Ashley National Forest Assessment

Wildland Fire Baseline Report

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for:
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Contents

Tables

Figures

Wildland Fire, a Primary Driver

The effects of wildland fire have the potential to drive ecosystem change at a landscape scale (Hessburg and other 2015). As such, wildland fire is considered a primary disturbance agent that both currently and pre-historically has created this type of change. Insects, pathogens, geologic hazards, and climate change are also disturbance agents having similar potential. Because of the impacts of these changes to the social, economic, and environmental benefits provided by forest ecosystems, it is important to identify these types of disturbances, their effects, and why they occur. This report provides an understanding of the various components of wildland fire and its influence on the Ashley National Forest, as it relates to driving ecosystem change.

Ecological disturbances disrupt an ecosystem, community, population structure, and change elements of the biological and/or physical environment (Malesky and others 2016). A disturbance regime is the cumulative effect of multiple disturbance events over space and time (Keane 2013).

Across the Ashley National Forest, fire has influenced vegetative patterns, composition, structure, and development of both individual stands and the larger landscape. Existing disturbance regimes are markedly altered from natural disturbance regimes (Bassman and others 2015). Today's landscape patterns are largely a byproduct of the cumulative effects of human activities and altered disturbance regimes.

The Ashley National Forest has a mixture of forest types resulting from variations in moisture, temperature, and vegetative composition. These forests have undergone extraordinary changes during the 20th century. The evidence is based on repeat photography, fire-scar analyses, forest stand reconstructions, and pollen and charcoal studies. Among the changes are substantial increases in the density of trees and landscape-scale continuity of heavy fuels (flammable vegetation and other naturals that would be "fuel" for a fire). Today, in place of an open understory, conditions reflect brush, downed timber and many young trees. Fires that start on the ground can spread quickly and then climb through the branches of small trees, which create a "ladder" to the larger trees in the forest canopy.

Data presented in this assessment quantifies current and historical indicators and stressors that are linked to wildland fire within the Ashley National Forest. The forest vegetation types associated with Utah Fire Groups, and non-forested vegetation types, are assessed to quantify their departure from historical Fire Regime Groups across the Ashley National Forest. In addition, the stressors and indicators for existing conditions are described to provide information on their contribution to ecosystem function.

Historical Stressors and Indicators

Correlation to Historical and Existing Vegetation Conditions:

The Ashley National Forest is representative of broader regional trends in the Rocky Mountains. Fire exclusion and suppression have caused significant changes in forest vegetation and stand conditions. In return, these deviations in stand structure and species composition have altered natural disturbance regimes, with significant long-term consequences (Byler and Hagle 2000, figure 1).

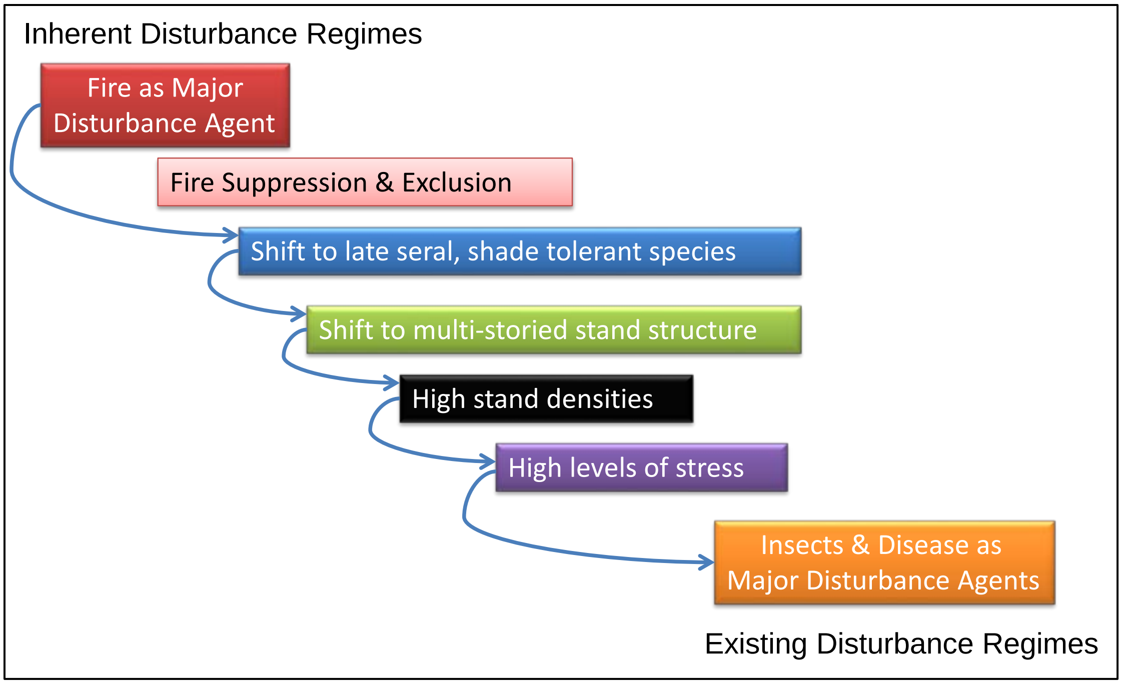

Figure 1. Changes to natural disturbance regimes resulting from fire exclusion in the Northern and Southern Rockies

Fire Regimes

On the Ashley National Forest, wildland fire has influenced patterns of species, composition, structure, age, and succession of both individual stands and the larger landscape. The mosaic of forest and rangeland vegetation in the analysis area developed under low-, mixed-, and high-severity fire regimes. The mosaic varies with moisture, temperature, and vegetative composition (Bradley and others 1992).

Drought cycles and fire fuel availability have considerable influence on fire regimes. Pre-settlement wildland fires generally burned through the early summer season until extinguished by monsoonal precipitation. In the settlement period before 1941, wildland fire suppression efforts were often not successful and resulted in fires burning thousands to tens of thousands of acres. Fire suppression efforts since then have altered natural fire regimes and reduced the number of forested acres burned each year (Arno 1996a). The combination of fire suppression, fire exclusion, and natural disturbance processes has allowed fuels to accumulate in unmanaged forested stands. For many vegetation types, the current fire regimes have moderate to high departure from natural fire regimes. These regimes, in turn, are responsible for higher tree densities and fuel accumulations that support wildfires with uncharacteristically severe effects (Arno 1996b).

Additionally, a fire regime describes the frequency, predictability, and severity of fire in an ecosystem. A generalized system of classifying fire regimes, given the wide range possible, is to define fire severity categories of high, moderate, and low.

- Low severity fire regimes typically have frequent, low intensity fires
- Moderate severity fire regimes (also called mixed severity) have complex combinations of high, low and moderate severity fires
- High severity fire regimes have infrequent but stand-replacing fires (Agee 1996)

The LANDFIRE classification system defines the five natural fire regime groups, based on the average number of years between fires (fire frequency), combined with characteristic fire severity reflecting percent replacement of dominant overstory vegetation (see table 1) (National Interagency Fuels Fire and Technology Transfer System 2010).

Table 1. Fire regime group descriptions from the LANDFIRE classification system

Group	Frequency (years)	Severity	Severity Description
I	0 – 35	Low / mixed	Generally low-severity fires replacing less than 25 percent of the dominant overstory vegetation; can include mixed-severity fires that replace up to 75 percent of the overstory.
II	0 – 35	Replacement	High-severity fires replacing greater than 75 percent of the dominant overstory vegetation.
III	35 – 200	Mixed / low	Generally mixed-severity; can also include low severity fires.
IV	35 – 200	Replacement	High-severity fires.
V	200 plus	Replacement / any severity	Generally replacement severity; can include any severity type in this frequency range.

To better understand the historical fire disturbances within each of the vegetation types, LANDFIRE fire regime groups are used to characterize the severity and frequency of fires within forested and non-forested vegetation types (see table 2). Natural fire regimes are usually defined in a historical sense. The regimes are typically restricted to the pre-1900s, but are natural in the sense of incorporating effects of indigenous cultures. This is because we cannot, in most cases, separate out the human component of natural fire regimes.

