- Regenerate aspen to ensure long-term healthy aspen populations.
- Restore natural waters and wetlands to ensure healthy riparian communities.
- Restore grasslands by reducing tree encroachment and restoring fire.

The priority need for change to protect seep, springs, and ephemeral wetlands is not addressed directly in this report. However, the objectives in the action alternatives for modifying stand structure and density towards desired conditions and restoring historic fire regimes, which is addressed in this section, plays an indirect role in protecting seeps and springs under the action alternatives as they would move vegetation surrounding seeps and springs towards desired conditions, thereby promoting hydrologic function (Baker and Ffolliot 2003).

Though not identified in the CER, the Management Review by the Forest leadership team identified several additional key items to address in the proposed Forest Plan. Only one is addressed in this analysis as it has strong ties to fire and vegetation condition:

- Management response in the years immediately following large disturbance events.

A brief discussion of each revision topic follows, identifying the needs for change from the current condition.

Modify forest structure and species composition to restore or maintain sustainability, and restore historic fire regimes.

This need for change addresses the following current conditions:

- Ponderosa pine is more even aged and less multi-storied than in desired conditions.
- The larger and older tree classes are less frequent than desired (historic) in many areas, especially on the Williams and Tusayan Ranger Districts.
- Tree density has increased in all but the largest size classes of trees over the past hundred years in much of the ponderosa pine and frequent fire mixed conifer vegetation type in Northern Arizona.
- There has been an increase in shade tolerant species over the past 100 years in frequent fire mixed conifer vegetation communities. This has resulted in a shift in the dominant tree species, which was historically ponderosa pine.
- Spatial homogeneity is greater than the desired conditions for ponderosa pine, and most mixed conifer.
- Understory vegetative cover and diversity are much lower than historic conditions.
- Increases in ladder fuels (generally small suppressed trees), canopy bulk density, canopy cover, and fuel loading have resulted in a marked increase in the total number of acres burned by uncharacteristic, high severity wildfire.
- Areas affected by large, high severity fires usually have significantly reduced seed sources and are unable to regenerate on their own without planting.
- There is a moderate risk of uncharacteristic insect and/or disease outbreaks, which is also a function of increased tree density.

The major vegetation communities addressed in the report are ponderosa pine, frequent fire (dry) mixed conifer, the second and third largest vegetation communities on the Forest. Together they cover around 40 percent of the Forest. Also addressed are the aspen component of ponderosa pine and mixed conifer, and grasslands.

Not addressed are the pinyon-juniper vegetation types which occupy 40 percent of the Forest, infrequent fire mixed conifer, spruce-fir, and the rest of the fourteen vegetation types on the Forest that occupy the other 20 percent. There are no objectives in any of the developed alternatives for these vegetation types, recognizing the limited capacity for treatment during the planning period. This does not prevent treatments from being planned and implemented in these vegetation types as funding and personnel become available. Since there are no objectives developed for these vegetation types, no meaningful comparison of alternatives is possible, and no evaluation criteria are developed, and they are not analyzed in this report.

Resiliency and adaptation to climate change

Modifying forest structure, towards desired conditions and restoring historic fire regime is more important in light of the uncertainty of climate prediction. The alternative that makes the most progress towards this Need for Change will provide the best resiliency and adaptation in ponderosa pine and frequent fire mixed conifer in the face of climate change.

Uncertainty here does not refer to unlikelihood, or to lack of knowledge, but rather the possibility of more than one outcome (West and others 2009). Climate models provide a range of possibilities that vary according to assumptions in the climate model used, and the social assumptions about future greenhouse emissions. Modeling done for the southwestern United States, however, does show consistency in several areas. Current drought levels may become the norm; water-stressed forests would be more prone to large scale pathogen attacks; at the lower elevations of the vegetation types where they are most stressed, uncharacteristic disturbances may occur; hotter, drier environments are likely to enhance the size and severity of wildfires, and fire disturbance will increase; post fire vegetation is likely to be less like the historical forest as severe disturbances favor states such as grasslands and shrublands over pine forest. The ponderosa pine

and mixed conifer vegetation types, are likely to migrate northward and upwards in elevation. (Fulé 2008)

Some have questioned if restoration toward reference conditions is relevant or useful at a time when climate may dramatically change. Fulé (2008) suggests that reference conditions should not be regarded simply as a snapshot of what existed for a couple of thousand years prior to human-caused degradation, but in a long-term functional view as the result of evolutionary processes.

Prior to recent fire suppression, fire-adapted pine forests of western North America were among the most frequently burned in the world. From this perspective of evolutionary history, the frequent occurrence of fire played a role in developing fire adaptations in pine species. Fire will likely continue to play a role as an agent of ecosystem maintenance, as with surface fire, or as an agent of change, as with stand replacing fire. Ponderosa pine and frequent fire mixed conifer, have already exhibited great flexibility and adaptation over the millennia, occupying a variety of climates, and are not necessarily fragile. As we move into what is predicted to be a more fire prone environment, "it makes sense to use fire and fire-related characteristics of structure and composition to enhance resistance to loss and facilitate migration (Fulé 2008)."

Management approaches that enhance ecosystem resiliency and ability to adapt during climate change include:

- Reducing anthropogenic stresses.
- Reducing uncharacteristic disturbances.
- Allowing disturbances that promote adaptation and biodiversity. (Fulé 2008, West and others 2009)

The primary anthropogenic stress to ponderosa pine and mixed conifer vegetation communities has been a century of fire suppression in conjunction with past, unsustainable grazing practices. The result is that the ponderosa pine and frequent fire mixed conifer vegetation communities are highly departed from reference conditions on the Kaibab National Forest and other forests in the Southwest. These forest types are more dense, with greater canopy bulk density and canopy continuity making them more susceptible to uncharacteristic stand replacing fires. Restoring the historical high-frequency, low-intensity fire regime, counters this anthropogenic stress.

Modifying stand structure reduces the canopy bulk density, reduces canopy continuity with the creations of interspaces and openings, and promotes an abundant grass/forb understory that in turn promotes the high-frequency, low-intensity historic fire regime. "Restoration of patterns of burning and fuels/forest structure that reasonably emulate historical conditions prior to fire exclusion is consistent with reducing the susceptibility of these ecosystems to catastrophic loss (Fulé 2008)." In the desired condition, stand replacing fires do not occur even during periods of elevated fire danger. The positive results of more open stands and restoring historic fire regimes is already being realized on the Tusayan Ranger District. The ponderosa pine type on this District is less highly departed than on the other two Districts, and the majority of the pine type has had one to several fire entries in the past fifteen years. In areas that have already seen one fire disturbance or more in that time period, wildfires have been able to perform their natural role as a disturbance factor even during the traditional peak of fire season in late June. This is true in parts of the Williams Ranger District as well. It is not uncommon on the Kaibab to have wildfires and prescribed burns being used to achieve resource benefits in on one part of the forest, while suppression action is being taken on multiple or large wildfires in other more departed areas.

Continued application of wildland fire, from both prescribed burns and wildfires, mimicking the historical fire regime, allows fire to continue to enhance resistance to loss, and to facilitate natural (evolutionary) adaptation, and migration as climate changes.

Regenerate aspen to ensure long-term healthy aspen populations.

This need for change addresses the following current conditions:

- Aspen is declining as a component of the ponderosa pine and frequent fire mixed conifer vegetation communities, particularly on the Williams Ranger District. With the combined effects of ungulate browsing, insects, disease, severe weather events, and lack of fire disturbance, aspen decline is expected to continue.

Restore grasslands by reducing tree encroachment and restoring fire.

This need for change addresses the following current conditions:

- Grasslands are less abundant than they were historically due to limited nutrient cycling and conifer encroachment associated with the lack of characteristic fire disturbance.
- Tree encroachment is of particular concern in the montane/subalpine grasslands on the North Kaibab Ranger District. Because they long and narrow in shape, even limited tree encroachment from the edges can rapidly transition the area from grassland to a forested type.

Management response in the years immediately following large disturbance events.

The current Plan does not contain standards, guidelines or objectives for responding to large disturbance events. Because there has been a trend toward larger, high severity, uncharacteristic fires, this emerged as a priority need for change from the current Plan. The size of these disturbed areas likely inhibits natural regeneration due to the distance to seed sources. The time to regenerate, grow, and restore these areas to desired conditions is indefinite, and likely measured in centuries.

Disturbance events large enough to inhibit natural regeneration, other than high severity fires, have not been documented on the Kaibab, with the possible exception of one or two tornado paths on the Kaibab Plateau. In the case of the tornados, the narrowness of the paths of disturbance may have allowed natural regeneration from seed sources along the edges but were, none-the-less, reforested with planted trees.

Insects and disease outbreaks, drought, and other stressors accompanying climate change may play larger role in the future as large-scale disturbances which may also create areas which do not regenerate naturally.

Short and long term adverse outcomes from stand replacing fire, in the ponderosa pine and frequent fire mixed conifer communities where they are occurring, include:

- Substantial soil loss (over two inches on the Point Fire in 1993, for example).
- Associated soil productivity loss.
- Associated damage to water diversions and other improvements.
- Displacement of native understory species by non-natives.
- Little or very slow recovery of desired tree species and stand structure.

Description of Alternatives

Alternative A, Current Plan and Current Management (No Action)

Under Alternative A, no changes would be made to the current Kaibab Land Management Plan and management practices would continue at current rates. The current plan contains very few goals that describe the desired conditions for any of the Forest's vegetation resources.

Guidelines in the current plan for vegetative management follow the recommendations for managing northern goshawk habitat and its prey. These guidelines specify that the Forest manage for uneven-aged stand conditions for live trees, and retain live reserve trees, snags, downed logs, and woody debris levels throughout woodland, ponderosa pine, mixed conifer and spruce-fir forest cover types. The current plan has guidelines with implied desired conditions for a specific size class distribution, which uses vegetative structural stage (VSS) to describe dominant tree size in six diameter size classes: VSS1 (0" - .9") or regeneration, VSS 2 (1.0" – 4.9"), VSS 3 (5.0" to 11.9"), VSS 4 (12.0" – 17.9"), VSS 5 (18.0" – 23.9"), and VSS 6 (> 24.0"). VSS class is determined by the predominance of the tree size class. The guideline for a specific distribution of VSS for ponderosa pine, mixed conifer, and spruce-fir forests is 10% each in VSS 1 and VSS 2 and 20% each in VSS 3, VSS 4, VSS 5 and VSS 6, where all VSS classes are within 3% of the desired distribution. Ponderosa pine canopy cover outside Post-fledging Family Areas (PFAs) should average 40% + in VSS 4, VSS 5, and VSS 6 forest. Inside PFAs, VSS 4 should have 1/3 60%+ and 2/3 50%+. In VSS 5 and VSS 6 canopy cover should average 60%+. The plan also describes opening size and reserve tree requirements (a specified number of trees retained according to opening size) by forest type. These guidelines have had differing interpretations, which has resulted in difficulty with implementation.

Alternative A identifies about 400,000 acres of land that is managed for timber production. Currently, the Forest mechanically thins about 2,100 acres a year in ponderosa pine and around 200 acres per year in frequent fire mixed conifer to alter or restore stand structure.

The current Plan was signed before the 1995 Federal Wildland Fire Policy was enacted, and does not have objectives for acres to be treated with prescribed burns or wildfires exhibiting beneficial fire effects. In the late 1970s, the understanding and acceptance of the role of fire in the ecosystem emerged, and fire managers on the Kaibab began to implement prescribed burns. Currently, fire managers are burning an average of 8,500 acres per year with prescribed fire and manage wildfires to achieve multiple objectives on an average of 11,700 acres per year, totaling an average of about 20,000 acres per year that receive beneficial fire disturbance.

In MSO critical habitat on the North Kaibab, which includes the all the mixed conifer vegetation type, suppression action must be taken on all wildfires in accordance with the terms and conditions associated with the Wildland Fire Use Amendment to the Plan in 2000.

The Wildland Fire Use amendment of the current plan (2000) includes prescriptive restrictions defining when wildfires must be suppressed in Mexican spotted owl habitat on the Williams District.

Other restrictions of wildfire management in the current plan include suppressing all wildfire starts within a two mile radius of North Canyon Spring in Saddle Mountain Wilderness on the North Kaibab Ranger District, within the 145 acre Frank's Lake Geologic-Botanical Area (also on the North Kaibab Ranger District), and within the 490 acre Arizona Bugbane Conservation Area on the north aspect of Bill Williams Mountain on the Williams District.

The current plan does not contain objectives for restoring or monitoring aspen. However, aspen restoration projects have been occurring and are expected to continue because aspen is recognized as an important and declining resource on the Williams District.

The current plan contains no objectives for restoring grasslands. Grassland restoration has been occurring at a variable rate. Approximately 8,000 acres of natural grassland are currently designated to be managed for timber production would continue to be managed as part of the suitable timber base.

In ponderosa pine and frequent fire mixed conifer forests, uncharacteristic openings following large disturbance events, such as high severity fires, are so slow to recover desired forest structure; some management effort is required to begin progress toward desired conditions. The current plan contains no objectives or guidelines to provide direction for actions in the years immediately following large disturbance events.

