Santa Fe Mountain Landscape Restoration Project

Fuels and Wildfire Behavior – Air Quality – Climate Change and Carbon Storage

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For: Santa Fe National Forest

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Issue 13: Would the proposed treatments contribute to global climate change?

Issue 14: What chemicals are used for ignitions in prescribed burns? What impacts would these chemicals have on human health and the environment?

Issue 15: Would the proposed prescribed burning treatments impact local air quality?

Resource Indicators and Measures

The effects of forest thinning and prescribed burning to wildfire behavior, air quality, climate change (greenhouse gases) and carbon storage and storage are analyzed in this report. Other project activities including riparian restoration and road closure are not analyzed, as they are not relevant to these resource concerns and are analyzed in other specialist reports. Table 1 shows resource indicators and measures concerning forest thinning and prescribed burning.

Table 1. Resource condition indicators and measures for assessing effects. See Forest Plan direction under Consistency with Relevant Laws, Regulations, and Policy below and the direction is not repeated in this table.

Issue	Indicator or Measure	Source
Fuels and Wildfire Behavior	**Surface Fuels Tons Per Acre (Quantitative)** **Flame Lengths and Fire Intensity (Quantitative)** **Crown Fire Activity (Quantitative)** **Integrated Hazard (Quantitative)** Integrated Hazard in IFTDSS combines two important measures - burn probability and conditional flame length - into a single characteristic that can be mapped.	- Forest Service Manual 5140 – Hazardous Fuels Management and Prescribed Fire - Santa Fe NF Land and Resource Management Plan 1987/2010 as amended - Greater Santa Fe Fireshed Coalition Wildfire Risk Assessment. 2018. - Santa Fe Community Wildfire Protection Plan. 2008. - Santa Fe National Forest Plan Final Assessment Report. 2016. - Santa Fe NF Land and Resource Management Plan DEIS - Desired Conditions for Use in Forest Plan Revision in the Southwestern Region. Development and Science Basis. 2019.
Air Quality	**Compliance with Air Quality Regulations (Quantitative/Qualitative)** - Air Quality Health Standards - Visibility	- Forest Service Manual 2500 – Watershed and Air Management – Air Resource Management - Santa Fe NF Land and Resource Management Plan 1987/2010 - Santa Fe National Forest Plan Final Assessment Report. 2016. - Santa Fe NF Land and Resource Management Plan DEIS - New Mexico Environment Department, Air Quality Bureau regulations - New Mexico is required to develop and submit to EPA its own regional haze plans by July 31, 2021.

Climate Change and Carbon Storage	**Effects of Climate Change to Forest Ecosystems (Quantitative/Qualitative)** **Greenhouse Gas Emissions (Quantitative)** **Changes to Carbon Storage (Quantitative)**	- Public scoping comments - Forest Service Policy 2009 - Santa Fe National Forest Plan Final Assessment Report. 2016. - Santa Fe NF Land and Resource Management Plan DEIS - Desired Conditions for Use In Forest Plan Revision in the Southwestern Region. Development and Science Basis. 2019.

This report analyzes the wildfire, fuels, air quality, greenhouse gas emissions and carbon storage aspects of the Santa Fe Mountain Landscape Restoration Project (SFLRMP).

Fire and Fuels Characteristics

Fuels include snags and coarse woody debris, as well as smaller diameter woody debris, needles, leaves, grasses, and other flammable materials on the forest floor. Fuels also include ladder fuels, which are shrub or tree species that create vertical connectivity from the forest floor to the dominant canopy layer. The presence of ladder fuels in frequent-fire forests greatly increases the risk of canopy fires occurring, increasing fire severity and often leading to fire spread over larger areas. Fuel moisture is a key component of the flammability of fuels; the drier the fuels are, the greater the likelihood that they will burn when contacted by an ignition source (e.g., lightning, humans) (LRMP DEIS, 2019).

In fire dependent ecosystems, wildfire behavior can have positive, neutral, or negative effects on natural resources (table 4 below) and directly affect fire suppression capabilities. The Santa Fe National Forest suppresses wildfires that threaten public health and safety or negatively affect natural, cultural and infrastructure resources (Santa Fe National Forest Land and Resource Management Plan 1987/2010 as amended). Fire behavior is the manner in which a fire reacts to the influences of fuel, weather, and topography. Fire behavior is typically modeled at the flaming front of the fire and described most simply in terms of fireline intensity (flame length) and in rate of forward spread. Generally, higher flame lengths are produced in shrubs and forest stand fuels. Faster rates of spread occur in grass and herbaceous fuels. The implications of observed or expected fire behavior are important components of suppression strategies and tactics, particularly in terms of the difficulty of control and effectiveness of various suppression resources. The Hauling Chart is a tool for measuring the safety and potential effectiveness of various fireline resources given a visual assessment of active flame length. It was so named because it infers the relative intensity of the fire behavior to trigger points where hauling various resources to or away from a fire should be considered (Fireline Handbook, National Wildfire Coordinating Group, 2006; Rothermel 1983; principally adapted from Andrews and Rothermel 1982). Figure 2 shows a visual example of the relationship between flame lengths (feet) to fireline intensity (heat per unit area) and rate of spread. The effects of flame lengths on fire suppression capabilities are described in Table 2.

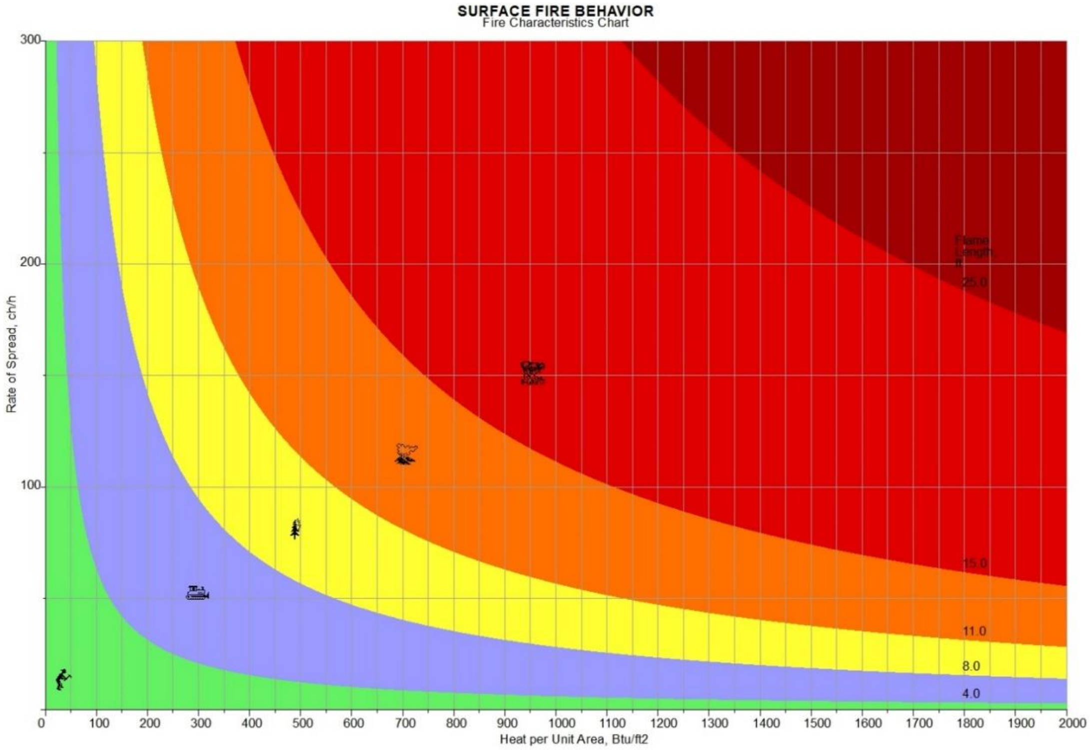


Figure 1. Hauling Chart.

Table 2. Hauling Chart interpretaion

Flame Length (Feet)	Fireline Intensity (BTU/Ft/Sec)	Interpretation
0-4	0-100	Persons using handtools can generally attack fires at the head or flanks by constructing handline, burning out and holding. Handline should hold the fire.
4-8	100-500	Fires are too intense for direct attack on the head by persons using handtools. Handline cannot be relied on to hold fire. Equipment such as dozers, engines, and retardant aircraft can be effective.
8-11	500-1,000	Fires may present serious control problems such as torching, crowning, and spotting. Control efforts at the head of the fire will probably be ineffective.
11+	1,000+	Crowning, spotting, and major runs are common, control efforts at the head of the fire are ineffective.

The term Hazard is used by the wildland fire community to define a variety of conditions or situations where damage to assets by fire is being evaluated. Hazard is quantified and categorized in IFTDSS using the Landscape Burn Probability (LBP) model evaluating:

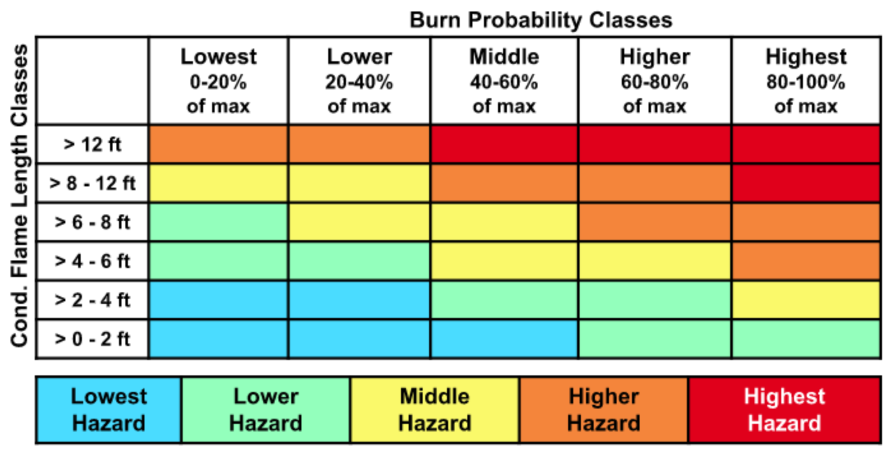
- The probability of a fire occurring at a specific point under a specified set of conditions, and
- The intensity at a specific point given a fire occurs.

Integrated Hazard in IFTDSS combines two important measures - burn probability and conditional flame length - into a single characteristic that can be mapped. IFTDSS Integrated Hazard is categorized with seven distinct classes. The first two are for pixels that did not burn and the remaining five classes are dynamic based on the integrated hazard matrix above. They include:

- Non-burnable
- Burnable but not burned
- Lowest hazard
- Lower hazard

- Middle Hazard
- Higher Hazard
- Highest Hazard

Table 3. For each pixel shown in the Integrated Hazard maps a value is assigned based on the Burn Probability and Conditional Flame Length Class using this table



Methodology

Relevant documents were reviewed to determine compliance with applicable legal, regulatory and policy requirements and direction.

For the current condition and post treatment wildfire behavior analysis several data sources and models are used. The Santa Fe Mountains fire weather was downloaded from a National Wildfire Coordinating Group data library. The FireFamily Plus fire weather analysis model was used to determine 90th percentile burning conditions in the Santa Fe Mountains (Appendix A). The Interagency Fuels Treatment Decision Support System was used to model pre and post treatment wildfire behavior and burn probability. Forest Inventory Analysis stand exams data was processed with the Forest Vegetation Simulator to determine thinning treatment forest stand carbon storage. The First Order Fire Effects Model was used to estimate wildfire and treatment fuel loading and carbon reduction, and smoke criteria air pollutant and greenhouse gas emissions.

Assumptions

Fuels, Wildfire Behavior, Smoke Emissions and Carbon Modeling

The Interagency Fuel Treatment Decision Support System (IFTDSS) is a web-based application designed to make fuels treatment planning and analysis more efficient and effective. The application provides a step by step process for testing a variety of fuels treatment impacts (thin, clear cut, mastication, slash burn, prescribed burn) on fire behavior and comparing results to determine which modeled treatment best achieves desired results in terms of reduced fire behavior potential, integrated hazard and exposure analysis. IFTDSS model runs used LANDFIRE 2014 GIS base map layers. The map layers were updated on February 2, 2020 with the LANDFIRE 2016 edition and IFTDSS Default Fuels Treatment Edit Rules are not yet compatible with LANDFIRE 2016. Default Fuels Treatment Edit Rules are used in modeling the effects of project treatments on wildfire behavior. In future versions of IFTDSS New Default Fuels Treatment Edit

Rules will be developed, but there is not yet a timeline established for when the updates will be completed. The LANDFIRE 2016 IFTDSS wildfire behavior and burn probability model runs show increases in both model outputs due to changes in several LANDFIRE GIS map layers. In addition to a wildfire scenario three treatment scenarios were used:

- Low Severity Prescribed Fire: Fire with resulting mortality of above ground vegetation <25%.
- Light Thinning; Pile Burn - Thins the stand to ~80% of present density by removing understory up to 8" DBH. Subsequent pile burning of thinned material.
- Heavy Thinning; Pile Burning - Thins the stand to ~35% of present density with no upper diameter limit.

First Order Fire Effects Model (FOFEM) - First order fire effects are those that concern the direct or indirect or immediate consequences of fire. First order fire effects form an important basis for prediction secondary effects such as tree regeneration plant succession, and changes in site productivity, but these long-term effects generally involve interaction with many variables (for example, weather, animal use, insects, and disease) and are not predicted by this program. Currently, FOFEM provides quantitative fire effects information for tree mortality, fuel consumption, mineral soil exposure, smoke emissions and soil heating. FOFEM default fuel loading inputs were based on SFLMRP Ecological Response Units (ERU's) values. The fuel consumption and smoke emissions modules were used for this analysis.

The fuel consumption module used the following fuel loading inputs/outputs:

- Litter
- Wood (0-1/4 inch)
- Wood (1/4-1 inch)
- Wood (1-3 inch)
- Wood (3+ inch) Sound - 3->6, 6->9, 9->20, 20->
- Wood (3+ inch) Rotten - 3->6, 6->9, 9->20, 20->
- Duff
- Herbaceous
- Shrubs
- Crown foliage
- Crown branchwood

Ground and Surface Fuel Carbon Loading

- Litter
- Wood
- Duff
- Herbaceous
- Shrub
- Foliage+Branch

The smoke emissions module uses the fuel consumption module computations to produce the following criteria air pollutant and greenhouse gas emissions outputs:
Criteria Pollutants:

- CO – Carbon Monoxide
- NOx – seven types of NOx are included in FOFEM NOx emissions including NO2
- SO2 – Sulfur Dioxide
- PM2.5 – Particulate Matter
- PM10 – Particulate Matter

Greenhouse Gases:

- CO_2 – Carbon Dioxide
- CH_4 - Methane

The FOFEM model was run with a wildfire fuel moisture scenario and consumed 75% of tree foliage, and a prescribed fire scenario that consumed 25% of tree foliage (Appendix A).

FlamMap (FARSITE) Spotting Distance - The FlamMap fire mapping and analysis system describes potential fire behavior for constant environmental conditions (weather and fuel moisture). Fire behavior is calculated for each pixel within the landscape file independently. Potential fire behavior calculations include surface fire spread, flame length, crown fire activity type, crown fire initiation, crown fire spread and spotting distance. Dead fuel moisture and conditioning of dead fuels in each pixel based on slope, shading, elevation, aspect, and weather.

The existing Albini spotting models were originally devised to predict the maximum distance burning embers would travel over flat and regularly undulating terrain. The maximum spotting distance is determined by the balance between particle size, burnout rate, and time or distance traveled. Smaller particles are lofted higher and transported further, but burnout sooner than larger particles. Thus, as published, Albini's equations for the maximum spotting distance cannot be implemented for complex topography because winds, terrain, and forest canopy can all vary.

At present only the model for spotting from torching trees by Albini is present in FARSITE. The purpose of the spotting capability of FARSITE is to compute the maximum distances that particles of different sizes would travel over complex landscapes. These indicate the potential distances ahead of the fire that spotting could be found, assuming winds vary only as a function of height above ground or as specified spatially by the weather/wind grid. Nevertheless, this greatly oversimplifies reality in mountainous terrain.

Depending on topography, Albini's equations may suggest the farthest spotting distances are produced by larger particles that aren't transported over deep ravines. The spotting model in FARSITE does not intend to predict the number of embers produced, or exact locations that embers will land, only the direction and distance embers might land.

Spotting is produced whenever some form of crown fire develops (passive and active crown fire). The torching tree model of ember lofting was not intended for representing ember lofting from a running crown fire. It will likely underestimate both the ember sizes, lofting height, and ultimate spotting distances under conditions of running crown fire.

Air Quality

Air quality emissions from toxics known to be present in smoke, such as metals (including mercury, radionuclides, and byproducts of accelerants), are not expected to approach federal and state ambient air quality standards or result in long-term public health impacts and are therefore not analyzed in the report.

Fugitive dust from roadwork is not expected to approach federal and state ambient air quality standards. Impacts from these types of emissions were not directly modeled. Fugitive dust are likely to last for a very short period of time, a few months rather than years, and the dust would be isolated to very small areas and would not pose a threat to visibility or air quality standards.

Vehicle emissions and operation of chainsaws and chippers associated with roadwork and equipment used for mechanical treatments, thinning, and harvesting forest products are confined locally and are temporary.

Equipment use exhaust emissions are not expected to negatively affect ambient concentrations, which are very good.

Ozone concentrations from prescribed fire under the Proposed Action are not expected to approach federal and state ambient air quality standards.

Spatial and Temporal Context for Effects Analysis Including Cumulative Effects

The spatial boundary for analysis of fuels and fire behavior, is the SFMLRP area and Santa Fe watershed. The temporal boundary is up to ten years which is longest time period the IFTDSS model can forecast.

The spatial boundary for analysis of climate change and carbon storage is the same as the SFMLRP area and Santa Fe National Forest for showing the effects of climate change and changes in carbon storage to the project and forest area. The temporal boundary for greenhouse gas emissions and carbon storage is during and immediately post treatment. Climate change effects can be shown up to 2100 given the limitations of climate forecast models and research.

The air quality spatial analysis boundary is the same as state of New Mexico, New Mexico Air Quality Control Region 4, and Santa Fe and San Miguel Counties. These areas are used for comparing SFMLRP emissions to state and local emissions. The temporal boundary is several days to weeks for prescribed burning emissions and annual for comparisons of SFMLRP emissions to state and local emission inventories.

Affected Environment

Existing Condition

Fuels and Wildfire Behavior

Analysis of natural fire regimes, vegetation condition classes, and the historical fire regimes in the Southern Sangre de Cristo Mountains combined with current fire danger, fuels and potential wildfire behavior shows that most of the project area does not meet forest plan desired conditions for wildfire behavior, and current conditions may result in high intensity, widespread, damaging wildfires.

Natural Fire Regime

A natural fire regime is a general classification of the role fire would play across a landscape in the absence of modern human mechanical intervention but including the possible influence of aboriginal fire use. The five natural fire regimes are classified based on the average number of years between fires (fire frequency or mean fire interval [MFI]) combined with characteristic fire severity reflecting percent replacement of dominant overstory vegetation. Most of the project area is in fire regime group I and III, (Table 4) (FRCC, 2008; LANDFIRE, 2020). The vast majority of the project area has not burned in over 100 years (Figure 2). (NWCG, 2020a; Margolis et al., 2020).

There are five ERU's covering about 565 acres in the SFMLRP area that not listed in LMRP DEIS, 2019 and therefore at this time the forest does not have fire regime information or desired condition direction for the ERU's. These areas are mostly riparian and the SFMLRP will not implement any treatments in these ERU's except that prescribed fire may be allowed to burn into the areas:

- Alpine and Tundra, 10 acres
- RMAP[1] Narrowleaf Cottonwood / Shrub, 503 acres
- RMAP Ponderosa Pine / Willow, 31 acres
- RMAP Upper Montane Conifer / Willow, 15 acres
- RMAP Willow - Thinleaf Alder, 6 acres

Table 4. Fire Regime Group Descriptions and Ecological Response Unit SFMLRP Acreages

Group	Frequency (years)	Severity	Severity Description	Ecological Response Unit	SFMLRP Acreage
I	0 – 35	Low / mixed	Generally low-severity fires replacing less than 25% of the dominant overstory vegetation; can include mixed-severity fires that replace up to 75% of the overstory	Mixed Conifer - Frequent Fire	17,875
				Ponderosa pine forest	17,347
				Piñon-juniper grass,	1
				Juniper grass	223
II	0 – 35	Replacement	High-severity fires replacing greater than 75% of the dominant overstory vegetation	Colorado Plateau / Great Basin Grassland	140
				Montane / Subalpine Grassland	491
III	35 – 200	Mixed / low	Generally mixed-severity; can also include low-severity fires	Mixed Conifer - Frequent Fire	17,875
				Mixed conifer with aspen	456
				Piñon-juniper sagebrush	0
				Piñon-juniper woodland	8,436
IV	35 – 200	Replacement	High-severity fires	Mixed conifer with aspen	456
				Spruce-fir forest	5,022
				Sagebrush shrubland	0
V	200+	Replacement / any severity	Generally replacement- severity; can include any severity type in this frequency range	Spruce-fir forest	5,022
				Piñon-juniper sagebrush	0
				Piñon-juniper woodland	8,436

[1] Regional Riparian Mapping Project (RMAP)

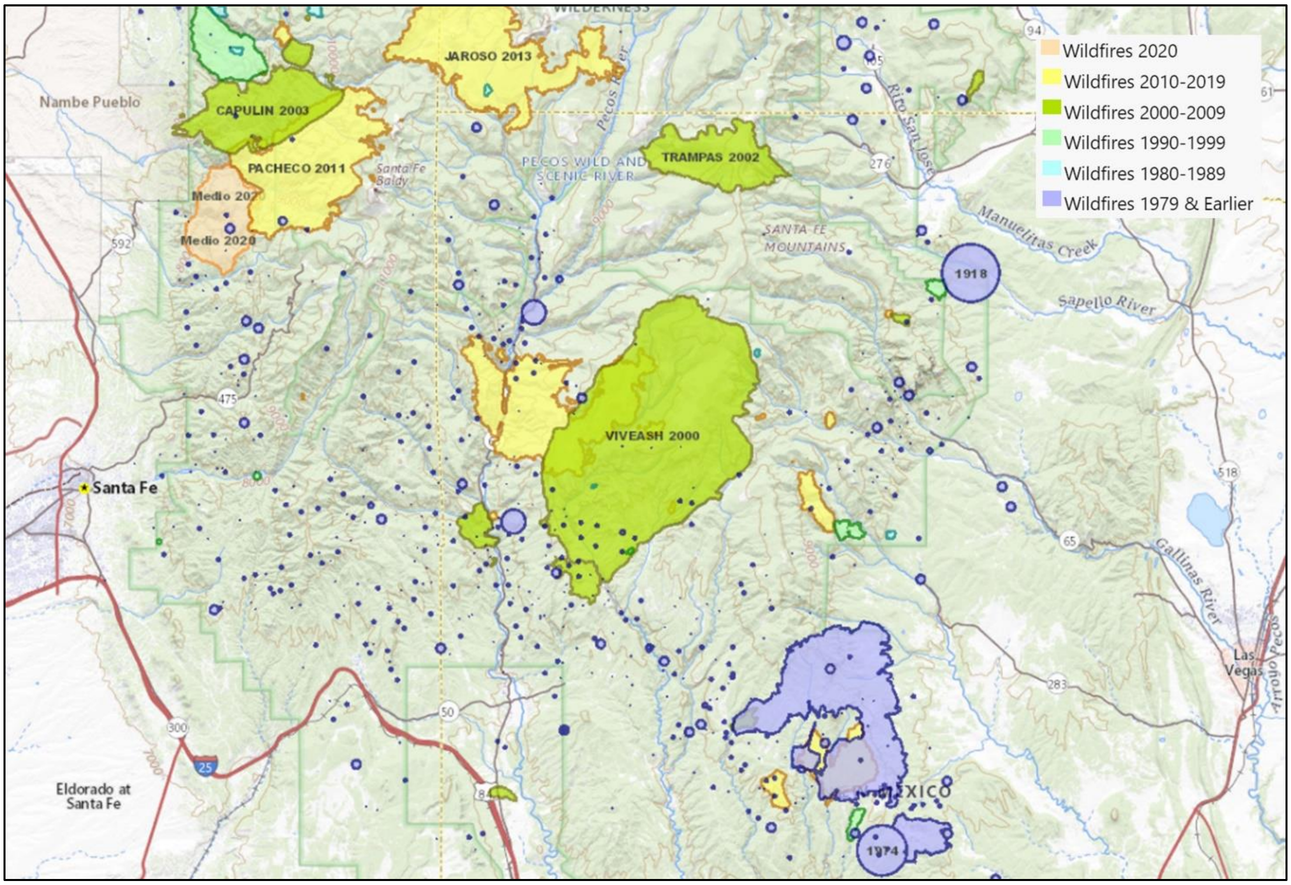


Figure 2. Fire history map of the SFMLRP area. The Pacheco fire (2011) and Medina (2020) are the only large fires to have burned in the project area since approximately 1900 or when the federal government began recording fire occurrences in the area (LANDFIRE, 2020)

Vegetation Dynamics Development Tool (VDDT)

As part of the Forest plan revision a VDDT analysis was completed and used models based on a historic reference period to determine the degree of departure of fire regimes, including fire frequency and severity. Research considers the historic reference period to be prior to European-American settlement when extensive land-use patterns changed with the introduction of grazing, fire suppression, and forest fragmentation. The projected changes to vegetation derived from the analyses were given a departure rating based on the degree to which they differed from desired conditions (Table 5).