Table 2. Fire regime group (FRG) within forested and nonforested vegetation types by percent of area

Vegetation Types	FRG I	FRG II	FRG III	FRG IV	FRG V	Other*	Total % Area
Ponderosa pine	63.96%	0.13%	10.55%	21.62%	3.65%	0.11%	100%
Lodgepole pine	21.65%	1.93%	4.01%	34.17%	36.95%	1.29%	100%
Douglas-fir	65.24%	0.17%	16.54%	7.92%	8.01%	2.13%	100%
Mixed conifer	18.24%	0.80%	4.02%	15.45%	59.09%	2.40%	100%
Engelmann spruce	2.73%	2.34%	1.52%	0.72%	86.05%	6.64%	100%
Miscellaneous	30.09%	3.45%	22.93%	15.21%	21.92%	6.40%	100%
Seral aspen	59.85%	0.76%	4.81%	14.75%	19.00%	0.83%	100%
Persistent aspen	79.91%	0.42%	6.55%	8.18%	4.41%	0.53%	100%
Sagebrush	23.78%	0.72%	11.87%	56.41%	4.84%	2.38%	100%
Pinyon juniper	18.81%	0.02%	32.05%	33.80%	2.53%	12.79%	100%
Desert shrub	0.25%	0.01%	2.65%	79.59%	10.89%	6.61%	100%

*Other includes water, barren ground, or sparse vegetation

Vegetation Condition Class:

Vegetation condition class is a measure of departure from reference (pre-settlement, natural, or historical) ecological conditions that typically results in alterations of native ecosystem components (see table 3 for vegetation condition class descriptions). Vegetation condition class is used to assess the ecological departure from the natural fire regimes for each of the existing forest and nonforest vegetation types (see table 4). One or more of the following activities may have caused departures:

- Fire suppression
- Timber harvesting
- Livestock grazing
- Introduction and establishment of exotic plant species
- Introduced insects or diseases
- Other management activities (National Interagency Fuels Fire and Technology Transfer System 2010)

For landscapes that were moderately or severely departed, those acres can provide the foundation for how many acres potentially need restoration. Additional to vegetation condition class, ecosystem attributes loadings could also contribute to departure from historical ecological conditions. These attributes include species composition, structural stage, stand age, canopy closure, and fuel.

Table 3. Vegetation condition class descriptions from the LANDFIRE classification system

Vegetation condition class	Description
1. Vegetation Condition Class I.A	Very Low, Vegetation Departure 0-16%
2. Vegetation Condition Class I.B	Low to Moderate, Vegetation Departure 17-33%
3. Vegetation Condition Class II.A	Moderate to Low, Vegetation Departure 34-50%
4. Vegetation Condition Class II.B	Moderate to High, Vegetation Departure 51-66%
5. Vegetation Condition Class III.A	High, Vegetation Departure 67-83%
6. Vegetation Condition Class III.B	Very High, Vegetation Departure 84-100%
Other	Water, snow and ice, non-burnable urban, burnable urban, barren, sparsely vegetated, burnable agriculture

Table 4. Vegetation condition class (VCC) in forested and nonforested vegetation types by percent of area

Vegetation Types	VCC IA	VCC IB	VCC IIA	VCC IIB	VCC IIIA	VCC IIIB	Other[1]	Total % Area
Ponderosa pine	0.01%	6.76%	48.38%	25.98%	16.40%	0.12%	2.35%	100%
Lodgepole pine	0.19%	0.12%	43.50%	46.21%	5.29%	1.92%	2.77%	100%
Douglas-fir	0.03%	11.04%	41.81%	37.05%	7.34%	0.17%	2.56%	100%
Mixed conifer	0.32%	0.62%	65.36%	28.53%	1.63%	0.82%	2.72%	100%
Engelmann spruce	1.85%	0.18%	84.94%	3.73%	0.05%	2.43%	6.83%	100%
Miscellaneous[2]	1.27%	1.73%	55.05%	22.30%	6.05%	3.46%	10.15%	100%
Seral aspen	0.05%	0.68%	35.02%	50.04%	12.09%	0.75%	1.38%	100%
Persistent aspen	0.04%	0.69%	16.28%	55.47%	25.53%	0.42%	1.58%	100%
Sagebrush	0.63%	5.47%	57.14%	24.55%	7.79%	0.72%	3.70%	100%
Pinyon juniper	0.79%	20.40%	42.16%	21.37%	1.94%	0.02%	13.32%	100%
Desert shrub	5.99%	5.19%	3.38%	78.51%	0.05%	0.01%	6.87%	100%

1. Other includes water, barren ground, or sparse vegetation
2. Miscellaneous forest vegetation types includes subalpine fir, blue spruce, 5-needle pines, riparian forest

Fire Groups and Forested Vegetation Types:

Some habitat types represent later seral stages, or vegetation succession in the absence of significant disturbance. Wildland fire can reset vegetation communities to an earlier seral state. In some locations, the fire may prevent vegetation from reaching a late seral condition. Likewise, an early-mid seral state can be perpetuated by the presence of wildland fire.

The classification of Utah fire groups are used to further describe the role of wildland fire and the influence it has on the representation of forested vegetation types on the Ashley National Forest. Fire groups are based on the presence of forest vegetation that make up individual habitat types. Additionally, the 12 fire groups are assigned based on the biological response of the tree species to disturbance and shade (Bradley and others 1992). See table 5 for fire group descriptions. The exception is fire group zero, which is used to describe grassland, riparian, and rock-scree communities.

Table 5. Utah fire group descriptions

Fire Group	Vegetation Types	Brief Description and Role of Fire
0	Alpine/rock miscellaneous	Miscellaneous sites that are dominated by deciduous trees, shrubs, or herbaceous meadows. In addition, scree, rock outcrops, and unburnable areas, such as lakes and large bodies of water, fall in this fire group. These fire groups were not analyzed for fire regime groups and vegetation condition class.
1	Pinyon juniper	Prior to European settlement, these sites burned more frequently, current estimates demonstrate longer frequencies between fires. Stand-replacing, high severity fires occurring every 200 years (fire regime group IV) are most common in the pinyon/juniper type. Large fires, such as the Mustang Ridge Fire of 2002, consumed close to 15,000 acres of pinyon/juniper communities, leaving only small pockets to provide seed sources. The potential increase in fire severity and the change in the overall fire return interval for this vegetation types generates a higher percent classified as vegetation condition class IIB. Fuel conditions vary greatly depending on the canopy closure of pinyon-juniper. More open stands consist of grasses and shrubs while closed stands have less surface fuels. Fuel loadings are usually less the two tons/acre with variable fuel heights. Fire spread and flame lengths vary greatly depending the condition of the stands and the wind speeds. Livestock grazing will reduce fire behavior characteristics. Exotics such as cheatgrass may significantly increase fire spread rates.
3	Ponderosa pine	Stands in pre-settlement times were typically open and experienced frequent, low severity fire occurrence. In properly functioning stands the majority of ground fuels are perennial grasses, small diameter branch wood, and needle cast. (Bradley and others 1992). With fire exclusion the predominant historical fire regime group I has been altered and an unnatural buildup of litter and downed woody material has increased. As a result, overstocking and crowding occurs increasing the presence of more shade tolerant species. Many of these areas have moderate to high departure and are classified as vegetation condition class IIA, IIB, and IIIA. In his technical fire management report on ponderosa pine on the Flaming Gorge Ranger District, Palmer determined the mean fire return interval to be 21 years (Palmer 1992). This study represents about 16,000 acres of ponderosa pine between Dowd Mountain and Gorge Creek, where 13,205 acres have been treated between 1992 and 2016, with 2,305 acres having already lapsed the average return interval.