Description of Alternative B, Preferred Alternative

The preferred alternative would accelerate the rate of mechanical treatment, and shift the focus of mechanical thinning treatments over the next decade to larger-scale dense forest areas where effective modification of stand structure toward desired conditions can be implemented.

Objectives under this proposal would increase the rate of mechanical thinning (primarily using group selection cuts, with matrix thinning) to average 11,000 to 19,000 acres annually in ponderosa pine and 1,200 to 2,100 acres annually in frequent fire mixed conifer.

This alternative does not have a prescriptive guideline for VSS distribution, but provides for the habitat needs of the northern goshawk and its prey through desired conditions. The preferred alternative proposes the following standards for vegetation management:

- The maximum size opening that may be created in one harvest operation for the purpose of creating an even-aged stand shall not exceed 40 acres except when it is following a large-scale disturbance event such as a stand replacing fire, wind storm, or insect or disease outbreak.

- When openings are created with the intent of regeneration, effort shall be made to ensure that lands can be adequately restocked within 5 years of final harvest.

The preferred alternative proposes the following guidelines for vegetation management:

- Projects in forested communities that change stand structure should generally retain at least historic frequencies of trees by species across broad age and diameter classes at the mid-scale. As such, the largest and oldest trees are usually retained.

- On suitable timberlands, projects should retain somewhat higher frequencies of trees across broad diameter classes to allow for future tree harvest.

- Project design should manage for replacement structural stages to assure continuous representation of old growth over time.

- Project design and treatment prescriptions should generally not remove:

    - Large, old ponderosa pine trees with reddish-yellow, wide platy bark, flattened tops, with moderate to full crowns and large drooping or gnarled limbs (e.g.

Thomson's age class 4, Dunning's tree class 5 and/or Keen's Tree Class 4, A and B [appendix C]).

- Mature trees with large dwarf mistletoe induced witches' brooms suitable for wildlife nesting, caching, and denning, except where retaining such trees would prevent the desired development of uneven-aged conditions over time.
- Large snags, partial snags, and trees (>18 inches d.b.h.) with broken tops,cavities, sloughing bark, lightning scars >4″ wide, and large stick nests (>18 inches in diameter).
- Gambel oak >8 inches d.r.c.
- Known bat roost trees.

- The location and layout of vegetation management activities should effectively disconnect large expanses of continuous predicted active crown fire.
- Vegetation management prescriptions should provide for sufficient canopy breaks to limit crown fire spread between groups, allow for the redevelopment and maintenance of a robust understory, and mimic the spatial arrangement of the reference conditions.
- Vegetation management activities in mixed conifer forests should incorporate experimental design features and monitoring to accelerate learning and adaptive management.
- Trees established after 1890 should generally not be retained in areas where biophysical conditions would have supported stable openings over time.
- Vegetation management activities should meet or exceed goals for scenic beauty (scenic integrity objectives) by creating natural patterns, structure and composition of trees, shrubs, grasses, and other plants.
- Vegetation management should favor the development of native understory species in areas where they have the potential to establish and grow.
- Even aged silvicultural practices may be used as a strategy for achieving the desired conditions over the long term, such as bringing dwarf mistletoe infection levels to within a sustainable range, or old tree retention.
- Seed and plants used for revegetation should originate from the same PNVT and general ecoregion (i.e. southern Colorado Plateau) as the project area.
- Heavy equipment and log decks should not be staged in montane meadows.

This alternative includes wildland fire objectives for the ponderosa pine and mixed conifer vegetation communities. In ponderosa pine, an average of 13,000 to 55,000 acres per year would be treated with wildland fire, whether from prescribed burns or wildfires exhibiting beneficial fire effects. In frequent fire mixed conifer, an average of 1,000 – 13,000 acres would be treated with wildland fire.

The only guideline directing suppression action on wildfires would be for fires in the desert communities of Kanab Creek Wilderness as fire is not believed to be a natural disturbance process in this vegetation type. Suppression in this area would also limit further noxious weed

invasion, particularly cheatgrass. In all other areas, wildfires could be allowed to function in their natural role as a disturbance process when weather and fuel conditions are appropriate, and current and expected fire effects are desirable.

The preferred alternative includes objectives to fence 200 acres of aspen within 10 years of plan approval and reduce conifer encroachment on 800 acres of aspen within 10 years of plan approval.

The preferred alternative identifies about 381,500 acres of land to be managed for timber production. This is about 19,000 acres less than Alternative A. The difference is composed of approximately 8,000 acres of grassland PNVT, areas where restoration is not cost efficient, and the potential wilderness areas mentioned above that would no longer be managed for timber production.

The preferred alternative includes an objective to replant and average of 300-700 acres annually in ponderosa pine to restore forest structure in uncharacteristic openings following large scale disturbances.

Description of Alternative C

Alternative C is the same as the preferred alternative in regards to vegetation, fuels, and fire, except:

- Alternative C would replace the proposed old tree retention guideline with “Projects should not cut trees with physical characteristics typical of those that were established prior to 1890 (i.e., generally larger than 16 inches in diameter at breast height, with yellowing platy bark).” The differences between the old tree retention guidelines in Alternative B and C are subtle; they have the same intent to generally retain large old trees, but implementation of this guideline would result in leaving all presettlement trees regardless whether they would meet other desired conditions such as low risk of stand replacing wildfire or insect and diseases within endemic levels.
- It would establish a new Land Management Area (LMA) on the North Kaibab Ranger District called the "North Kaibab Wildlife Habitat Complex”. This area is approximately 265,000 acres and includes most of the Kaibab Squirrel National Natural Landmark, and eight linked ephemeral riparian valleys and canyons. In this LMA there would be a guideline that states "Mechanical thinning would be used initially to restore the desired forest structure. Thereafter, the desired conditions should primarily be maintained with fire and other natural disturbances." Because this area would not be managed for timber or biomass production, it would be removed from the Suitable Timber base.

Description of Alternative D

Alternative D is the same as the preferred alternative in regards to vegetation, fuels, and fire except:

- Forestwide, the stand structure would be restored to desired conditions using a combination of mechanical thinning treatments and wildland fire. Thereafter, desired conditions would be largely maintained with wildland fire. No lands would be managed for timber or biomass production

- This alternative proposes has the same presettlement tree retention guideline and recommended wilderness areas as Alternative C.

Methodology and Analysis Process

Vegetation composition and structure are used to evaluate or predict a number of ecosystem functions related to the Priority Needs for Change. These include the likelihood of various types of disturbance and succession, species habitats, social and economic values. A number of sources were used to display current conditions. Various models were used to predict trends in vegetation and disturbances in response to natural and anthropogenic forces by alternative. Alternatives are evaluated in relation to their progress toward priority needs for change and associated desired conditions.

The primary sources for natural and existing vegetation conditions are:

- A Potential Natural Vegetation Type (PNVT) classification, based primarily upon the map units from the Terrestrial Ecosystem Survey, was developed and used to compare existing vegetation to characteristic vegetation. Characteristic vegetation is the vegetation composition and structure that would exist under a natural disturbance regime, and considered to be ecologically sustainable, and more resilient to climate change.

- A mid-scale existing vegetation inventory completed in 2008 across the Coconino and Kaibab National Forests, provided geospatial polygons with characteristics of life form (tree, shrub, grass-forb), size class (for trees) and canopy cover class.

- Forest Inventory and Analysis (FIA) plot data were used primarily to calibrate the Vegetation Development Dynamics Tool model (VDDT), to estimate relative proportions of even- and uneven-aged conditions on the Forest, and to estimate proportions of various types within pinyon-juniper systems.

- Field-sampled vegetation data gathered on the Kaibab.

- Stand-replacing fire area over time (frequency) for the Kaibab and across the National Forests along the Mogollon Rim.

The primary models used to evaluate trends are:

- The Vegetation Development Dynamics Tool (VDDT). VDDT is a state-and-transition modeling tool which provides a framework for examining the role of various disturbance agents and management actions in vegetation change. The interaction of human activity, fires, insects, pathogens, growth and competition is complex, and the combined effects are difficult to predict over long periods. The development tool allows for testing of the sensitivity of the ecosystem to a multitude of activities and agents of disturbance, to compare alternatives. In using VDDT, a vegetation type is divided into the various states (percent in each potential state) as they occur on the on the landscape. Some of these states are seral states found within the historic range of variability, and others are uncharacteristic states that did not historically occur. Inputs to the model are agents of disturbance as probabilities of occurrence, such as the probability that a unit of land will be mechanically treated to restore stand structure, or the probability that a unit of land will be burned by fire under low, moderate or high fire weather conditions; probabilities are also assigned to each state affected by a disturbance that would transition it into a new state or remain in the same state. Outputs are the final ratios of the transition states for the landscape at the end of a given time period.

  VDDT models for ponderosa pine and frequent fire mixed conifer were developed by the Forest Service at the Regional level to be used specifically to compare alternatives for

Forest Land Management Plans in Region 3. The development process of these models is documented in Appendix B of the Kaibab National Forest Final Environmental Impact Statement (EIS). The Forest began with the models for the Ponderosa Pine Forest/Bunchgrass (PPG), Ponderosa Pine Forest –Oak (PPO) and Mixed Conifer Frequent Fire, aka Mixed Conifer-Dry (MCD) Models. The PPG model is similar to the Ponderosa Pine Forest/Oak (PPO) model, so the two were evaluated together (PPF). This model provides a base comparison of the relative progress Plan alternatives are predicted to make toward desired conditions; outputs are then supplemented by other extra-model information. VDDT was also used for most of the wood production and potential values calculations as required under the 1982 planning rule procedures. Much of the modeling response in VDDT was calibrated using FIA data inputs and results from Forest Vegetation Simulator (FVS) runs.

Forest Vegetation Simulator runs were used for special cases outside of the VDDT model when more resolution was needed for an issue than VDDT could provide. FVS can be more sensitive to management because it models the fate of individual trees over time, rather than finite states of stand averages. This was needed to better represent the probable outcomes of specific treatments such as the tree retention guidelines. FVS has better resolution for quantifying the results of specific treatments, which differ from the stand averages over time. The FVS modeling of the tree retention guideline is documented in the document, 'Diameter caps and forest restoration – Evaluation of a 16-inch cut limit on achieving desired conditions," (Triepke et al 2011).

Various spreadsheets that calculate relative differences between alternatives for similarity to historic size and density states, interspersion of states, understory production as a function of overstory tree density and correlations of tree canopy cover to tree basal area have been developed.

Goals or Desired Conditions used to evaluate contributions to sustainability come from:

- Forest Service Region 3 consistent desired conditions, which were developed using an interdisciplinary process.
- Kaibab National Forest specific Desired Conditions (DCs) that are modifications to the Region 3 consistent desired conditions. These are usually quite similar to the Region 3 consistent desired conditions, with some minor modifications based upon internal or public input to the broad desired conditions. There are also several DCs developed for PNVTs not addressed in the R3-consistent process.

To compare how well each Alternative addresses the Priority Needs for Change, evaluation criteria were developed for each priority need for change. The criteria for each need for change are listed in the Environmental Consequences section.

Assumptions

In the vegetation analysis, the following assumptions have been made:

- The land management plan provides a programmatic framework for future site-specific actions.
- Land management plans do not have direct effects. They do not authorize or mandate any site-specific projects or activities (including ground-disturbing actions).
- Land management plans may have implications, or environmental consequences, of managing the forests under a programmatic framework.

- The plan decisions (desired conditions, objectives, standards, guidelines, management areas, monitoring) will be followed when planning or implementing site-specific projects and activities.
- Law, policy, and regulations will be followed when planning or implementing site-specific projects and activities.
- Monitoring will occur and the land management plan will be amended, as needed.
- The Forest will be funded similar to past budget levels (past 5 years).
- The planning timeframe is 15 years; other timeframes may be analyzed to compare anticipated trends into the future).
- The population and calibration of VDDT using FIA plots and FVS modeling of growth and disturbances generally represents the response of forested PNVTs well enough to compare these responses in a relative way to mid-scale DC attainment.
- Alternative B is modeled using group matrix thinning. Alternatives C and D are modeled for thinning to a 16" diameter cap because of the large tree retention guideline that calls for generally retaining all pre-settlement trees established prior to 1890. Pre-settlement trees can often be identified by having the plated yellow bark frequently exhibited by these large old trees, rather than the rougher black bark exhibited by younger pines. The models used for comparing alternatives do not have the ability to select on bark characteristics. As a result, these alternatives were modeled with a 16 inch diameter maximum as a conservative surrogate for age. Additionally, it is likely that prescriptions developed to meet this guideline would be written as a diameter cap because size is easier than age to determine in the field. Group selection matrix thinning and thinning to a diameter cap are equally effective in stands where there is a lack, or a desired number, of large trees. However, when thinning to a diameter cap in stands that already have many large trees, it becomes necessary to remove most or all the smaller trees to achieve the desired openness of a stand.

Environmental Consequences

The land management plan provides a programmatic framework that guides site-specific actions but does not authorize, fund, or carryout any project or activity. Because the land management plan does not authorize or mandate any site-specific projects or activities (including ground-disturbing actions) there can be no direct effects. However, there may be implications, or longer term environmental consequences, of managing the forests under this programmatic framework.

The environmental consequences for each Alternative are evaluated using criteria for how well each addresses the Priority Needs for Change.