Table 5. Scales of departure for vegetation analysis

Departure	Range (%)
Low	0-33%
Moderate	33-66%
High	66-100%

These fire regime departure ratings help build a greater picture of ERU condition in the planning area when compared with the departure ratings determined by VDDT models. These departure ratings help prioritize which ERUs are the most departed from the historical reference condition, so that focused treatments would be directed where they will be the most effective at restoring ecosystem function. Table 6 shows the VDDT values for the various ERU's with the SFMLRP area (LRMP DEIS, 2019).

Table 6. VDDT analysis showing the degree of seral state departure from reference conditions for selected ERUs within the SFLMRP area.

System	ERU Code	ERU Name	Departure	Departure Index
Forest	PPF	Ponderosa pine forest	High	97
Grassland	CPGB	Colorado Plateau/Great Basin	High	93
Forest	MCD	Mixed conifer-frequent fire	High	74
Forest	SFF	Spruce-fir forest	Moderate	54
Forest	MCW	Mixed conifer with aspen	Moderate	47
Woodland	JUG	Juniper grass	Moderate	45
Woodland	PJO	Piñon juniper woodland	Low	28

Vegetation Condition Class (VCC)

VCC represents a simple categorization and indicates the general level to which current vegetation is different from the simulated historical vegetation reference conditions. Due to fire exclusion most of the forest stands in the Santa Fe Mountains are in VCC IIa: moderate to low vegetation departure; and IIb: moderate to high vegetation departure (LANDFIRE, 2014. IFTDSS, 2020).

Historical Fire Regimes in the Southern Sangre de Cristo Mountains

In a recent 2020 study about historical fire regimes in the southern Sangre de Cristo Mountains, Ellis Margolis analyzed 1,298 crossdated fire scars from 272 fire-scarred trees in 33 plots (mean plot elevation equals 8,900 ft). An additional 104 fire-scarred trees located outside of the plots were used for mapping historical fire extents. Margolis found fire scars dating back to the early 1300's and the last recorded fire burned in 1902 (Figures 3-4) (Margolis et al., 2020).

Fire frequency

The fire regime in the dry conifer forests at the southern extent of the Rocky Mountains historically burned frequently and was dominated by low-severity fire. This is similar to other dry conifer forests of the region (Swetnam and Baisan, 1996) and across the West (Taylor and Skinner, 2003; Brown et al., 2008). Fires occurred in consecutive years on multiple occasions, but usually in different locations, suggesting a fuel limitation immediately following fire that prevents re-burning. Individual plots burned less frequently, on average (7 – 32-year median intervals). Widespread fires that burned at least half of the plots and crossed watersheds occurred relatively frequently (e.g., 20-year intervals).

These fire frequency estimates at different spatial scales are useful for planning fire treatments and fire frequency for fire regime restoration and maintenance burning. For three hundred years (1600 – 1902), the longest period without a fire in the study area was 10 years (1892 – 1902). The current fire-free interval (119 years) is over 11 times the historical maximum fire-free interval. These fire frequency estimates are like other studies across the region (Swetnam and Baisan, 1996).

Fire synchrony between the Santa Fe Watershed and adjacent areas

The majority (64%) of the fires that burned in the Santa Fe watershed also burned in adjacent watersheds. The last synchronous fire was > 135 years ago (1886). The degree of reconstructed historical synchrony, combined with observations of modern fires commonly burning across watershed boundaries, suggests that fire spread between the Santa Fe watershed and adjacent watersheds was likely common. Currently, the prevailing winds are generally from the south to the west during the fire season (May and June), which suggests that fires in adjacent watersheds have the high potential to spread into the Santa Fe watershed, particularly the upper Santa Fe watershed. This indicates that a landscape-scale perspective to forest, fire, and watershed management is necessary.

Fire seasonality – management implications

Similar to other fire history studies in the Southwest, the predominant fire season was in the spring and early summer (dormant or early earlywood scars -- early growing season), with few fall fires recorded. This contrasts with the current primary season for prescribed fire across the region, which is the fall. However, it is important to note that prescribed fire in previously treated areas in the Santa Fe Watershed are increasingly occurring in spring, which was historically more common. Burning during the historical fire season is more ecologically beneficial, but in many cases, this is not feasible until fuel levels are reduced by initial mechanical or late-season fire treatments. Mid-summer, monsoon-season, fires did occcur in the past and can be an intermediary goal, or another alternative to burning in the windy and dry spring and early summer.

Potential early human alteration of the fire regime in the Rio Chupadero drainage

There is some evidence to suggest a possible early human interuption in the fire regime beginning in the late 1700s in the Rio Chupadero. The three plots that surround a large meadow (Vigil Grant) along the Rio Chupadero experienced an 80-year fire-free period beginning in 1780. Meanwhile, the surrounding plots were burning in widespread fires (e.g., 1801 and 1845 fires). This anomalous fire free period at the three plots surrounding the Rio Chupadero meadow was followed by high-severity fire that killed all sampled trees at these plots. Prior to this 80-year fire free interval, these three plots were burning repeatedly at low severity, with some individual trees surviving up to ten fires. The meadow in the Rio Chupadero is at the junction of the drainage and the Borrego (goat or sheep) Trail. The Borrego Trail was used historically to move sheep north and south, to and from Santa Fe from the villages to the north. The Rio Chupadero was possibly also an early travel route from Tesuque Pueblo east into the Sangre de Cristo Mountains. It is possible that early grazing in and around the meadow at the intersection of the Rio Chupadero and the Borrego Trail eliminated surface fuels (grass) necessary to facilitate fire spread in this area, as well as created animal trails that would have further fragmented surface fuels. The long fire-free intervals likely increased fuels load and generated ladder fuels (young trees), so that when the area finally burned again, the fire killed the forest that had survived many prior fires. Culturally modified (bark-peeled) ponderosa pine have been observed in the study area, particularly along the Borrego Trail, and dating the years of the modifications may be one way of dating human presence and testing this localized grazing hypothesis, in conjunction with written historical records (Margolis et al., 2020).

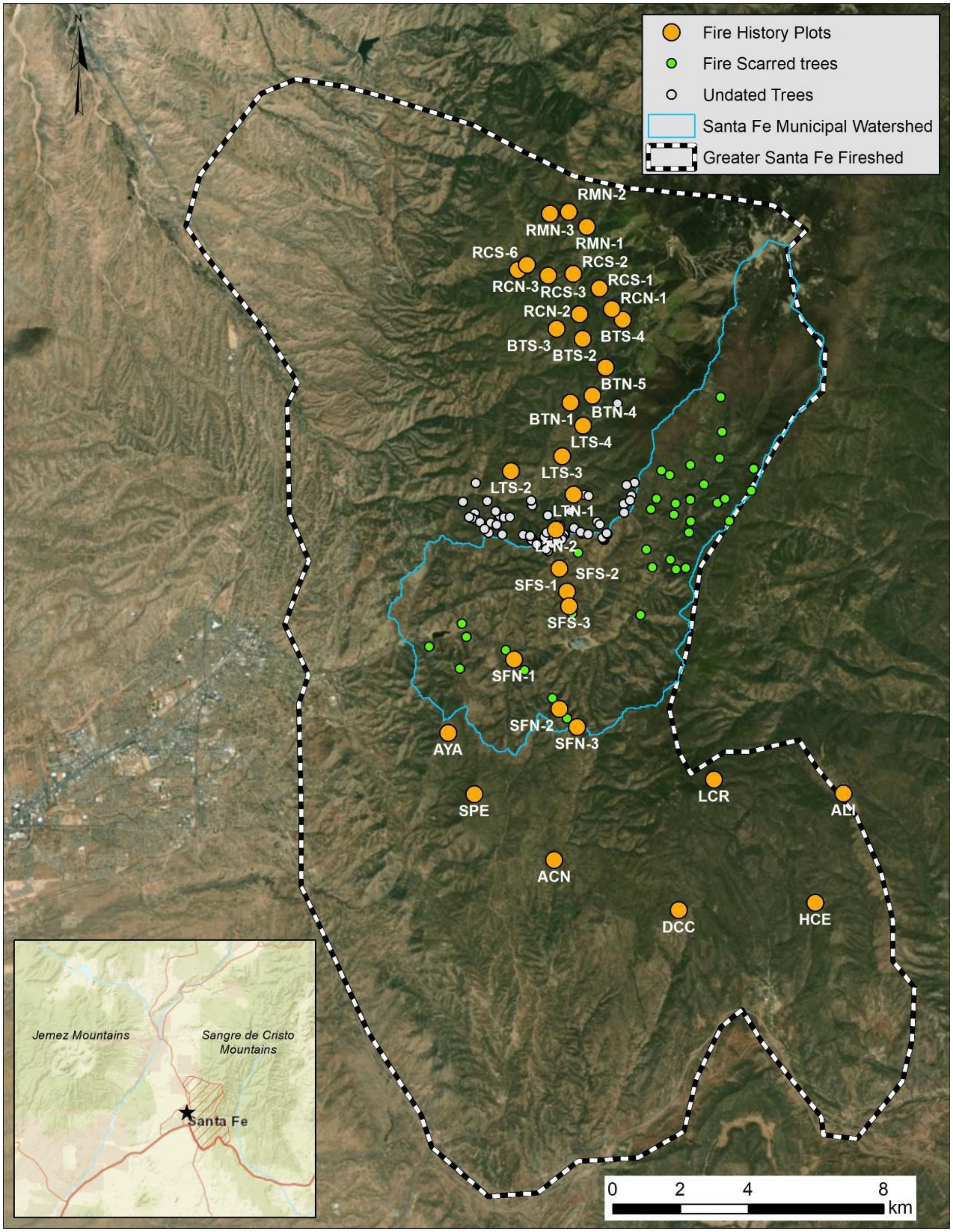


Figure 3. Map of tree-ring fire-scar plots and trees in the Santa Fe Fireshed, located at the southern - most extent of the Rocky Mountains. Plots were located throughout the dry conifer (ponderosa pine and mixed conifer) forests of the Santa Fe Municipal watershed and adjacent watersheds (Margolis et al., 2020)

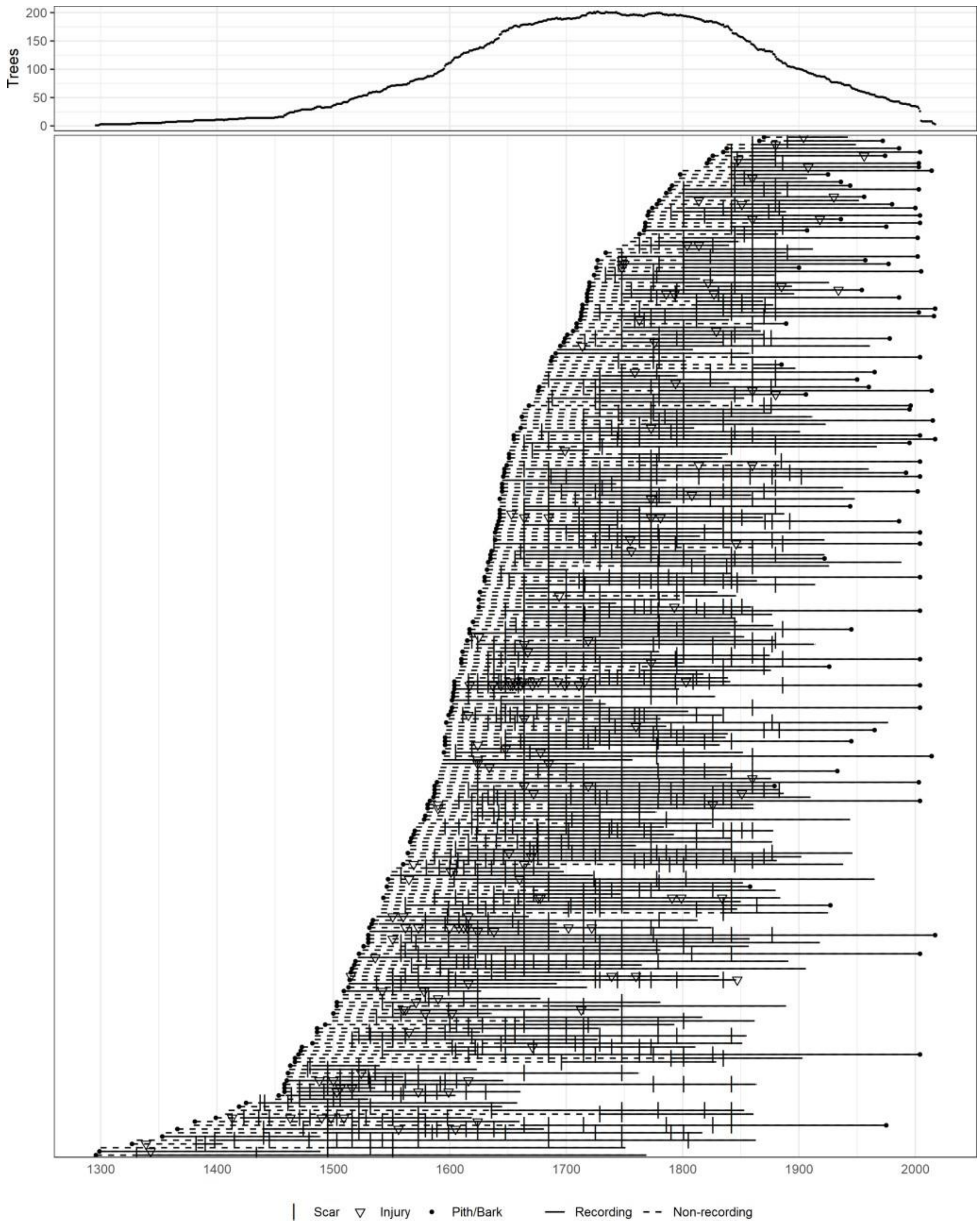


Figure 4. Fire chart for trees in plots in the Santa Fe Fireshed (n = 272 trees, 1296 – 2017 Common Era). Horizontal lines are trees and vertical ticks are fire scars. Top plot is sample depth. Note the lack of fire since 1880 (Margolis et al., 2020).

Fire Danger

The Forest Service operates two fire weather Remote Automated Weather Stations (RAWS) in the Santa Fe Mountains that are representative of the project area's weather conditions. The Santa Fe RAWS is located on the south end of the project area at 7,674' above sea level (ASL) and Truchas RAWS is located on the north end of the project area at 8,340' ASL. Useful data from the stations range from 12-17 years. The National Fire Danger Rating System shows steady fire danger at the Santa Fe RAWS from 2007-2018, and a slight decrease in fire danger at the Truchas RAWS from 2002-2018 for Burning Index (BI)[2] and Energy Release Component (ERC)[3] indices. The BI is the potential flame lengths and ERC is the potential total heat release per unit area in the forested stands in the Santa Fe Mountains if the area burns under 90th percentile wildfire conditions (Figures 5-6) (NWCG, 2019b).

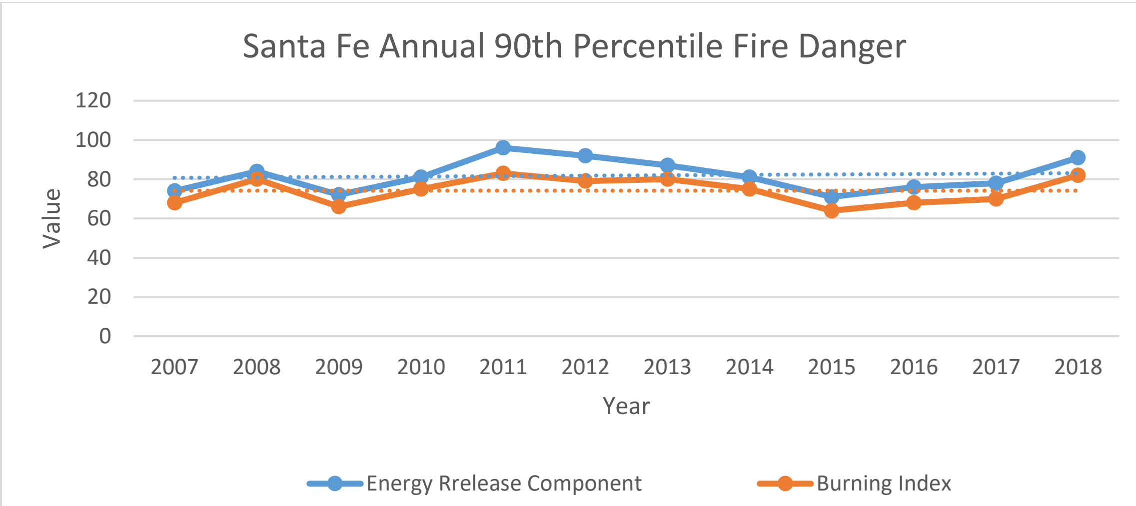


Figure 5. Santa Fe RAWS 90th Percentile Burning Index and Energy Release Component from 2007-2018

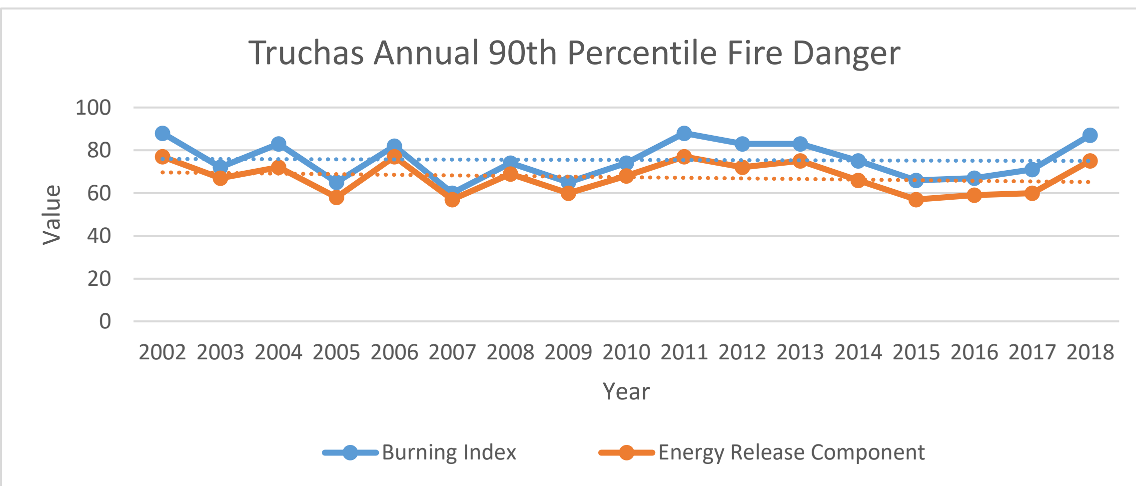


Figure 6.Truchas RAWS 90th Percentile Burning Index and Energy Release Component from 2002-2018

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[2] Burning Index (BI) - An estimate of the potential difficulty of fire containment as it relates to the flame length at the head of the fire. Doubling the burning index indicates that twice the effort will be required to contain a fire in that fuel type as was previously required, providing all other parameters are held constant. The BI number represents a flame length measured in feet and is based on a specific fuel model and fire weather and fuel moisture conditions inputs used in the National Fire Danger Rating System model. Example: A BI of 60 is the equivalent to a 6-foot flame length.
[3] Energy Release Component (ERC) - The computed total heat release per unit area (British thermal units per square foot) within the flaming front at the head of a moving fire.

In a recent 2018 Santa Fe fireshed wildfire risk assessment for the Greater Santa Fe Fireshed Coalition, Steven Bassett studied the threat from wildfire to valued resources and assets (VRAs) (Figure 7) (GSFFC, 2018).

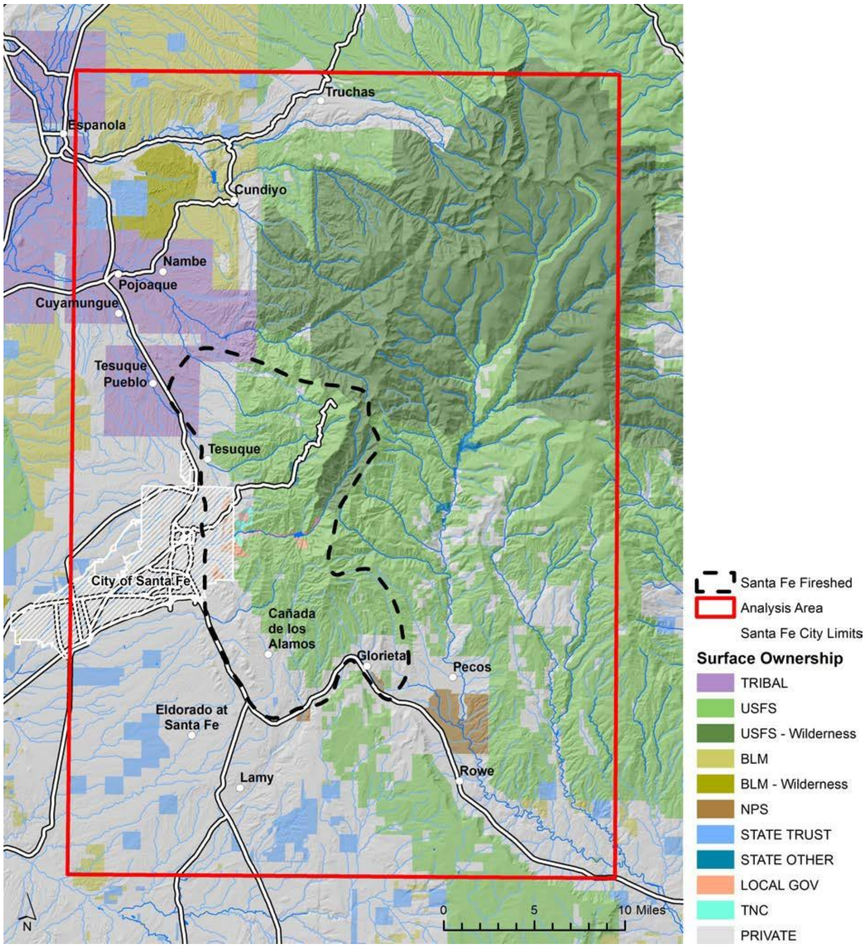

Figure 7. The analysis area used in this wildfire risk assessment (red line, 853,899 acres) extends beyond the official boundary of the Santa Fe Fireshed (black dashed line, 107,626 acres). The analysis area is larger to accommodate fires that begin outside but spread into the official boundary.

In summary Bassett found:

> VRAs are the reason wildfire risk exists; if there is not something of value that could be damaged by fire, then there would not be a reason to consider the threat of wildfire. VRAs vary widely, ranging from tangible assets like homes, to abstract concepts like the flood mitigation potential of a stand of trees. Within the area there are innumerable VRAs. Analyzing risk to all VRAs was infeasible with the time and resources available for this assessment, so risk was analyzed for a representative set of VRAs identified by interviewing subject matter experts within the Coalition (Table 7).

Table 7. Valued resources and assets (VRAs) included in this wildfire risk assessment.

Category	VRA	Sub-VRA
Private Investment	Private Land	
	Structures	
Watershed Function	Water for Irrigation	
	Water for People	
	Erosion Mitigation	Erosion Hazard Class
	Debris Flow Mitigation	Debris Flow Hazard Class
	Flood Control	
Infrastructure	Roads	Erosion Hazard Class
	Powerlines	
Recreation and Cultural Use	Developed Recreation Area	
	Trails	Erosion Hazard Class
Ecosystem Function	Spruce-Fir Forest	
	Mixed Conifer - Frequent Fire Forest	
	Ponderosa Pine Forest	
	PJ Grass	
	PJ Woodland	
	Juniper Grass	
	Colorado Plateau / Great Basin Grassland	
	Other Vegetation	

Negative expected net value change following the next fire is high throughout the study area, though there are areas where the next expected fire will not have a negative outcome (Figure 8). In these risk maps, each, risk is classified into bins that represent a doubling of wildfire risk. The transition between colors represents a doubling of risk. Dark red areas are expected to lose the most value relative to other areas. Dark blue areas are expected to increase in value relative to other areas. Investments in reducing wildfire risk (including reducing the intensity and likelihood of wildfire through forest restoration and fuels reduction treatments and decreasing the susceptibility of VRAs through hardening resources and assets to the effects of fire) should be prioritized in the highest risk areas. Investments in maintaining low risk areas through prescribed fire and re-treatment may be necessary to prevent low risk (blue) areas from becoming high-risk (red).