Fire Group	Vegetation Types	Brief Description and Role of Fire
4	Ponderosa pine, Douglas-fir	Ponderosa pine and understory grasses are often important constituents of this forest type. These sites often burned with high frequency and low severity fires. Without frequent fires, Douglas-fir will become the dominant species increasing fire severity. Historically, wildfires burned frequently with low to moderate severity in the dry Douglas-fir vegetation types. Many of these areas favored the development of ponderosa pine or on drier sites the establishment of shrub and grasses. With the absence of fire, the density of trees along with an increase in ladder fuels promote higher severity fires. Historically, a majority of these vegetation types had frequent low to mixed severity fires falling within fire regime group I, and with the absence of fire, a high percent of these types are classified as vegetation condition class IIA and IIB. The Douglas-fir vegetation type fits into Utah fire groups 4 and 5, with 53 percent being fire group 4: drier Douglas-fir habitat. Surface fuels are typically light, consisting of small branch wood, with occasional grasses and shrubs. Fire behavior is characterized by low spread rates and flame lengths. Only under extreme fire weather conditions, can crown fire be initiated.
5	Douglas-fir, lodgepole pine	Thirty-three percent of the area falls within the cool or moist Douglas-fir habitat types. These forests are dominated by Douglas-fir and lodgepole pine that historically had mix of stand replacement to light surface fire based on the topographic position, structure, and fuel loading. Under moist Douglas-fir types a considerable increase in dead downed fuels has occurred with heavier surface fuel loadings. The dense overstory create ladder fuel conditions that increase the potential for crown fires to occur. Therefore, the spread rates and flame lengths can increase substantially (Bradley and others 1992). Stand replacement fire was common in those areas dominated by lodgepole pine and aspen, while Douglas-fir generally burned more frequently with lower severity.
7	Persistent and seral aspen	Utah fire group classifies aspen stands in relation to fuels into five types that are a mixture of forbs and shrubs. The frequency of fire may differ between even and uneven aged aspen stands. Persistent and seral aspen have a high percent of the area classified as fire regime group I. During the last century, fire suppression and grazing have altered the fire frequency and potential severity in this type creating a higher percent of the area falling into vegetation condition class IIB and IIIA. Persistent Aspen: Weather conditions seldom occur where entire stands of persistent aspen may experience high fire severity. Fuel conditions in these types have low fuel loading. Fire behavior is characterized by slow rates of spread and low flame lengths. Seral Aspen: The seral aspen vegetative group is perhaps the most complex due to the multiple species in which it interacts. In early successional stages aspen is dominant but eventually gives way to conifer species that are typically more shade tolerant or out compete the aspen for nutrients. Viable aspen clones may remain on site for numerous years, but will eventually die out without disturbance. Fuels generally consist of leaf litter and conifer needles that are characterized by light fuel loading. Ground fire are generally slow-burning with low flame lengths. Some fire may encounter an occasional “jackpot” or heavy fuel concentration that can flare up. Under increased conifer encroachment and severe weather conditions, these fuels can pose fire hazards.

Fire Group	Vegetation Types	Brief Description and Role of Fire
8	Lodgepole pine, mixed conifer	Lodgepole pine can be a seral or climax species. Fire either perpetuates lodgepole or renews it. Fire frequencies and severities are highly variable, with ranges from less than 50 years to more than 300 plus years. Well known as a high severity, stand replacement species with a fire return interval of 35 to 200 years, lodgepole pine is typified as a fire regime group IV and V species. Currently a majority of the lodgepole pine falls within vegetation condition class IIA and IIB, with a moderate to low departure. The greatest amount of down dead woody debris can be found within this vegetation type, mainly due to the Rocky Mountain pine beetle outbreak in the late 1970s and early 1980s. The majority of the trees killed in this epidemic have since toppled and await treatment through natural fire or prescribed fire. More recently, within the past 5-8 years, additional beetle activity has added to that mortality that will further increase fuel loading within the next several years. Average fuel loads are 15 to 18 tons per acre with maximum loads being much higher, depending on the impacts of insects such as mountain pine beetle. Typically, most of this loading is in the large-fuel category. The nature of fuels changes over time in lodgepole pine stands, with many stands having a high degree of variability depending on the age class and disturbance that has affected the stands. Fires in Rocky Mountain lodgepole pine stands are highly variable ranging from a surface fire with low fire spread rates and flame lengths, consuming litter and duff, or high-severity, stand-replacing crown fires. (Bradley and others 1992).
10	Mixed conifer miscellaneous[1]	These types are not in cold or moist landscapes. Subalpine fir and Engelmann spruce are the climax species. This group contains the heaviest downed woody fuel loads, particularly where lodgepole pine is the seral species. Fires historically burned in mosaic patterns and are thought to be less frequent than those in the drier fire groups. Where lodgepole pine or aspen occurred, higher frequency of fires favored long-term dominance by these species. Under a natural fire regime, these types are similar to stands dominated by Engelmann spruce and subalpine fir that promote highly destructive stand-destroying fires. As a result, they are defined by fire regime groups I, II, and V. Due to the lack of disturbance via wildfire or fuels treatment, the majority of the mixed conifer falls into vegetation condition classes IIA and IIB. Historical loadings in the mixed conifer type were probably no more than one fourth to one-third of present-day loadings. Fuel loads are higher than in lower elevation montane stands, and the fuel beds tend to be irregular and have large amounts of needle litter accumulating under the narrow crowned trees (Fischer and Bradley 1987). Under high or extreme fire weather conditions, fire behavior characteristics exhibit increased rates of spread with passive or active crown fire and long range spotting.
11	Mixed conifer, Engelmann spruce	Subalpine forest habitat types generally found adjacent to riparian areas, on moist benches, or as stands associated with late-melting, high-elevation snowbanks are included in this group. Engelmann spruce is often a persistent seral or climax co-dominate with subalpine fir and is best represented by this fire group. Fuels consist of large diameter dead downed logs. Fires are generally less frequent, however the severity of fires are much greater due to the longer intervals and high fuel loads. Fire frequencies are usually greater than 300 years—fire regime group V. In addition, a high percent of the Engelmann spruce has a moderate-low departure and is classified as vegetation condition class IIA.

Fire Group	Vegetation Types	Brief Description and Role of Fire
12	Engelmann spruce miscellaneous[1]	These types are generally above 10,000 feet and climax subalpine fir and Engelmann spruce are usually the only seral species. Fire is generally infrequent, occurring primarily in drier autumn periods. With cooler, moisture conditions prevailing, this species has a fire return interval that exceeds 200 years and severity that most commonly is stand replacing. As a result, a majority of this vegetation type falls within fire regime group V. In addition, a high percent of the Engelmann spruce has a moderate-low departure and is classified as vegetation condition class IIA. Engelmann spruce is a subalpine species that thrives in cold, moist, high elevation conditions that are generally too harsh for other species (Bradley and others 1992). The fuel structure in stands dominated by Engelmann spruce and subalpine fir promotes highly destructive stand-destroying fires. Fuel loads are higher than in lower elevation montane stands, and the fuel beds tend to be irregular and have large amounts of needle litter accumulating under the narrow crowned trees (Fischer and Bradley 1987). Fire behavior is generally characterized by low spread rates and flames lengths under normal conditions, but under extreme fire weather, the chance of higher intensity crowns may occur.
None[2]	Desert shrub	Desert shrub is not a Utah fire group. This vegetation type encompasses many individual plant species adapted to arid environments. The most notable species include Wyoming big sagebrush, saltbush, shadscale, spiny hopsage, desert shrub, winterfat, greasewood, gray molly, and bud sagebrush. These vegetation types are best represented by fire regime group IV. Some species, such as greasewood for example, tend to have a greater fuel bed continuity that produces a stand replacement severity characteristic when burned. Other species tend to grow in clumps that are broken by bare soil and tend not to carry fire as well. Vegetation condition class IIB best represents the desert shrub with many of these vegetation types not having experienced any recorded disturbance in modern record, although the introduction of cheatgrass may favor more frequent fire. Fuels consist of discontinuous scattered shrub component with live and dead shrub twigs and foliage. Fuel loading is generally light with a majority of the fuels less than one foot tall. Without significant fire weather conditions, fire spreads are generally low, with low flame lengths. Under more continuous fuel beds, fire spread and flame increases greatly.
None[2]	Sagebrush	Sagebrush is not a stand-alone Utah fire group. However, it is an important subspecies to many other habitat groups such as Utah fire group 1, 3, and 4. The most abundant of the brush types on the Ashley National Forest is mountain big sagebrush. Additional species include: Wyoming big sagebrush, basin big sagebrush, spiked big sagebrush, black sagebrush, fringe sagebrush, and silver sagebrush. A majority of this vegetation type is characterized by fire regime groups I, III, and IV and vegetation condition classes IIA and IIB. The fire regime group depends largely on the species of sagebrush, its association with other vegetation types, and the horizontal fuel continuity. For example, Wyoming and black sagebrush thrive in areas unfavorable to grass production. Therefore, they have longer fire return intervals and higher severity fires. Furthermore, mountain big sagebrush has a high percent of the area that is highly variable with regard to fire regime groups and vegetation condition class. Fuel conditions are linked closely with the various sagebrush species. Both live herbaceous and live woody fuels can be associated with within these types. The fuel loading also varies depending the productivity of the site and can range from less than one ton/acre to several tons/acre. Fire spread rates also vary greatly and are highly dependent on fuel continuity and increased wind speeds. Where exotics such as cheatgrass has replaced these communities, fire spread rates can greatly increase.