Evaluation criteria for: Modify forest structure and species composition to restore or maintain sustainability and restore historic fire regimes.

Evaluation criteria in ponderosa pine or frequent fire mixed conifer communities are outputs from Vegetation Dynamics Development Tool (VDDT) analysis.

The midscale desired condition for these communities includes an open, uneven-aged forest with all age classes and structural stages present. Evaluation criteria are:

- Frequency of the desired structural state (State K in the VDDT analysis for this report) is one of the 14 vegetative structural states developed for ponderosa pine and dry mixed conifer VDDT models. It represents the large, open, multi-storied state in the mid-scale

desired conditions. This is expressed as the percentage of the vegetation type in the desired structural state at each time mark for each alternative.

- Time Departure Index. This relative index is a measure of the relative time to attainment of desired structural state from all other VDDT States. The principle behind this index is that it takes more time for some States to grow or be treated to attain the desired structural state than it does others. For example, an open State with only seedlings and saplings would take much longer to grow and develop into the desired structural state than it would to thin a closed, multistoried uneven aged stand to achieve the same State. Further discussion of the development of this index is found in Appendix A. The highest value possible would be 1 if all the vegetation type were in desired structural state. The higher the value for this index, the less time that alternative is expected to take to move towards the desired condition.

- Density Departure Index. This relative index is an indicator of the relative risk of uncharacteristic loss of forest structure using an index sensitive to tree density and somewhat to dominant tree size selection This index focuses on the immediate threat posed from density-dependent disturbance, such as active crown fire, rather that the time to attain desired conditions or the similarity or difference from desired conditions. The highest value is 1 which would indicate the least density departure. (See Appendix A.)

The fine scale desired conditions for these communities includes a composition of irregularly-spaced groups of trees with variable spacing that are surrounded by openings comprised of a grass-forb-shrub mix. Trees within groups have similar or variable ages and groups are typically less than one acre in size. The fine scale states therefore, have high interspersion. The evaluation criterion is:

- Interspersion Creation Index. This index an indicator of the relative frequency of application of treatments, such as group selection with matrix thinning or burning with moderate fire effects that create the fine scale structural state interspersion in the desired conditions. Currently there is much less interspersion (fine-scale heterogeneity) than desired. The highest value possible would be 4, indicating a very high frequency of treatment application likely to produce the desired fine scale heterogeneity of structural states. (See Appendix A.)

Percent of potential understory abundance is an important indicator of the ability to carry frequent surface fire. Understory vegetative cover is lower than historic conditions. The evaluation criterion is:

- Understory abundance index. This index is based on tree overstory basal area and canopy cover relationships to understory productivity. It is expressed as a percentage of potential understory productivity, where the highest rating would be 100%. (See Appendix A.)

The desired condition for fire behavior in ponderosa pine and frequent fire mixed conifer is the same. Fires burn as a surface fire under all weather scenarios, but single tree torching, and isolated group torching are not uncommon (passive crown fire). Fire does not spread from group to group as active crown fire. Canopy bulk density and canopy cover continuity determine the potential for undesirable active crown fire. Lower crown bulk density, and gaps and interspaces among groups of trees inhibit the spread of active crown fire from group to group. The evaluation criterion for desired fire behavior is:

- Percentage in Open States. This criterion is simply the sum of the percentage of the vegetation type modeled to be in the VDDT Open States (States A, B, C, D, E, J, K and

N), with 30 percent crown cover or less, at each time mark. Open states promote surface fire over active crown fire. It is also an indicator of the amount of particulate emissions that would result from a wildfire, with surface fires producing less than crown fires. This latter is addressed in depth in the Kaibab National Forest Air Quality Specialist Report (Kaibab 2011a).

All criteria above are evaluated at the current, 10-year, 15-year, 50-year and 250-year time-marks.

Evaluation criteria for: Regenerate aspen to ensure long-term healthy aspen populations.

- Acres of aspen fenced (with elk-proof construction) in ponderosa pine on the Williams and Tusayan Ranger Districts.
- Acres of reduced conifer encroachment on aspen in ponderosa pine vegetation communities.
- Percentage of vegetation type at or approaching desired structural state (States J and K). Aspen clones in ponderosa pine and frequent fire mixed conifer, across the Kaibab National Forest, are likely to be more resilient – able to withstand droughts, regenerate in place, and to move gradually - when the surrounding forest is in a more characteristic condition than it currently is. In the modeling analysis, the characteristic condition is represented by State K , the larger, open, multi-storied state that represents the characteristic condition. State J is similar to State K except the largest trees are the next smaller tree size in the model, and nearing the characteristic condition. This evaluation criterion is evaluated at the current, 10-year, 15-year, 50-year and 250-year time-marks.

Evaluation criteria for: Restore grasslands by reducing tree encroachment and restoring fire.

- Acres of grassland communities with tree canopy cover reduced below ten percent. This evaluation criterion is evaluated at the current and 10-year time-marks.

Evaluation criteria for: Management response in the years immediately following large disturbance events.

Experience on the Kaibab National Forest has shown little success in recovery of forest structure following stand replacing fire by relying upon natural regeneration processes. Conversely, planting has been quite successful, with about 69% success with any individual planting event in ponderosa pine (Higgins 2008). The evaluation criteria are:

- Acres planted to reduce the time to achieve the desired stand structure.

These evaluation criteria are evaluated at the current, 10-year, 15-year, 50-year and 250-year time-marks.

Environmental Consequences for Vegetation, Fuels and Fire: Alternative A-Current Plan, Current Management (No Action)

Modify Stand Structure and species composition to restore or maintain sustainability, and restore historic fire regime: Table 3 below presents the Alternatives' responses to the evaluation criteria for this need for change, currently and at four future time marks for ponderosa pine. Table 4 does the same for frequent fire mixed conifer. The values presented either come directly from the VDDT model outputs or come from indices that use input directly from the model and

other values derived from research (when available) or professional judgment. The indices are documented in Appendix B of the EIS and are also presented in Appendix A of this document.

Table 3. Response of Alternatives to Evaluation Criteria in Ponderosa Pine. The response best meeting the desired conditions is highlighted.

Criteria	Alternative	Time Mark				
		0	10	15	50	250
% Desired Structural State	A	2	4	5	10	13
	B		16	20	28	29
	C		3	4	8	11
	D		3	3	10	12
Time departure rel. index	A	0.55	0.55	0.55	0.58	0.58
	B		0.60	0.61	0.62	0.62
	C		0.54	0.55	0.59	0.58
	D		0.54	0.55	0.60	0.57
Density departure rel. index	A	0.52	0.58	0.59	0.66	0.69
	B		0.67	0.70	0.75	0.76
	C		0.57	0.59	0.73	0.71
	D		0.57	0.60	0.76	0.68
Intersper-sion creation rel. index	A	2.71	2.74	2.72	2.75	2.80
	B		3.73	3.71	3.68	3.71
	C		2.42	2.43	2.50	2.47
	D		2.42	2.43	2.60	2.69
% Potential understory abundance	A	32	32.1	32.5	33.7	35.6
	B		35.9	36.5	37.4	37.9
	C		31.1	31.2	34.5	36.2
	D		31.3	31.4	35.8	38.4
% Unnatural Open State	A	2	2.1	2.1	2.1	3.7
	B		1.8	1.6	1.3	1.9
	C		1.9	1.8	1.7	4.2
	D		1.8	1.8	1.6	6.7
% in Open States	A	36	46	48	59	67
	B		64	68	76	78
	C		42	46	68	70
	D		44	47	75	71

Table 4. Response of Alternatives to Evaluation Criteria in Frequent Fire Mixed Conifer. The most desirable response is highlighted.

Criteria	Alternative	Time Mark				
		0	10	15	50	250
% Desired Structural State	A	0.5	3	4	7	9
	B		9	11	15	15
	C		4	5	7	8
	D		4	5	8	8
Time departure rel. index	A	0.48	0.47	0.47	0.47	0.47
	B		0.49	0.49	0.49	0.48
	C		0.46	0.46	0.46	0.45
	D		0.46	0.45	0.45	0.44
Density departure rel. index	A	0.43	0.43	0.44	0.45	0.45
	B		0.50	0.52	0.53	0.54
	C		0.49	0.50	0.51	0.51
	D		0.50	0.51	0.51	0.51
Intersper-sion creation rel. index	A	1.6	2.5	2.5	2.6	2.6
	B		3.0	3.1	3.1	3.1
	C		2.4	2.4	2.6	2.6
	D		2.5	2.4	2.7	2.6
% Potential understory abundance	A	34.4	29.0	29.2	30.0	29.6
	B		33.0	33.7	34.1	33.9
	C		32.3	32.7	32.9	32.7
	D		33.4	33.7	33.8	33.5
% Unnatural Open State	A	12.0	11.5	11.4	12.1	21.5
	B		11.4	11.2	11.5	19.0
	C		11.4	11.2	12.0	20.1
	D		11.4	11.2	13.0	24.1
% in Open States	A	33	28	30	34	43
	B		43	47	52	59
	C		41	44	46	50
	D		44	47	47	53

Under Alternative A, in ponderosa pine, progress toward the desired open, multistoried, uneven aged condition at the mid-scale occurs but the rate is not sufficient to reduce the threat of uncharacteristic wildfire, or to open the canopy to allow for a response in understory production.

In ponderosa pine, the percent of the area in the desired structural state increases from the current condition of 2 percent to 4 percent in 10 years. At the 50 year time mark, the area in the desired structural state rises to 10 percent.

In frequent fire mixed conifer, the percent of the area in the desired structural state rises 0.5 percent to almost 3 percent within 10 years. At the 50 year time mark is increases increase to 7 percent.

The percentage of the ponderosa pine and frequent fire mixed conifer in the desired structural state is 12 to 18 percent lower at all time marks than in Alternative B, the preferred alternative. This is due to the lower rate of mechanical thinning treatments under current management practices to achieve desired stand structure.

The temporal departure index is lower than the preferred alternative at all time marks indicating that the relative time to attain the desired structural state is longer. This, again, is due to the lower application of mechanical thinning treatments.

The density departure index is also lower than the preferred alternative at all time marks in ponderosa pine and frequent fire mixed conifer. This indicates a greater risk of density dependent uncharacteristic disturbance, such as active crown fire. The rate of treatment to improve stand structure in Alternative A is too slow to make a difference, so density is not improved over time.

The interspersion creation index is lower than the preferred alternative at all time marks, because Alternative A has a lower rate of application of treatments that create fine scale heterogeneity.

The percentage of relative potential understory productivity is somewhat lower at all time marks than in the preferred alternative. The abundance of fine fuels that are the carrier of the desired low intensity high frequency fires would be lower than under the preferred alternative.

This alternative has a lower percentage of area in open states that promote surface fire over active crown fire than the preferred alternative. It has the least percentage in desirable open states of all alternatives at the 50 and 250 year time marks in ponderosa pine, and at all time marks in frequent fire mixed conifer. The percentage of area in the ponderosa pine type in open states is11 to 20 percent lower under this alternative than in the preferred alternative, and 15 to 18 percent less of the area is in open states in frequent fire mixed conifer. The higher percentage of closed states, with canopy cover greater than 30 percent under this alternative indicates a corresponding high risk of uncharacteristic wildfire. Lower understory abundance diversity and abundance is also indicated by this criterion.

Under Alternative A, the guideline in the current Plan for vegetation structural state, intended to provide for uneven-aged stands with sustainable size-class distribution over time, has had differing interpretations, which has resulted in difficulty in implementation. Project design has often used more conservative prescriptions to ensure the guidelines are met, which has resulted in leaving tree densities that are higher than in the desired range, and this trend would be expected to continue.

Suppression action would continue to be taken on all wildfires in Mexican spotted owl critical habitat on the North Kaibab, which includes the all the mixed conifer vegetation type, in accordance with the terms and conditions associated with the Wildland Fire Use Amendment to the Plan in 2000. The risk of moving most or all of this vegetation type to an uncharacteristic open state, with minimal natural regeneration, as the result of one or several high severity wildfire incidents is high, as demonstrated by wildfires that have occurred during the past 15 years. The immediate risk of converting the entire mixed conifer type on the North Kaibab Ranger District to aspen or grassland as a result of one or a few high severity fires would persist. These current Plan restrictions would also encumber cross-boundary fire management of wildfires burning on the Kaibab Plateau between the Grand Canyon National Park and the Forest that could be otherwise be used to reduce the risk of stand replacing fires on both jurisdictions.

The prescriptive restrictions defining when wildfires must be suppressed in Mexican spotted owl habitat on the Williams Ranger District would continue to limit the opportunities to restore the historic fire regime, and to reduce the threat of high severity wildfire to MSO habitat by managing wildfires to consume accumulated fuels when fire weather and fuel moisture conditions are appropriate.

Fires would continue to be suppressed within a two mile radius of North Canyon Spring in Saddle Mountain Wilderness on the North Kaibab Ranger District, within the 145 acre Frank’s Lake Geologic-Botanical Area (also on the North Kaibab Ranger District), and within the 490 acre Arizona Bugbane Area on the north aspect of Bill Williams Mountain on the Williams District. Wildfires could not be managed to reduce the threat of high severity wildfire to these biologically

unique areas by managing wildfires to consume accumulated fuels when fire weather and fuel moisture conditions are appropriate.