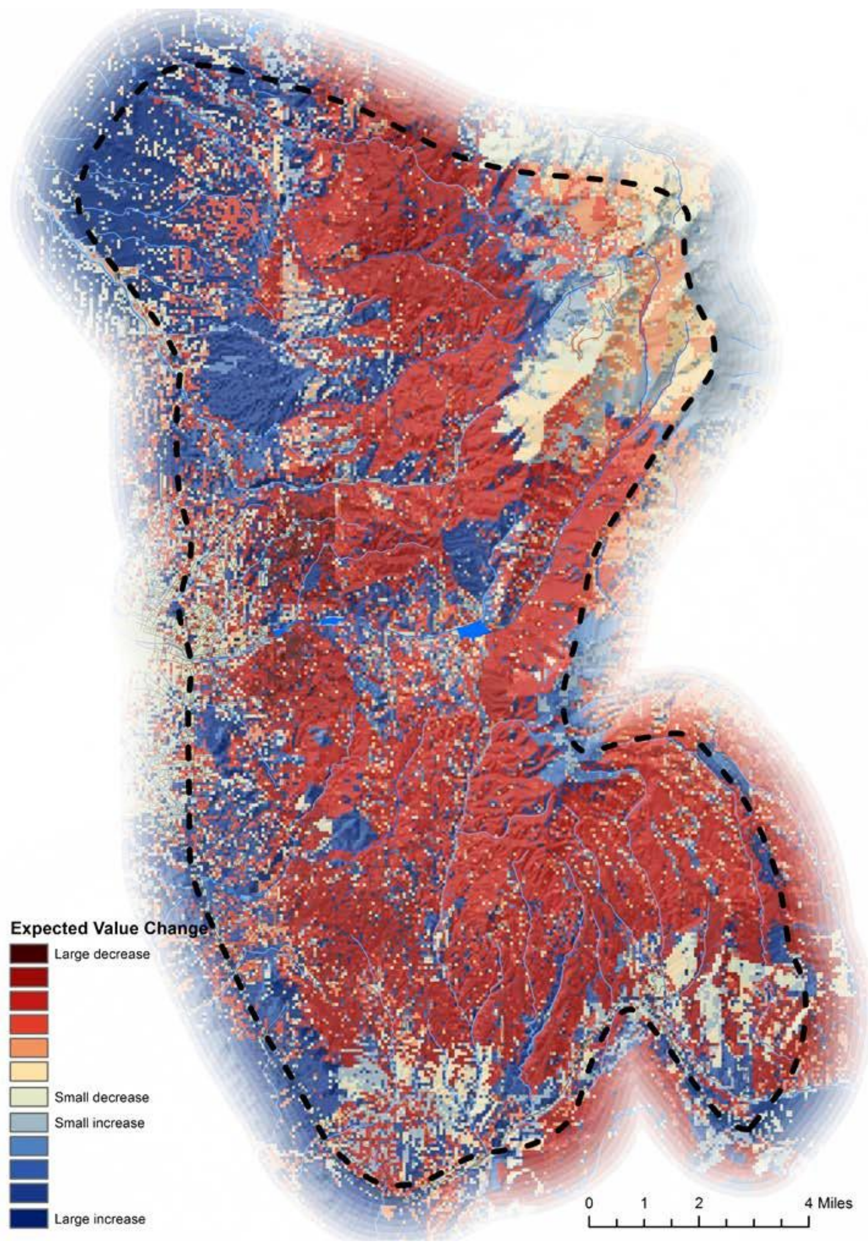

Figure 8. Expected net value change (eNVC) for all VRAs included in this wildfire risk assessment.

Air Quality

Air quality and the values dependent on-air quality in the Santa Fe NF are generally in good condition or are improving as most pollutants are decreasing as a result of stricter regulations. However modeled critical loads from nitrogen deposition are being exceeded, primarily for lichens. Conditions are expected to continue to improve due to projected emissions. Of greater concern are impacts to visibility and ambient air quality conditions associated with particulate matter, which are expected to increase as a result of larger, more severe wildfires and increases in fugitive dust as the effects of climate change are realized (LMRP DEIS, 2019).

Fine particle pollution is the principal pollutant of concern in wildland fire smoke for the relatively short-term exposures typically experienced by the public. The individual particles in wildland fire smoke are very small; collectively, they are visible to the naked eye as smoke. Particles in wildland fire smoke are primarily PM10 and smaller particles. PM10 are particles 10 microns in diameter and smaller. The <PM2.5 particles form about 70% of PM10. In other words, the vast majority of PM10 particles are the smaller <PM2.5 size particles.

Besides PM, components of smoke with implications for human health include carbon monoxide (CO), a colorless, odorless gas produced by incomplete combustion of wood or other organic materials. At high levels, CO can cause dizziness, nausea, and impaired mental function. Carbon monoxide levels are highest during the smoldering stages of a fire, especially in close proximity to the fire, and mostly affects fire personnel. Carbon monoxide breaks down quickly and generally does not impact the public.

Smoke also contains a number of toxic air pollutants such as aldehydes (including formaldehyde and acrolein) and organic compounds such as polycyclic aromatic hydrocarbons and benzene. Acrolein and formaldehyde are potent eye and respiratory irritants. Benzene is a known carcinogen that can cause headaches, dizziness, and breathing difficulties. These compounds also mostly effect fire personnel who work in close proximity to fires.

Ground level ozone (O3) is a secondary pollutant in that it is not emitted directly from wildland fires but can form downwind when volatile organic compounds (VOC's) and nitrogen oxides (NOx) react in the presence of sunlight. Wildland fire smoke is an important source of VOCs as well as a source of NOx. While there are instances in which ozone levels can be affected by wildland fire emissions, typically the NOx involved in ozone formation originates from urban and industrial sources, such as vehicles and power plants (NWCG, 2018).

Figure 9 shows the ratio of <PM2.5 size particles to PM2.5-PM10 and >PM10. As a rule of thumb one can calculate that <PM2.5 size particles comprise about 70% of smoke emission particulates.

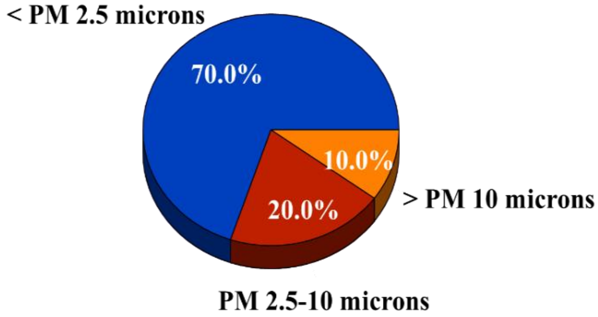

Figure 9. Size classes of smoke emissions particulates

Table 8 shows the amount of annual criteria pollutant (CP) particulates (PM10) and nitrogen dioxide (NO2) emissions from various sources at the local (SFMLRP counties), state and national levels. This information will be compared to estimated project emissions below.

Table 8. 2014 National Emissions Inventory of annual criteria pollutant data at the local, state and national levels (tons)

Source	CP PM2.5	CP PM10	CP NO2
San Miguel County – All Sources	1,647	11,595	1,833
Santa Fe County – All Sources	3,763	31,108	5,752
New Mexico – All Sources	65,784	443,856	186,869
National – All Sources	5,405,521	18,209,509	13,463,097
San Miguel County – Prescribed Fires	287	338	41
San Miguel County – Wildfires	21	25	3
San Miguel County – Agricultural Field Burning	3	4	1
Santa Fe County – Prescribed Fires	3	4	0.4
Santa Fe County – Wildfires	0.1	0.1	0.03
Santa Fe County – Agricultural Field Burning	U/A	U/A	U/A
New Mexico – Prescribed Fires	3,329	3,929	541
New Mexico – Wildfires	5,676	6,698	906
New Mexico – Agricultural Field Burning	151	206	29
National – Prescribed Fires	780,812	919,895	152,426
National – Wildfires	886,245	1,045,755	119,147
National – Agricultural Field Burning	64,628	87,356	20,358

Air Quality Health Standards

Recent air quality in the forest area has been good and the area complies with the National Ambient Air Quality Standards (NAAQS). Figure 8 shows the locations of EPA certified air quality monitoring stations in northern New Mexico. Particulate and ozone monitoring data from the Coyote Ranger District, Taos and Santa Fe stations closest to the SFMLRP are shown in Figures 9-12 (EPA, 2020b).

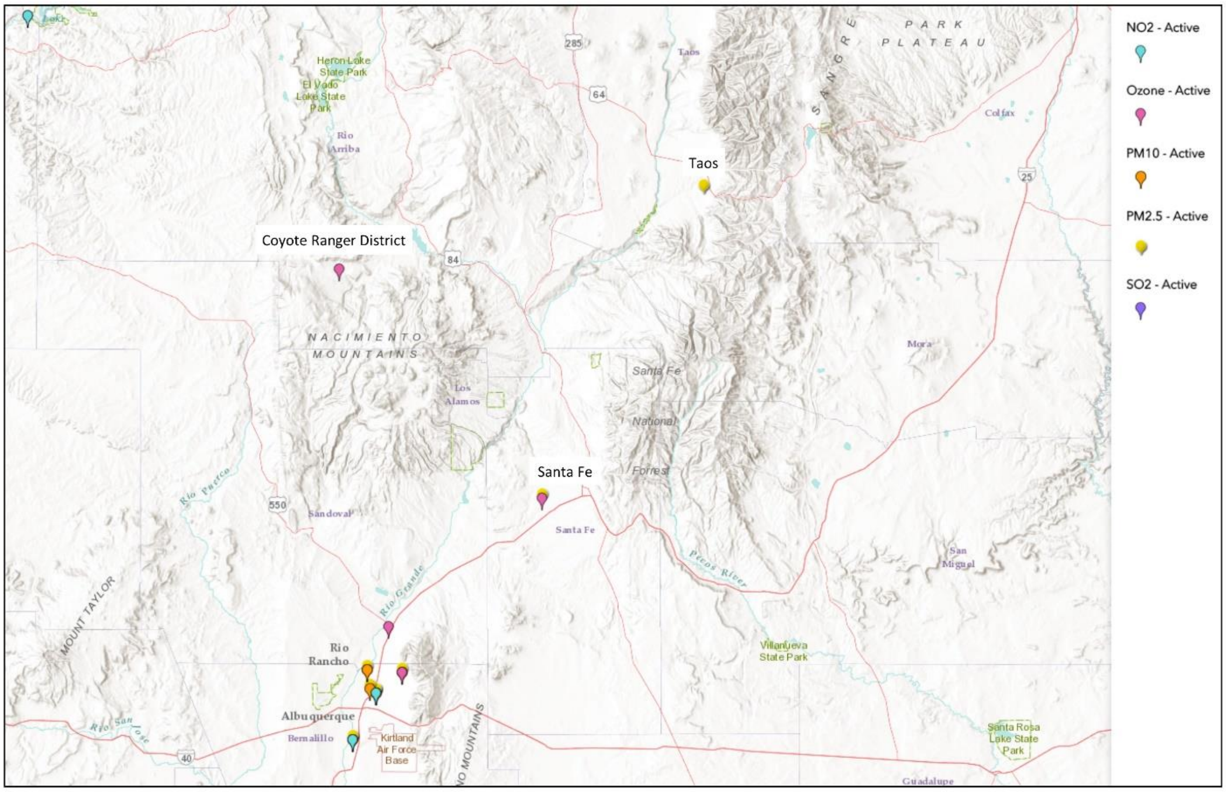

Figure 10. Locations of EPA certified air quality monitoring locations in northern New Mexico (EPA, 2020b).

Table 9 shows the available PM2.5 annual concentration data for Santa Fe and Taos Counties from 2005-2019[4]. The PM2.5 NAAQS level is 12 micrograms per cubic meter. The table also shows available ozone data from 2007-2019 for Rio Arriba, Sandoval and Santa Fe Counties[5]. The NAQQS level for ozone is 0.070 ppm. The data shows concentrations below the standards except for a 2018 Sandoval County ozone exceedance (EPA, 2020a).

Table 9. PM2.5 and ozone data for four local counties in the SFMLRP area

Year	Santa Fe County Annual PM2.5 (ug/m3)	Taos County Annual PM2.5 (ug/m3)	Rio Arriba County Annual 8-Hour Ozone (ppm)	Sandoval County Annual 8-Hour Ozone (ppm)	Santa Fe County Annual 8-Hour Ozone (ppm)
2005	5	-	-	-	-
2006	5	-	-	-	-
2007	5	-	-	-	0.063
2008	5	-	-	-	0.066
2009	4	-	-	-	0.059
2010	4	-	-	-	0.064
2011	5	-	-	0.065	0.063
2012	5	-	-	0.062	0.068
2013	3	-	0.066	0.067	0.068
2014	3	-	0.065	0.062	0.064
2015	2	-	0.064	0.066	0.062
2016	2	-	0.063	0.064	0.064
2017	5	9	0.07	0.067	0.065
2018	4	6	0.07	***0.073***	0.069
2019	3	5	0.061	0.065	0.066

Visibility

Currently New Mexico does not have visibility goals and the state is required to develop and submit to EPA its regional haze plan by July 31, 2021.

The Class I areas in northern New Mexico are Bandelier Wilderness, San Pedro Parks Wilderness, Pecos Wilderness and Wheeler Peak Wilderness. The Forest Service cooperates with the state in monitoring air quality conditions through the Interagency Monitoring of Protected Visual Environments (IMROVE) program. The nearest IMPROVE monitoring sites are located at Espanola (35-039-9000), Los Alamos (35-028-1002), and Taos (35-055-9000). Each site has shown similar improvement in the visibility conditions represented by the 20 percent most impaired days and 20 percent clearest days from 2000-2017 which is mostly reflected by reductions in sulfate, and may be a result of emissions control

[4] PM2.5 averaging time 1-year annual mean, averaged over 3 years.
[5] Ozone averaging time 8 hours - annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.

technology improvements at coal-fired electric generating stations in the Four Corners (Figures 11-16) (LMRP DEIS, 2019; NMED, 2020).

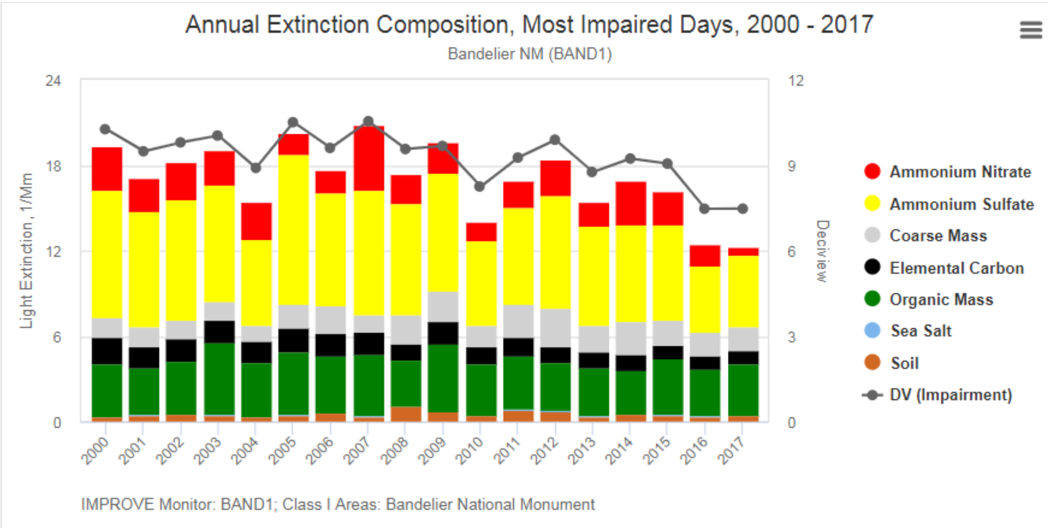

Figure 11. Bandelier National Monument Annual Extinction, Most Impaired Days, 2000-2017 (deciviews[6])

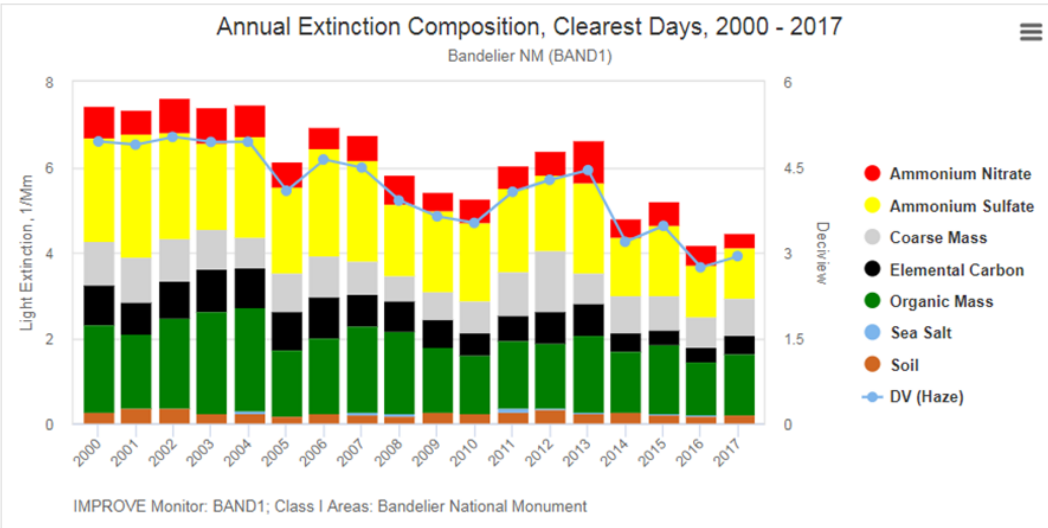

Figure 12. Bandelier National Monument Annual Extinction, Clearest Days, 2000-2017 (deciviews)

[6] The unit of measurement of haze, or "haze index". Deciview is a measure of visibility derived from light extinction that is designed so that incremental changes in the haze index correspond to uniform incremental changes in visual perception, across the entire range of conditions from pristine to highly impaired. The haze index [in units of deciviews (dv)] is calculated directly from the total light extinction [bext expressed in inverse megameters (Mm_{-1})] as follows: $HI = 10 \ln (b_{ext}/10)$ The haze index will be less than 0 for best values below 10.

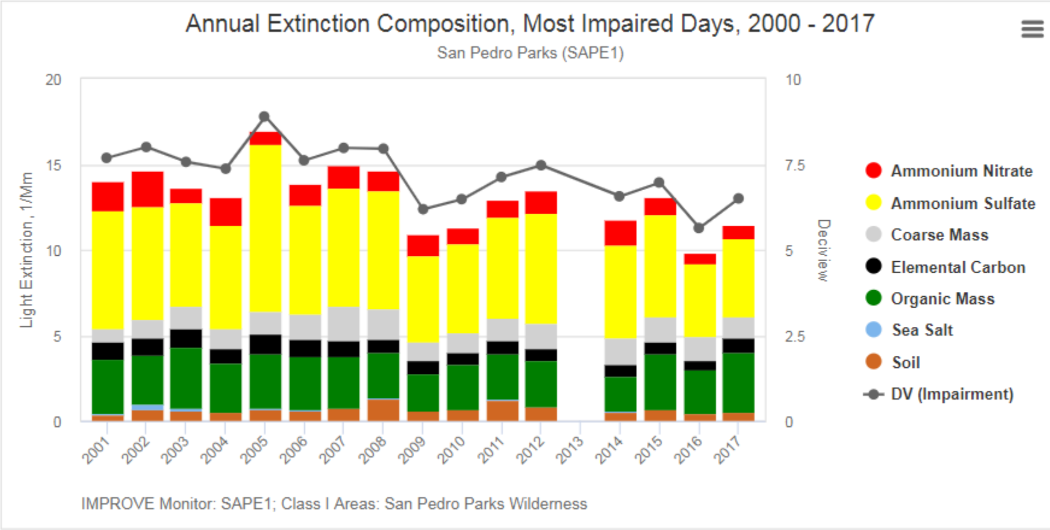

Figure 13. San Pedro Parks Wilderness Annual Extinction, Most Impaired Days, 2000-2017 (deciviews)

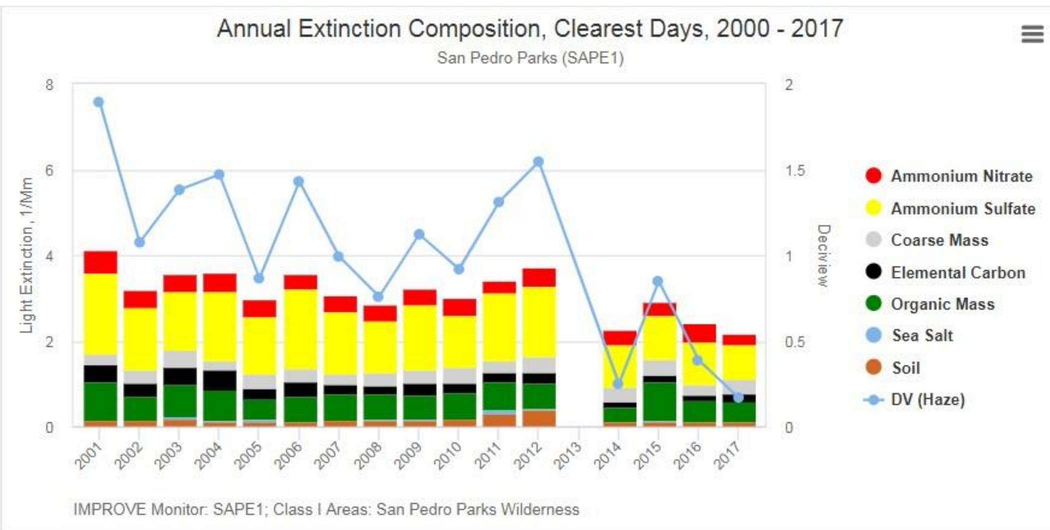

Figure 14. San Pedro Parks Wilderness Annual Extinction, Clearest Days, 2000-2017 (deciviews)

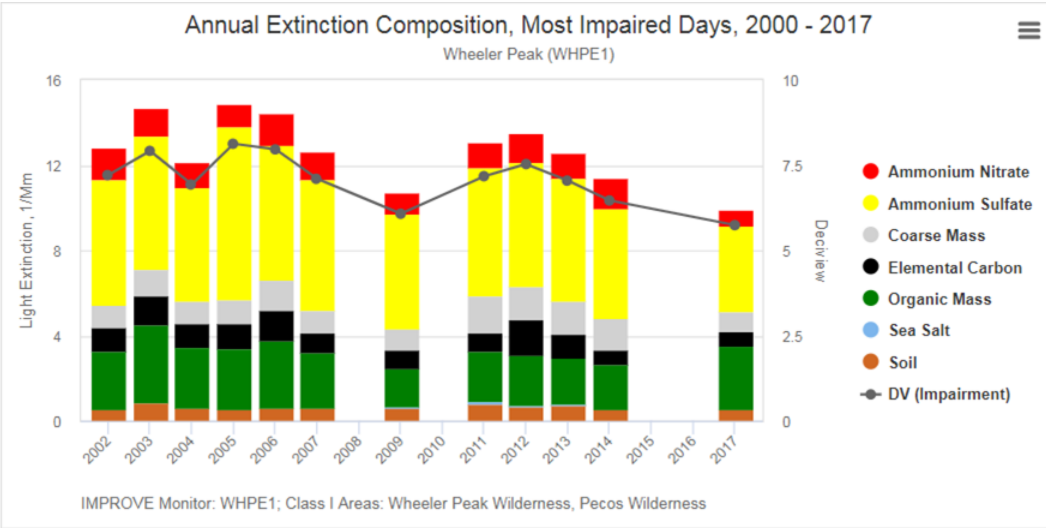

Figure 15. Wheeler Peak and Pecos Wilderness Annual Extinction, Most Impaired Days, 2000-2017 (deciviews)

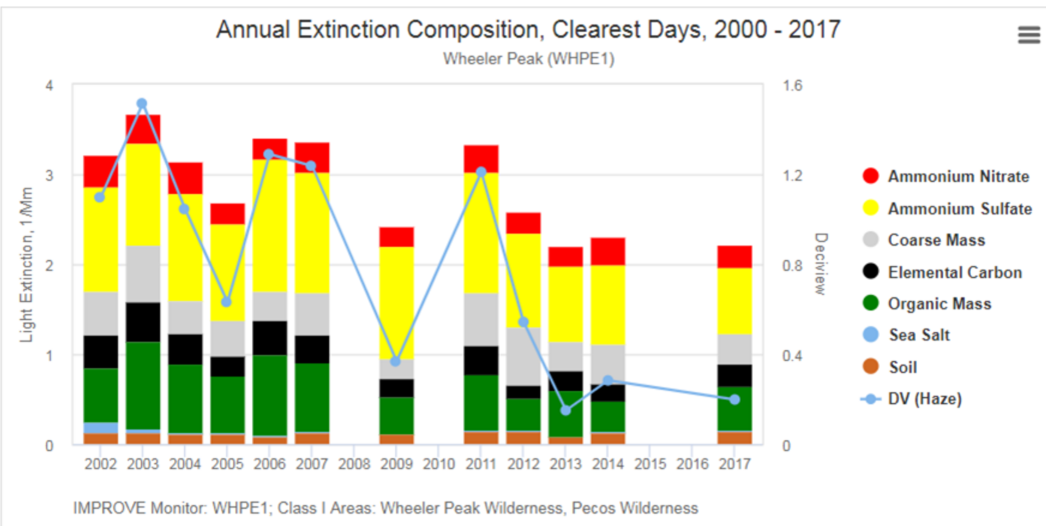

Figure 16. Wheeler Peak and Pecos Wilderness Annual Extinction, Clearest Days, 2000-2017 (deciviews)

Climate Change and Carbon Storage and Storage

Greenhouse Gases

New Mexico emitted 18,632,809 tons of carbon dioxide and 6,658 tons of methane in 2014 from all sources (Table 10) (EPA, 2020c). This information will be compared to estimated project emissions below.

Table 10. 2014 National Emissions Inventory of annual greenhouse gas emissions at the local, state and national emissions (tons)

Source	GHG CO2	GHG CH4
San Miguel County – All Sources	341,033	219
Santa Fe County – All Sources	1,349,777	102
New Mexico – All Sources	18,632,809	6,658
National – All Sources	2,257,756,571	1,108,327
San Miguel County – Prescribed Fires	37,155	164
San Miguel County – Wildfires	2,614	12
San Miguel County – Agricultural Field Burning	U/A	U/A
Santa Fe County – Prescribed Fires	385	2
Santa Fe County – Wildfires	20	0.07
Santa Fe County – Agricultural Field Burning	U/A	U/A
New Mexico – Prescribed Fires	463,827	1,887
New Mexico – Wildfires	781,826	3,221
New Mexico – Agricultural Field Burning	U/A	U/A
National – Prescribed Fires	108,914,013	423,651
National – Wildfires	110,380,596	508,106
National – Agricultural Field Burning	U/A	U/A

Climate Change

Although regional climates persist for centuries, they gradually change, and vegetation responds on a similar scale over time. The ecosystems we see today are products of species evolution and migration over time, occurring on a constantly shifting landscape driven by climate. Climates change at a variety of scales. Long-term, persistent trends in temperature and humidity determine the extent and location of various life zones, the elevation at which one biotic community replaces another. Short-term fluctuations, on the order of years to decades, determine drought cycles, fire frequencies, and pulses of tree reproduction. The Southwest Region is strongly influenced by oscillation in the Pacific Ocean-atmosphere system. El Niño years bring increased annual precipitation, but less rain in the summer, and La Niña years bring the opposite (LRMP DEIS, 2019).