[1]Miscellaneous forest vegetation types includes subalpine fir, blue spruce, 5-needle pines, riparian forest

[2] Nonforested types that do not have a Utah fire group classification

Photo of persistent aspen stand

Nonforested Vegetation Types

In addition to the fire group classification for forested vegetation types, the primary non forested vegetation types (such as desert shrub and sagebrush vegetation types) are described by fire regime groups, vegetation condition class, and current fuel and fire behavior characteristics.

Desert Shrub

As the name implies, the desert shrub vegetation type encompasses many individual plant species adapted to arid environments. The most notable species include the following:

- Wyoming big sagebrush;
- semi-barrens;
- saltbush;
- shadescale;
- spiny hopsage;
- desert shrub;
- winterfat;
- greasewood;
- gray molly; and
- bud sagebrush.

These vegetation types are best represented by fire regime group IV. Some species, such as greasewood for example, tend to have a greater fuel bed continuity that produces a stand replacement severity characteristic when burned. Other species tend to grow in clumps that are broken by bare soil and tend not to carry fire as well. Vegetation condition class IIB best represents the desert shrub, with many of these vegetation types not having experienced any recorded disturbance in modern records.

The fuels consist of a discontinuous scattered shrub component, with live and dead shrub twigs and foliage. Fuel loading is generally light, with a majority of the fuels less than one foot tall. Without significant fire weather conditions, fire spreads are generally low, with low flame lengths. Under more continuous fuel beds, fire spread and flame increases greatly.

Sagebrush

Sagebrush is not a stand-alone vegetation in the Utah fire group. However, sagebrush is an important sub-species to many other habitat groups, such as Utah fire group 1, 3, and 4.

The most abundant of the brush types on the Ashley National Forest are mountain big sagebrush. Additional species include Wyoming big sagebrush, basin big sagebrush, spiked big sagebrush, black sagebrush, fringe sagebrush, and silver sagebrush.

A majority of this vegetation type is characterized by fire regime groups I, III, and IV and vegetation condition classes IIA and IIB. The fire regime group depends largely on the species of sagebrush, it association with other vegetation types, and the horizontal fuel continuity. For example, Wyoming and black sagebrush thrive in areas unfavorable to grass production, therefore, they have longer fire return intervals and higher severity fires. Furthermore, mountain big sagebrush makes up a high percentage of the area that is highly variable with regard to fire regime groups and vegetation condition class.

Fuel conditions are linked closely with the various sagebrush species. Both live herbaceous and live woody fuels can be associated within these types. The fuel loading also varies, depending on the productivity of the site and can range from less than one ton per acre to several tons per acre. Fire spread rates also vary greatly and are highly dependent on fuel continuity and increased wind speeds. Where exotics, such as cheat grass has replaced these communities, fire spread rates can greatly increase.

Current Stressors, Indicators, and Trends

Topography and Weather Patterns

Topography and weather patterns are essential factors in determining fire behavior for a given landscape. Aspect, elevation and topographic features have an impact on moisture profiles across the landscape that directly affect vegetation types and resultant fuel types (Malesky and others 2016). In addition, slope and aspect affect fire spread and surface fuel moistures. The following geographical areas encompass the Ashley National Forest: the east-west range of the Uinta Mountains, the Wyoming Basin, and the Tavaputs Plateau. Elevations range from 5,480 feet at the eastern edge of the Flaming Gorge Ranger District along the Green River, to 13,528 feet at Kings Peak on the Duchesne-Roosevelt Ranger District, the highest mountain in the State of Utah.

The Ashley National Forest has steep canyons and high mountain peaks, glaciated basins, and large open meadow areas. Significant Forest features include the Sheep Creek Geological loop, the High Uintas Wilderness, the Flaming Gorge National Recreation Area, and the Uintah Mountains (a major east-west oriented mountain range in North America) (Erskine 2013). An aggregation of geographic and topographic features influence the fire season weather patterns that occur across the Ashley National Forest.

Photo looking west along the Uintas Mountains

Typical fire season weather patterns (June through September) are influenced by high-pressure systems that establish over the Great Basin area in May or June. The stationary high-pressure influence will normally last until mid-July. The high pressure will begin to wander from the center of the Great Basin, which will open the door to tropical moisture from the south and west. The shift will begin the monsoon season. Prior to mid-July, thunderstorms are often of the dry variety or only moderately wet. As the monsoon season gets into full swing, normally in late July and August, the daily afternoon thunderstorms will be significantly more wet, especially at the higher elevations (7,000 feet or greater). The monsoon influence will begin to lessen in late August and early September. By late September and early October, the weather pattern usually dries out (Erskine 2013).

To better understand the influence of local topography and geography on weather, weather information was obtained from http://famweb.nwcg.gov/weatherfirecd/ for the Yellowstone remote automated weather station, for the time period from 1970 through 2014. The computer program Fire Family Plus Version 4.1 (USDA Forest Service 2004), was used to compare historical and current fire weather parameters associated with temperature, wind, and precipitation. Based on this analysis, the average temperatures and precipitation have slightly increased, while winds have changed to a predominant south-southwest direction. In addition, these weather parameters are analyzed to determine trends associated with fire danger, fire behavior characteristics, and overall fire preparedness staffing (see figure 2, figure 3, and figure 4) for temperature, wind, and precipitation comparisons.