Regenerate aspen to ensure long-term healthy aspen populations:

Under Alternative A, and the current Plan, there would be no objectives to fence areas of aspen on the Williams and Tusayan Districts, and no objectives for reducing conifer encroachment in aspen in the ponderosa pine type. Some aspen restoration treatments are occurring under the current Plan, and would continue under the "no action" alternative, but the rate of implementation is expected to be variable due to limited funding and competing resource needs. There are no guidelines for retaining large, old trees under the current plan, so the effectiveness of those treatments that would occur is expected to be good as conifer could be more adequately removed during aspen restoration treatments.

As previously discussed, stands at, or approaching the desired characteristic States J and K for ponderosa pine and frequent fire mixed conifer promote the retention and regeneration of aspen. Table 5 presents the predicted frequency of these larger, open, multi-storied States, currently, and at four future time marks by alternative.

Table 5. Area in larger, open, multi-storied states over time for ponderosa pine and frequent fire mixed conifer. The most desirable response is highlighted.

Vegetation Type	Alternative	Time Mark				
		0	10	15	50	250
Ponderosa Pine	A	9	12	13	15	17
	B		32	36	40	40
	C		8	8	10	13
	D		9	9	11	16
Frequent Fire Mixed Conifer	A	1	6	12	14	16
	B		15	18	20	19
	C		7	8	11	12
	D		8	9	13	12

Alternative A has considerably less area in States J and K than the preferred alternative at all time marks (Table 5), with 20 to 25 percent less ponderosa pine area in states that promote the retention and regeneration of aspen, and 3 to 9 percent less area in States J and K in frequent fire mixed conifer.

Alternative A - does not allow wildfires to play natural role as a disturbance factor in the mixed conifer type on the Kaibab Plateau. Wildfires could not be used under appropriate conditions to encourage the regeneration of aspen in smaller, more ephemeral patches.

Restore grasslands by reducing tree encroachment and restoring fire:

Under Alternative A, and the current plan, there would continue to be no specific plan direction or objectives governing the removal of encroaching trees from grasslands. Some grassland restoration would likely be accomplished even without plan objectives if funding were available, but perhaps not to the extent that would be accomplished under the action alternatives.

Management Response to large disturbance events:

The current Plan has no objectives for planting after large disturbance events. Current rates of planting would not keep up with the rate of occurrence of stand replacing fire in order to move stand structure on a trajectory back towards desired conditions.

If the climate gets warmer and drier, trends away from desired conditions are anticipated to be exacerbated.

Environmental Consequences for Vegetation, Fuels, and Fire Common to All Action Alternatives

Modify Stand Structure and species composition to restore or maintain sustainability, and restore historic fire regime:

Objectives under all action alternatives would be to mechanically Thin 11,000 to 19,000 acres annually in ponderosa pine, and 1,200 to 2,100 acres annually in frequent fire mixed conifer. This increased treatment rate in ponderosa pine and mixed conifer would be sufficient to move trends towards desired conditions of open, multi-storied, uneven-aged stand structure, instead of remaining static, or moving away. The more open canopy would promote an increase in understory diversity and abundance. Openings in the canopy would break up continuous canopy cover, promote surface fire behavior, and reduce the risk for high severity wildfires that result in uncharacteristic large openings that do not regenerate naturally.

Ground disturbance is a byproduct of mechanical treatments to improve and restore stand structure, and is also present, in varying amounts under all Alternatives. The risk of non-native plant invasion is increased by even small-scale ground disturbance. The impacts of ground disturbance are further discussed in the Non-Native Plant Specialist Report (Kaibab 2011b).

Continued application of wildland fire, in the form of both prescribed burns and management of wildfires mimicking the historic fire regime, would further enhance resistance to uncharacteristic disturbances, enhance and maintain stand structure, and facilitate natural (evolutionary) adaptation and migration as climate changes. Objectives under all action alternatives would be to treat with fire an average of 13,000 to 55,000 acres annually in ponderosa pine, and an average of 1,000 to 13,000 acres annually in frequent fire mixed conifer using a combination of prescribed fire and naturally ignited wildfires. The full range of management responses to wildfires would be available across the Forest, except in the desert communities where wildfire is not a characteristic disturbance. Elsewhere fires could be managed for resource objectives when fuel and weather conditions are appropriate.

Smoke is a byproduct of prescribed burns and wildfires under all alternatives. While all Alternatives are expected to meet the desired conditions for Air Quality in complying with State and Federal emissions regulations, the public tolerance for smoke is often reached long before health and visibility standards are exceeded. Air Quality impacts are further discussed in the Kaibab National Forest Air Quality Specialist Report (Kleindienst 2012).

All action alternatives have a guideline to retain at least historic frequencies of trees by species across broad diameter classes to provide for uneven-aged stands with sustainable size-class distribution over time. These guidelines are expected to be easier to implement than current guidelines to move stand structure toward desired conditions.

Regenerate aspen to ensure long-term healthy aspen populations:

Under all the action alternatives, there are objectives to fence 200 acres of aspen and reduce conifer encroachment on 800 acres of aspen within 10 years of plan approval; aspen regeneration and mortality are specified in the monitoring plan. This emphasis on aspen restoration in the action alternatives would make it a priority on the Williams and Tusayan Districts.

Under the Alternatives B, C, and D, wildfires could be used under appropriate conditions to reduce the likelihood of stand replacing fire, and encourage the regeneration of aspen in smaller, more ephemeral patches.

Restore grasslands by reducing tree encroachment and restoring fire:

Under all the action alternatives, there are objectives to reduce tree and shrub density in grasslands to less than to 10% on 5,000 to 10,000 acres of historic grasslands annually. This emphasis on grassland restoration would make it a priority on the Williams and North Kaibab Districts. Overall, the amount of grassland restoration treatment is not expected to be different between the action alternatives, and is not expected to be a driver for selecting one alternative over another.

The large tree retention guidelines in the action alternatives would apply to grassland restoration activities as well. As such, treatments could be less effective under Alternatives C and D as large old trees that might be removed under Alternative A would be retained under these alternatives.

Management Response to large disturbance events:

All action alternatives include the following proposed guideline for management response to large disturbance events, “Where extensive mortality results from fires, insect epidemics, or wind events, and sufficient timber value exists, salvage of dead trees should be considered where it would facilitate meeting public safety objectives, and long-term restoration.” Economically, receipts from the sale of disturbance killed trees can facilitate restoration work by offsetting the cost of such efforts. However, there is much conflicting research regarding the ecological value of salvage harvest and its associated impacts.

Some studies indicate that reducing coarse woody debris early in the post-fire period has long term benefits in reducing future fire severity, thereby promoting restoration efforts (Brown et al 2003, Monsanto and Agee 2008). Another study found mixed results in the efficacy of salvage in reducing future fire severity (Fraver et al 2011). Still others indicate that leaving the large wood on the landscape has multiple roles in the ecological recovery of disturbed ecosystems that far outweigh the ecological impacts and cost of salvage efforts (Breschta et al 2004, Lindenmayer and Noss 2006).

The guideline for Alternatives B, C, and D is worded such that salvage operations can be evaluated on a site specific basis using the best available science post-disturbance. At a minimum, the snag, log and coarse woody debris retention guidelines for the vegetation type would still apply within the disturbance area.

All action alternatives include an objective to replant and average of 300 to 700 acres annually. This is to restore forest structure in uncharacteristic openings following large scale disturbances in ponderosa pine and frequent fire mixed conifer vegetation types to set conditions on a trajectory toward desired conditions.

Environmental Consequences for Vegetation, Fuels and Fire: Alternative B - Preferred Alternative

Modify Stand Structure and species composition to restore or maintain sustainability, and restore historic fire regime:

In Ponderosa pine, the percent of the area in the desired structural state at the mid-scale would go from its current condition of 2% of the vegetation type to more than 15% within 10 years. Within 50 years, this area is anticipated to nearly double, but then level off (Table 3). In frequent fire mixed conifer, the percent of the area in the desired uneven-aged open, multistoried condition at the mid-scale would move from its current condition of 0.5% of the vegetation type to almost 10% within 10 years. At the 50 year time mark it is expected to increase to about 15% and then level off (Table 4). Alternative B has nearly double area in the desired structural state at all time marks of all other alternatives. The difference between the Proposed Action and other alternatives is large for this evaluation criterion. The difference is due to the effects of modeling for group selection matrix thinning under the Proposed Action versus thinning to a 16 inch DBH-cap in Alternatives C and D (see Modeling and Analysis Process Assumptions). In stands where there are a lack, or a desired condition number of, large trees, both group selection matrix and diameter cap are equally effective. However, with a DBH-cap treatment in stands that already have many large trees, it becomes necessary to remove most or all the smaller trees to achieve the desired openness of a stand. This results in a more single storied State. This is why group selection matrix thinning is more effective at creating multi-storied, uneven aged states than treatments with an imposed diameter cap.

The index for time departure for Alternative B indicates the least time for attainment of mid-scale desired conditions at all time marks for both ponderosa pine and frequent fire mixed conifer. Overall, the differences between the alternatives are smaller for this evaluation criterion than other mid-scale desired condition attainment differences. This difference is again due to modeling for group selection matrix thinning in Alternative B versus diameter cap treatments. With thinning from below it takes longer to achieve a multi-storied state, if it is ever achieved.

The preferred alternative has the lowest density departure from the mid-scale desired conditions at all time marks except for at the 50 year time mark in ponderosa pine. Alternative B shows the least risk of density related uncharacteristic disturbance, such as active crown fire over the four time marks. In Alternative A, the rate of treatment to restore stand structure is too slow to make decrease density over time. In Alternatives C and D, without reentry with mechanical treatment into stands treated once with a diameter cap, trees continue to grow and become more dense over time.

Alternative B has more fine scale interspersion created at all time marks for both ponderosa pine and frequent fire mixed conifer. The differences between the preferred alternative and other alternatives are relatively large for ponderosa pine and moderate for mixed conifer. Group selection matrix thinning is more effective at creating uneven-aged groups of trees with interspaces and openings. Diameter cap thinning works against creating interspersion, as larger trees are retained in what could otherwise become an interspace. With reference condition interspaces, maintaining desired stand structure with fire alone might be possible. Without interspaces created, and trees continuing to grow in interspaces, the forest becomes more dense, canopy bulk density and canopy cover increase, and the probability of active crown fire increases. In denser, departed states, fire is not effective at creating or maintaining stand structure on its own. Under low and moderate fire severity conditions, very few trees above the seedling size are thinned; under high severity fire conditions, too many, or all trees are removed.

This alternative has the highest percentage of potential understory abundance at three of four time marks in ponderosa pine, and at all four in mixed conifer. This is a function of having the greatest amount of State A – a characteristic open state, such as interspaces between groups at the fine scale, and the most Open States with less than 30 percent canopy cover. This understory abundance would best support the desired high frequency, low intensity fire regime. Differences for this evaluation criterion are smaller in mixed conifer than in ponderosa pine due to lower rates of treatment to create desired stand structure with interspaces.

Since Alternative B has the highest percentage of Open States, with 30 percent canopy cover or less, at all time marks, in both ponderosa pine and frequent fire mixed conifer, it also best promotes surface fire over active crown fire. Open States in ponderosa pine increase in 10 years from 36 percent of the vegetation type to 64 percent, and continue to gradually increase after that. In frequent fire mixed conifer, Open States increase in 10 years from 33 percent to 43 percent, and again continue to gradually increase over time. It should be noted that the preferred alternative also has the least percentage of area in the unnatural open State from high severity wildfire at all time marks as well.

This alternative contains a tree retention guideline to protect and retain large old trees with structural characteristics desirable for wildlife habitat to increase the numbers of these trees over time. These guidelines are currently implemented on the Forest, but are not part of the current plan. A guideline is necessary because these important features are less abundant than in reference conditions and take more than a century to replace if removed.

Regenerate aspen to ensure long-term healthy aspen populations:

Alternative B includes the objectives to fence 200 acres of aspen and reduce conifer encroachment on 800 acres of aspen within 10 years of plan approval. This emphasis on aspen restoration would make it a priority on the Williams and Tusayan Districts.

This alternative has considerably more area in large, open states at all time marks than the other alternatives that would promote the retention and regeneration of aspen since aspen is a shade-intolerant species. The percent of ponderosa pine in these desirable states increases from 9 percent to 32 percent in 10 years, and continues to gradually increase over time. In frequent fire mixed conifer, the area in these states moves from 1 percent to 15 percent in 10 years, and again gradually continues to increase over time (Table 5).

The differences in the large tree retention guidelines between the action alternatives could result in more effective aspen restoration and grassland restoration treatments under Alternative B than under C or D. In Alternative B, the retention guideline focuses on the structural characteristics of desirable large old trees (see description of Alternative B). In Alternatives C and D, the tree retention guideline would specify that all pre-settlement trees (with physical characteristics indicating they were established prior to 1890) would not be cut. Both guidelines have been implemented on the Forest previously. While the difference between the guidelines is subtle, it does result in differences in project implementation.

Under the Retention guideline in Alternative B, based on structural characteristics, the trees to be retained are visually determined by project implementers.