Climate change is anticipated to have lasting, large-scale impacts to a variety of ecological, social, and economic resources around the Santa Fe National Forest. Mean annual temperatures in the planning area have increased in the last several decades, mostly with increased nighttime temperatures. There has been a decrease in the amount of snow at low to mid-elevations, and an increase inyear-to-year precipitation variability (wetter wet years and drier dry years). At higher elevations, overall snowfall and spring snow-water equivalent (amount of water in snowpack) have remained steady in most southern areas, but snowmelt now occurs earlier in the year. Changes in temperature and in amounts and timing of precipitation have led to earlier peak stream flow rates in most streams, with higher spring flows and lower summer flows, and will have a major influence on fire across the western United States, especially in mid-elevation forests (LRMP DEIS, 2019).

The most important determinant of fire severity is fuel condition, while two other important factors for determining fire regimes are vegetation type (or ERU) and weather or climate patterns. Fire history and dendrochronological studies provide ample evidence of past relationships between fire and climate. That evidence makes it clear that a changing climate will profoundly affect the frequency and severity of fires and change vegetation structure and composition as a response to more severe or prolonged droughts. Warmer temperatures, more variable precipitation, and increased moisture deficit are likely to stress vegetation, and make high-elevation forests more vulnerable to fire, insects, and disease. Fires will likely be more frequent and widespread. Insects such as western spruce budworm and spruce beetle are likely to proliferate in stressed and weakened trees, and mortality is likely to increase as a result of these outbreaks. However, past spruce budworm outbreaks have been associated with periods of increased moisture, and warmer, more drought-prone conditions could reduce budworm activity and temper the severity of future outbreaks. Root rot is also likely to increase in stressed forests. Increased tree mortality due to extended or severe drought, will change fuel structure and dead fuel loads, further impacting fire frequency and severity. The increased burning of forests will also result in carbon release, changing western forests from carbon sinks to carbon sources, contributing to increased greenhouse gas emissions (LRMP DEIS, 2019).

At the forest level, the effects of climate change on vegetation are magnified where vegetation structure and composition are outside the natural range of variation, especially in high-elevation forests that are moderately (e.g., MCW, MCD, PPF) to highly (e.g., ALP, SFF) vulnerable to climate change on a landscape scale. Vulnerability ratings are based off of each ERU's ability to resist non-normal ecological conditions and rank their degree of resilience to these disturbances, where ERUs ranked highly vulnerable have little resistance to non-normal disturbances and less ability to recover following these types of disturbance. Across the forest, 8 percent of all ecosystems are at very high vulnerability risk, 14 percent are at high vulnerability, 54 percent are at moderate vulnerability, and 24 percent are at low vulnerability (CCVA 2015). The ERUs with the highest vulnerability to climate change at the plan unit scale include ALP, PJG, and PJS. On more localized scales, a very high to high vulnerability risk could be expected in the northwest zone (Cuba) in PJG, PJS, and SFF; southwest zone (Coyote, Jemez Springs) in JUG, PJG, PJO, PPF, and SFF; northeast zone (Pecos and Las Vegas) in SFF; southeast zone (Glorietta Mesa, Anton Chico) in CPGB, JUG, PJG, PJO, PPF, and SFF; and central zone (Los Alamos, Caja del Rio) in CPGB, MCD, PJG, PJS, PPF, and SFF (CCVA 2015) (LRMP DEIS, 2019).

Outside of the impacts that changes in climate could have on vegetation, such as structural and composition changes, type shifts across elevational gradients, increased mortality or predisposition to secondary disturbances like disease or insects, and increased competition pressure from growing invasive species populations, changes in ERUs would affect wildlife, recreation opportunities, and socio-economic factors. For instance, five at-risk species in the forest rely on CPGB or on PJS and PJG, all of which are at very high vulnerability to climate change at various scales. Recreation opportunities could suffer from the loss of SFF areas (such as the forested areas surrounding the Santa Fe Ski Basin), as increased tree mortality would make hiking or riding on popular trails exceedingly dangerous. In wilderness areas, trail maintenance would become increasingly difficult with additional tree mortality. Socio-economic impacts of climate change-affected vegetation in the forest may include reduced availability of forest products needed for heat (fuelwood) or sustenance (piñon nuts), medicinal uses, and cultural traditions or practices. Scenery may also be negatively impacted, resulting in fewer (non-local) visitors to the Santa Fe, bringing less revenue into the area and reducing the need for some existing seasonal or permanent positions (LRMP DEIS, 2019).

A large proportion of ERUs are well outside of the natural range of variation and are highly departed from desired conditions. Uncharacteristically dense vegetation has a lower resilience to climate change, fire, insects, and pathogens. Moreover, plant compositions that have shifted toward dominance of less drought- and fire-tolerant species have decreased resilience to climate change. The best way that land managers can align forest conditions to adapt with a changing climate is by reintroducing fire into fire-adapted ecosystems. Implementing managed fire and other management techniques in highly departed areas now is paramount to shape sustainable and resilient ecosystems for the future in the face of a changing climate (LRMP DEIS, 2019).

Climate data gathered in the Santa Fe Mountains region started in the late 1800's at weather stations that are mostly located in valleys surrounding the mountains. Four long term stations shown in table 4 range in elevation from 5,590-6,965 feet above sea level (ASL). Average annual temperature and precipitation data from the stations are summarized in Table 11 and the data from these and many other long-term stations are used in modeling climate change shown below (WRCC, 2020). (LRMP DEIS, 2019).

Table 11. Average annual data from four long term weather stations in the Santa Fe Mountains vicinity

Weather Station	Period of Record	Elevation (feet)	Average Max. Temperature (F)	Average Min. Temperature (F)	Average Total Precipitation (inches)	Average Total Snowfall (inches)
ESPANOLA, NEW MEXICO (293031)	04/01/1895 to 10/07/2012	5,590	68.6	34.6	9.88	11.7
PECOS NM, NEW MEXICO (296676)	01/01/1916 to 01/31/2016	6,876	65.8	32.9	16.15	27.2
SANTA FE CO MUNI AP, NEW MEXICO (298078)	05/27/1941 to 06/09/2016	6,348	64.9	36.9	9.54	27.7
TAOS, NEW MEXICO (298668)	12/01/1892 to 04/30/2016	6,965	63.6	31.0	12.35	29.5

The emission of greenhouse gases (GHGs) by human activities and natural processes contribute to the warming of the Earth's climate. Warming could have significant ecological, economic, and social impacts at regional and global scales (IPCC, 2007). The U.S. Climate Resilience Toolkit shows[7] historic and projected Santa Fe and San Miguel Counties temperatures and precipitation from 1950-2100. The climate projections are based on lower and higher greenhouse gas emissions scenarios and show significant increases in maximum and minimum temperatures and slight decreases in precipitation (Figures 17-22) (USCRT, 2020).

[7] Based on global climate models developed for the United Nations Intergovernmental Panel on Climate Change, Climate Explorer's (Toolkit) graphs and maps show projected conditions for two possible futures: one in which humans reduce and stabilize global emissions of heat-trapping gases (labeled Lower emissions), and one in which we continue increasing emissions through the 21st century (labeled Higher emissions). Decision makers can compare climate projections based on these two plausible futures, and plan according to their tolerance for risk and the timeframe of their decisions.

Figure 17. Santa Fe County Total Precipitation 1950 – 2100.

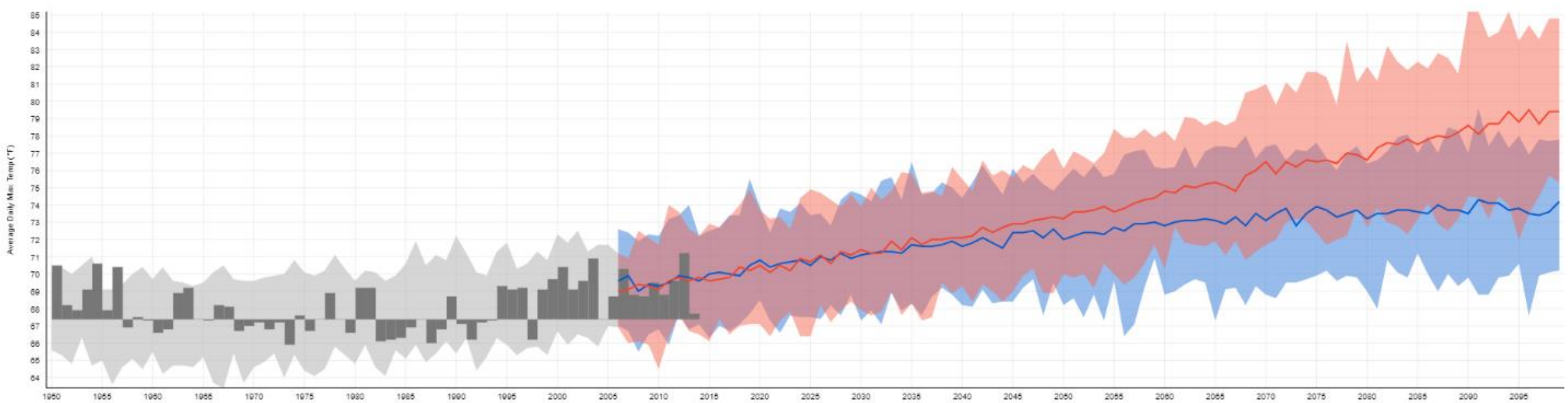

Figure 18. Santa Fe County Average Daily Max Temperature 1950 – 2100.

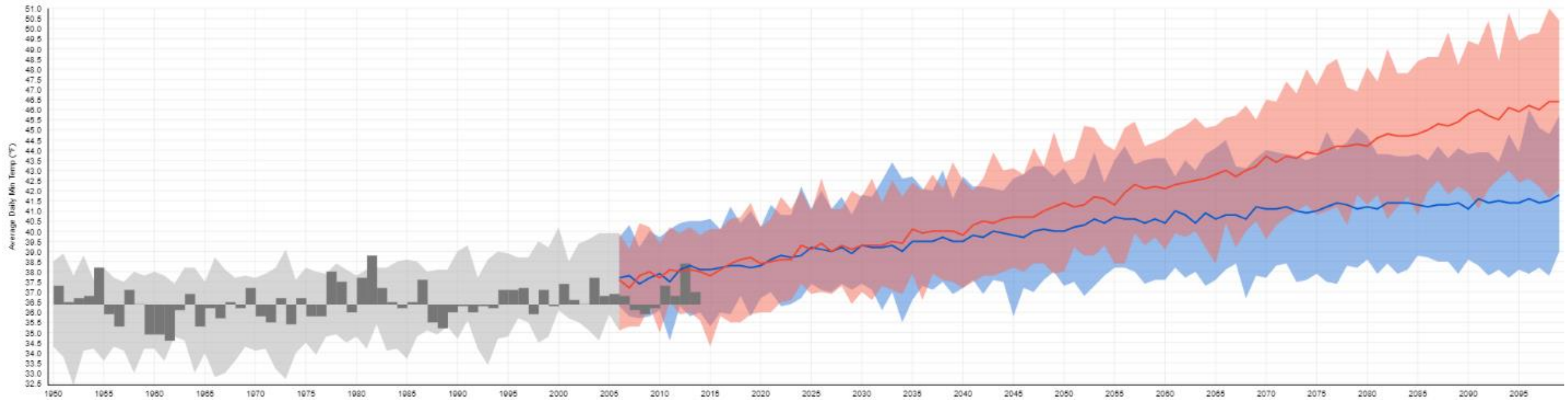

Figure 19. Santa Fe County Average Daily Min Temperature 1950 – 2100.

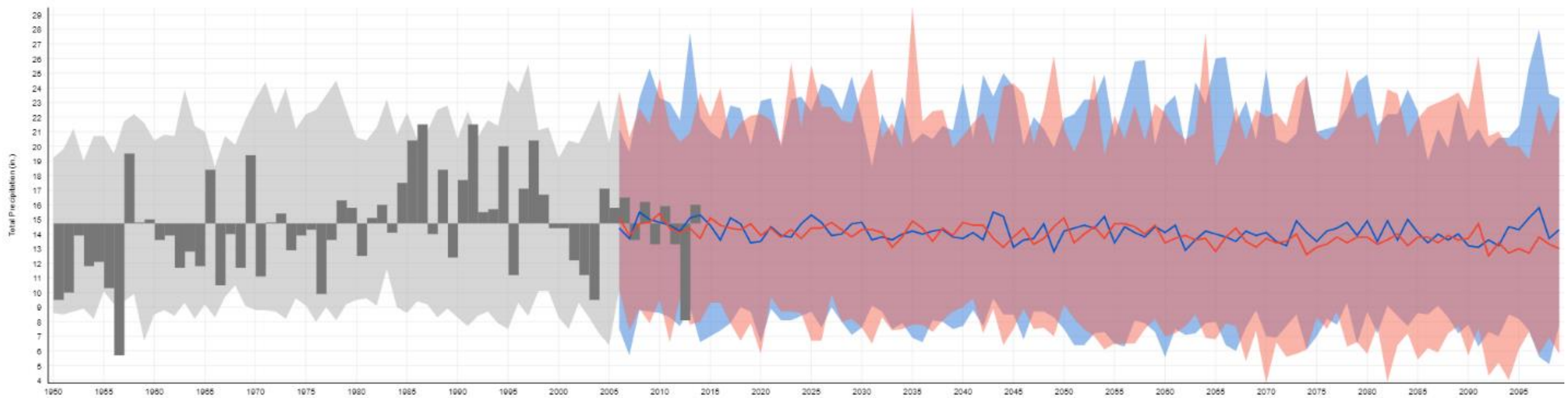

Figure 20. San Miguel County Total Precipitation 1950 – 2100.

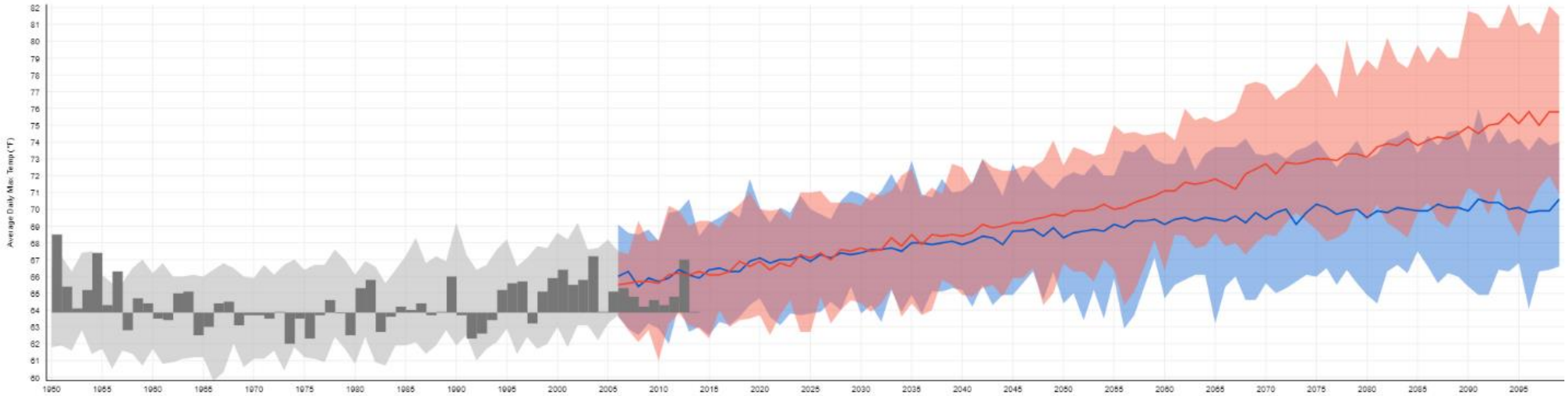

Figure 21. San Miguel County Average Daily Max Temperature 1950 – 2100

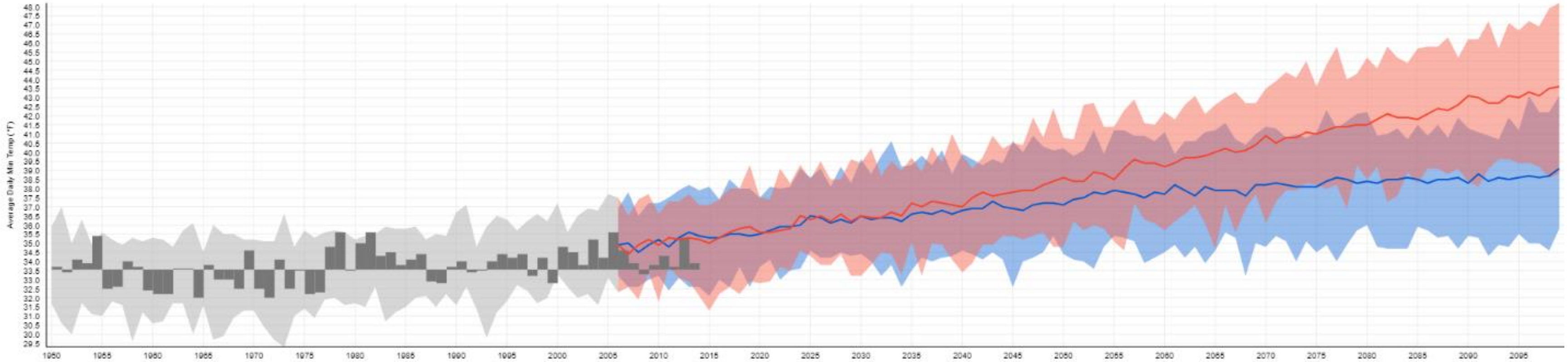

Figure 22. San Miguel County Average Daily Min Temperature 1950 – 2100.

Both Santa Fe and Truchas RAWS also show overall increases in annual minimum, mean and maximum temperatures through 2018 (Figures 23-24) (NWCG, 2020).

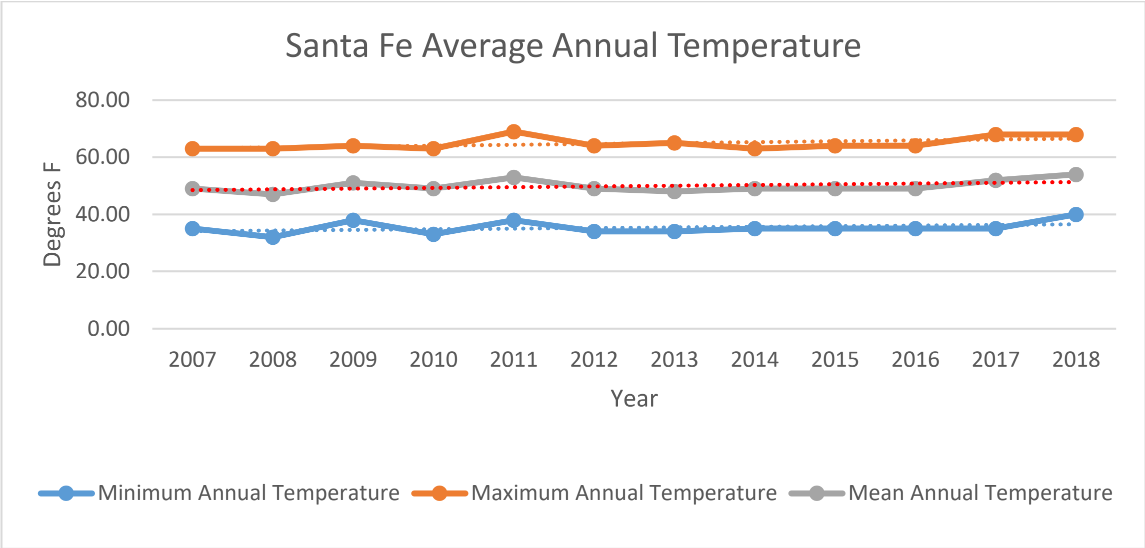

Figure 23. Santa Fe RAWS average annual temperature data 2007-2018

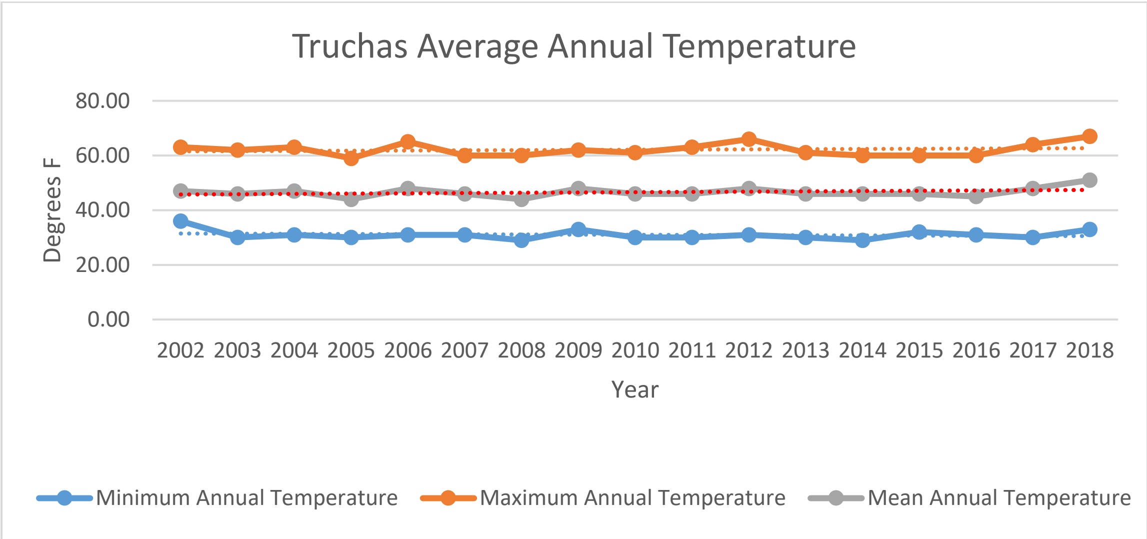

Figure 24. Truchas RAWS average annual temperature data 2002-2018

Spring melting is occurring earlier in the year; the Colorado River, Rio Grande, and several other southwestern rivers have hydrographs that peak earlier, suggesting that the spring temperatures in these regions are warmer than in the past (EPA, 2016). Several researchers have specifically studied Santa Fe NF watersheds. Fritze et al. (2011) showed that snowmelt is occurring 5 to 20 days earlier in the southern Sangre de Cristo Mountains with higher streamflow in March and April, but less from May-June (based on 60 years data from 1948-2008); the Santa Fe and Gallinas municipal watersheds are dependent on these upland snow sources (LRMP DEIS, 2019).

Climate Change Vulnerability Assessment

The Climate Change Vulnerability Assessment project (CCVA) was developed as an ecosystem-based evaluation of the potential vulnerability of Southwest ecosystems to the projected climate of late 21st century. The CCVA results infer vulnerability based on the projected climate departure from the historic climate envelope for a given ERU and location. In broad terms it may be helpful to think of future climate simply as a potential stressor of significant change (i.e., on structure, composition, function), with the vulnerability rating on par with risk or probability of stress – either low, moderate, high, or very high. In more specific terms, vulnerability can be considered the relative probability of type conversion. Two key components of the CCVA are the ability of ecosystems to resist climate change effects and maintain resilient ecosystem functions:

- Resistance – The ability of an ecosystem to endure disturbance and maintain structure, composition, and function that are characteristic of the system. Resistance may be reduced as departure from current vegetation condition class increases, especially for some ecosystems (e.g., BP, MPO, MEW, PPE, MCD, PPF, PJG).
- Resilience – The ability of an ecosystem, following disturbance, to regain structure, composition, and function that are characteristic of the system on a time span consistent with its successional patterns, Resiliency may be reduced as departure from current vegetation condition class increases especially for some ecosystems (e.g., BP, MPO, MEW, PPE, MCD, PPF, PJG).

According to the assessment all of the watersheds within the SFMLRP area have a composite vulnerability score of moderate vulnerability (Figure 25) (USDA 2015b).