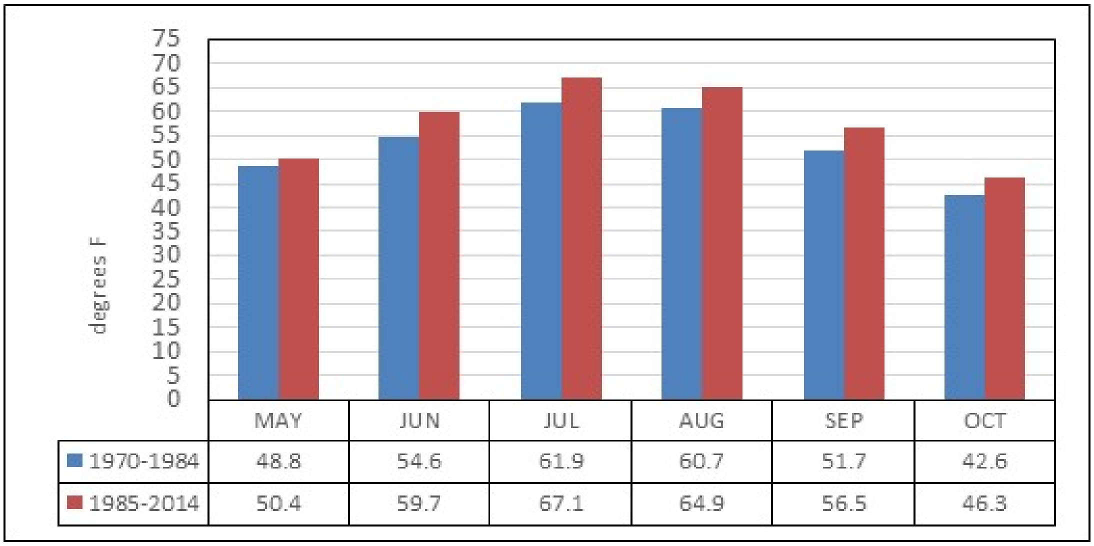

Figure 2. Average monthly temperature from May to October, 1970-2014

Figure 3. Average monthly precipitation from May to October, 1970-2014

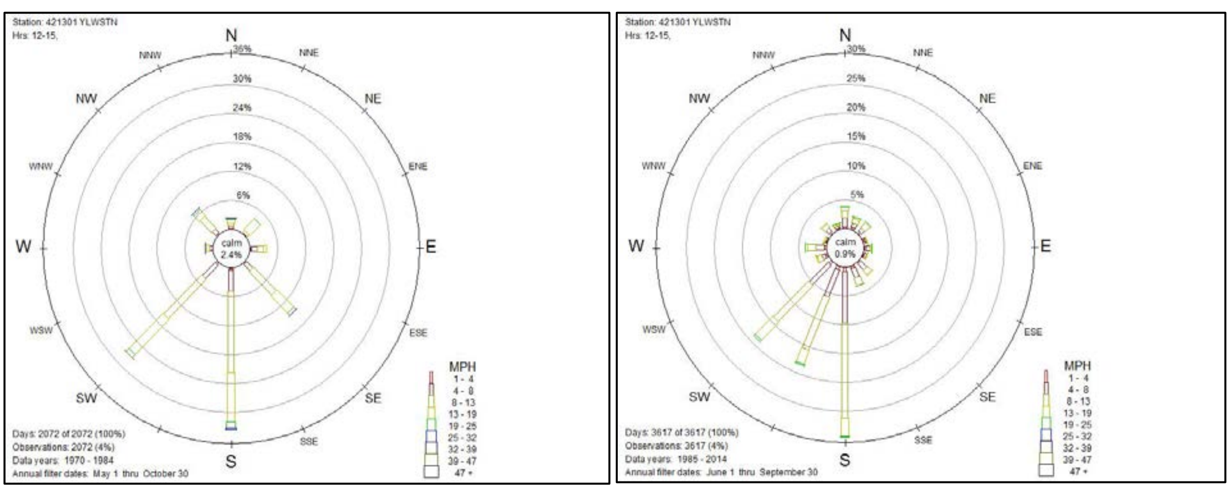

Figure 4. Average monthly wind direction and speed from May to October, 1970-2014

Climate Change:

With or without change in precipitation, temperature increases can result in decreased snow depth, alter timing and rate of snowmelt, lengthen or alter the timing of the growing season, and affect soil moisture levels. Climate changes will affect disturbances in the ecosystem - with fire, insects and disease being the most notable for the Ashley National Forest (Malesky and others 2016) . Increasing air temperatures are expected to change the frequency, severity, and extent of wildfires. Large wildfires that have occurred during a warmer climatic period during the past two decades signify a future in which wildfire is an increasingly dominant feature of western landscapes (Vose and others 2016).

With an increase in temperature over the last several decades, there has been an increase in the number of years of drought. Drought has a clear correlation to the biotic and abiotic (living and dead) conditions within forested and rangeland vegetation types, and drought increases the potential for large fires (Vose and others 2016). Although some of these interactions are predictable, they can be difficult to quantify. By analyzing the energy release component and Palmer drought severity index, a correlation of recent drought conditions to an increase in large fires on Ashley National Forest can be inferred.

Fire Danger Index Energy Release Component (ERC) and Climatology

Regional fire potential is correlated to regional climate and stand (of trees) conditions. The association of weather and fire behavior to any significant change in climate will affect the frequency and severity of conditions suitable for the ignition and spread of fires. In addition, each type of fuel has characteristic physical and chemical properties that affect flammability, and these properties vary with climate and weather (Brown 2000). Because drought influences fire directly (through fuel moisture) and indirectly (through biological and ecological effects on vegetation), the potential fire hazard can be quantified by both drought indices and fire behavior metrics. Interpretation of these metrics is complicated by the fact that not all vegetation types respond the same to meteorological drought, in terms of fuel availability and flammability. But the probability of fire ignition increases in most fuels when fuel moisture is low. Although fuels can burn under different conditions in different ecosystems, even short-term drought generally increases wildland fire risk through its effects on fuel moisture, and thus on the probability of ignition and spread rate (Vose and others 2016).

An indicator that is most often used to describe the fuel conditions associated with climatology changes throughout a fire season is the fire danger index energy release component for fuel model G. The energy release component is a number related to the available energy (British thermal unit) per unit area (square foot) within the flaming front at the head of a fire (Bradshaw and others 1983). An energy release component index, as used in the U.S. National Fire Danger Rating System (NFDRS), provides an approximation of dryness based on estimates of fuel moisture in a fuel model G (Andrews and others 2003). Thus, the larger the energy release component value, the ‘hotter’ and potentially more severe the fire. Values typically range from zero to 100, though they can be higher depending on weather extremes and fuel model (Brown and others 2004). Specifically, the energy release component is used to describe fire danger trends because it is sensitive to wetting rains that change fuel conditions. The energy release component calculation is also affected by fuel loadings in different size classes. Fuel model G, which includes both live and dead fuels, has a significant portion of the fuel load driven by large dead fuels. These large fuel moistures (also called 1,000-hour fuels) are driven by weather conditions during the previous 1.5 months, which is the time it takes to mostly equilibrate to constant ambient conditions (Fosberg and others 1981). Because the energy release component varies across different ecosystems, the raw values are commonly converted to percentiles to indicate departure from average conditions (Riley and others 2013).

An analysis using Fire Family Plus 4.1 was conducted by comparing the changes in energy release component values for the Yellowstone remote automated weather stations that are representative of weather and fuel conditions within the Ashley National Forest. In addition, the number of large fires over 1,000 acres was used to realize the significant changes that weather and fuel conditions have on the promoting large fires. Both the 90 and 97 percentile energy release component conditions were used to determine the difference for a May 1 through October 31 time period, from 1970 to 1984 compared to 1985 to 2014. The increase in large fire activity within the Ashley National Forest has a direct correlation to the histrionic increase in the energy release component for this period.

Table 6. Energy release component (ERC) data comparison 1970 to 2014 from the Yellowstone remote automated weather station (kcfast and Fire Family Plus v4.1)

Year Range	90th percentile ERC	97 percentile ERC	Fires > 1,000 acres
1970-1984	60	69	2
1985-2014	80	89	12

Palmer Drought Severity Index and Climatology

Another tool that is used to assess periods of drought is the Palmer drought severity index (PDSI). The Palmer drought severity index is commonly used to monitor regional climatic conditions, and is reasonably successful at quantifying long term drought within a region by using temperature data and a physical water balance model. The index can capture the basic effect of global warming on drought, through changes in potential evapotranspiration. As a long term measure, single precipitation events seldom drastically affect the Palmer drought severity index. Generally, the index is based on the relative dryness or wetness of an area, so areas with differing water budgets may be compared (Dai 2016).

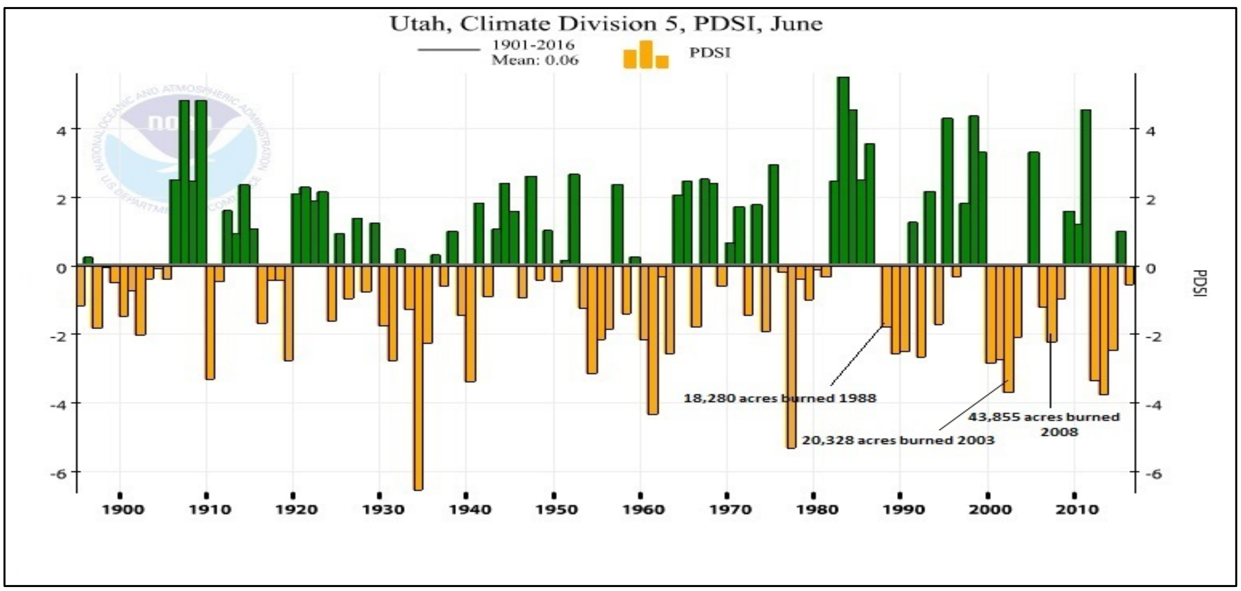

Figure 5. Palmer drought severity index from 1901 to 2016 and large fire growth for Utah Climate Division 5, Northern Mountains

In the mid- to late-20th century, the relationships between the area burned and climate both parallel those in the fire history record. From 1980 forward, the area burned on Federal lands can be related to monthly PDSI. The sign and magnitude of the relationships were consistent with reconstructed fire histories (Westerling and others 2003). The Palmer drought severity index has some weakness and variability associated with mountainous terrain and the correlation of area burned. On the Ashley National Forest, there is an indication of large fire growth of the month of June and early July (NOAA 2016) (see figure 5).