Restore grasslands by reducing tree encroachment and restoring fire:

Alternative B includes the objective to reduce tree density to less than 10 percent on 5,000 to 10,000 acres of historic grasslands annually, as do Alternatives C, and D. Overall, the amount of grassland restoration treatment is not expected to be different between the action alternatives.

The differences in the large tree retention guidelines between the action alternatives could result in more effective grassland restoration treatments under Alternative B than under C or D as discussed under Protect and Regenerate Aspen, above.

Environmental Consequences for Vegetation, Fuels and Fire: Alternatives C and D

Modify Stand Structure and species composition to restore or maintain sustainability, and restore historic fire regime:

In ponderosa pine, the percent of the area in the desired structural state at the mid-scale increases from the current condition of 2 percent to 3 percent in both Alternatives C and D in 10 years. Within 50 years, the area in the desired structural state rises to 8 percent in Alternative C and 10 percent in Alternative D.

In frequent fire mixed conifer, the percent of the area in the desired uneven-aged open, multistoried condition at the mid-scale rises 0.5 percent to almost 4 percent for both Alternatives C and D within 10 years. At the 50 year time mark it increases to 7 percent in Alternative C and 8 percent in Alternative D.

Alternative C and D have less area in the desired condition, State K, at all time marks than in the preferred alternative. In ponderosa pine, these alternatives have 13 to 20 percent less area in the desired structural state; in frequent fire mixed conifer they have 5 to 8 percent less area in the desired structural state. The differences between the preferred alternative and Alternatives C and D are large for this measure. The difference is due to the effects of modeling for group selection matrix thinning in the preferred alternative versus modeling for thinning to a 16 inch diameter cap in Alternatives C and D.

Alternatives C and D are modeled for thinning to a 16” diameter cap because of the large tree retention guideline that would retain all pre-settlement trees established prior to 1890 (see Modeling and Analysis Process Assumptions). As discussed under Alternative B above, implementation of this retention guideline would likely result in thinning from below to reduce tree density to desired condition. Group selection matrix thinning and thinning to a diameter cap are equally effective in stands where there is a lack, or a desired number, of large trees. However, when thinning to a diameter cap in stands that already have many large trees, it becomes necessary to remove most or all the smaller trees to achieve the desired openness of a stand. This would be the case in areas where there are continuous dense old trees as occurs in some areas on the North Kaibab Ranger District. This results in a more single storied State. This is why group selection matrix thinning is more effective at creating multi-storied, uneven aged states than treatments with an imposed diameter cap.

The temporal departure index is lower in both Alternative C and D than the preferred alternative at all time marks indicating that the relative time to attain the desired structural state is longer due, again, to the single storied State that results from thinning from below.

The density departure index is also lower than the preferred alternative at all time marks in ponderosa pine and in three of four time marks in frequent fire mixed conifer, indicating a greater risk of density dependent uncharacteristic disturbance, such as active crown fire. With reduced mechanical treatment over time in these alternatives into stands treated previously thinned from below, trees continue to grow and become more dense.

The interspersion creation index is lower than the preferred alternative at all time marks indicating less fine scale heterogeneity. Thinning to a diameter cap works against creating interspersion, as it results in more single storied state, and because larger trees are retained in what could otherwise become an interspace. Without interspaces created, and trees continuing to grow in interspaces, the forest becomes more dense, canopy bulk density and canopy cover increase, and the probability of active crown fire increases.

Understory abundance in ponderosa pine in these alternatives is expected to remain stable through the first 15 years, and to continue to increase gradually over time, Alternative D has the highest potential understory abundance at Year 250 Time Mark because it has the most area in the uncharacteristic State resulting from stand replacing fire. Because this State is open and unshaded, understory abundance is high. For frequent fire mixed conifer, understory abundance will slightly decrease and remain stable for the long term. The differences between alternatives are fairly small for this evaluation criterion. The percentage of relative potential understory productivity is somewhat lower at all time marks than in the preferred alternative indicating the fine fuels that are the carrier of the desired low intensity high frequency fires would be less abundant than under the preferred alternative.

There is a marked increase in the percentage of area in Open States from the current condition to the 10 year time mark. This is due to the increased rate of mechanical treatments to modify stand structure modeled in these alternatives until areas are transferred out of the suitable timber base. In ponderosa pine, Open States increase from 36 to 42 percent for Alternative C, and from 36 to 44 percent in Alternative D. In frequent fire mixed conifer Open States increases from 33 to 41 percent under Alternative C, and from 33 to 44 percent under Alternative D. The percentage of area in Open States continues to gradually increase over time, though some of this increase is in the uncharacteristic open State, particularly in Alternative D at the 250 year time mark.

These alternatives have a lower percentage of area in Open States than the preferred alternative. In ponderosa pine the difference is large at first and decreases over time; the difference at the 10 and 15 year time marks is 20 to 22 percent less area in Open States, but by year 50 is only 1to 8 percent less open. The differences in frequent fire mixed conifer are not as large, as the rate of mechanical treatment is lower in this vegetation community; they range from 1to 6 percent less area in Open States than the preferred alternative. The higher percentage of closed states, with canopy cover greater than 30 percent under these alternatives indicates a corresponding higher risk of uncharacteristic wildfire and lower understory abundance.

Regenerate aspen to ensure long-term healthy aspen populations:

Alternatives C and D also include the objectives to fence 200 acres of aspen and reduce conifer encroachment on 800 acres of aspen within 10 years of plan approval., This emphasis on aspen restoration would make it a priority on the Williams and Tusayan Districts.

These alternatives have considerably less area in States J and K that would promote the retention and regeneration of aspen at all time marks than the preferred alternative. In ponderosa pine, these alternatives have 23 to 30 percent less area in States J and K than the preferred alternative, and 7 to 10 percent less area in frequent fire mixed conifer. Alternative C has the least area in States J and K of all alternatives at all but one time mark (Table 5).

The differences in the pre-settlement tree retention guideline in Alternative C and D may result in less effective treatments for reducing shade and competition from conifers than under the large tree retention guideline in Alternative B as more conifers would likely be retained. This is because the tree retention guideline in Alternative C and D, based on the age of the tree cannot be

accurately determined visually, and coring individual trees to determine age is labor and cost intensive. To facilitate implementation, a diameter cap is used to avoid the cost and labor. Because all coniferous trees above the diameter cap would be retained, treatment would likely result in more trees being retained, and less effective grassland restoration treatments than under Alternative B.

Restore grasslands by reducing tree encroachment and restoring fire:

Alternatives C and D include objective to reduce tree density to less than 10 percent on 5,000 to 10,000 acres of historic grasslands annually. Again, the amount of grassland restoration treatment is not expected to be different between alternatives.

The differences in the pre-settlement tree retention guideline in Alternative C and D may result in less effective treatments for reducing conifer encroachment than under the large tree retention guideline in Alternative B as more conifers would likely be retained.

Management Response to large disturbance events:

All action alternatives include an objective to replant and average of 300 to 700 acres annually to provide a seed source and restore forest structure in uncharacteristic openings following large scale disturbances in ponderosa pine and frequent fire mixed conifer vegetation types to set conditions on a trajectory toward desired conditions. Alternative D and the Wildlife Habitat Complex in Alternative C are not to be managed for timber production once stand structure is restored. Current law, regulation and policy calls for planting following stand replacing fire in areas that are in the suitable timber base. Because these areas would not be managed for suitable timber, and planting on suitable timber lands would take priority, it is less likely that scarce funds would be expended for planting on these lands following uncharacteristic fire. Without planting, the time to return to the desired condition is significantly increased.

Comparison of Alternatives

Modify Stand Structure and species composition to restore or maintain sustainability, and restore historic fire regime:

Alternative B is more effective overall at meeting the evaluation criteria for this priority need for change than all others, and would best promote resiliency in the face of climate change. This is the case for both ponderosa pine and dry mixed conifer.

Alternative B is more effective in achieving the desired stand structure, State K, than all other alternatives, with more than double the area in the mid-scale desired condition in ponderosa pine at all time marks. The same is true for frequent fire mixed conifer at the 10, 15, and 50 year time marks.

The index for time departure for Alternative B indicates the least time for attainment of mid-scale desired conditions at all time marks for both ponderosa pine and frequent fire mixed conifer. Overall, the differences between the alternatives are smaller for this evaluation criterion than other mid-scale desired condition attainment differences. Alternative A takes more time to reach desired conditions because the current rate of treatment is lower than in Alternative B. Alternative B responds better than Alternatives C and D for this evaluation criterion because of group selection matrix thinning in Alternative B versus treatments thinning from below in Alternatives C and D which takes longer to achieve a multi-storied state.

Alternative B scores the highest on the density departure index indicating the least relative risk of uncharacteristic loss of forest structure from density dependent disturbance such as active crown fire. Again, in Alternative A, the rate of treatment to modify stand structure is lower than in the action alternatives. In Alternatives C and D, mechanical treatment decreases over time, and trees continue to grow and stands become more dense. Overall, the differences between the alternatives are intermediate compared to other mid-scale desired condition attainment differences.

Fine scale heterogeneity is expected to be higher under Alternative B, providing more of the fine scale desired condition of irregularly-spaced groups of trees with variable spacing that are surrounded by openings, and the mix of similar or variable ages within groups. Alternative A has a lower rate of application of treatments that create fine scale heterogeneity. The pre-settlement tree retention guideline in Alternatives C and D, which is likely implemented by thinning from below or thinning to a diameter cap, results in more single storied states, and more trees retained in potential interspaces that with the large tree retention guideline in Alternative B. Differences between alternatives are intermediate for this criterion.

In ponderosa pine, Alternative B has the highest relative potential understory abundance at three of four time marks. Alternative D has the highest at Year 250 because it has the most area in the uncharacteristic State resulting from stand replacing fire. In frequent fire mixed conifer, Alternative D has the highest percentage of potential understory abundance at the 10 year time mark, the same percentage as Alternative B at the 15 year time mark, with Alternative B having the highest at the 50 and 250 year time mark. Differences between alternatives for this criterion are fairly small. Differences are smaller in mixed conifer than in ponderosa pine due to the lower rates of treatment to create stand structure with interspaces.

In ponderosa pine, Alternative B is expected to have more area in characteristic Open States with 30 percent canopy cover or less, than all other alternatives. With less canopy continuity the risk of uncharacteristic high severity fires would be the least under this alternative. Alternative B has the highest percentage of Open States at all time marks. In frequent fire mixed conifer, all the action alternatives have more area in Open States than in Alternative A; in Alternative A the treatment rate is too slow to create and maintain open states in a dynamic environment. Alternative D has the most area in Open States at the 10 year time mark, the same as Alternative B at the 15 year time mark, with Alternative B having the highest at the 50 and 250 year time mark. Differences between alternatives for this criterion are fairly small.

Alternative A would continue to require suppression action on wildfires within the mixed conifer type of the North Kaibab Ranger District, within a two mile radius of North Canyon Spring, in the Frank's Lake Geologic Botanic Area, and in the Arizona Bugbane Conservation Area. It also places prescriptive criteria on when wildfires must be suppressed in the pine-oak habitat type on the Williams Ranger District; wildfires could not be managed to reduce the threat of high severity wildfire to these biologically unique areas by managing wildfires to consume accumulated fuels when fire weather and fuel moisture conditions are appropriate. In all action alternatives the full range of management responses to wildfires would be available across the Forest, except in desert communities where wildfires would be suppressed.

Regenerate aspen to ensure long-term healthy aspen populations:

All action alternatives have objectives for the fencing and reducing conifer encroachment in aspen stands which would make this work a priority on the Williams and Tusayan Ranger District, but Alternative A does not. Treatments would likely continue under Alternative A, but perhaps not to the extent under the action alternatives.

Effectiveness of treatments is likely to be greater under Alternative A than in the action alternatives, as it would not have large tree retention guidelines, so shading and competition from conifers could be more effectively removed. Under Alternatives B, C and D, trees meeting the large tree retention guidelines would not be removed. The retention guidelines in Alternative C and D that retains all pre-settlement trees would likely retain more conifer encroachment than under the large tree retention guideline in Alternative B.

Alternative B is expected to have more area in desired, and nearing desired conditions in ponderosa pine and frequent fire mixed conifer than the other alternatives, where aspen clones are likely to be more resilient – able to withstand droughts, and regenerate in place. Alternative A has 20 to 25 percent less area in States J and K in ponderosa pine, and 3 to 9 percent less area in these States in frequent fire mixed conifer. Alternatives C and D have 23 to 30 percent less area in States J and K in ponderosa pine than the preferred alternative, and 7 to 10 percent less area in these stated in frequent fire mixed conifer.

Restore grasslands by reducing tree encroachment and restoring fire:

All action alternatives have objectives for reducing tree and shrub encroachment in grasslands which would make this work a priority on the Williams and North Kaibab Ranger District, but Alternative A does not. Treatments would likely continue under Alternative A, but perhaps not to the extent under the action alternatives.

Overall, the amount of grassland restoration is not expected to be very different between alternatives. Effectiveness of treatments is likely to be somewhat higher for Alternative A than for Alternatives B, C, and D which have large tree retention guidelines. C and D would likely be less effective than B, as all pre-settlement trees, would be retained.