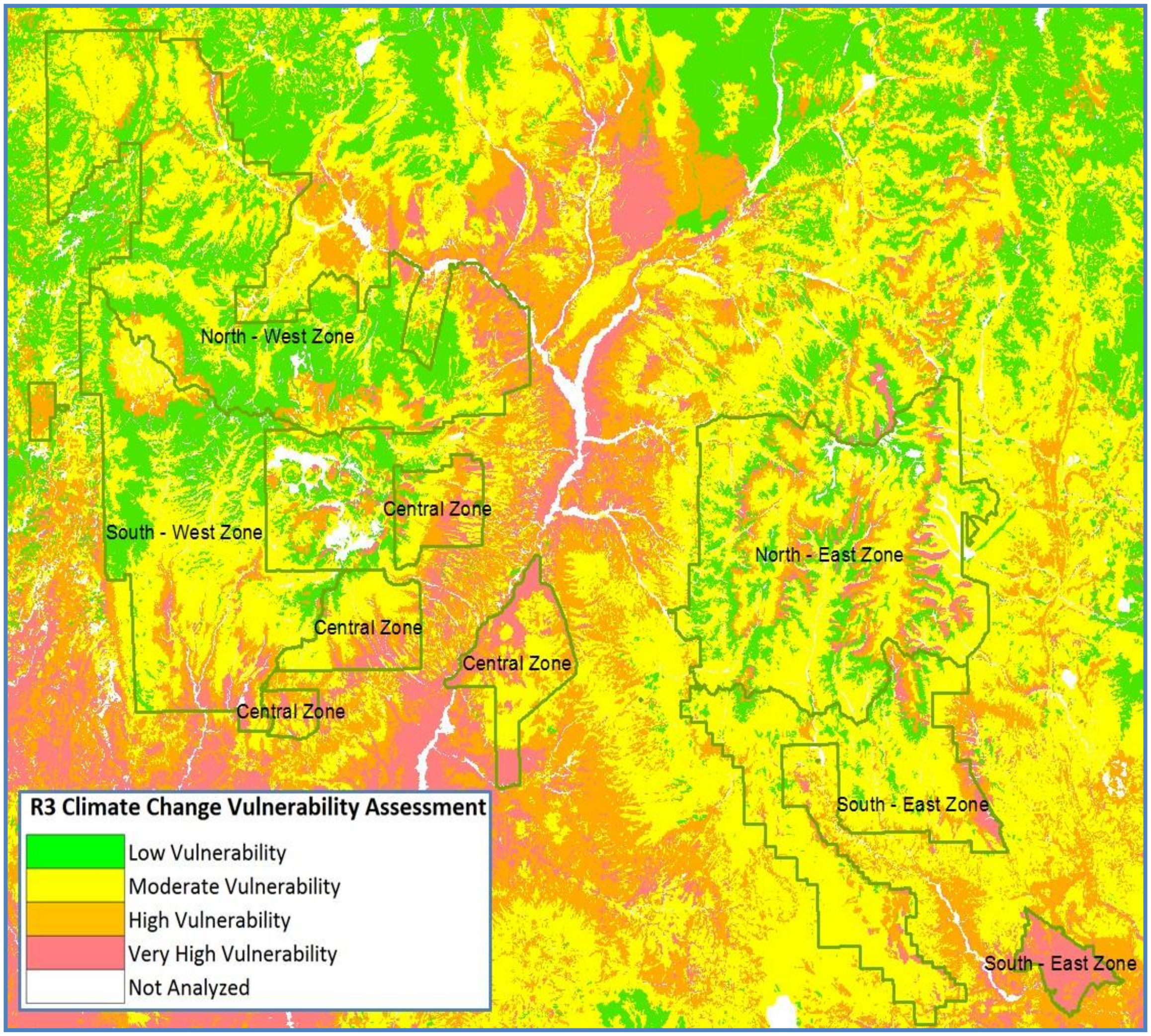

Figure 25. Patterns of vulnerability to climate change on the Santa Fe NF and surrounding lands of northern New Mexico. The Santa Fe NF and its local-scale units are represented by extents within the dark green borders.

Carbon Storage

Forests play an important role in carbon storage, which is the direct removal of CO2 from the atmosphere through biologic processes, such as forest growth. Carbon storage by forests mitigates greenhouse gas emissions by offsetting losses through removal and storage of carbon. Over at least the past several decades, temperate forests have provided a valuable ecosystem service by acting as a net sink of atmospheric carbon dioxide, partly offsetting anthropogenic emissions. Carbon dioxide uptake by forests in the conterminous United States offset approximately 16 percent of our national total carbon dioxide emissions in 2011. Forests and other ecosystems generally act as carbon sinks because, through photosynthesis, growing plants remove CO2 from the atmosphere and store it. Keeping forests as forests is one of the most cost-effective carbon storage measures. Restoration—bringing badly disturbed forests and grasslands back to producing a full range of environmental services—is another (LRMP DEIS, 2019).

Carbon stocks are estimated by linear interpolation between Forest Inventory and Analysis survey years for the seven ecosystem carbon pools – above-ground live tree, below-ground live tree, understory, standing dead trees, down dead wood, forest floor, and soil organic carbon. Total forest ecosystem carbon stored in the Southwestern Region decreased between 1990 and 2013, with 584 terragrams (Tg[8]) in 1990 and 551 Tg in 2013. Figure 26 displays these trends for each of the national forests between the years 1990 and 2013, where the Gila National Forest stored the largest amount of carbon in the region, approximately 103 Tg in 1990 and 99 Tg in 2013. During this period, the Santa Fe, Carson and Kaibab national forests generally increased in ecosystem carbon stocks, while the Apache-Sitgreaves, Coconino, Tonto, Cibola, Coronado, Lincoln, and Prescott national forests generally decreased (USDA, 2015a).

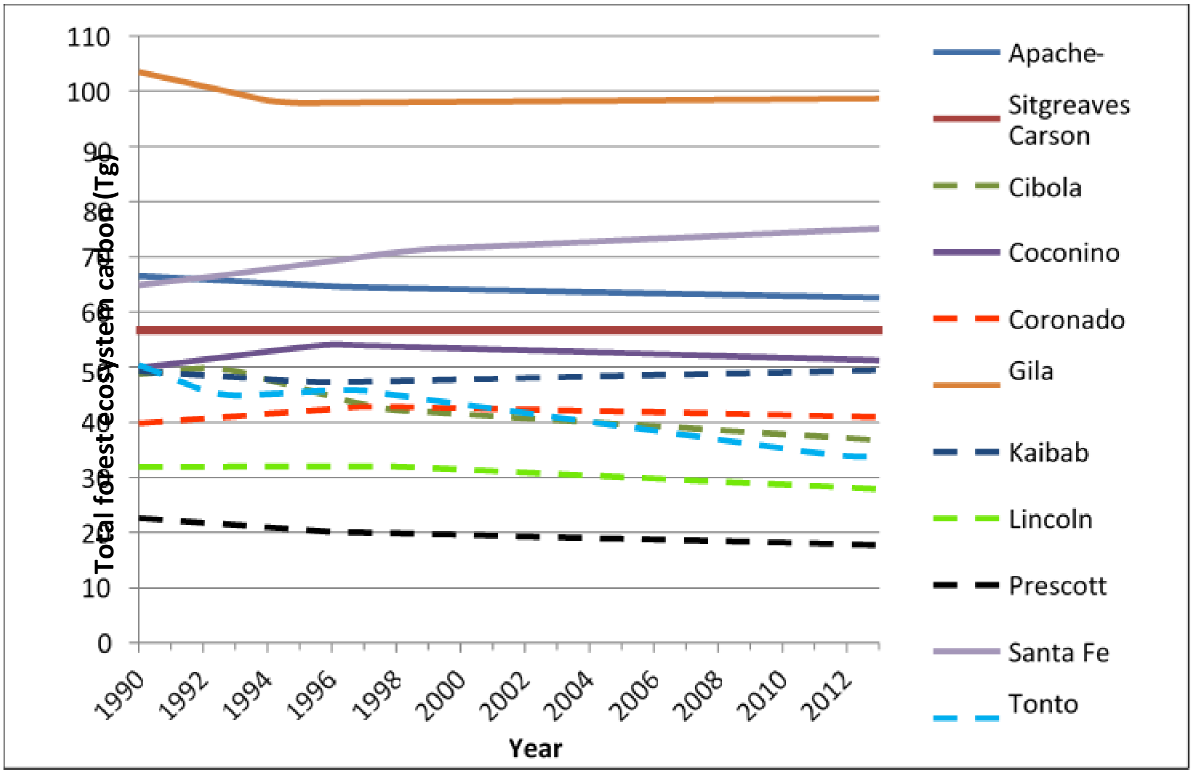

Figure 26. Total forest ecosystem carbon (Tg) for the national forests in the Southwestern Region from 1990 to 2013

The Santa Fe NF can be stratified into 11 major ecosystem types referred to as Ecological Response Units or ERUs. Each ERU contributes differently to biomass carbon stocks based on its spatial extent, vegetation community composition and structure, and ecosystem dynamics. Generally speaking, relative contributions to carbon stocks are lowest in grassland and shrubland ERUs, with increasing contributions by woodland and forest ERUs, respectively. Table 12 shows reference condition, current condition and projected biomass carbon stocks for major ERUs of the entire Santa Fe National Forest (USDA, 2016). This information will be compared to estimated project carbon emissions and storage below.

[8] 1 terragram (Tg) = 1,102,311 tons.

Table 12. Santa Fe National Forest biomass carbon stock per ERU in reference condition, current condition and projected +100 years (tons)

ERU	Acres	Reference Condition (tons)	Current Condition (tons)	Projected +100 years (tons)	Projected +100 years (% change from current)
MSG Montane Subalpine Grassland	17,707	25,622	57,079	70,476	23.5%
CPGB Colorado Plateau – Great Basin Grassland	41,639	123,173	Data Unavailable	Data Unavailable	Data Unavailable
SAGE Sagebrush Shrubland	37,457	184,597	224,343	262,950	17.2%
PJS Pinyon Juniper Sagebrush	30,449	368,605	268,348	443,589	65.3%
PJG Pinyon Juniper Grassland	43,356	615,908	532,127	941,636	77.0%
JUG Juniper Grassland	97,470	1,418,465	1,330,627	1,828,469	37.4%
PJO Pinyon Juniper Woodland	231,508	5,077,819	4,031,786	4,620,260	14.6%
PPF Ponderosa Pine Forest	403,915	12,073,018	17,103,934	16,396,685	-4.1%
MCD Mixed Conifer – Frequent Fire	429,967	25,217,432	29,800,962	27,264,090	-8.5%
MCWE Mixed Conifer – With Aspen (w/ Elk)	40,174	3,524,277	3,175,945	2,674,948	-15.8%
SFFE Spruce Fir Forest (w/ Elk)	250,481	24,000,294	21,718,522	22,439,765	3.3%
Total	**1,624,123**	**45,104,640**	**78,243,672**	**76,942,868**	**-1.7%**

Environmental Consequences

No Action Alternative

Under the no action alternative, current management plans would continue to guide management of the project area. No prescribed burning, vegetation and restoration treatments, or road maintenance, would be implemented to accomplish project goals within the project area, unless approved through a separate NEPA document and decision. Without implementing the treatments, forest conditions would continue to depart from desired conditions. The risk of uncharacteristic fire severity would continue to increase within the project area. Forest structure would continue to be somewhat homogenous and would continue to be dominated by a single age class. Forests would lack the desired level of diversity in structure, composition, and density. Forest susceptibility to insects and disease (e.g. bark beetles and mistletoe) would continue to increase. Ultimately, the landscape would not be moved toward desired conditions, and as such, the no action alternative would not meet the purpose and need for the project.

Fuels and Wildfire Behavior

Under the no action alternative forest surface, crown foliage and branchwood fuel loads in the project area would continue to range from approximately 18-33 tons per acre and would continue to increase over time (Table 17). This is a result of fire exclusion that has caused unnaturally dense forest stands with high amounts of ladder and surface fuels. Modeling of very high wildfire behavior as depicted in Tables 13–14, Figures 27-29, shows the project area is currently at risk of sustaining high intensity, widespread, damaging fire over most of the project area.

Wildfire flame lengths over approximately 60% of the project area would be greater than 4 feet and generally too intense for safe and effective fire suppression action by ground resources, table 2. Wildfire passive or active crown fire activity would burn forest canopies over approximately 74% of the project area.

Table 13. Modeling of existing condition very high fire danger wildfire behavior (90th percentile burning conditions[1] for the SFMLRP (acres)

Flame Lengths 0 to 4 feet	Flame Lengths >4	Surface Fire[2]	Passive Crown Fire[3]	Active Crown Fire[4]	Non-Burnable or Burnable and Not Burned
11,535	39,041	12,889	35,018	2,426	233 [5]

1. The 90th percentile wildfire burning conditions are very high fire weather and fuels conditions and occur on 10 percent of the days during the fire season, March 1 to June 30, based on Santa Fe RAWS data.
2. Surface fire burns loose debris on the surface, which includes down and dead logs, branches, leaves, low vegetation, litter and duff.
3. Passive crown fire burns the crowns of trees in which trees or groups of trees torch, ignited by the passing front of the fire.
4. Active Crown Fire develops a solid flame in the crowns of trees, but the surface and crown phases advance as a linked unit dependent on each other.
5. Crown Fire Activity.

About 32% percent of the project area is at higher-highest risk of burning, 31% middle hazard, and 37% lowest-low hazard, table 9 (IFTDSS, 2020).

Table 14. Modeling of existing condition integrated hazard under very high fire danger (90th percentile burning conditions) for the SFMLRP (acres)

Lowest Hazard	Lower Hazard	Middle Hazard	Higher Hazard	Highest Hazard	Non-Burnable or Burnable and Not Burned
10,018	8,744	15,166	9,911	5,812	916

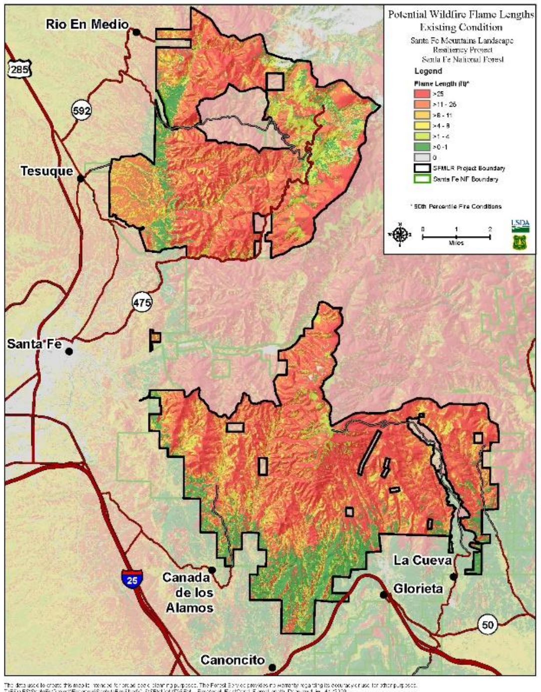

Figure 27. Existing Condition Wildfire Flame Lengths

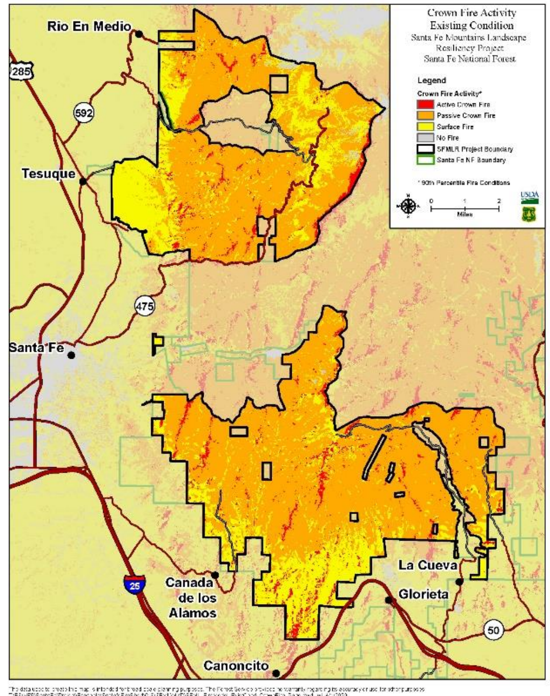

Figure 28. Existing Condition Wildfire Crown Fire Activity

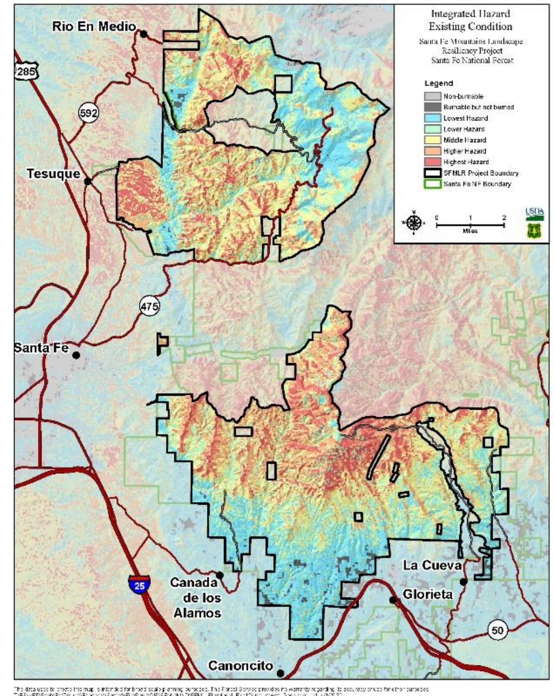

Figure 29. Existing Condition Wildfire Integrated Hazard

Air Quality, Climate Change and Carbon Storage

Smoke Emissions

Under the no action alternative, the SFLMRP area would remain at risk of sustaining damaging, widespread wildfires. Compared to average annual estimated New Mexico wildfire emissions (comparison to Table 8 above), if the entire SFMLRP area was to burn in a wildfire, criteria pollutant emissions would be 122% of PM2.5, 162% of PM10, 100% of NOx, greenhouse gas emissions would be 121% of CO2, and 166% of CH4 (Table 10). Wildfire emissions would release sequestered surface and ground carbon and would be reduced by approximately 291,000 tons or about 0.4% of current forest wide sequestered carbon (comparison to Table 12) (Table 15).

Table 15. Wildfire Fuel Loading, Surface and Ground Carbon Stoarge[9], Smoke and Green House Gas Emissions[10]

Ecological Response Unit	Acres	Pre-Burn Fuel Load (tons)	Pre-Burn Carbon (tons)	Post Burn Fuel Load (tons)	Post Burn Carbon (tons)	CP PM2.5 Emissions (tons)	CP PM10 Emissions (tons)	CP NOx Emissions (tons)	GHG CO2 Emissions (tons)	GHG CH4 Emissions (tons)
Colorado Plateau / Great Basin Grassland	7	15.12	7.56	2.94	1.47	0.035	0.042	0.039	21.90	0.024
Juniper Grass	223	481.68	240.84	93.66	46.83	1.12	1.34	12.27	0.34	0.45
Mixed Conifer – frequent fire	15,879	527,817.96	248,823.93	193,564.01	96,861.90	4,430.24	6,550.08	325.52	465,897.79	3,294.89
Mixed Conifer with Aspen	438	16,411.86	7,502.94	2,938.98	1,467.30	183.96	297.62	8.54	18,002.24	151.33
Pinyon Juniper Woodland	4,463	81,985.31	38,694.21	24,323.35	12,183.99	439.61	756.47	107.11	89,108.26	363.73
Ponderosa Pine Forest	16,849	300,080.69	136,139.92	76,831.44	38,415.72	1,693.32	2,881.19	421.25	345,909.97	1,373.19
RMAP[11] Narrowleaf Cottonwood / Shrub	423	5,393.25	2,504.16	1,269.00	634.50	22.42	38.49	9.73	6,736.06	17.34
RMAP Upper Montane Conifer / Willow	97	248.32	118.34	69.84	34.92	1.07	1.60	0.44	292.84	0.72
RMAP Willow - Thinleaf Alder	6	15.36	7.32	4.32	2.16	0.067	0.10	0.03	18.11	0.045
Spruce-Fir Forest	503	19,682.39	9,074.12	4,994.79	2,494.88	173.35	279.42	15.34	20,677.32	140.08
Total	**38,888**	**952,131.94**	**443,113.34**	**304,092.33**	**152,143.67**	**6,945.19**	**10,806.35**	**900.27**	**946,664.83**	**5,341.80**

[9] Ground and Surface Fuel Carbon Loading.
[10] Particulates - PM10; Nitrogen Dioxide - NO2, Carbon Dioxide - CO2; Methane - CH4.
[11] Regional Riparian Mapping Project (RMAP)

Visibility

Under the no action alternative, wildfire smoke emissions would result in impacts to air quality within and near the project area. Management of wildfire could affect air quality and visibility on National Forest System lands and the surrounding areas depending on the location of the fire and wind conditions. When wildfires occur, they would burn unnaturally heavy fuels over large areas causing adverse air quality and visibility impacts for as long as the wildfire event occurs. Visibility would likely be compromised during wildfires, and depending on the size of the wildfires, the fires could adversely impact visibility at nearby Class I areas. Reduced visibility may also indicate elevated levels of particulates due to dust storms and wood burning stove emissions during winter months.

Table 16 shows a summary of resource indicators and effects of the no action alternative compared to the proposed action alternative. Under the no action alternative potentially adverse effects to forest ecosystems would continue and increase over time.

Table 16. Resource indicators and measures for the No Action Alternative and Proposed Action Alternative

Resource Element	Resource Indicator	No Action Alternative	Proposed Action Alternative
Fuels and Wildfire Behavior	**Surface Fuels Tons Per Acre (Quantitative)** - **Dry Mixed Conifer Forest (Mixed Conifer – Frequent Fire) Desired Conditions** Downed logs (>12-inch diameter at mid-point, >8 feet long) average 3 per acre within forested areas. Coarse woody debris, including downed logs, ranges from 5 to 15 tons per acre. - **Pinyon-Juniper Grass and Juniper Grass Desired Conditions** Coarse woody debris increases with succession and averages 1-3 tons per acre. - **Pinyon-Juniper Woodland Desired Conditions** Coarse woody debris increases with succession and averages 2-5 tons per acre. - **Ponderosa Pine Forest Desired Conditions** Coarse woody debris, including downed logs, ranges from 3 to 10 tons per acre.	Fuel loads would continue to exceed natural range of variability values and increase from existing overall averages of 18-33 tons per acre.	Overall average surface fuels would range from approximately 4-14 tons per acre.
Fuels and Wildfire Behavior	**Fire Danger (Quantitative)** - Flame lengths average 4 feet under 90th percentile burning conditions in most ERU's.	In the short-term average flame lengths of 7'-9' in forest stands under 90th percentile wildfire conditions would continue. Long term significant increases in temperatures, slight decreases in precipitation and longer fire seasons would increase wildfire behavior over time.	In the short term there would be no change in fire danger and reduced fuel loads would reduce wildfire behavior. Long term significant increases in temperatures, slight decreases in precipitation and longer fire seasons would increase wildfire behavior over time.

Fuels and Wildfire Behavior	**Effects of fuel loadings to wildfire behavior post treatment, 2-5 years and 6-10 years post treatment (Quantitative)** **Pre and post treatment, at 2-5 years and 6-10 years, surface and ladder fuel loadings and wildfire behavior desired conditions under very high wildfire behavior conditions (Quantitative)** **Flame Lengths and Fire Intensity (Quantitative)** - **Dry Mixed Conifer Forest (Mixed Conifer – Frequent Fire) Desired Conditions** Frequent, low severity fires (Fire Regime I) are characteristic, including throughout goshawk home ranges. - **Pinyon-Juniper Grass and Juniper Grass Desired Conditions** Fires are typically frequent and low severity (Fire Regime I). - **Pinyon-Juniper Woodland Desired Conditions** Fire as a disturbance is less frequent and variable due to differences in ground cover, though some sites are capable of carrying surface fire. The fires that do occur are mixed to high severity (Fire Regime III, IV, & V). - **Ponderosa Pine Forest Desired Conditions** Frequent, low severity fires (Fire Regime I) are characteristic in this type, including throughout goshawk home ranges. **Crown Fire Activity (Quantitative)** - **Dry Mixed Conifer Forest (Mixed Conifer – Frequent Fire) Desired Conditions** A small percentage of the landscape may be predisposed to larger even-aged patches, based on physical site conditions that favor mixed-severity and stand replacement fire and other	Wildfire flame lengths over approximately 60% of the project area would be greater than 4 feet and too intense for safe and effective fire suppression action by ground resources. Wildfire passive or active crown fire activity would burn forest canopies over approximately 74% of the project area. About 32% percent of the project area is at higher-highest risk of burning, 31% middle hazard, and 37% lowest-low hazard.	All the treatment types would be effective in reducing wildfire behavior and integrated hazard and meeting desired conditions during the first few years after treatments are completed. In units treated with prescribed burning only, wildfire behavior and integrated hazard would increase 2-5 years and would be highest 6-10 years. Compared to prescribed burn only, wildfire behavior and integrated hazard would decrease in units that are treated with light thinning/piles burned and underburned. Wildfire behavior and integrated hazard would be lowest in units treated with heavy thinning/piles burned and underburned.

	disturbances. Disturbances sustain the overall age and structural distribution. - **Pinyon-Juniper Grass and Juniper Grass Desired Conditions** Fires are typically frequent and low severity (Fire Regime I). - **Pinyon-Juniper Woodland Desired Conditions** Fire as a disturbance is less frequent and variable due to differences in ground cover, though some sites are capable of carrying surface fire. The fires that do occur are mixed to high severity (Fire Regime III, IV, & V). - **Ponderosa Pine Forest Desired Conditions** Fires burn primarily on the forest floor and do not spread between tree groups as crown fire. **Integrated Hazard (Quantitative)** **Wildland Urban Interface (WUI) Desired Conditions:** Wildland fires in the WUI result in the minimal loss of life, property, or characteristic ecosystem function. Wildland fires in the WUI are low intensity surface fires as ladder fuels are nearly absent. Firefighters are able to safely and efficiently suppress wildfires in the WUI. In forested vegetation communities, the area occupied by interspace with grass/forb/shrub vegetation is on the upper end of, or above, the range given in the vegetation community desired conditions. Trees within groups may be more widely spaced with less interlocking of the crowns than desirable in adjacent forest lands. Interspaces between tree groups are of sufficient size to discourage isolated group torching from spreading as a crown fire to other groups. The tree basal area in the WUI is on the lower end of the range given in the vegetation community desired conditions. When WUI intersects vegetation types with a mixed or high-severity fire regime, such as spruce-fir, basal area may fall below the desired range to avoid facilitation of crown fires.		