Forest Fuels and Fire Behavior:

The greatest effect of fire suppression and exclusion, in unison with other natural disturbance processes, has allowed biomass to accumulate in most unmanaged timber stands. The bulk of the biomass is dead standing and downed trees and shrubs, live shade-tolerant true firs, spruce, lodgepole pine, and Douglas-fir. The combination of dead fuel and continuous live vegetation (from the forest floor to the upper forest canopy) creates a complex of fuel that, when ignited under severe fire conditions, has a higher occurrence of crown fire.

The vegetation conditions that are represented by the standard fire behavior fuel models on the Ashley National Forest are highly variable from the high desert to the alpine zone. Grasses and shrubs of the desert transition into pinyon-juniper and ponderosa pine forests at the mid mountain elevations, which in turn give way to grasses and shrubs of the high mountain elevations. Aspen occurs along the mid elevations of the Ashley National Forest, transitioning into mixed aspen-conifer, followed by conifer forests. The conifer forests are comprised primarily of lodgepole pine, with a mix of subalpine fir, Douglas-fir, and Engelmann spruce. At the highest elevations, krummholz fir borders grasses, forbs, and rock talus slopes above timberline.

In order to calculate how fires may burn within the vegetation types, an estimate of the fuel bed is used to define fuel models. A representative fuel model can be used to quantify fire behavior characteristics and the potential effects on vegetation. Fuels are made up of the various components of vegetation, live and dead, that occur on a site. These components include litter and duff layers, the dead and downed woody material, grasses and forbs, shrubs, regeneration, and timber. Various combinations of these components define the major fuel groups of grass, shrub, timber, and slash. The differences in fire behavior among these groups are related to the fuel load and its distribution among the fuel particle size classes. In addition to surface fuels, crown fuels are described by canopy bulk density (the foliage contained per unit crown volume), canopy base height (the average height from the ground to the lowest living foliage), and canopy fuel load (the volume of canopy fuel load) (Scott and Burgan 2005). Identified in table 7 through table 12 are the current surface fire behavior fuel models across the Ashley National Forest. (Landfire 2012) (Scott and Burgan 2005).

Photo of fire-fighting operations

Table 7. Acres and percent of the non-burnable fire behavior fuel model across the Ashley National Forest

Fuel Model Number	Total Acres	Percent Total Area
91, 92, 93 98, 99	251,518	18 %

Table 8. Acres and percent of the grass fire behavior fuel model across the Ashley National Forest

Fuel Model Number	Total Acres	Percent Total Area
101	51,823	4 %
102	49,301	4 %
104	3,443	<1 %

Table 9. Acres and percent of the grass/shrub fire behavior fuel model across the Ashley National Forest

Fuel Model Number	Total Acres	Percent Total Area
121	106,184	8 %
122	165,152	12 %

Table 10. Acres and percent of the shrub fire behavior fuel model across the Ashley National Forest

Fuel Model Number	Total Acres	Percent Total Area
141	7,824	1 %
142	18,481	1 %
143	16	<1 %
145	33,306	2 %
147	7,777	1 %

Table 11. Acres and percent of the timber understory fire behavior fuel model across the Ashley National Forest

Fuel Model Number	Total Acres	Percent Total Area
161	79,638	6 %
162	245	<1 %
165	352,929	25 %

Table 12. Acres and percent of the timber litter fire behavior fuel model across the Ashley National Forest

Fuel Model Number	Total Acres	Percent Total Area
181	1,396	<1 %
182	206	<1 %
183	264,223	19 %
185	853	<1 %
186	278	<1 %
188	4,937	<1 %
189	1	<1 %

Fire Behavior Modeling

Fire behavior modeling is performed to estimate a number of fire behavior characteristics. There are three main categories of inputs to fire behavior modeling; weather, fuels, and topography.

The standard fire behavior fuel models are used to predict fire behavior resulting from various weather and topographic inputs. Crown fuels are important for determining crown fire characteristics, such as whether a fire can transition from the ground to the tree crowns.

There are several outputs calculated from fire behavior modeling that are important to fire management decisions. The outputs of most concern include flame length and type of fire. Flame length is important in determining fire suppression techniques. In addition, these fire behavior characteristics are used to estimate resistance to control. This resistance is defined as the relative difficulty of constructing and holding a control line, as affected by resistance to line construction and by fire behavior (NWCG 2014). See table 13 for fire behavior characteristics and potential control mechanisms (NWCG 2006).

Table 13. Fire behavior characteristics and potential control mechanisms

Flame Lengths (feet)	Fireline Intensity (BTU/feet/second)	Possible Methods of Attack	Interpretation
0-4	0-100	Direct	Hand and ground crews at fire edge
4-8	100-500	Direct/Indirect	Mechanized equipment supported by hand and ground crews at fire edge
8-11	500-1000	Indirect	Primarily an indirect attack with line construction away from fire edge using a combination of aerial resources, mechanized equipment and hand and ground crews
>11	>1000	Indirect	Indirect attack is only option with line construction away from fire edge using a combination of aerial resources, mechanized equipment and hand and ground crews

In addition to flame length, the type of fire also defines what suppression resources and tactics are used and the potential resistance of control. Fire scientists and managers recognize three general types of wildland fire, depending on the fuel stratum in which the fire is burning.

Ground Fire - A ground fire burns in ground fuels such as duff, organic soils, roots, rotten buried logs, etc. Ground fires are generally ignited by surface fires. Ground fires have very low spread rates. For these reasons, ground fires are not predicted or further discussed in this analysis because they would be secondary to and in association with a surface fire.

Surface Fire - A surface fire burns in the surface fuel layer, which lies immediately above the ground fuels, but below the canopy or aerial fuels. Surface fuels consist of needles, leaves, grass, and dead and down branch wood and logs, shrubs, low brush, and short trees. Surface fire behavior varies widely, depending on the nature of the surface fuel complex. Surface fires are generally easier to contain than any type of crown fire.

Photo of a surface fire

Crown Fire - A crown fire burns in the elevated canopy fuels. Canopy fuels normally consumed in crown fires consist of the live and dead foliage, lichen, and very fine live and dead branch wood found in the forest canopy. There are three types of crown fire: passive, active and independent.

- **Passive -** A passive crown fire - also called torching or candling - is one in which individual or small groups of trees torch out, but a solid flame is not consistently maintained in the canopy. These can encompass a wide range of fire behavior, from the occasional tree torching out, to a nearly active crown fire. Passive crowning is common in many forest types, especially those with an understory of shade-tolerant conifers.
- **Active -** An active crown fire is a crown fire in which the entire fuel complex becomes involved, but the crowning phase remains dependent on heat released from the surface fuels for continued spread. Medium- and long-range spotting associated with active crowning leads to even greater rate of fire growth. Containment of active crown fires is very difficult.

Photo of a torching fire

- **Independent -** An independent crown fire is one that burns in canopy fuels without aid of a supporting surface fire. Independent crown fires are not addressed because they occur so rarely and because no model of their behavior is available.

In order to quantify fire behavior characteristics and the potential mechanisms to control a wildfire, fire behavior modeling was used across the entire Ashley National Forest. As a result, fire behavior outputs were calculated from the national fire behavior modeling and mapping system called FlamMap. FlamMap's outputs are widely accepted by the fire modeling community because it is specifically designed to generate fire behavior characteristics across a large area.