Management Response to large disturbance events:

In Alternative A, there are no objectives for planting to move stand structure on a trajectory back towards desired conditions following uncharacteristic, large scale disturbances, such as stand replacing wildfire. Planting does occur, but not at a rate sufficient to counter loss of forest structure from uncharacteristic disturbance.

All action alternatives contain an objective to plant an average of 300 to 700 acres annually in ponderosa pine and frequent fire mixed conifer.

Alternative D and the Wildlife Habitat Complex in Alternative C are not to be managed for timber production once stand structure is restored. Current law, regulation and policy calls for planting following stand replacing fire in areas that are in the suitable timber base. Because these areas would not be managed for suitable timber, and planting on suitable timber lands would take priority, it is less likely that scarce funds would be expended for planting on these lands following uncharacteristic fire. Without planting, the time to return to the desired condition is significantly increased.

Table 6. Summary of plan alternatives' response to evaluation criteria (Kleindienst 2012).

✓✓ = very good response to evaluation criteria

✓ = good

– = neutral

✘ = poor

✘✘ = very poor

Priority Need for Change	Evaluation Criteria	Response to evaluation criteria			
		Alt. A	Alt. B	Alt. C	Alt. D
Modify stand structure to meet mid-scale desired conditions for ponderosa pine and frequent fire mixed conifer	Percent of vegetation type in desired structural State	✓	✓✓	✓	✓
	Time to achieve desired conditions	–	✓	–	–
	Reduced risk of uncharacteristic loss of stand structure due to density related disturbances, primarily active crown fire	✓	✓	✓	✓
Modify stand structure to meet fine-scale desired conditions for ponderosa pine and frequent fire mixed conifer	Fine-scale heterogeneity	–	✓✓	–	–
Restore historic fire regime	Potential understory abundance	✘	✓	–	–
	Percent of vegetation type in Open States with 30% crown cover or less that promote surface fire rather than active crown fire	✓	✓✓	✓✓	✓✓
Protect and regenerate aspen	Objectives would exist in the land management plant to make this work a priority on the Williams and Tusayan Ranger District	✘	✓	✓	✓
	Percent of area in States J and K that promote the restoration and regeneration of aspen	✓	✓✓	✓	✓
	Guidelines in the land management plan would not limit effective removal of conifer encroachment	✓	–	✘	✘
Restore grasslands	Objectives would exist in the land management plant to make this work a priority on the Williams and Tusayan Ranger District	✘	✓	✓	✓
	Guidelines in the land management plan would not limit effective removal of conifer encroachment	✓	–	✘	✘
Management response to large disturbance events	Acres planted	✘	✓✓	✓	–

Relationship of Short-Term Uses and Long-Term Productivity

None of the uses discussed in this report are expected to result in a trade-off with long-term productivity. Indeed, all three action alternatives seek to harmonize short-term uses with long-term productivity rather than create trade-offs.

The biggest risk to long-term productivity is from stand-replacing fire, with soil losses (KNF 2013a), decreased wood production (discussed in the economics specialist report) and decreased native understory or grassland productivity (discussed in this report). There are differences in alternatives that result in more or less modification of stand structure, which correlates to the amount of stand-replacing fire and understory productivity in ponderosa pine and dry mixed conifer systems.

Some wood is expected to be coincidentally produced from activities that restore grasslands and aspen clones, likely removing them from future wood production. However, the trade-off here is between different long-term productivity choices rather than a short-term use.

Cumulative Environmental Consequences

Cumulative effects to vegetation and fire behavior are examined from a temporal point of view as the sum of the effects of past management practices over time on the Kaibab National Forest. Cumulative effects are then explored in the larger spatial context as the contribution of the Forest's vegetation and fire management practices to the surrounding landscape.

Temporal Cumulative Environmental Consequences

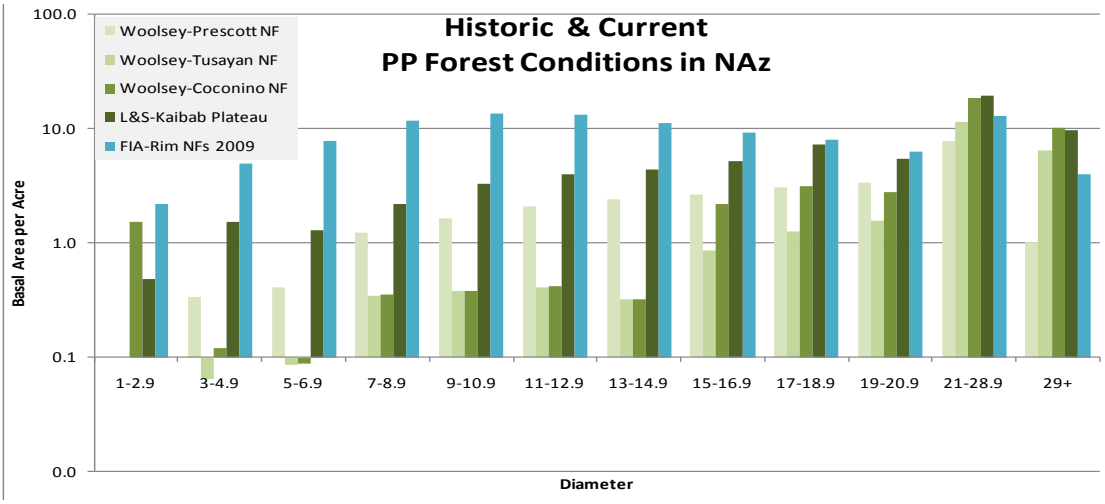
The sum of past management actions over time have resulted in the departure of most vegetation communities from their characteristic states on and around the Kaibab National Forest. (See Table 2). Figure 4 displays this departure for ponderosa pine. Data in this figure from vegetative surveys compares historic conditions on or near the Kaibab to current forest basal area by size class. Very similar departures for dry mixed conifer have been documented on and near the Kaibab (Fulé and others 2003).

The Lang & Stewart reconnaissance and the Woolsey inventories were collected ca 1909 from northern Arizona National Forests in 'average conditions' or 'average stands' for timber valuation purposes. Lang & Stewart's data was from the Kaibab Plateau while the Woolsey inventories were collected on the Prescott, Kaibab and Coconino National Forests (Lang & Stewart 1909 and Woolsey 1911). The Forest Inventory Analysis (FIA) data is from across the Mogollon Rim area on the Apache/Sitgreaves, Tonto, Coconino, and Kaibab National Forests, queried in 2009. All data are for ponderosa pine forests. Basal area, on the Y axis is the measure in square feet per acre that is occupied by the cross-section of tree trunks and stems at breast height. This data shows that tree density has increased in all size classes of trees through 21"in diameter over the past century across the ponderosa pine area in Northern Arizona. For larger trees, the data is mixed.

These departures are largely due to fire suppression, in conjunction with past, unsustainable grazing practices, a focus on large-tree timber harvest, and other anthropogenic changes to natural processes. They have resulted in a dramatic increase in stand replacing fires, particularly since the mid-1990's, decreases in water yields, degradation of aspen stands, and the encroachment of grasslands; these conditions resulted in the Priority Needs for Change identified for Forest Plan Revision. Departures from reference conditions exist in all vegetation types on the Kaibab, and most continue to trend further from reference conditions. Further discussion of the causes of departure and trends is found in the Affected Environment section of this report, in the

Comprehensive Evaluation Report (KNF 2009), the Ecological Sustainability Report (KNF 2008a), and the Vegetation and Fire Ecological Need for Change Report (KNF 2008a).

Figure 4: Comparison of forest density from historic and contemporary ponderosa pine forest in Northern Arizona.



Some successes have been realized in the past two decades in restoring historic fire regimes on the Kaibab National Forest, particularly on the Tusayan Ranger District and to some degree on the Williams Ranger District. Through the use of prescribed burns and wildfires, most of the forested type on the Tusayan Ranger District, which consists of ponderosa pine and the transition zones from pinyon-juniper types into pine, has experienced low intensity fire once to several times in the past 15 years. Wildfires are now able to perform their natural role as a disturbance factor in many areas even during the traditional peak of fire season with rare, fine scale, undesirable fire behavior. Those fires that are suppressed are often due to social limitations for nuisance smoke, or limited resource availability to manage these fires for their longer duration due to other fire activity on or off the Forest. Similar benefits are starting to be seen on the more remote areas of the Williams District where forest structure is less departed from reference conditions.

Cumulative Environmental Consequences within the Context of the Surrounding Landscape

The Kaibab is inherently connected to its surrounding landscape, regardless of administrative boundaries. To compare the effects of Kaibab proposed management to the surrounding landscape in the spatial context, they are evaluated considering the management actions of other entities within shared Sections from Bailey's Ecoregion Units (Bailey et al. 1994, McNab and Avers 1994). For cumulative effects, each of the three sections that contain Kaibab lands is considered separately.

Bailey's Ecoregions is a hierarchal system for classifying ecosystems and commonly used for ecosystem analysis at mid- to large scales. This system divides the United States into Domains, then Divisions, and then further divides them into Provinces and Sections. Sections are described

by broad areas of similar sub-regional climate, geomorphic process, geology, geomorphic origin, topography, and drainage networks.

The Kaibab National Forest is located in the Dry Domain that covers much of the western United States. Table 7 displays the distribution of Kaibab National Forest lands within Bailey's Ecoregion Sections in that Domain.

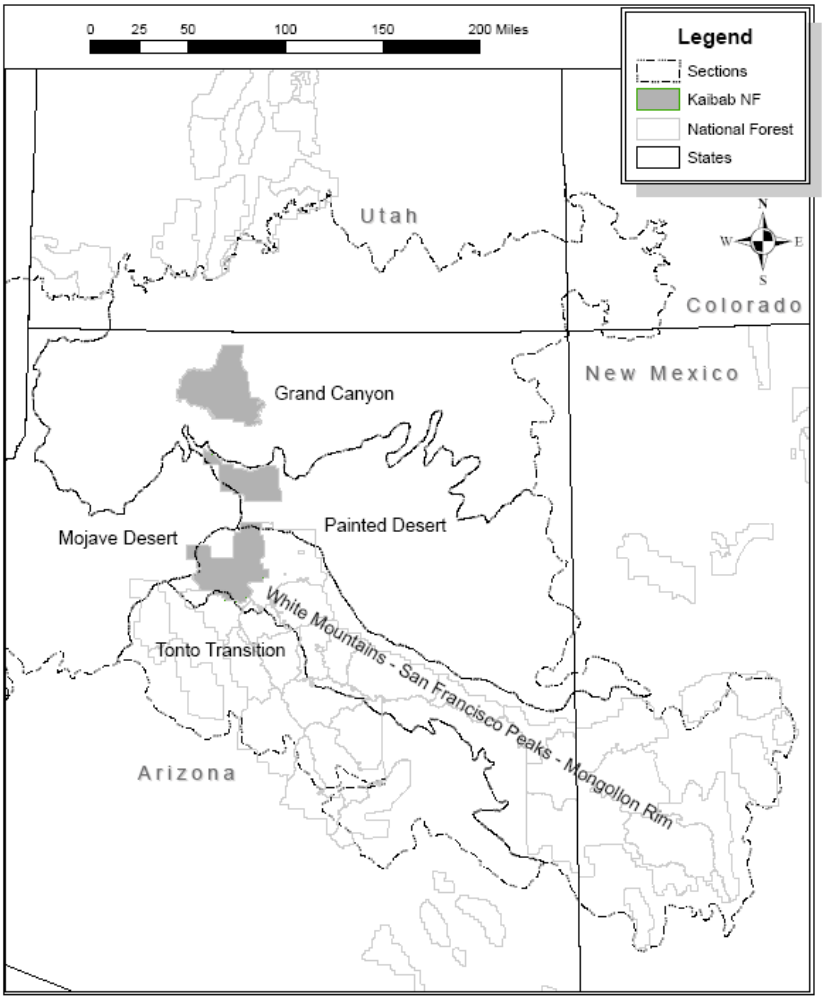
Table 7: Relationship of the land area between the Kaibab National Forest Ranger Districts and Bailey's Ecoregion Sections (Bailey et al. 1994).

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

*Less than 5% of the Tusayan and Williams Ranger Districts fall within the Mohave Desert Section and the Tonto Transition Section. Since there are no objectives analyzed for the vegetation types in this limited area all acres on the Tusayan Ranger District are analyzed as part of the Painted Desert Section, and all acres of the Williams Ranger District are analyzed as part of the White Mountains – San Francisco Peaks – Mogollon Rim Section.

Figure 5 displays the location of the Kaibab within the Sections. Each of the three Ranger Districts falls almost entirely into separate Sections, which highlights how different each Ranger District is from each other.

Figure 5: Bailey's ECOMAP Sections, containing the Kaibab National Forest. Other National Forest lands in or near the Sections are also shown.