Resource Element	Resource Indicator	No Action Alternative	Proposed Action Alternative
	In shrubland/chaparral vegetation communities, the live and dead fuel loading in the WUI is on the lower end of the range given for the vegetation community desired conditions. Enough cover exists to meet the needs of a variety of wildlife species. Logs and snags, which often pose fire control problems, are present in the WUI, but at the lower end of the range given in the appropriate vegetation community desired conditions. Dead and down fuel load is between 1 and 10 tons per acre, depending on ERU, with lower amounts in fire adapted ERUs, and higher amounts in infrequent fire types. This light fuel load applies even in vegetation types with higher reference fuel loads, such as wet mixed conifer or spruce-fir, to provide improved fire protection to human developments deemed to have special significance. Higher fuel loading or tree densities may occur in areas where it provides for important fine-scale habitat structure, as long as it meets the overall intent of protecting WUI values at risk (USDA 2019).		
Air Quality	**Compliance with Air Quality Regulations (Quantitative/Qualitative)** - Air Quality Health Standards	Wildfire emissions are likely to cause smoke impacts that may exceed health standards in smoke sensitive areas or populated communities surrounding the National Forest. Compared to average annual estimated New Mexico wildfire emissions, if the entire SFMLRP area was to burn in a wildfire, criteria pollutant emissions would be 122% of PM2.5, 162% of PM10, 100% of NOx.	Compared to the estimated annual New Mexico emissions from prescribed burning the SFLMRP would emit approximately 16-24% of PM2.5, 15-22% of PM10 and 7-10% of NOx on an annual basis. Wildfire emissions would be reduced and are unlikely to cause smoke impacts that may exceed health standards in smoke sensitive areas or populated communities surrounding the National Forest.

Resource Element	Resource Indicator	No Action Alternative	Proposed Action Alternative
Air Quality	**Compliance with Air Quality Regulations (Quantitative/Qualitative)** - Visibility	Wildfire emissions are likely to cause smoke impacts that may cause decreased visibility in Class I areas. New Mexico is required to develop and submit to EPA its own regional haze plans by July 31, 2021.	Wildfire emissions would be reduced and are unlikely to cause smoke impacts that may cause decreased visibility in Class I areas. New Mexico is required to develop and submit to EPA its own regional haze plans by July 31, 2021.

Climate Change and Carbon Storage	**Effects of Climate Change to Forest Ecosystems (Quantitative/Qualitative)** **Adjusting Desired Conditions to Account for Vulnerability to Climate Change:** In areas of high vulnerability to climate change, based on 100-year climate projections, tree basal area is restored or maintained at the low end of the desired range to mitigate water stress. In these areas, early mid seral species dominate over late-seral species, given the adaptations of many early-mid species for warmer and drier conditions. Encroaching species characteristic of lower life zones are maintained. Adjusting Desired Conditions to Account for Vulnerability to Climate Change In areas of high vulnerability to climate change, based on 100-year climate projections (Triepke 2016), tree basal area is restored or maintained at the low end of the desired range to mitigate water stress. In these areas, early mid seral species dominate over late-seral species, given the adaptations of many early-mid species for warmer and drier conditions. Encroaching species characteristic of lower life zones are maintained. While future effects of changing climate remain speculative, there is growing consensus among forest scientists, in the vein of Bradford and Bell (2017), that management aimed at reducing tree densities, especially but not only in frequent fire-adapted types, can serve proactively as resistance or realignment (transition) responses in areas vulnerable to drought and warmer temperatures. Untreated areas that have stem densities predisposed to high severity fire and subsequent type conversions may possess inevitable outcomes; but ignoring high stem densities on the basis of uncertainty precludes treatments that are aimed at conserving habitat and carbon by delaying type conversions (resistance), treatments that facilitate gradual transition and ecological acclimatization (realignment), or treatments that consider HRV (restoration) (Millar et al. 2007). In general, lowering tree densities can be an effective safeguard for resource	Decreasing ecosystem resistance and resilience to adverse climate change effects. Increasing risk of significant damage from drought and wildfires outside the natural range of variability.	Increased ecosystem resistance and resilience to adverse climate change effects. Decreased risk of significant damage from drought and wildfires outside the natural range of variability.

Resource Element	Resource Indicator	No Action Alternative	Proposed Action Alternative
	conservation and for optimizing ecological function and management options across planning cycles (USDA 2019).		
Climate Change and Carbon Storage	**Greenhouse Gas Emissions (Quantitative)**	If the SFMLRP area would burn in a wildfire approximately 946,664 tons CO_2 and 5,341 tons CH_4 would be emitted. Compared to average annual estimated New Mexico wildfire emissions, if the entire SFMLRP area was to burn in a wildfire, greenhouse gas emissions would be 121% of CO_2, and 166% of CH_4.	Compared to the estimated annual New Mexico greenhouse gas emissions from prescribed burning the SFMLRP would emit approximately 11-17% of CO_2 and 15-22% of CH_4 on an annual basis. Wildfire emissions would be reduced.

Resource Element	Resource Indicator	No Action Alternative	Proposed Action Alternative
Climate Change and Carbon Storage	**Changes to Carbon Storage (Quantitative)**	If the SFMLRP area would burn in a wildfire emissions would release surface and ground sequestered carbon and would be reduced by approximately 291,000 tons or about 0.4% of current forest wide sequestered carbon.	Increased ecosystem resistance and resilience to adverse climate change effects. Decreasing risk of significant damage from drought and wildfires outside the natural range of variability would stabilize carbon storage. Post prescribed burning surface and ground carbon storage would be approximately 248,697 tons. Compared to current Santa Fe National Forest carbon stocks the SFMLRP prescribed burning would reduce forest carbon by 0.3%. A comparison of no action (2020 existing condition) and proposed action carbon storage in 2070 shows the proposed action would increase carbon storage in thinning treatment units. Total estimated 2020 existing condition carbon storage in the proposed action thinning treatment units is 743,627 tons. Modeling results show that in 2070 carbon storage in the proposed action thinning treatment units would be 770,451 tons. Compared to forest wide existing condition carbon storage the carbon sequestered in the SFLMRP proposed action thinning treatment units in 2020 represent 0.95% of total forest wide sequestered carbon. Modeling results show that in 2070 the SFLMRP thinning treatment units would sequester 0.98% of existing carbon.

Proposed Action Alternative

Thinning and Prescribed Burning Direct and Indirect Effects

The primary goal of the SFMLRP is to reduce the risk of high intensity, widespread damage from wildfires and to increase ecosystem resistance and resilience to wildfires and drought conditions. There is a need to reduce heavy surface and ladder fuel loadings in areas characterized by continuous fuels in close proximity to valued natural and infrastructure resources. There is a need to provide defensible zones where firefighters can safely engage with wildfires. In ponderosa pine and mixed conifer-frequent fire forest types, meeting the desired conditions for resistance and resilience would also achieve desired conditions for wildfire risk reduction by reducing fuels and breaking fuel continuity in forest types that are dependent on the effects of frequent fire. There is a need to increase ecosystem resistance and resilience to the effects of climate change including increasing temperatures, decreasing snowpack and prolonged drought. There is a need to implement the continued use of naturally ignited wildfires and prescribed burning to maintain resilient forest ecosystems. Carbon stroage sustainability would be improved and reductions in carbon would be less than when the area is burned by high intensity wildfires in areas that have not burned in many decades. Air quality smoke emissions impacts would be mitigated by the use of controlled burning in compliance with air quality health standards.

Fuels and Wildfire Behavior

Under the proposed action mechanical, manual vegetation and prescribed fire treatments on up to 18,000 acres and prescribed fire only on up to 20,000 acres would impact fuel surface and ladder fuel loadings and move the project area towards meeting desired conditions. Analysis of the impacts of the proposed action was conducted using earlier estimates of treatment acreages (17,128 acres of vegetation and prescribed fire treatments and 20,128 acres of prescribed fire only). However, these numbers are very similar to the final treatment acreages, so the findings of this analysis are still sufficient for evaluating the impacts of the proposed action.

Removal of small diameter trees will decrease trees per acre and decrease basal area. Understory thinning eliminates some of the lower portion of the forest canopy, increasing the overall crown base height of the remaining forest canopy. Increasing crown base height reduces the potential for surface fires to transition into the forest canopy by increasing the distance between surface fires and the aerial fuel layer, thereby increasing the surface fire intensity required to ignite the crowns (Agee and Skinner 2004; Graham et al. 2004; Peterson et al. 2005; Cram et al. 2006). Decreasing crown bulk density reduces the ability of fire to spread horizontally through the forest canopy if it does transition from the surface layer into the aerial layer (Agee and Skinner 2004; Graham et al. 2004; Peterson et al. 2005).

Implementation of the proposed action would reduce project area surface and ladder fuels and create strategically located treatments along ridges and forest roads. The project would thin forest stands using tree felling and mastication. Activity slash and masticated fuels would be reduced by piling and burning, jackpot and broadcast burning. The use of lop and scatter slash disposal techniques would increase surface fuel loading. Excessive slash fuels that would produce undesirable flame lengths or fire behavior, would be removed to off site or pile and jackpot burned in order to reduce surface fuel loadings prior to broadcast prescribed burning or underburning. Forest stand thinning and prescribed burning would reduce surface, ladder and crown fuels in dense stands. In units where mechanical thinning is not needed to reduce ladder and crown fuels prior to burning, prescribed burning would reduce surface and ladder fuels and to a lesser extent crown fuels through isolated tree torching. Post treatment fuel loading should be reduced to amounts that would produce average flame lengths no greater than 4 feet under 90th percentile wildfire burning conditions. Table 17 shows estimated pre and post prescribed burning fuel loads. Post treatment ponderosa pine surface fuel loads would be one ton less per acre than the desired condition range, and mixed conifer would be two tons higher than the desired condition range.

Table 17. Estimated Preburn and Postburn Surface, Crown Foliage and Branchwood Fuels

ERU	Estimated Preburn Surface, Crown Foliage and Branchwood Fuels (tons per acre)	Estimated Postburn Surface, Crown Foliage and Branchwood Fuels (tons per acre)	Estimated Postburn Surface Fuels (tons per acre
Juniper Grass	2 (surface)	N/A	0.5
Mixed Conifer – frequent fire	33	18	14
Pinyon Juniper Woodland	18	11	4
Ponderosa Pine Forest	18	9	4

Post treatment wildfire behavior modeling shows that the SFMLRP area would generally meet Forest Plan wildfire behavior desired conditions, standards and guidelines.

Modeling was completed for the project area using low severity prescribed fire only[12], and light[13] and heavy[14] thinning treatment prescriptions followed by low severity prescribed fire. All of the treatment types would be effective in reducing wildfire behavior and integrated hazard and meeting desired conditions during the first few years after treatments are completed. In areas treated with prescribed burning only, wildfire behavior and integrated hazard would increase 2-5 years and would be highest 6-10 years. Compared to prescribed burn only, wildfire behavior and integrated hazard would decrease in areas that are treated with light thinning/piles burned and underburned. Wildfire behavior and integrated hazard would be lowest in areas treated with heavy thinning/piles burned and underburned (Tables 18-21, Figures 30-41). The modeling results assumes the entire project area would be either prescribed burned only, light thinned/piles burned or heavy thinned/piles burned followed by prescribed burning and completed in two years.

[12] Low Severity Fire: Fire with resulting mortality of above ground vegetation <25%.
[13] Light Thinning; Pile Burn - Thins the stand to ~80% of present density by removing understory up to 8" DBH. Subsequent pile burning of thinned material.
[14] Heavy Thinning; Pile Burning - Thins the stand to ~35% of present density with no upper diameter limit.

Table 18. Modeling of wildfire behavior under very high fire danger (90th percentile burning conditions) two to five years after treatments are completed for the SFMLRP (acres) (IFTDSS 2020)

Treatment	ERU	Flame Lengths 0 to 4 feet	Flame Lengths >4 feet	Surface Fire	Passive Crown Fire	Active Crown Fire	Non Burnable or Burnable and Not Burned
No Action Existing Condition	All ERU's	11,535	39,041	12,889	35,018	2,426	233
Prescribed Burning Only	Juniper Grass	190.8	32.0	198.2	24.3	0.3	
	Mixed Conifer – frequent fire	13,013.1	4,861.7	14,632.6	2,825.5	330.4	86.3
	Pinyon Juniper Woodland	6,989.5	1,446.7	7,556.3	850.6	8.6	20.6
	Ponderosa Pine Forest	14,527.1	2,819.9	15,669.8	1,586.8	89.5	0.9
Light Thinning Prescribed Burning	Juniper Grass	204.1	18.7	213.0	9.8		
	Mixed Conifer – frequent fire	13,554.0	4,320.7	16,540.1	1,148.1	102.8	83.8
	Pinyon Juniper Woodland	7,322.7	1,113.5	8,014.4	395.2	4.4	22.2
	Ponderosa Pine Forest	15,092.6	2,254.4	16,714.2	589.8	42.3	0.7
Heavy Thinning Prescribed Burning	Juniper Grass	207.6	15.2	221.5	1.3		
	Mixed Conifer – frequent fire	16,778.1	1,096.7	17,672.1	116.4		86.3
	Pinyon Juniper Woodland	6,910.2	1,526.0	8,285.3	130.0	0.2	20.6
	Ponderosa Pine Forest	16,281.0	1,066.0	17,206.8	139.1	0.2	0.9

Table 19. Modeling of integrated hazard under very high fire danger (90th percentile burning conditions) two to five years after treatments are completed for the SFMLRP (acres) (IFTDSS 2020)

Treatment	ERU	Lowest Hazard	Lower Hazard	Middle Hazard	Higher Hazard	Highest Hazard	Non Burnable or Burnable and Not Burned
Prescribed Burning Only	Juniper Grass	202.7	14.8				5.3
	Mixed Conifer – frequent fire	11,743.8	4,965.0	699.1	238.6		228.2
	Pinyon Juniper Woodland	7,180.5	1,037.7	32.7	2.4		182.9
	Ponderosa Pine Forest	13,933.8	2,834.1	197.3	51.2		330.6
Light Thinning Prescribed Burning	Juniper Grass	213.3	9.5				0.0
	Mixed Conifer – frequent fire	13,473.1	4,024.6	123.2	33.8		220.1
	Pinyon Juniper Woodland	7,587.8	740.4	2.3			105.6
	Ponderosa Pine Forest	14,983.5	2,219.3	26.8	2.4		115.0
Heavy Thinning Prescribed Burning	Juniper Grass	219.5	3.4				
	Mixed Conifer – frequent fire	16,864.7	230.9	0.6			778.6
	Pinyon Juniper Woodland	8,283.1	116.6	3.6			32.9
	Ponderosa Pine Forest	16,927.1	162.0	21.2			236.8

Table 20. Modeling wildfire behavior under very high fire danger (90th percentile burning conditions) six to ten years after treatments are completed for the SFMLRP (acres) (IFTDSS 2020)

Treatment	ERU	Flame Lengths 0 to 4 feet	Flame Lengths >4 feet	Surface Fire	Passive Crown Fire	Active Crown Fire	Non Burnable or Burnable and Not Burned
Prescribed Burning Only	Juniper Grass	154.4	68.4	158.8	63.5	0.5	
	Mixed Conifer – frequent fire	4,641.6	13,233.2	6,146.0	11,105.9	536.6	86.3
	Pinyon Juniper Woodland	4,514.7	3,921.4	5,084.2	3,314.5	16.8	20.6
	Ponderosa Pine Forest	8,315.5	9,031.5	9,827.0	7,354.3	164.9	0.9
Light Thinning Prescribed Burning	Juniper Grass	175.9	46.9	183.3	39.5		
	Mixed Conifer – frequent fire	4,933.2	12,941.6	8,291.9	9,342.0	157.0	83.8
	Pinyon Juniper Woodland	4,867.4	3,568.8	5,667.8	2,741.1	5.1	22.2
	Ponderosa Pine Forest	9,618.7	7,728.3	12,071.9	5,219.5	54.9	0.7
Heavy Thinning Prescribed Burning	Juniper Grass	204.1	18.7	213.7	9.1		
	Mixed Conifer – frequent fire	16,283.9	1,590.9	17,549.3	241.6		83.8
	Pinyon Juniper Woodland	6,582.3	1,853.9	7,754.7	659.3		22.2
	Ponderosa Pine Forest	15,691.8	1,655.2	16,847.9	498.3		0.7

Table 21. Modeling of integrated hazard under very high fire danger (90th percentile burning conditions) six to ten years after treatments are completed for the SFMLRP (acres) (IFTDSS 2020)

Treatment	ERU	Lowest Hazard	Lower Hazard	Middle Hazard	Higher Hazard	Highest Hazard	Non Burnable or Burnable and Not Burned
Prescribed Burning Only	Juniper Grass	180.2	34.2	3.9	0.0		4.6
	Mixed Conifer – frequent fire	3,098.7	4,857.7	5,844.2	2,620.4	1,304.0	149.8
	Pinyon Juniper Woodland	4,764.1	1,703.4	1,356.6	267.4	73.4	271.2
	Ponderosa Pine Forest	7,930.9	4,111.3	3,659.6	1,034.2	222.6	388.4
Light Thinning Prescribed Burning	Juniper Grass	195.4	26.5	0.9			0.0
	Mixed Conifer – frequent fire	5,454.9	5,853.4	4,884.5	1,215.1	341.7	125.2
	Pinyon Juniper Woodland	6,131.1	1,657.0	522.8	31.2	2.2	91.7
	Ponderosa Pine Forest	10,229.1	4,144.4	2,534.0	326.5	46.0	67.1
Heavy Thinning Prescribed Burning	Juniper Grass	211.8	11.0				0.0
	Mixed Conifer – frequent fire	16,674.8	637.3				562.6
	Pinyon Juniper Woodland	7,922.0	473.3	5.7	3.6		31.6
	Ponderosa Pine Forest	16,417.6	793.9				135.5

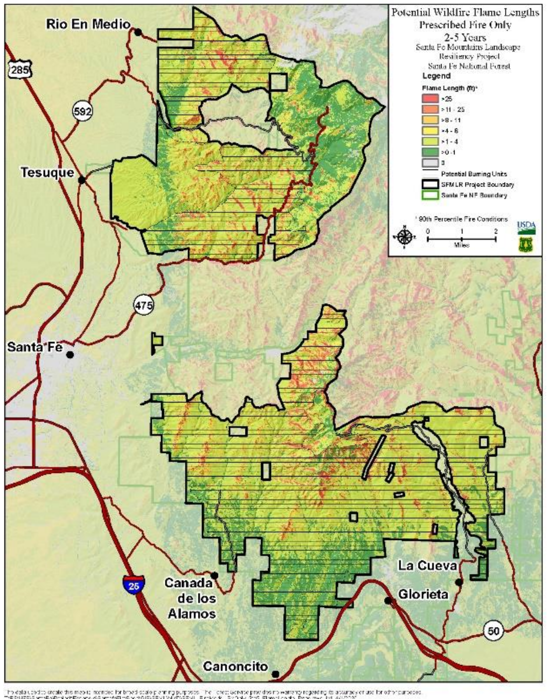

Figure 30. Proposed Action Prescribed Burning Only - Wildfire Flame Lengths 2-5 Years Post Treatment

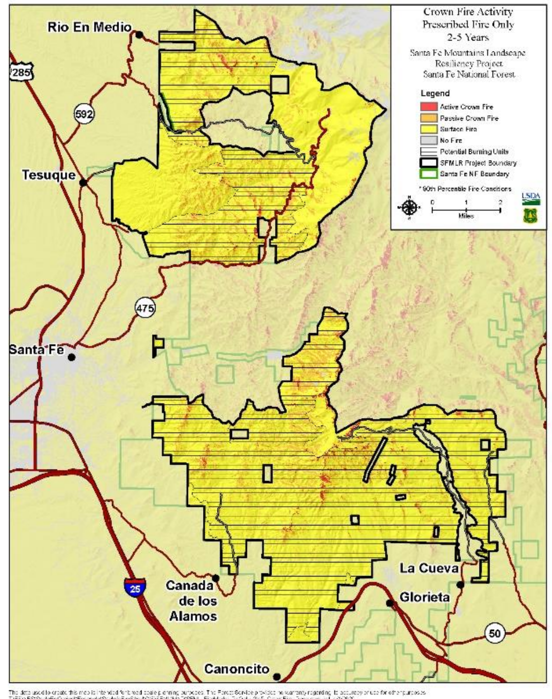

Figure 31. Proposed Action Prescribed Burning Only - Wildfire Crown Fire Activity 2-5 Years Post Treatment

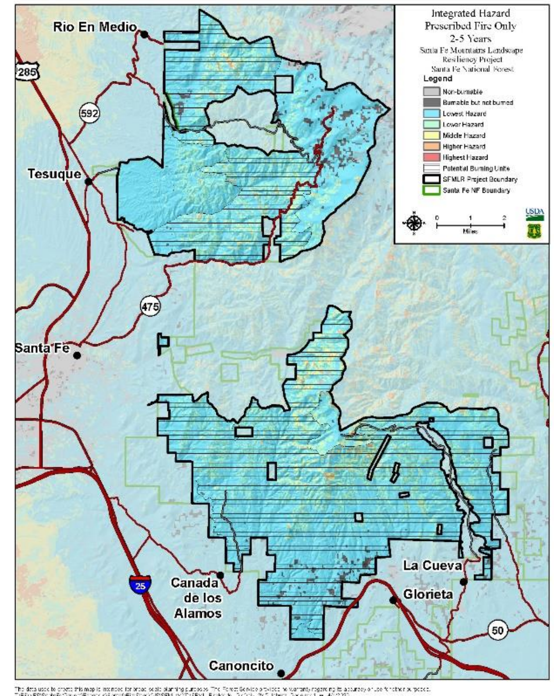

Figure 32. Proposed Action Prescribed Burning Only - Wildfire Integrated Hazard 2-5 Years Post Treatment

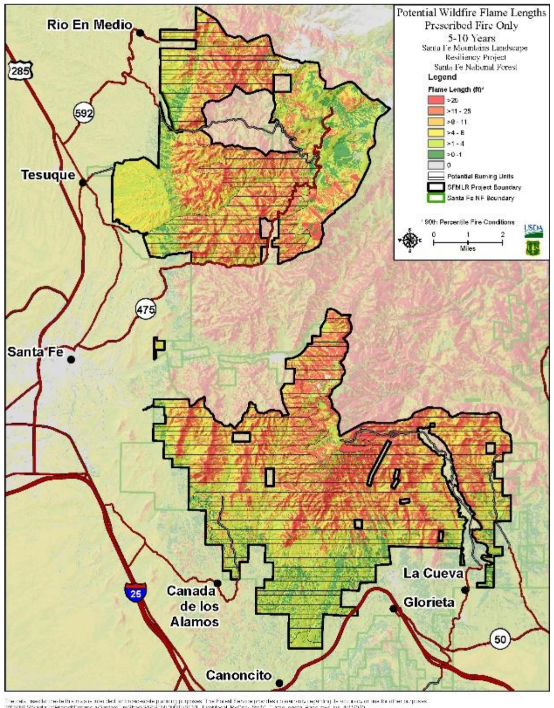

Figure 33. Proposed Action Prescribed Burning Only - Wildfire Flame Lengths 6-10 Years Post Treatment

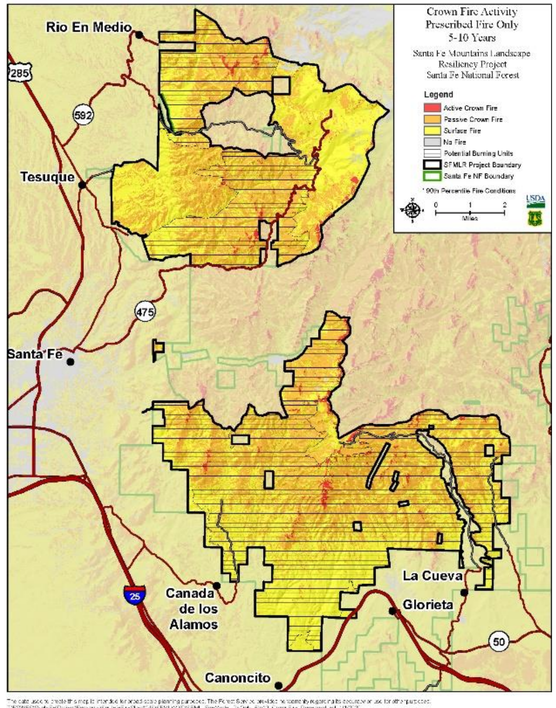

Figure 34. Proposed Action Prescribed Burning Only - Wildfire Crown Fire Activity 6-10 Years Post Treatment

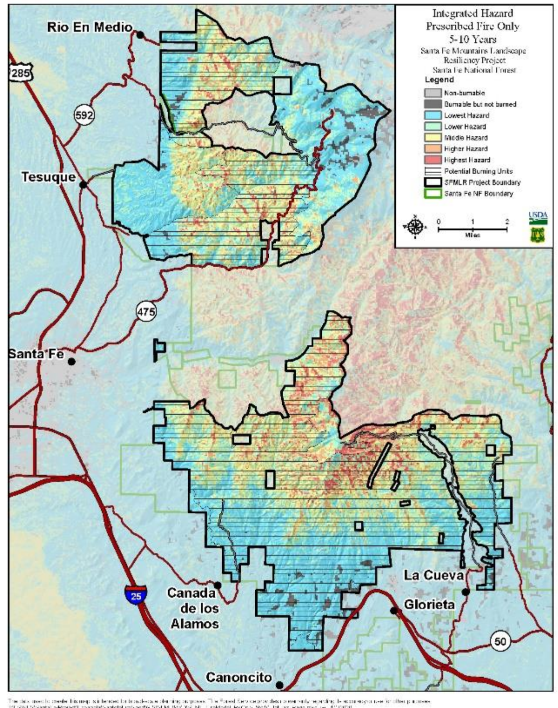

Figure 35. Proposed Action Prescribed Burning Only - Wildfire Integrated Hazard 6-10 Years Post Treatment