By using the 90th percentile climatological information and the standard fire behavior fuel models, FlamMap produced fire behavior outputs for flame length and fire type. As described in table 13 above, those fire behavior outputs determine the fire hazard and management actions taken across Ashley National Forest. See table 14 and table 15 for flame length and fire type acres and percent across the Ashley National Forest.

Table 14. Flame length and percent of total area across Ashley National Forest

Flame Length Classes	Acres	Percent Total Area
Less than 0 feet	250,685	18 %
0 to 4 feet	625,265	45 %
4 to 8 feet	380,747	27 %
8 to 11 feet	64,404	5 %
More than 11 feet	79,160	5 %

Table 15. Fire type acres and percent of total area across Ashley National Forest

Fire Type	Acres	Percent Total Area
Unburnable	250,685	18 %
Surface fire	664,025	47 %
Passive crown fire (torching)	479,880	34 %
Active crown fire	5,670	<1 %

Recent Fire History and Trends:

The likelihood of existing and future fire starts can be interpolated by determining the statistical trends of fire starts. The total number of acres burned has increased considerably over the last three decades. There was an abrupt transition in the mid-1980s from a regime of infrequent large wildfires that were generally short duration, to one with much more frequent larger fire events. Reduced winter precipitation, early spring snowmelt and warmer dry seasons have played a role in this shift. An increase of large wildfires greater than 1,000 acres is particularly robust in lower to mid-elevation forests, where these forests have missed one or more fire return intervals over the last 100 years. This area consists of dry forest types (such as ponderosa pine, Douglas-fir and pinyon pine) where fire exclusion has created a departure from the natural fire regimes (Westerling and others 2006).

Over the last three decades, many areas have also experienced mountain pine beetle infestations. Those stands that have significant beetle infestations will continue to change the fuel profile and foliar moisture content over time, creating conditions that are potentially more susceptible to higher intensity wildfires (Cleetus and Mulik 2014).

While large fires have burned a significant number of acres across the Ashley National Forest, they are generally rare, with less than one percent of these fires burning more than 1000 acres. Due to the strong influence of the monsoon weather, the fire season is determined by its occurrence, or lack of occurrence. Lightning resulting from thunderstorms typically begins in late May and accounts for 68 percent of the fires. Due to vegetation green up, 77 percent of the fires are usually less than ¼ of an acre and are easily managed. The potential for larger fires (greater than 100 acres) usually occurs between late-June and mid-July. As the monsoons get in full swing by mid to late July, all fires are less than 100 acres in size. As the monsoon influence subsides in the fall, fires usually remain relatively small and manageable, due to the shorter days and reduced fire danger (Erskine 2013). Figure 6 through figure 9 describe the fire statistics for the Ashley National Forest since 1970.

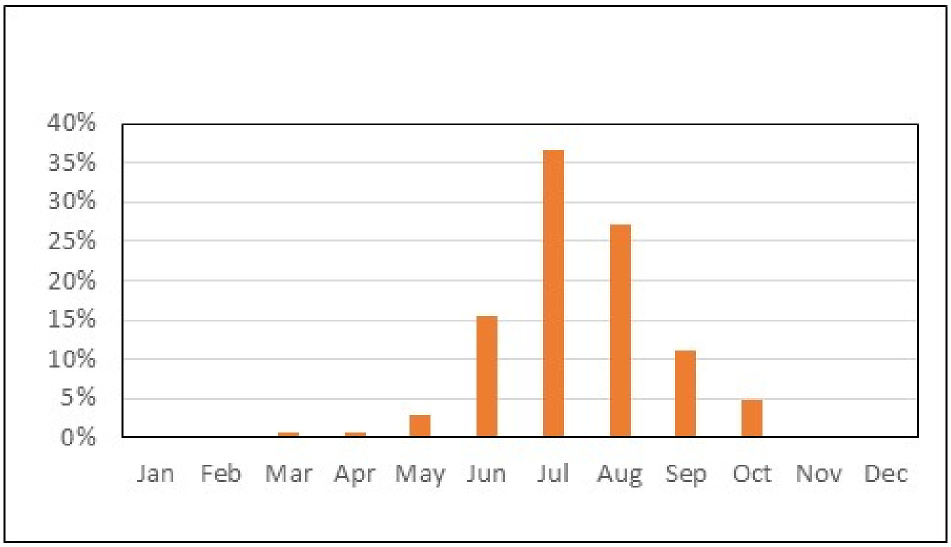

Figure 6. Ashley National Forest percent of fire by each month from 1970 to 2014

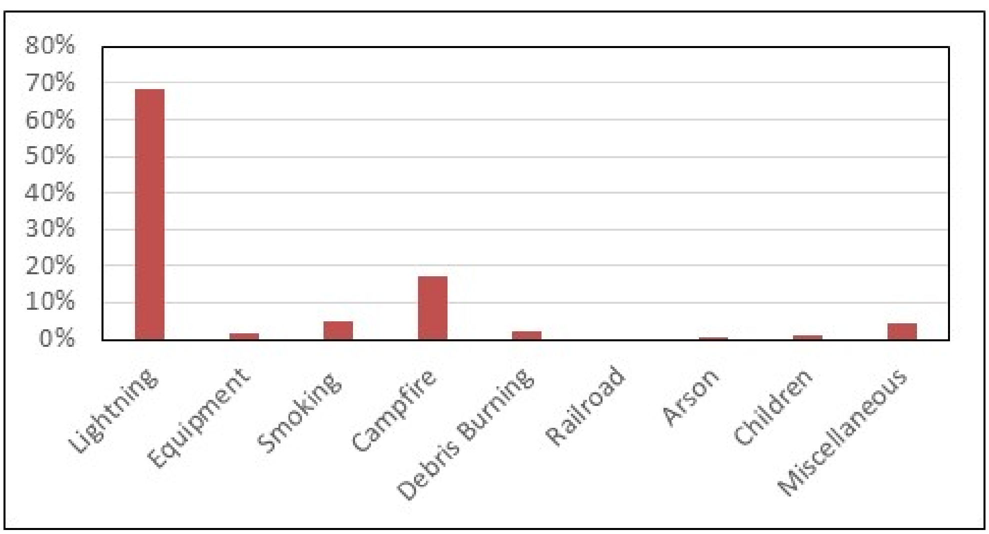

Figure 7. Ashley National Forest percent of fires by cause class

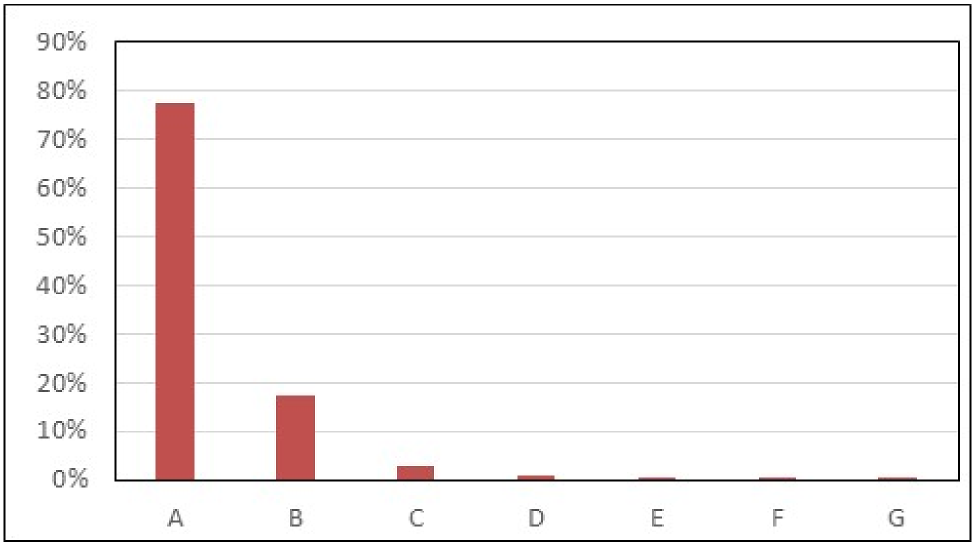

Figure 8. Ashley National Forest percent of fires by size class from 1970 to 2014