North Kaibab Ranger District in Context of the Grand Canyon Section

The North Kaibab Ranger District is in the Grand Canyon Section. This section includes lands administered by the Navajo Nation, Hopi tribe, Southern Utah Paiute Tribe, Arizona Strip BLM, Grand Canyon and other National Park Service area, the State of Arizona, slivers of the Dixie National Forest, and all of the North Kaibab Ranger District. In this section, the elevation of the Kaibab Plateau has led to its description as a green island in the midst of an ocean of desert. This "island" contains most of the ponderosa pine, mixed conifer and other forested types in the Section. The Grand Canyon National Park and the Kaibab National Forest are the primary land management agencies. The North Kaibab Ranger District covers only 3 percent of the Section, yet it has 28 percent of the ponderosa pine, 39 percent of the mixed conifer, and 44 percent of the spruce-fir vegetation type. The Park implements limited mechanical treatments to modify stand structure, usually to protect human improvements and heritage resources. In the past two decades, however, the Park has used wildland fire extensively, with a wide range of effects, to restore historic fire regimes and improve the resiliency of the forested types. On parts of the boundary between the agencies, this has reduced the risk of high severity fires originating on the Park burning onto the Forest, pushed by predominant summer southwesterly winds, where until recently fuel loads were much higher, and forest stands much denser. This risk is still present and high on other parts of the boundary area. Isolated pockets of ponderosa pine on the Park, such as on the Powell Plateau, have seen little, if any fire suppression, and are used as a guide for reference conditions in the type. The Forest uses both mechanical treatments and wildland fires.

The use of wildland fire in mixed conifer types is limited to prescribed fires on the Forest under the current plan, which limits the ability to manage wildfires across boundary with the Park to reduce the risk of stand replacing fires. Under the action alternatives, wildfires could be managed across the boundary to achieve similar objectives of improving the resiliency of the mixed conifer type on the Plateau. Outside of Plan restrictions, few barriers to such cross boundary management exist as there is one interagency Fire Management organization, comprised of both Park and Forest Service personnel, responsible for all fire management on the Kaibab Plateau.

Objectives to accelerate the rate of modification to enhance or restore forest structure in the ponderosa pine and mixed conifer types, under the action alternatives, would improve the resiliency of these vegetation types to climate change. Because of their limited extent in the Section they provide the habitat for many species that does not exist elsewhere in the Section. Such restoration would have positive outcomes in limiting susceptibility to stand replacing fire. Using wildland fire to reduce large scale uncharacteristic events is not without risk.

For lower elevation vegetation types also present on the Kaibab and in the Section, the Bureau of Land Management & tribal lands are the predominant land management agencies, with the Park Service and Forest Service playing a lesser role. These vegetation types are all departed and little treatment is being done to improve departures from reference condition. The North Kaibab Ranger District contains 25 percent of the montane/subalpine grassland vegetation type in the section, and objectives to remove encroachment in the action alternatives will benefit this type in the larger context of the section. The cottonwood-willow vegetation type in Kanab Creek Wilderness is highly departed due to tamarisk invasion, and the lack of flood disturbances due to impoundments upstream and off the Forest. Few options for management actions to improve conditions exist, and so did not rise as a Priority Need for Change within the planning period, but will still likely provide a refugium for species requiring a low elevation riparian habitat within the Section.

Tusayan Ranger District in Context of the Painted Desert Section

The Tusayan Ranger District is located in the Painted Desert Section. This section includes lands administered by the Kaibab National Forest, the Navajo Nation, the Hopi Tribe, a small portion of the Coconino National Forest, and the State of Arizona. The Tusayan District occupies about four percent of the section. Despite its limited extent, it contains 78 percent of the ponderosa pine vegetation type, and 100 percent of the montane grasslands in the Section.

The ponderosa pine vegetation on the south side of the Grand Canyon National Park lies within the Grand Canyon Section, but shares borders with the Tusayan Ranger District. As on the Tusayan Ranger District, most of the ponderosa pine type on the Park has experienced one or several fire entries in the past decades, and is approaching the historic fire regime. Prescribed burning projects are coordinated across boundaries to complement each other to achieve maximum benefit in reducing the risk to highly valued human improvements, maintain reference fuel loads, and improve ecosystem resiliency to uncharacteristic fire. The first wildfire to be used to accomplish resource benefits across agency boundaries, the Ruby Complex, occurred in 2009. Objectives and tactics for the fire were slightly different on each agency's lands, but were successfully achieved with a single incident command structure, and no adverse outcomes during peak fire season for the year. This cross boundary management approach is included in the Management Approach in the action alternatives for the Revised Plan, as well as in the Federal Wildland Fire Policy.

Objectives in the action alternatives would promote continued modification of stand structure to reduce susceptibility to large uncharacteristic fire events. The first recorded large fire event over 1,000 acres, since shortly after the turn of the century, on the Tusayan Ranger District occurred in April of 2007. The X Fire was a human caused fire originating from a campfire, which burned 2,048 acres during a wind event after a dry March, with high percentage of stand replacing fire. This fire demonstrates that structural change to move towards reference conditions is a necessary compliment to treatment with fire, as much of this area had been burned with prescribed fire within the last 15 years. Under 90th percentile fire weather conditions and above, wildfire can still exhibit uncharacteristic outcomes in departed stand structure despite reference fire return intervals.

Objectives for restoration of grasslands in the action alternatives would continue and enhance refugiua for grassland related species, as this vegetation type does not occur elsewhere in the Section.

Aspen clones on the Tusayan Ranger District are small and rare in that there are a dozen or less, and even rarer in the Section. This is believed to be true under reference conditions as well. Objectives in the aspen alternatives to retain and regenerate aspen clones could be achieved with limited funds and resources. Though small, these tiny rare clones have high biodiversity, and provide small pockets of refugia for aspen related species, and not found elsewhere in the section. Climate change may eliminate these rare components of the ponderosa pine type in the Section despite management action.

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

This Section is located on the Mogollon Plateau above the Mogollon Rim -a pronounced demarcation in elevation in Northern Arizona. The Williams Ranger District on the Kaibab, as well as the Coconino National Forest, the Apache-Sitgreaves National Forest, Fort Apache Tribal lands, and Arizona State administer lands in this Section. The Williams Ranger District occupies just over four percent of the section. Less than 5 percent of the ponderosa pine is on the District,

and has around two percent of the mixed conifer vegetation type. For montane/subalpine grassland, however, it has 23 percent of the vegetation type, and 100 percent of the Gambel oak shrubland. The latter may be because this vegetation type on the Coconino National Forest was classified as another woodland type.

The Coconino National Forest and the Apache-Sitgreaves National Forest are in the process of revising their land management plans concurrently with the Kaibab based upon the same Regional vegetative desired conditions, standards and guidelines, and similar objectives for ponderosa pine and mixed conifer. Though the Kaibab has a small percentage of the ponderosa pine and mixed conifer types in the Section, the cumulative restoration activities from the action alternatives from these plans could have a pronounced effect on modifying stand structure to be less susceptible to stand replacing fire in these vegetation types across the Section, and improving the resiliency and adaptability of these types to climate change. The long term in carbon sequestration at this scale would be notable.

Recognized across agency boundaries is that the current rate of stand structure modification is not sufficient to compensate for increasingly departed states from reference conditions. To accelerate structure modification, to get ahead of increasing departure, planning at scales large enough to attract a market for small diameter biomass, in areas where consensus from stakeholders is high, and desired states can be rapidly achieved through mechanical treatments is necessary. This means focusing on dense forest areas in larger states where effective mechanical structural modification can reduce stand structure to desired conditions, and away from areas where risk cannot be effectively treated due to limitations of law, regulation or policy, such as Mexican spotted owl protected activity centers. It also diverts treatment from areas that may not be in the desired state due to low tree density, that are at low risk of stand replacing fire, and that will take decades to grow to desired stand structure.

One such planning effort, already underway, is the Four Forest Restoration Initiative. Stakeholders are actively participating in this planning process to complete landscape scale planning over a 2.4 million acre analysis area. The cumulative effect of structural modification of the ponderosa pine type towards desired conditions as part of this project, in conjunction with the portions of the project on the Williams and Tusayan Ranger Districts would have widespread beneficial outcomes in restoration of the ponderosa pine type across the Section and beyond. If successful, this effort could decrease susceptibility to large and uncharacteristic disturbances, increase water yields from winter snowfall through the creation of interspaces, and provide long term carbon sequestration in large old trees at a scale meaningful to improving the resiliency and ability to adapt to climate change of in the ponderosa pine type of the southwest.

Objectives for aspen in the action alternatives will benefit the aspen component of ponderosa pine and mixed conifer that are declining throughout the Section. Elk herbivory is accelerating aspen decline on the Williams District outside of other uncertain influences on aspen decline. The high biodiversity associated with this component of the vegetation types merits the limited planning, funding and resource requirements to deter further aspen decline.

With 23 percent of the montane/subalpine grassland in the Section, the objectives for reducing encroachment in this vegetation type would provide a refugium for grassland related species.

Wildland fire is widely used on all agency lands in the Section, including some burning by the State on State lands and the Navajo Army Depot, and by the City of Flagstaff and other municipalities. Due to such widespread burning across the Section, smoke management is critical to maintain public support for prescribed burns and the use of wildfires to achieve resource benefits. This topic is covered in the Air Quality Specialist Report (Kaibab 2011a).

Summary of Cumulative Effects

The sum of past management actions over time have resulted in the departure of most PNVTs from their characteristic states on and around the Kaibab National Forest. These departures are largely due to fire suppression, in conjunction with past, unsustainable grazing practices, and other anthropogenic disturbances of natural processes. It has resulted in a dramatic increase in stand replacing fires, particularly since the mid-1990's, decreases in water yields, degradation of aspen stands, and the encroachment of grasslands, and lead to the Priority Needs for Change identified for Forest Plan Revision. Departures from reference conditions exist in all vegetation types on the Kaibab, and most continue to trend further from reference conditions.

The cumulative effects of proposed management actions on the Kaibab in the context of the larger landscape for the North Kaibab Ranger District and the Tusayan Ranger District are largely to provide a refugium for species in the Section requiring ponderosa pine, mixed conifer (on the North Kaibab), aspen, and grasslands, as these vegetation types are rare elsewhere in the Grand Canyon and Painted Desert Sections of Bailey's Ecoregions.

The cumulative effects of proposed management actions on the Kaibab in the context of the larger landscape for the Williams Ranger District include providing refugiua for grassland related species, and contributing it's part to modifying stand structure in ponderosa pine towards desired conditions and restoring historic fire regimes at a broad scale across the White Mountain-San Francisco Peak-Mogollon Rim Section to reduce large scale disturbance and increase resiliency and ability to adapt to climate change to a significant portion of the ponderosa pine type in Northern Arizona.

Unavoidable Adverse Impacts

Land management plans provide a programmatic framework that guides site-specific actions but does not authorize, fund, or carry out any project or activity. Before any ground-disturbing actions take place, they must be authorized in a subsequent site-specific environmental analysis. Therefore none of the alternatives cause unavoidable adverse impacts.

Smoke is a byproduct of prescribed burns and wildfires under all alternatives. While all Alternatives are expected to meet the desired conditions for Air Quality in complying with State and Federal emissions regulations, the public tolerance for smoke is often reached long before health and visibility standards are exceeded. All Alternatives recognize the critical role of fire in the ecosystem, and promote fire disturbance within the range of historic fire regimes. The number of acres that can be burned per year, however, is limited not only by legal limits, but also by social, climatological, and logistical limits. Land managers must be responsive to the public's fluctuating tolerance for smoke to maintain public support for prescribed burns and the beneficial use of wildfires. Air Quality impacts are further discussed in the Kaibab National Forest Air Quality Specialist Report (KNF 2012).

Ground disturbance is a byproduct of mechanical treatments to improve and restore stand structure, and is also present, in varying amounts under all Alternatives. The risk of non-native plant invasion is increased by even small-scale ground disturbance. The impacts of ground disturbance are further discussed in the Draft Invasive Species Specialist Report (KNF 2013b).

Irreversible and Irretrievable Commitment of Resources

Land management plans provide a programmatic framework that guides site-specific actions but does not authorize, fund, or carryout any project or activity. Because the land management plan

does not authorize or mandate any site-specific project or activity (including ground-disturbing actions), none of the alternatives cause an irreversible or irretrievable commitment of resources.

Adaptive Management

All alternatives assume the use of adaptive management principles. Forest Service decisions are made as part of an on-going process, including planning, implementing projects, and monitoring and evaluation. The land management plan identifies a monitoring program. Monitoring the results of actions will provide a flow of information that may indicate the need to change a course of action or the land management plan. Scientific findings and the needs of society may also indicate the need to adapt resource management to new information. The Forest Supervisor annually evaluates the monitoring information displayed in the evaluation reports through a management review and determines if any changes are needed in management actions or the plan itself. In general, annual evaluations of the monitoring information consider the following questions:

- What are the effects of resource management activities on the productivity of the land?
- To what degree are resource management activities maintaining or making progress toward the desired conditions and objectives for the plan?
- What changes are needed to account for unanticipated changes in conditions?

In addition to annual monitoring and evaluation, the Forest Supervisor reviews the conditions on the land covered by the plan at least every 5 years to determine whether conditions or demands of the public have changed significantly. The Forest Supervisor may amend the plan at any time.