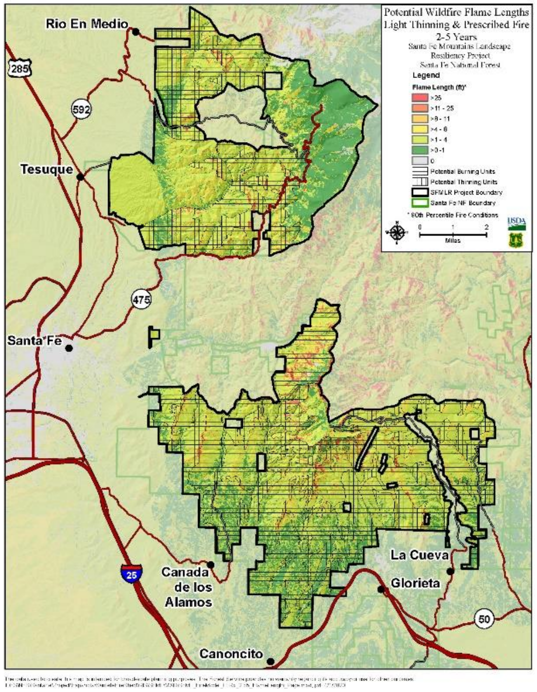

Figure 36. Proposed Action Light Thinning/Prescribed Burning - Wildfire Flame Lengths 2-5 Years Post Treatment

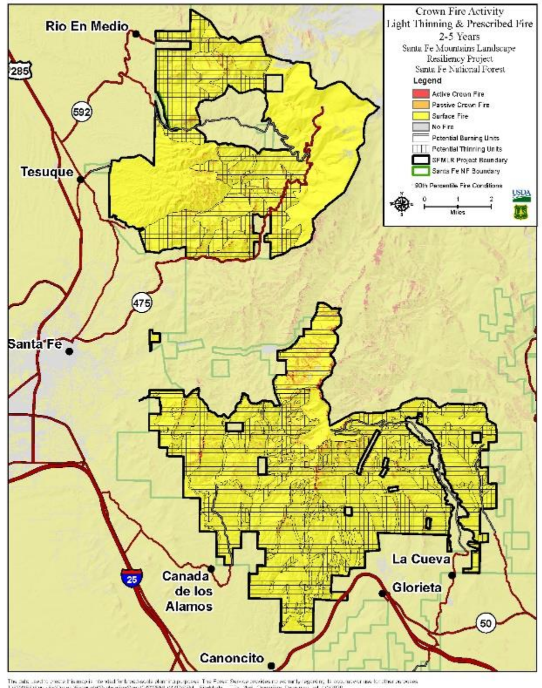

Figure 37. Proposed Action Light Thinning/Prescribed Burning - Wildfire Crown Fire Activity 2-5 Years Post Treatment

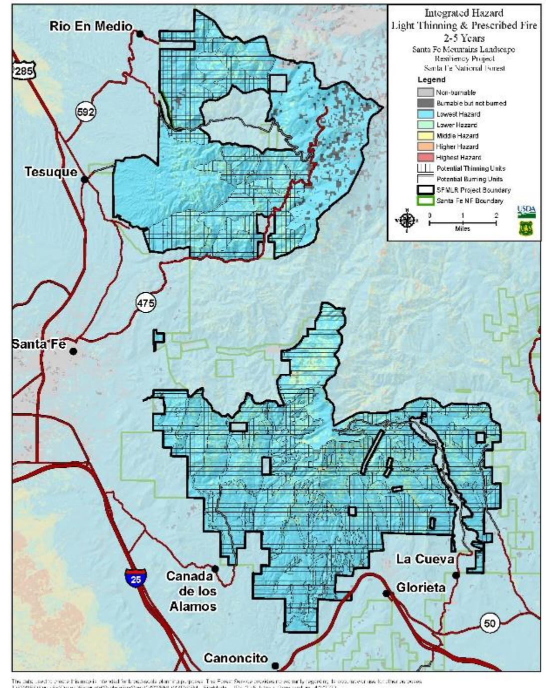

Figure 38. Proposed Action Light Thinning/Prescribed Burning - Wildfire Integrated Hazard 2-5 Years Post Treatment

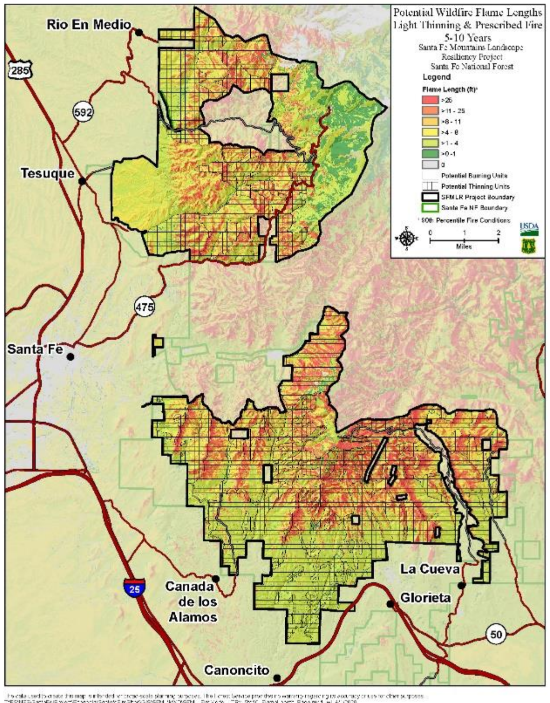

Figure 39. Proposed Action Light Thinning/Prescribed Burning - Wildfire Flame Lengths 6-10 Years Post Treatment

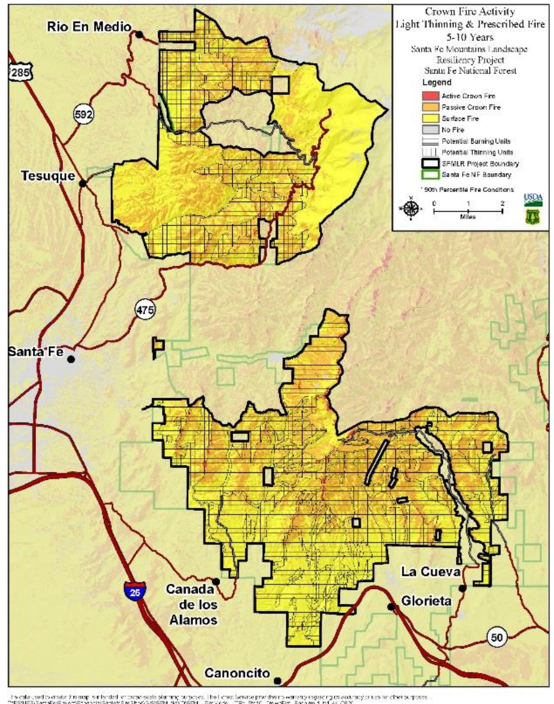

Figure 40. Proposed Action Light Thinning/Prescribed Burning - Wildfire Crown Fire Activity 6-10 Years Post Treatment

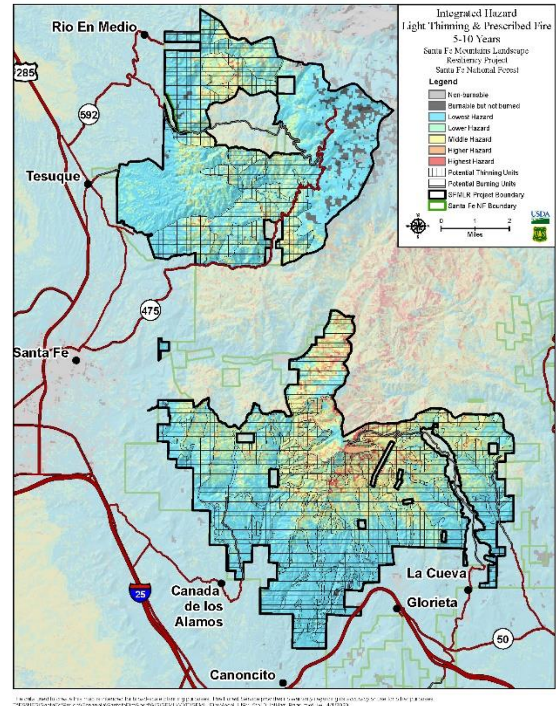

Figure 41. Proposed Action Light Thinning/Prescribed Burning - Wildfire Integrated Hazard 6-10 Years Post Treatment

Public Health and Safety

The implementation of the proposed action and other planned projects would reduce wildfire behavior in close proximity to and improve the protection of homes and infrastructure resources located along the Forest boundary that are at risk from damage by wildfires. The goal of the treatments would be to reduce wildfire average flame lengths to <4 feet, reduce crown fire activity and fire ember or fire brand [15] production, and increase firefighter safety and fire suppression effectiveness as described under Resource Indicators and Measures, Figure 1 and Table 2 above. Figure 42 shows the locations of communities and infrastructure resources in and surrounding the SFLMRP area (IFTDSS 2020).

[15] **Fire Embers or Fire Brands** can cause combustible materials to ignite out ahead of the main wildfire. Embers are small pieces of windblown burning material that are generally produced in large numbers at the flaming front of a wildfire from burning leaves, needles, dry grass/herbaceous plants, shrubs, trees or other heavy fuel loading sources such as wood piles and structures. Fire embers can ignite combustible materials several hundred feet from their source. Compared to embers, fire brands are larger pieces of burning material such as pine needles and tree bark that can be carried by strong winds long distances up to one mile or more before landing and igniting spots fires long distances out ahead of the main fire.

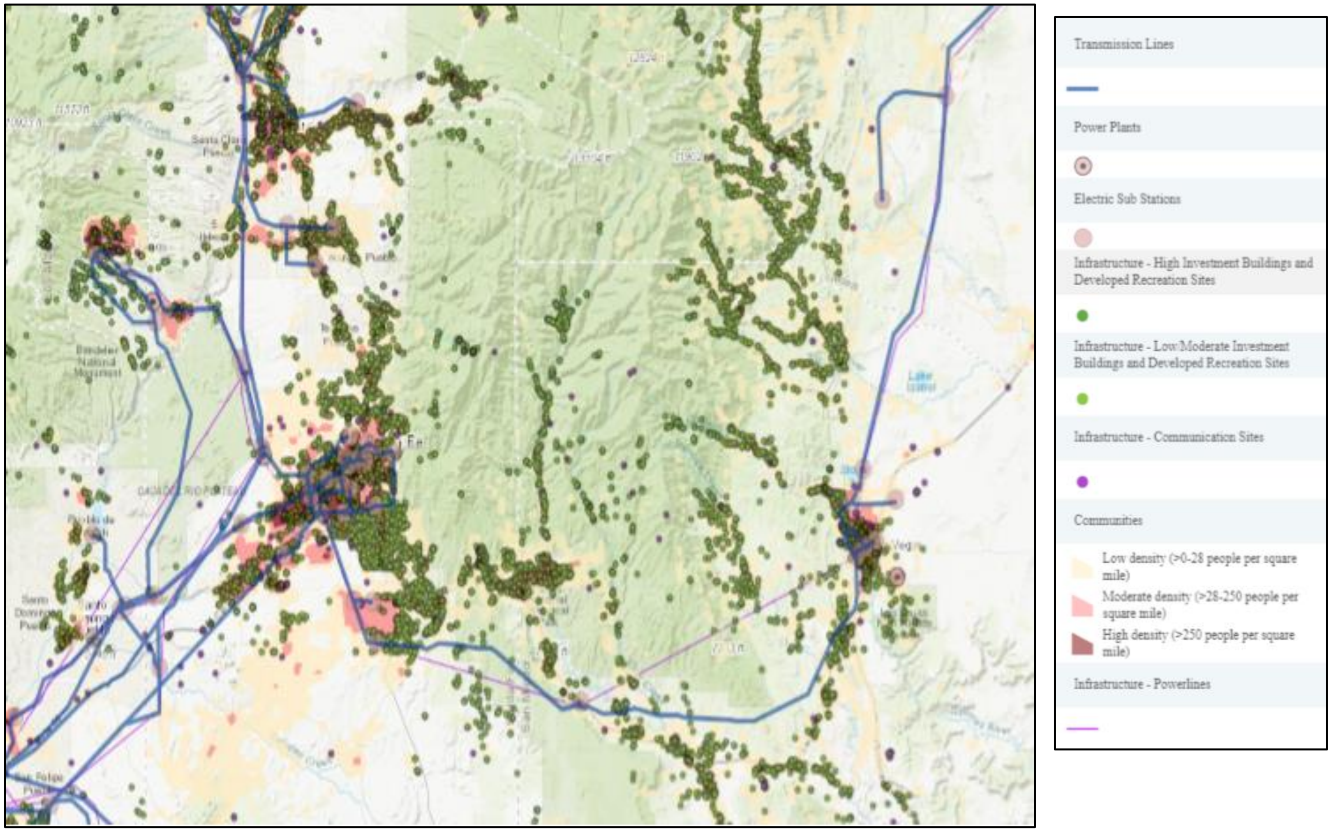

Figure 42. Map showing communities and infrastructure resources in and surrounding the SFLMRP area (IFTDSS 2020)

Extensive research by Jack Cohen and others has shown that the majority of homes that are susceptible to exterior ignition are damaged or destroyed by wildfires from windblown fire embers or fire brands, and to a lesser extent by radiant heat or direct flame contact from other burning homes or adjacent burning materials (Cohen J.D. 2000a; Cohen J.D. 2000b; Cohen J. 2001; Cohen J.D., Stratton R.D. 2003; Cohen J.D. 2004; Cohen J.D. et al. 2008). Figure 43 shows the potential distances that fire embers and brands that are produced by crown fire could ignite structures out ahead of a wildfire burning under 90th percentile burning conditions. The spotting distances in the figure range from 1-1,600 feet with the vast majority of spotting occurring from 1-1,000 feet. Fuel treatments that reduce crown fire potential on lands adjacent to homes would reduce the potential ignition of homes from windblown fire embers and brands. Fuel treatments that are 1,000 to 2,000 feet wide would reduce the number of embers and brands that would reach homes adjacent to the treated area.

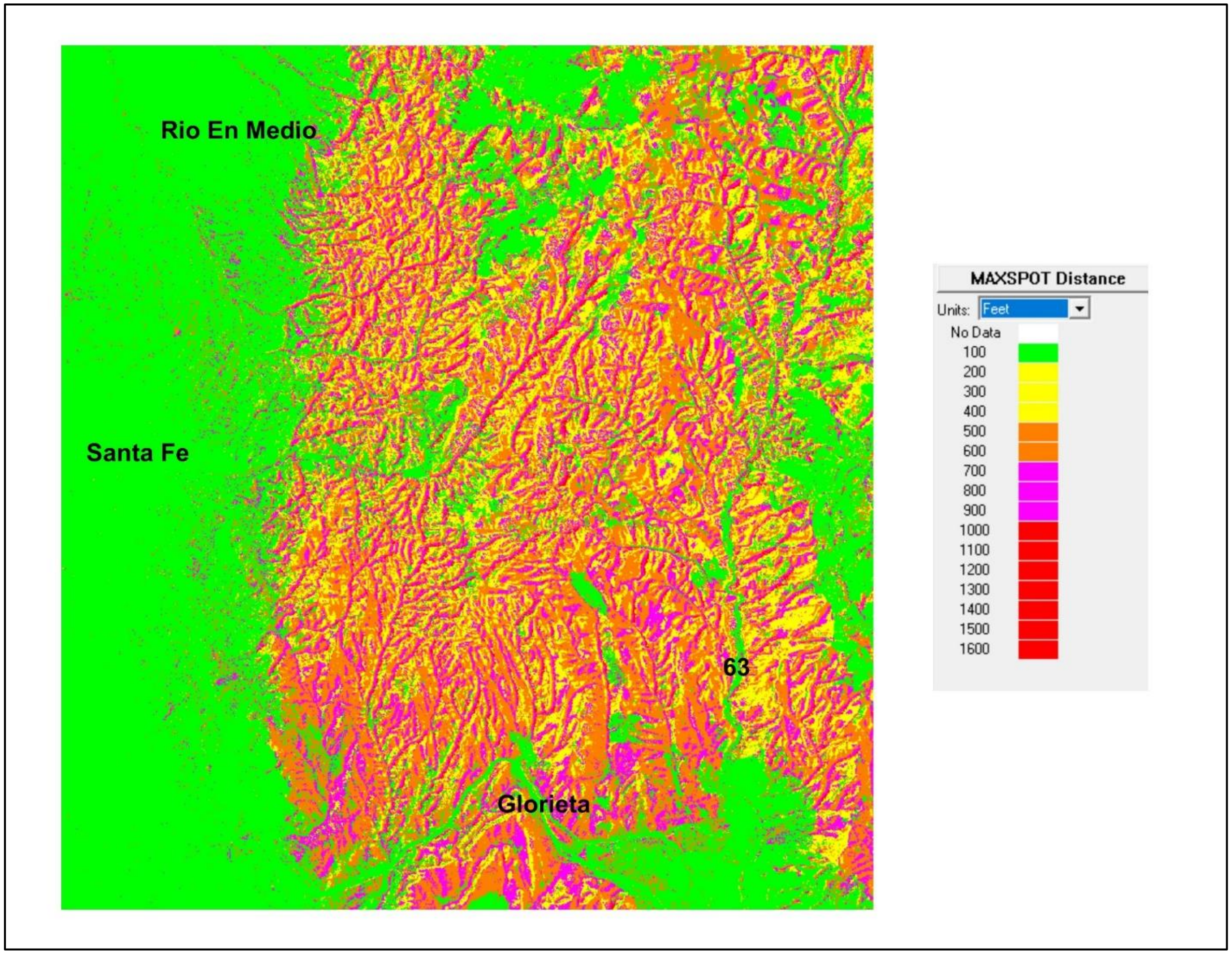

Figure 43. Map showing spotting distances from crown fire activity under 90th percentile wildfire burning conditions. (FamMap 2020)

Climate Change and Carbon Storage

Compared to the estimated annual New Mexico greenhouse gas emissions from prescribed burning the SFMLRP would emit approximately 11-17% of CO2 and 15-22% of CH4 on an annual basis. Table 29 shows a comparison of the range of annual SMLARP greenhouse gas emissions to several sources and geographic areas.

Summary

Under the proposed action, modeling results show that average post treatment ponderosa pine surface fuel loads would be one ton less per acre than the desired condition range (4 tons per acre), and mixed conifer would be two tons higher than the desired condition range (14 tons per acre). Under the no action alternative fuel loads would continue to exceed natural range of variability values and increase from existing overall averages of 18-33 tons per acre. While proposed action results may be slightly low or high most of the project treatment areas would move towards meeting desired conditions.

Compared to the no action alternative, implementation of the proposed action would significantly reduce the potential of damaging wildfires occurring in the treated areas for about one decade:

Wildfire Burning Conditions 2-5 Year Post Treatment Period

Compared to the no action alternative wildfire scenario, the number of acres burning with flame lengths <4 feet would increase:

- Prescribed Burning Only – 71%
- Light Thinning/Prescribed Fire – 73%
- Heavy Thinning/Prescribed Fire – 75%

Compared to the no action alternative wildfire scenario, the number of acres burning with surface fire would increase:

- Prescribed Burning Only – 71%
- Light Thinning/Prescribed Fire – 76%
- Heavy Thinning/Prescribed Fire – 77%

Wildfire Burning Conditions 6-10 Year Post Treatment Period

Compared to the no action alternative wildfire scenario the number of acres burning with flame lengths <4 feet would increase:

- Prescribed Burning Only – 47%
- Light Thinning/Prescribed Fire – 53%
- Heavy Thinning/Prescribed Fire – 74%

Compared to the no action alternative wildfire scenario the number of acres burning with surface fire would increase:

- Prescribed Burning Only – 49%
- Light Thinning/Prescribed Fire – 59%
- Heavy Thinning/Prescribed Fire – 74%

After ten years vegetation growth and fuels accumulations would increase wildfire intensities towards existing, no action conditions. Subsequent implementation of prescribed fire and the management of wildfires to meet resource benefit purposes would be needed to maintain forest frequent fire regime areas within the natural range of variability. Doing so would also increase the forest ecosystem's resistance to the adverse effects of climate change and increase their sustainability over time.

Implementation of the proposed action would reduce the potential of windblown fire embers or brands from igniting homes adjacent to federal lands. After treatments are completed uncontrolled wildfires would mostly burn in surface fuels and there would be a significant reduction in crown fire behavior. Compared to crown fires, surface fires produce far less embers and brands that would be blown by the wind towards homes and fuel treatments that are 1,000 to 2,000 feet wide would reduce the number of embers and brands that would reach homes adjacent to the treated area Under the no action alternative, tree crowns burning in wildfires would produce uncontrolled numbers of fire brands that could ignite homes (figure 43 above).

Mexican Spotted Owl Recovery Plan and Forest Plan Amendment(s)

The implementation of the 2012 Mexican Spotted Owl Recovery Plan in subsequent compliance amendment(s) to the Forest's Land and Resource Management Plan may or may not result in the effective reduction of the potential of damaging wildfires in areas designated for the protection of the owl. The plan's complexity and limitations on vegetation and fuels management treatments in areas outside the natural range of variability could result in owl habitat not being treated in an effective and timely manner thusly extending the time that habitat could be damaged or destroyed by wildfire. Compared to no action, the proposed action may have the same negative effects to owl habitat if treatments are not or never implemented.

Air Quality

Smoke Emissions and Public Health

The amount of emissions emitted from a wildfire or prescribed fire is directly proportional to the amount of biomass combusted. Implementation of the proposed action would reduce future wildfire smoke emissions and air quality impacts and mitigate the potential long term loss of stored carbon. In a comparison of wildfire emissions with prescribed fire emissions, Liu et al. (2017) found that airborne particulate matter "from wildfires is substantially larger than that from prescribed fires, which may reflect different fire behavior and fuel conditions between prescribed fire and wildfires." A study by Meigs et al. (2009) found that mixed-conifer forests that burned at low to moderate intensities (prescribed fire conditions) were a slight carbon sink and those that burned at high-intensity were a large carbon source. In their evaluation of ponderosa pine forests, they found that stands burned at low-severities were carbon neutral, with moderate-severity stands a source and high-severity stands were a large source. The total emissions per unit area are directly related to the amount of biomass consumed by the fire. Prescribed fire is typically lower intensity and consumes less biomass than wildfire, leading to lower per unit area emissions (Wiedinmyer and Hurteau, 2010). Empirical measurements of wildfire versus prescribed fire emissions show that particulate matter emissions are larger from wildfire (Liu et al., 2017).

Mechanical fuel treatments and prescribed fire would have minimal impacts on air quality. Fuels management and preparation of the treatment areas for prescribed burning could improve the effectiveness of a response to unplanned wildfire by lowering fuel loading across the landscape, thereby resulting in beneficial impacts to regional air quality.

Smoke impacts can be minimized by timing and scheduling the burn to be completed during periods of favorable atmospheric conditions. However, even with favorable atmospheric conditions, residences and other inhabited nearby areas being treated with prescribed fire can experience undesirable levels of smoke for periods lasting several hours.

As night falls, so does the smoke. The smoke then settles more heavily into areas closest to the burn and impacts would be greatest during nighttime hours when smoke settles into low lying areas – valleys and canyons. Most communities are located in valleys and low-lying areas. The Santa Fe River gorge and Pecos River valley funnels nighttime smoke from fires burning in the Santa Fe Mountains down and into the Santa Fe and Pecos city areas and surrounding communities. Smoke would be heaviest in the early morning hours. As daytime heating increased, smoke would then begin to mix with upper level air flows over a larger area, so it does not impact localized areas as heavily. Smoke decreases each day after initial burning but can last for several weeks after ignitions based on fuel loadings, fuel moistures and precipitation events.

The impact of smoke on local community members and visitors would depend on weather conditions when fires are active and an individual's sensitivity to smoke. The Forest Service would take measures to manage smoke impacts resulting from prescribed fire. Prior to implementing a prescribed fire, a prescribed fire plan would be written to follow the New Mexico Smoke Management Program. Prescribed fires would be carefully evaluated to consider smoke dispersal into nearby communities surrounding the Santa Fe Mountain. As a result, the effects on air quality from prescribed fire would be short term and localized near the prescribed fire area. The duration of the impact would coincide with the duration of prescribed burn activities.

Tables 22-25 show project area smoke emissions estimates for two scenarios – prescribed burning only, thinning and prescribed burning (vegetation thinning combined with the use of prescribed fire). The tables show pre and post burn fuel loadings, pre and post burn surface and ground carbon

storage, criteria pollutants (PM10, NOx) and greenhouse gas emission (CO2, CH4).Table 22. Prescribed Burning Only Fuel Loading, Surface and Ground Carbon Stroage, Smoke and Green House Gas Emissions

Ecological Response Unit	Acres	Pre Burn Fuel Load (tons)	Pre Burn Carbon (tons)	Post Burn Fuel Load (tons)	Post Burn Carbon (tons)	CP PM2.5 Emissions (tons)	CP PM10 Emissions (tons)	CP NO2 Emissions (tons)	GHG CO2 Emissions (tons)	GHG CH4 Emissions (tons)
Juniper Grass	24	51.84	25.92	10.08	5.04	0.12	0.14	0.13	74.09	0.05
Mixed Conifer – frequent fire	8,742	290,584.08	139,609.74	153,159.84	74,307	3,055.32	2,880.49	109.28	187,358.54	1,455.54
Pinyon Juniper Woodland	733	13,465.21	6,355.11	8,282.90	4,031.50	105.19	85.03	7.33	7,602.30	42.15
Ponderosa Pine Forest	10,629	189,302.49	85,882.32	99,912.60	48,149.37	1,068.22	1,264.85	154.12	136,093.72	595.23
Total	**20,128**	**493,403.62**	**231,873.09**	**261,365.42**	**126,492.91**	**4,228.85**	**4,230.51**	**270.86**	**331,128.65**	**2,092.97**

Table 23. Thinning and Prescribed Burning Fuel Loading, Surface and Ground Carbon Storage, Smoke and Green House Gas Emissions

Ecological Response Unit	Acres	Pre Burn Fuel Load (tons)	Pre Burn Carbon (tons)	Post Burn Fuel Load (tons)	Post Burn Carbon (tons)	CP PM2.5 Emissions (tons)	CP PM10 Emissions (tons)	CP NOx Emissions (tons)	GHG CO2 Emissions (tons)	GHG CH4 Emissions (tons)
Juniper Grass	199	429.84	214.92	83.58	41.79	1.00	1.19	1.09	614,31	0.40
Mixed Conifer – frequent fire	7,135	237,167.40	111,805.45	125,005.20	60,647.50	1,990.67	2,350.98	89.19	152,917.32	1,187.98
Pinyon Juniper Woodland	3,729	68,501.73	32,330.43	42,137.70	20,509.50	367.31	432.56	37.29	38,675.32	214.42
Ponderosa Pine Forest	6,220	110,778.20	50,257.60	28,363.20	14,181.60	625.11	740.18	90.19	79,640.88	357.65
Total	**17,283**	**416,877.17**	**194,608.4**	**195,589.68**	**95,380.39**	**2,984.09**	**3,524.91**	**217.76**	**271,878.52**	**1,760.45**

Table 24 shows the total numbers of emission from no action existing condition wildfire and SFLMRP prescribed burning only, thinning and prescribed burning pre and post burn fuel loadings, pre and post burn carbon storage, criteria pollutants (PM10, NO2) and greenhouse gas emission (CO2, CH4).