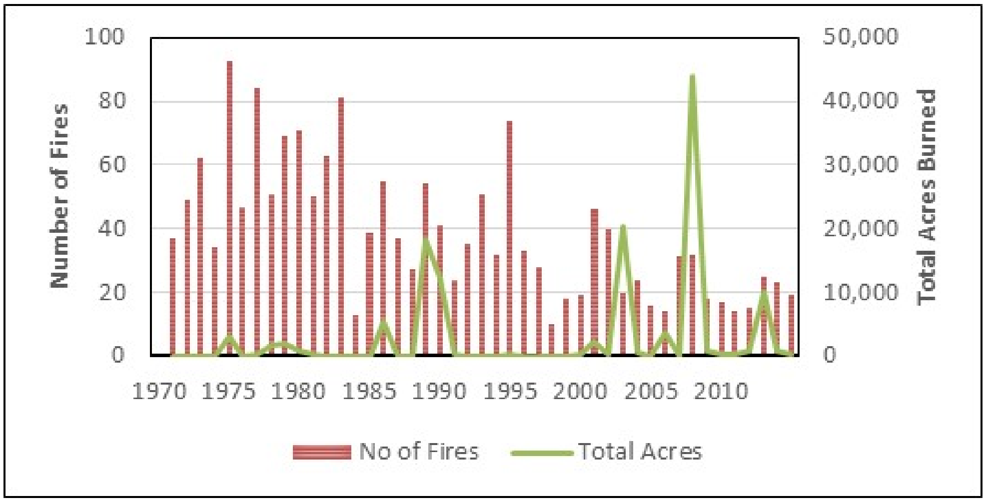

Figure 9. Ashley National Forest number of fires and total acres burned from 1970 to 2014

Wildland-urban Interface and Values at Risk

Decades of fire exclusion in many areas have impeded the ecological benefits that result from fire. As a result, there has been a significant increase of fuel accumulations in systems that historically burned with high frequency at low severity. At the same time, there has been an increase in human improvements within or adjacent to the wildland fuels. These improvements continue to push outward from communities into the areas that have a higher risk of fire (Malesky and others 2016) .

The wildland-urban interface is an area that both human improvements and structures meet and intermingle with wildland vegetation on the Ashley National Forest. There are areas that could be threatened by a fire burning within wildland fuels. The values associated with these areas include the following:

- Private land and structures
- Summer home sites
- Above-ground utility corridors
- Developed recreation sites

- Administrative sites
- Watershed improvements
- Reservoirs
- Canals
- Electronic and communication sites
- Oil and gas facilities

See figure 10 for the percent of the total area associated with wildland-urban interface values across the Ashley National Forest.

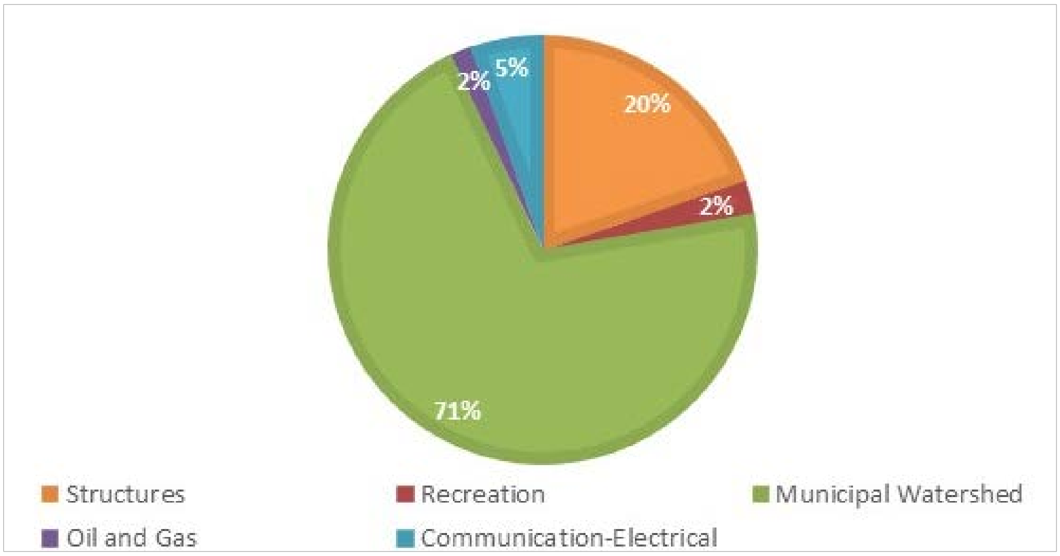

Figure 10. Percent of the total area associated with the wildland-urban interface values across the Ashley National Forest

Fire and risk are inevitably linked together and provide the foundation for fire managers to assess its potential effects. Current wildfire risk is represented by the possibility of loss or harm occurring from a wildfire. The risk is displayed by the fire risk index rating, from very low to extreme. Wildfire risk is used to determine the potential of a wildfire affecting these values. The fire risk index rating combines the likelihood of a fire occurring and the potential hazard (fire behavior characteristics) in relation to those current values of concern (Utah 2016). A majority of the fire risk is rated relatively low. However, with the exclusion of fire and continuation of climate change, more acres will continue to move toward the moderate to high risk. See table 16 for current fire risk index acres and percent across Ashley National Forest.

Table 16. Acres and percent of Ashley National Forest identified by the fire risk index rating

Fire Risk Index Rating	Acres	Percent
NB	205,969.18	18%
Very low	610,938.20	53%
Low	120,302.73	10%
Low to moderate	99,411.91	9%
Moderate	70,677.49	6%
Moderate to high	35,869.61	3%
High	12,951.14	1%
Very High	4,495.48	0%
Extreme	1,478.01	0%

Current Fire Management Policy:

In October 2000, an environmental assessment for an amendment to the forest plans for all the national forests in Utah was published. The Utah fire amendment covered each forest plan in Utah. In May 2001, the decision on the environmental assessment and finding of no significant impact were signed, selecting option B. The goal of option B states "Ecosystems are restored and maintained, consistent with land uses and historic fire regimes, through wildland fire use and prescribed fire." There are standards and guidelines for four areas of fire management: fire suppression, prescribed fire, wildland fire use, and fuels. This decision allows for the full range of fire management responses and management of fuels.

The Utah amendment covers the entire Ashley National Forest. However, wildland fire use is not allowed in:

- administrative sites;
- developed recreation sites;
- summer home sites;
- designated communications sites;
- oil and gas facilities;
- mining facilities;
- above-ground utility corridors; and
- high-use travel corridors.

The amendment acknowledges the risks associated with increased fire management and prescribed burning. However, it was recognized that staying on the course - as outlined in the original plan - would result in unacceptable loss and greater risks in general, as fires will continue to occur, but outside their normal natural range of variation.

The amendment was written because new science has shown fire is a necessary part of the ecosystem that had been removed. National policy has been changing to allow for fire to take its natural role. However, the original plan did not allow for any other management of fire other than suppression. The amendment's purpose also includes management of hazardous fuels through prescribed burning and other vegetation management methods. The authorization of prescribed fire or allowing fire to burn naturally, does not supersede the original plan's requirement for protection of sensitive areas, as outlined in the plan. The opportunity for fire management and other resource concerns should be weighed together.

The Utah fire amendment is consistent with and takes full advantage of current national policy, as outlined in Guidance for Implementation of Federal Wildland Fire Management Policy (February 13, 2009) and the Review and Update of the 1995 Federal Wildland Fire Management Policy (January 2001). The term "wildland fire use" was the term used at the time the amendment was written for allowing natural ignitions to burn on the landscape. Currently there is no established terminology or classification of wildfire similar to the term "wildland fire use". Rather, the current national policy makes the distinction between wildland fire and structural fires. Wildland fires are defined as "Any non-structure fire that occurs in vegetation or natural fuels". There are two types of wildland fire: wildfire and prescribed fire. Wildfires are both unplanned ignitions and prescribed fires that are declared wildfires. Prescribed fires are planned ignitions.

This policy allows fires to be managed for resource benefit, dependent on direction in the Ashley forest plan. According to the policy, each fire will have a set of objectives, commensurate with the values at risk. Therefore, a fire may have a mix of resource benefit and suppression objectives. The documentation for the decision of the strategic direction of the fire is made in the wildfire decision support system. Every fire with a resource objective or that escapes initial attack must have a decision in wildfire decision support system. Since the amendment was signed, the Ashley National Forest has managed one or two fires with objectives other than full suppression.

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