Consistency with Law, Regulation, and Policy

All alternatives are designed to guide the Kaibab National Forest management activities in meeting federal law, regulations, and policy

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Appendix A - Indices

Several criteria used to evaluate progress toward desired conditions have a number of moving parts. One example is that the VDDT models for both PPF and MCD have 14 states, with only one that represents the DC. So, how do changes in the other states represent progress? It can be quite difficult to compare alternatives directly. To facilitate comparisons, a number of indices were developed that weight these moving parts in some way and reduce them to a single value at any time mark. The indices used are documented below.

Interspersion Creation Index

A key fine-scale element of the DCs for PPF and MCD is interspersion of structural states. Currently, there is much less interspersion (fine-scale heterogeneity) than desired. Various disturbances can be very effective at creating or further destroying interspersion. Some have little effect upon it. Some, such as frequent surface fire, could be very effective at maintaining interspersion over time but are ineffective at creating it. This index is aimed at creating interspersion, since it is generally deficient currently.

Interspersion creation index

Fine-scale Interspersion Creation Matrix

Disturbance	Value		Crosswalk
B Free thin all sizes to target BA	4	All Alternatives derive their index values from this cell range.	All IntThinning - IntThin16inchLimit
C Thin from below to target BA	3		-
D Thin under 16-inch diameter to BA	2		IntThin16inchLimit
E GroupSelect with matrix thin	5		GroupSelection
F Shelterwood seed cut to target BA	2		All RegenHarvest
G Clearcut with legacy trees	1		-
H Clearcut-Coppice	1		-
I Plant Seedlings	0		All Initiate Regeneration - All NatRegen
J RX FIRE ONLY low conditions	2		0.25 * (All Prescribed Burning)
K RX FIRE ONLY moderate conditions	3		0.75 * (All Prescribed Burning)
L RX FIRE ONLY high conditions	0		-
M Thin under 9-inch diameter to BA	2		-
Insect and Disease	3		Insect/Disease
Natural Regeneration	3		All NatRegen
Nonlethal Fire	2		None modeled
Mixed Severity Fire	4		None modeled
Stand Replacing Fire	0		Stand Replacing Fire

Figure 1. Assigned Interspersion Creation Values and Area Crosswalk to VDDT Outputs.

The shaded column of Figure 1 displays the assigned values for most disturbances available to model in the PPF and MCD VDDT models. Only a few of these were actually used in modeling for the KNF. The right side of the figure provides a crosswalk between the modeled disturbances and the summary reporting from VDDT. For example, VDDT reports 'All Prescribed Burning'. The crosswalk on the right allocates it as 25% to "J Rx Fire…" and 75% to "K RX Fire…."The acres of disturbance at each time mark are allocated as shown in the crosswalk and then multiplied by the value in the shaded column. All the results for a time mark are summed and divided by the total acres for all the disturbances to arrive at an index value for the time mark. Example: In PPF - Alternative A at time mark 10, the VDDT model reported 18,783 acres of All Prescribed Burning. 25% of this is assigned to "J Rx Fire…", or 4696 acres. This area is weighted by 2 to create an "Interspersion Raw Value" of 9392. Figure 2 shows this example in the shaded

row. Summing this raw value with all the others for year 10 (= 70,823) and dividing by the total area for all of them (= 25,807) results in an interspersion creation value of 2.7.

Interspersion creation raw value				
0	10	15	50	250
2200	2864	2343	1302	2343
1100	1757	1367	1041	1041
4965	5858	5044	3905	5858
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
6500	9392	9596	9485	9211
29250	42263	43182	42683	41450
0	0	0	0	0
0	0	0	0	0
1943	8689	6792	6949	4934
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
45958	70823	68324	65366	64837

Interspersion creation index				
0	10	15	50	250
2.7	2.7	2.7	2.7	2.8

Figure 2. Example of Interspersion Raw Values and Index values from PPF, Alternative A.

Time Departure Index

This index is based upon attainment of State K (the middle-scale desired condition) having a value of "1" and other states having lesser values, depending upon how "far" they are from State K in the time it would take for each state to grow into State K.

Beginning with State A, a relatively optimal pathway from any state to State K is assumed. For State A, it is assumed it would take 200 years to reach State K. This time is consistent with Table 1, Appendix 5, of "The Management Recommendations for the Northern Goshawk in the Southwestern United States." The assumption includes a basal area of 60 and periodic disturbances that generally maintain an open-canopied condition at the middle scale and that multiple stories gradually develop within the middle scale polygon. Hence, State A has a value of 1/200, or 0.005.

For single-storied states (at the middle scale) it is assumed that it will take 80 years (two disturbances that create openings that can regenerate trees plus the subsequent time to regeneration actually establishing) to develop three age classes. So, single-storied states with a multi-storied corollary have an index value of 80/200, or 0.4 lower than the multi-stored state corollary to account for the 80 years to develop three stories. For example, State E is very large and open, but single-storied, so its multi-storied corollary is State K. State K has a value of 1, so State E has a value of 1 – 0.4, or 0.6.

It is also optimistically assumed that it will take 5 years to move from a closed state to an open state; presuming management efforts will be robust and focused upon opening up dense middle-

scale states. Therefore dense states have a 5/200, or 0.025 lower value than their open-state corollaries.

Movement out of State N is assumed to not occur without planting - setting the index value of State N to 0 (0.0001). However, planting is assumed to succeed within twenty years, creating a State B. This Forest has successfully reestablished at least historic densities of PP through planting [and none through natural means] in every crown fire area evaluated on 4 fires since the late 1960s (Higgins 2008). A weighted average of reforestation success is about 69% per attempt.

Index values for States A, E, I, K and N were used as "sideboards" to impute the values for the remaining states. For a given alternative and time mark, percents of each state are multiplied by the corresponding state value and summed to arrive at the index value.

Figure 3 shows an example for Alternative A in ponderosa pine forest. The sideboard state index values on the left side have green (dark) shading. The left side shows conditions at time mark 10 and the right side shows all four time marks evaluated – 10, 15, 50 and 250 years.

State	A	B	C	D	E	
Index	0.005	0.100	0.225	0.525	0.600	
% of PNVT	5.18%	2.70%	2.92%	10.86%	9.83%	
State	N	F	G	H	I	
Index	0.000	0.075	0.200	0.500	0.575	
% of PNVT	2.10%	3.36%	7.20%	17.14%	4.68%	
State				J	K	
Index				0.850	1.000	
% of PNVT				7.85%	4.15%	
State				L	M	
Index				0.825	0.975	
% of PNVT				18.79%	3.27%	

	Inputs (from the 'D' tab for the Alt)			
State	10	15	50	250
A	5	5	4	3
B	3	3	2	2
C	3	3	3	3
D	11	10	6	4
E	10	13	27	34
F	3	4	4	3
G	7	7	8	7
H	17	15	8	5
I	5	5	4	4
J	8	7	5	4
K	4	5	10	13
L	19	17	12	8
M	3	4	4	5
N	2	2	2	4
Index:	0.550	0.552	0.577	0.583

Figure 3. Time Departure Index Example: PPF - Alternative A.

For example, on the left side (time mark 10), 5.18% of the forest is in State A. This value appears on the right side as "5" in the cell in the State A row under the column for (time mark) 10. State A contributes 0.005 * 5.18% = 0.00259 to the index value on the bottom of the right side with yellow (light) shading in the time mark 10 column. Similar calculations are made for all the states to arrive at the overall index value of 0.550 for Alternative A at time mark 10. This compares to the ideal index value of 1.0, which would be the case if all the forest (at the middle scale) were in State K.

It is important to reiterate that this evaluation is made at the middle scale (100 to 1000 contiguous acres.) State K (at the middle scale) contains many fine scale (10 acres or less) elements, representing various proportions of all other states except N. What is important at the middle scale is that these fine scale states "sum up" to an open, multi-storied (uneven-aged) forest with more basal area in large trees than in other tree sizes.

Density Departure Index

This index is similar to the time departure index except that it is designed to be highly sensitive to density and only somewhat sensitive to size. This index focuses much more on the immediate threat posed from density-dependent disturbance, such as crown fire, rather than on the relative time to or difference from DC. The “sideboard” index values are shaded in green (dark); index values for other states were imputed from these.

Figure 4 displays an example of this index for Alternative A – PPF at four time marks. The rest of the logic is identical for this index as it is for the Time Departure Index above.

State	A	B	C	D	E
Index	0.500	0.600	0.700	0.800	0.900
% of PNVT	5.18%	2.70%	2.92%	10.86%	9.83%

State	N	F	G	H	I
Index	0.000	0.300	0.350	0.400	0.450
% of PNVT	2.10%	3.36%	7.20%	17.14%	4.68%

State	J	K
Index	0.900	1.000
% of PNVT	7.85%	4.15%

State	L	M
Index	0.450	0.500
% of PNVT	18.79%	3.27%

State	Inputs (from Index inputs above)			
A	5	5	4	3
B	3	3	2	2
C	3	3	3	3
D	11	10	6	4
E	10	13	27	34
F	3	4	4	3
G	7	7	8	7
H	17	15	8	5
I	5	5	4	4
J	8	7	5	4
K	4	5	10	13
L	19	17	12	8
M	3	4	4	5
N	2	2	2	4
PNVT Index:	0.576	0.590	0.657	0.690

Figure 4. Density Departure Index Example: PPF - Alternative A.

Understory Abundance Index

There is a well-established inverse relationship between overstory tree density and understory (grass-forb-shrub) productivity in PPF on and near the KNF (Deiter 1989 and many others). This index uses derivations of productivity from the Deiter study and associates them with VDDT model states to make predictions about the relative overall native understory abundance for each alternative at four time marks.

However, because there are differences between measurement methodologies of understory production studies and VDDT states do not directly tie to any study, there are a number of subjective elements considered in this index. Professional judgment was used in making assignments of understory production relative to potential.

An unpublished study by Edminster 1993 that correlates tree basal area to tree canopy cover was considered in making judgments about where to break between uses of overstory measures in assigning relative understory productivity to states.

For opening states (A, N) or states dominated by smaller trees (B, C, F, G) a correlation between tree percent crown cover (densiometer) and percent total potential understory production was used. For example, in a canopy cover of 5% is assumed to be the average for State A (which ranges from 0% to 10%). In the left half of Figure 5, values derived from canopy cover information for PPF are highlighted in yellow (light) shading.

In Deiter's study, 5% crown cover is associated with about 90% potential understory production. However, this study was carried out in areas dominated by large trees and most of State A would be thinly occupied by very small trees, so an adjustment was made, assuming smaller trees would not have occupied the site as effectively. So, a value of 97% potential native understory production is assigned to State A.

For State N, tree crown cover is assumed to be essentially 0, however non-native plants are expected to be present. So, a value of 95% potential native understory production is assigned.

For larger tree states (D, E, H, I, J, K, L , M) a correlation between basal area and percent potential understory production was made. For larger trees, it was judged that basal area would be better correlated with understory productivity than percent tree canopy would. In the left half of Figure 5, values derived from basal area information for PPF are highlighted in orange (darker) shading.

For state D, median basal area is assumed to be about 65. This corresponds to about 47% of potential understory production.

Relative Native U/S Abundance Index						Input (from relative attainment index)				
State	CC	BA	SDI	% Pot U/S		0	10	15	50	250
A	5			97	All Alternatives derive their index values from this cell range.	9	5	5	4	3
B	15	20		50		1	3	3	2	2
C	25	23		35		4	3	3	3	3
D	50	65		47		8	11	10	6	4
E	52	71		40		3	10	13	27	34
F	60	89		9		1	3	4	4	3
G	65	105		9		8	7	7	8	7
H	70	120		18		25	17	15	8	5
I	70	120		18		5	5	5	4	4
J	52	71		40		7	8	7	5	4
K	52	71		40		2	4	5	10	13
L	70	120		18		23	19	17	12	8
M	70	120		18		2	3	4	4	5
N	0	0	0	95		2	2	2	2	4
					Indices:	32	32	32	34	36

Figure 5. Relative Native Understory Abundance Index Example: PPF - Alternative A.

The right half of Figure 5 shows the percent of Alternative A in each state currently ("0") in PPF, and at four time marks – 10, 15, 50 and 250. These values are multiplied by the percent of understory production potential, summed, and divided by 100 to arrive at a weighted average, shown as indices on the bottom of the figure. These are deemed to be a relative index, rather than

specific predictions of productivity because of the number of uncertainties in connecting the studies with VDDT states and median density values of states over time.

Studies of MCD are sparse for the KNF, however many understory plants and the dominant overstory in MCD is similar to PPF. The same index was used for both PPF and MCD.

Understory Diversity Index

There is less local science correlating understory diversity in PPF and MCD systems to overstory density than there is for understory productivity. However one study (Laughlin and Grace 2006) has been done. It found open forest had more native species diversity than closed forest and that forest openings had nearly three times as many species in the same area as other parts of the forest. Another study (Griffis et al 2001) found that areas with stand-replacing fire had less native gramnoid diversity than other areas.

These two studies were adapted to construct an understory diversity index as follows. In both PPF and MCD, for each alternative at four time marks (plus current conditions):

- Open forested state percents (B, C, D, E, J, K) were summed
- Forest opening percent (A) was multiplied by three and added to the previous step value
- Stand-replacing fire percent (N) was subtracted from the previous step result.

This is deemed to be only a rough relative index, rather than a specific prediction of diversity because of the number of uncertainties in connecting the studies with VDDT states and the paucity of research available.

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