Table 24. No Action Existing Condition Wildfire and SFLMRP Prescribed Burning Only, Thinning and Prescribed Burning Pre and Post Burn Fuel Loadings, Pre and Post Burn Surface and Ground Carbon Storage, Criteria Pollutants (PM10, NO2) and Greenhouse Gas Emission (CO2, CH4)

Disturbance	Pre Burn Fuel Load (tons)	Pre Burn Carbon (tons)	Post Burn Fuel Load (tons)	Post Burn Carbon (tons)	CP PM2.5 Emissions (tons)	CP PM10 Emissions (tons)	CP NOx Emissions (tons)	GHG CO2 Emissions (tons)	GHG CH4 Emissions (tons)
Prescribed Burn Only	493,403.62	231,873.09	261,365.42	126,492.91	4,228.85	4,230.51	270.86	331,128.65	2,092.97
Thinning and Prescribed Burning	416,877.17	194,608.4	195,589.68	95,380.39	2,984.09	3,524.91	217.76	271,878.52	1,760.45
Thinning Slash Piles (Average of 35–6'x6' piles per acre = 632,240 piles total)	118,764.09	51,636.52	11,876.41	26,824	721.49	828.38	50.61	177,829.68	299.55
SFMLRP Project Sub Total	**1,029,044.88**	**478,118.01**	**468,831.51**	**248,697.30**	**7,934.43**	**8,583.80**	**539.23**	**780,836.85**	**4,152.97**
No Action Existing Condition Wildfire	**952,131.94**	**443,113.34**	**304,092.33**	**152,143.67**	**6,945.19**	**10,806.35**	**900.27**	**946,664.83**	**5,341.80**

Table 25 shows annual project criteria pollutant and greenhouse gas emissions over ten to fifteen years. Compared to the estimated annual New Mexico emissions from prescribed burning (Table 28) the SFLMRP would emit approximately 16-24% of PM2.5, 15-22% of PM10 and 7-10% of NOx on an annual basis.

Table 25. Annual SFLMRP Criteria Pollutant and Greenhouse Gas Emissions over Ten and Fifteen Years.

Project Implementation	CP PM2.5 Emissions (tons)	CP PM10 Emissions (tons)	CP NOx Emissions (tons)	GHG CO2 Emissions (tons)	GHG CH4 Emissions (tons)
Annual Emissions Over 10 Years	793	858	54	78,083	415
Annual Emissions Over 15 Years	529	572	36	52,056	277

Aerial Ignition (Plastic Sphere Dispenser or "ping-pong balls")

Prescribed fire aerial ignition may be used in remote areas. Aerial ignition using polystyrene spheres, about the size of ping-pong balls and containing potassium permanganate crystals, are dispensed from a machine mounted in a helicopter. Just prior to release, a small amount of ethylene glycol is automatically injected into each sphere by the dispensing machine. Within 20 to 30 seconds, the sphere ignites on the ground and then ignites surface fuels.

This video shows how the system works: https://www.youtube.com/watch?v=3iPNOw-oQgo

Combustion of the spheres produces carbon dioxide, water vapor and styrene gases in small amounts and are minor compared to overall emissions from prescribed burning (Labat, 2002). Effects to watershed and aquatic wildlife is presented in the SFMLRP watershed report

Visibility

The reduction in wildfire risk and potential smoke emissions would likely result in a long-term benefit to visibility conditions because prescribed burning would produce less smoke emissions compared to no action wildfire emissions as seen in Tables 14 and 21-24. Fewer acres within the project area would have the conditions needed to support stand-replacing, uncharacteristic wildfires; therefore, the likelihood of large, uncontrolled smoke emissions would be lower under the proposed action. If wildfires burned the treatment units within 2-5 years after treatments are completed, the amount of acres burning with surface fire would increase by about 71-77% compared to the no action wildfire scenario that would sustain about 74% crown fire. If wildfires burned the treatment units within 6-10 years after treatments are completed, the amount of acres burning with surface fire would increase approximately 49-74% compared to the no action wildfire scenario.

Prescribed fire events would be planned in such a way as to avoid or minimize impacts to visibility. Therefore, adverse impacts to Class I areas are unlikely to occur from prescribed fire activities proposed as part of the proposed action.

Summary

Under the proposed action, compared to annual New Mexico estimated emissions from prescribed burning the SFMLRP would emit approximately 16-24% of PM2.5, 15-22% of PM10 and 7-10% of NO2 on an annual basis. Under the no action alternative, also compared to average annual estimated New Mexico prescribed fire emissions, if the entire SFMLRP area was to burn in a wildfire, criteria pollutant emissions would be approximately 208% of PM2.5, 275% of PM10, 166% of NOx.

Prescribed fire smoke emission impacts to human health would be mitigated by Forest Service compliance with the New Mexico State Smoke Management Program, which stipulates that all burners must comply with requirements of the Clean Air Act, as well as all city and county ordinances relating to smoke management and vegetative burning practices. Forest Service prescribed burning operations would only be conducted with authorization from the state after air quality meteorologists determine that atmospheric conditions would adequately disperse smoke away from smoke sensitive areas and that air pollutant concentrations would not exceed health standards.

Climate Change

The climate impact for the SFMLRP will be related to the additional greenhouse gas emissions it is predicted to emit into the atmosphere. Compared to estimated annual New Mexico greenhouse gas emissions from prescribed burning the SFMLRP would emit approximately 11-17% of CO2 and 15-22% of CH4 on an annual basis. Under the no action alternative, also compared to average annual estimated New Mexico prescribed fire emissions, if the entire SFMLRP area was to burn in a wildfire, greenhouse gas emissions would be approximately 204% of CO2 and 283% of CH4.

Carbon Storage

The Forest Service recognizes the vital role that our nation's forests and grasslands play in carbon storage, which is the direct removal of CO2 from the atmosphere through biologic processes, such as forest growth. Carbon storage by forests is one way to mitigate greenhouse gas emissions by offsetting losses through removal and storage of carbon (USDA, 2015a). Over at least the past several decades, temperate forests have provided a valuable ecosystem service by acting as a net sink of atmospheric carbon dioxide, partly offsetting anthropogenic emissions (Millar and Stephenson 2015). Carbon dioxide uptake by forests in the conterminous United States offset approximately sixteen percent of national total CO2 emissions in 2011 (EPA, 2013). Forests and other ecosystems generally act as carbon sinks because, through photosynthesis, growing plants remove CO2 from the atmosphere and store it (USDA, 2015a).

Keeping forests as forests is one of the most cost-effective carbon storage measures. Restoration of ecosystem resistance and resilience—bringing disturbed forests and grasslands that are outside natural ranges of variability back to producing a full range of environmental services—is another (U.S. Forest Service 2015b). Restoration increases resistance and resilience to damaging forms of disturbance such as drought stress and wildfire effects that are considered outside the natural range of variability. The proposed action would increase ecosystem resistance and resilience that could result in carbon storage beyond the 10-15 year project duration. Even though practices such as thinning and prescribed fire may release carbon in the short term, they focus growth and storage for the future on trees that are at lower risk and/or are more resilient to disturbance. Previous research in southwestern ponderosa pine forest has demonstrated that a restored condition that is maintained by regular surface fire can store more carbon than a fire-suppressed condition when the effects of unplanned wildfire are incorporated (Hurteau, 2017). Appropriate forest management and protection can substitute lighter, strategically placed, and more recoverable emissions for disturbance emissions that would be more severe, extensive, and less reversible (U.S. Forest Service 2015b). Because live trees continually sequester carbon and are a more stable carbon sink that dead biomass left on the site, treating stands is preferred for long-term mitigation of atmospheric carbon levels (Vegh and others 2013).

Additionally, reducing tree density through thinning has been shown to reduce drought stress and increase growth and carbon storage relative to a fire-suppressed condition during dry periods (Hurteau 2017). The restoration of forest structure and the maintenance of that structure with regular surface fire helped sustain the forest carbon sink, even under an increasingly hotter climate (Hurteau, 2017).

The current suite of issues facing forest managers is likely to be compounded by ongoing climate change. In forests of the southwestern United States, increasingly large wildfires and drought already carry ecological and socioeconomic costs, costs that have the potential to rise with the changing climate. While managing forests for an uncertain climate future requires a diversity of approaches, the results of a study by Hurteau (2017) suggest that restoring forest structure and surface fire to southwestern ponderosa pine provides an opportunity to maintain system structure and function, even under the projected warmer, drier future, which is likely to have increased fire frequency.

In a recent 2019 study about how thinning and prescribed burning treatment scenarios influence wildfire behavior and carbon dynamics in the Santa Fe watershed, D. J. Krofcheck found:

> Forests provide a range of services to society, including carbon storage, which helps regulate the climate. Wildfires impact a forest's contribution to climate regulation by releasing carbon to the atmosphere through combustion and by killing trees, which reduces the amount of carbon removed from the atmosphere. In forests that historically experienced frequent-fire, fire-exclusion has increased tree density and the amount of biomass available to burn. These changes have increased the risk of stand-replacing wildfires, and ongoing climate change is making forests more flammable. Management to reduce stand-replacing fire risk typically involves thinning small trees and prescribed burning, both of which reduce the amount of carbon stored in the forest. We sought to determine how management would influence wildfire behavior and carbon dynamics for two different scenarios under projected climate for a municipal watershed in the Sangre de Cristo Mountains of New Mexico. The prioritized scenario-placed thinning and burning treatments based on stakeholder and manager input. The optimized scenario-placed thinning treatments based on the chance of stand-replacing wildfires and applied prescribed burning to all frequent-fire forest types in the watershed. Both scenarios reduced the occurrence of stand-replacing fire. However, the optimized scenario stored more carbon because 54% less of the watershed was thinned. This reduced carbon losses from management and halved the time it took the watershed carbon storage to surpass that of the no-management scenario. Informing management based on risk helps build adaptive capacity to changing climate and maintains the climate regulation benefits of forests (Krofcheck et al., 2019).

Post treatment sequestered carbon would be reduced due to biomass removal and prescribed burning (greenhouse gas release or emissions). New and accelerated forest stands growth, especially in large trees, would offset the removed or released carbon. In addition, the post treatment forest stands would be more resilient and able to resist adverse wildfire effects which would allow for more steady carbon storage over time (Wiedinmyer and Hurteau, 2010). Compared to current Santa Fe National Forest carbon stocks (Table 11 above) the SFMLRP prescribed burning would reduce surface and ground forest carbon by 0.3%.

The Forest Vegetation Simulator (FVS) model is used for analysis of the no action and proposed action in the SFLMRP Silviculture Report. The model uses Forest Inventory Analysis plot data and provides analysis about changes to forest stand carbon over time based on modeling of forest stand growth and biomass changes and the effects of proposed action thinning/mastication and prescribed burning treatments. The FIA data and FVS model analyzes total stand carbon loading including ground/surface biomass (below ground live/dead, litter and duff, coarse woody debris), shrubs, living and dead trees. Table 26 shows a summary of existing or no action carbon storage within the proposed action treatment units broken out by ERU's, and the effects of proposed action treatments to carbon storage out to 2070. Total estimated 2020 existing condition carbon storage in the proposed action treatment units is 743,627 tons. Modeling results show that in 2070 total carbon storage in the proposed action treatment units would be 770,451 tons. Under the no action alternative, and assuming that there would not be any significant disturbances such as drought stress or insect infestations and wildfires that would reduce carbon storage, carbon would increase from 2020-2070. However, this assumption is unlikely, and we have shown that there is a significant potential of large-scale drought stress or insect infestations and wildfires that would occur in the SFMLRP area if no action is taken to treat vegetation and fuels. A comparison of no action in 2020 (existing condition) and proposed action carbon storage in 2070 shows the proposed action would increase carbon by 23% in dry mixed conifer, and reduce carbon by 15% and 18% in Ponderosa pine and Pinyon Juniper respectively (Table 26). This assumes that above and below ground carbon would increase under the no action due to primarily vegetation growth accumulations that is not reduced by drought stress or insect infestations and wildfires.

Table 26. Comparison of No Action and Proposed Action Carbon Storage[16] – Carbon Loading Includes Ground/Surface Biomass (below ground live/dead, litter and duff, coarse woody debris), Shrubs, Living and Dead Trees (assumes that above and below ground carbon would increase under the no action due to primarily vegetation growth and accumulations that is not reduced by drought stress or insect infestations and wildfires)

ERU	Proposed Action Thinning Mastication Prescribed Burning Units (acres)	2020 No Action Total Stand Carbon (tons)	2070 No Action Total Stand Carbon (tons)	2020/2070 No Action Change (%)	2070 Proposed Action Total Stand Carbon (tons)	No Action 2020 and Proposed Action 2070 Comparison Change (%)
Dry Mixed Conifer	8,941	305,411	774,760	+61%	396,283	+23%
Ponderosa Pine	8,676	311,615	542,661	+43%	266,663	-17%
Pinyon Juniper	4,362	126,601	175,876	+28%	107,505	-15%

Summary

Because local greenhouse gas emissions mix readily into the global pool of greenhouse gases, it is difficult and highly uncertain to assess the indirect effects of emissions from single or multiple projects of this size on global climate.

Compared to no action, implementation of the proposed action would have an insignificant effect to existing forest wide carbon stocks, would increase the resiliency and sustainability of carbon storage to future disturbances and the effects of climate change.

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[16] FVS modeling criteria – (1) All thinning/mastication happens in year 2020. (2) All Pile Burning happens in year 2021 but only in the Thinning treatments. (3) The initial prescribed burn happens in 2025. (4) Follow-up prescribed burns occur in Dry Mixed Con and Ponderosa Pine Types every 15 years (2040, 2055, 2070).

Add Effects from Proposed Forest Plan Amendments section (here or elsewhere in the analysis of the proposed alternative)

Cumulative Effects

Spatial and temporal boundaries are the same described above.

Table 27. Actions that May Have Cumulative Impacts to Resources within the Study Area

Action	Summary of Action	Cumulative Effects of SFMLRP Fuels Treatments, Emissions and Changes to Carbon Storage
Pacheco Canyon Forest Resilience Project	The scope of the project is to thin and use prescribe fire on approximately 2,042 acres northeast of the City of Santa Fe, near several popular recreation sites, including the Big Tesuque Campground, Aspen Vista Picnic Area, and the Santa Fe Ski Basin. Tesuque Pueblo lands are within and northeast of the project area. The purpose of the project is to change stand conditions in predominantly ponderosa pine forests in the Pacheco Canyon area. The actions proposed to accomplish this change would be thinning and burning about 2,042 acres. Decision signed on June 1, 2018.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.
La Cueva Fuelbreak Project	The purpose of the project is to change fire behavior in treated areas to reduce the risk of a large-scale, high intensity wildfire spreading to or from the communities of La Cueva, Dalton Canyon, and the Santa Fe Watershed. This project proposes creation of a shaded fuelbreak by thinning 995 acres and conducting prescribed burns (pile and broadcast burning) on approximately 1,100 acres. Decision signed on February 4, 2005	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.
County Line Fuel Wood Treatments	The purpose of the project is to improve forest health and wildlife habitat through a combination of thinning and prescribed burning across approximately 900 acres on Borrego Mesa. Decision signed on August 6, 2010	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.
Southern Rowe Mesa Restoration Project	The purpose of this project is to promote a mosaic of healthy forest stands and natural grasslands through thinning and prescribed burning activities on approximately 17,500 acres on Rowe Mesa. Decision signed on February 21, 2013.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.

Action	Summary of Action	Cumulative Effects of SFMLRP Fuels Treatments, Emissions and Changes to Carbon Storage
Hyde Park Wildland Urban Interface Project	The scope of the project is to thin and use prescribe fire on up to 1,840 acres. The project area is dominated by dense stands of ponderosa pine forests with a lesser component of mixed conifer and pinon-juniper. The project area is located in forests east of the community of Hyde Park Estates, near Hyde Memorial State Park, and adjacent to Black Canyon campground. The purpose of this project is to reduce the risk of uncharacteristic, stand-replacing wildfire and reduce the risk for insect and disease related tree mortality within the project area. Decision signed on March 21, 2018.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.
Santa Fe Municipal Watershed	The scope of the project is to use a combination of tree thinning and prescribed burning on up to 7,270 acres of national forest and city lands in the Santa Fe Municipal Watershed. The proposal is designed to reduce the risk of a severe crown fire and to restore sustainable forest and watershed conditions in the Watershed. Record of Decision signed in October 2001.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.
Santa Fe Municipal Watershed Pecos Wilderness Prescribed Burn Project	The project proposes to perform prescribed burns of between 200 and 2,100 acres at one time in ponderosa pine and mixed conifer stands within an approximately 2,900-acre, mid elevation (8,500 – 10,000 ft) treatment area within the Pecos Wilderness. Decision signed on April 28, 2015.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.
Rowe Mesa II (U.S. Forest Service n.d.)	Fuel treatment to promote a mosaic of healthy forests stands and natural grasslands by thinning and prescribed burning in pinon/juniper, and ponderosa pine trees that have encroached into the understory of woodlands and into meadows of Rowe Mesa. Project initiation 12/19/2018; expected implementation 4/2020.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.
Century Link/PNM Santa Fe to Los Alamos Fiber Optic Project (U.S. Forest Service n.d.)	Proposal to bury a fiber optic line along Forest Road 24 on Santa Fe National Forest land to a PNM transmission line where it will be carried to DOE facilities to improve service to Los Alamos National Lab and Los Alamos community. Notice of initiation 10/1/2018.	No significant cumulative effects.

Action	Summary of Action	Cumulative Effects of SFMLRP Fuels Treatments, Emissions and Changes to Carbon Storage
Issuance of Forest-wide Temporary and Priority Special Use Permits (SUPs) for Non-Motorized Over-Snow Activities (U.S. Forest Service n.d.)	Proposal to approve issuance of temporary and priority SUPs for outfitter and guides throughout the Santa Fe National Forest to conduct guided recreation activities related to over-snow uses, including but not limited to cross country skiing and snow shoeing. Notice of initiation 12/1/2019.	No significant cumulative effects.
Rio Chama Aquatic and Wetland Habitat Restoration Project (U.S. Forest Service n.d.)	Species habitat improvement project to increase diversity and quality of aquatic habitat for fish and invertebrates in Rio Chama downstream from Abiquiu Dam approximately 5.6 miles between Santa Fe and Carson National Forests to point 1.34 miles upstream of Highway 84 bridge. Notice of initiation 10/1/2019; expected implementation 4/2020.	No significant cumulative effects.
Comexico Jones Hill Exploration (U.S. Forest Service n.d.)	Exploratory drilling operation on unpatented mining claims in Pecos/Las Vegas Ranger District of SFNF. Proposal will cause approximately 5-7 acres of surface disturbance in an area that has been previously disturbed by earlier exploration date. All activities will occur within 1 year of the state date. Scoping was conducted in December 2019; expected implementation 10/2020.	No significant cumulative effects.
Pecos Bike Trails (U.S. Forest Service n.d.)	Project to develop trail system and impress access and promote visitor safety in Canada de Los Alamos/Glorieta area. Notice of initiation 11/1/2019; expected implementation 2/2020.	No significant cumulative effects.
Pecos Rio Grande Cutthroat (RGCT) Trout Restoration (U.S. Forest Service n.d.)	Project to restore RGCT populations to Willow Creek and upper Cow Creek by adding 9 miles of stream to currently occupied distribution. Scoping occurred February 2019.	No significant cumulative effects.
Non-Forest Service Projects		
Aztec Springs, Phase 2 & 3 (City of Santa Fe, The Nature Conservancy, New Mexico State Forestry)	150 acres of thinning, piling, and prescribed burning activities.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.

Action	Summary of Action	Cumulative Effects of SFMLRP Fuels Treatments, Emissions and Changes to Carbon Storage
Aspen Ranch (Pueblo of Tesuque)	160 acres of thinning, piling, and prescribed burning activities in ponderosa pine and mixed conifer.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.
Vigil Grant (Pueblo of Tesuque)	158 acres of thinning, piling, and prescribed burning activities in ponderosa pine and mixed conifer.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.
Hyde Memorial State Park (New Mexico State Forestry)	Thinning, piling, and prescribed burning across 276 acres in Hyde Memorial State Park.	The SFMLRP would decrease the potential of damaging widflires in the area; decrease the potential of greater wildfire emissions of criteria air pollutants and greenhouse gases; and stabilize carbon storage overall over several years.

Action	Summary of Action	Cumulative Effects of SFMLRP Fuels Treatments, Emissions and Changes to Carbon Storage
City of Santa Fe Planned Communities and Infrastructure Projects	Three master planned communities that is projected to absorb most of Santa Fe's growth through 2030 • Tierra Contenta Master Plan (1995) approved as many as 5,200 housing units and to date is 50% completed with up to 2,500 homes and apartment units completed. The western portion of Phase 2 and Phase 3 await construction and includes 400 acres of developable land and 100 acres of open space/parks. • Las Soleras Master Plan (2008) covers 400 acres with most of the land along I-25 slated for commercial and mixed use. Internal portion of master plan are reserved for residential units which could be developed with 1,000-1,500 housing units. • Northwest Quadrant (2010) covers approximately 160 acres of 2,000 acres the city owns in the northwest corner of the city. The Master Plan calls for 750 housing units to the southeast of Highway NM 599. Roadway improvements, trails and urban mixed use and parks (Southwest Activity Node, Las Soleras Park, and South Meadows Park) (City of Santa Fe 2017). Multiple drainage projects are proposed by City of Santa Fe in Council Districts 1, 2, 3, and 4 to be completed in three phases between 2019 and 2022 (City of Santa Fe n.d.).	No significant cumulative effects.
Santa Fe River Greenway R&PP Lease Project	EA (released 11/21/19) for the conveyance of 23.5 acres of BLM-administered public lands to Santa Fe County under the Recreation and Public Purpose Act (R&PP) for the construction and maintenance of a short segment of the greenway and for bank stabilization of the Santa Fe River. The proposed project will create a greenway of public parks and multi-use recreational trails along the Santa Fe River from Two-mile Reservoir in eastern Santa Fe west to the Santa Fe County wastewater treatment plant, which is located just west of New Mexico Highway 599 (BLM 2019a).	No significant cumulative effects.

Note: Projects that are listed as on hold in the January 2020 through March 2020 Schedule of Proposed Action (SOPA) were not included in this table.

Fuels and Wildfire Behavior

According to the Forest Plan, approximately 555,105 acres of forests and woodlands in the Sangre de Cristo Mountain Range are managed by the Santa Fe National Forest.

An inquiry of the online New Mexico Vegetation Treatment Mapping (NMVTM) system covering the southern Santa Fe Mountains and the SFLMRP vicinity shows about 23,300 acres of past and present vegetation management and fuels reduction projects in the Sangre de Cristo Mountain Range that are designed to improve forest health and reduce wildfire behavior adverse effects (11,713 acres of completed treatments, 5,087 acres of ongoing treatments, and 6,500 acres of historical treatments, for a total of 23,300 acres of treatments). There are planned treatments covering 57,130 acres including the SFLMRP. Several of the treatment areas have had overlapping or multiple completed or planned treatments (Figure 44) (NMVTM, 2020a).

The NMVTM system shows the area covering the entire eastern portion of the Santa Fe National Forest in the Sangre de Cristo Mountain Range has had about 88,313 acres of completed treatments, 5,087 ongoing treatments, and 77,112 historical treatments with another 130,918 planned treatments including the SFLMRP for 301,430 total acres (NMVTM, 2020b).

The past, present and proposed projects including the SFMLRP proposed action treatments would result in approximately 301,430 acres of treatments or about 54% of forests and woodlands (several of the treatment areas shown if Figure 44 have had overlapping or multiple completed or planned treatments). Due to fire suppression over the 120 years the vast majority of the forest stands in the Sangre de Cristo Mountain Range are in Vegetation Condition Class IIa: moderate to low vegetation departure; IIb: moderate to high vegetation departure. Ponderosa Pine and Mixed Conifer-Frequent Fire ERU's are at high vegetation departure (VDDT). The current fire-free interval (119 years) is over 11 times the historical maximum fire-free interval. The vegetation and disturbances are uncharacteristic of the natural regime and are at risk of experiencing unnaturally high intensity, widespread, damaging wildfires in Ponderosa pine and mixed conifer ecosystems. Past, present and proposed action vegetation management and fuels reduction treatments reduce the potential of widespread, damaging wildfires on about 54% of at risk forests and woodlands stands. Therefore, approximately 46% of the federal lands managed by the Santa Fe National Forest in the Sangre de Cristo Mountain Range would remain at risk of experiencing adverse climate change effects and damaging wildfires.

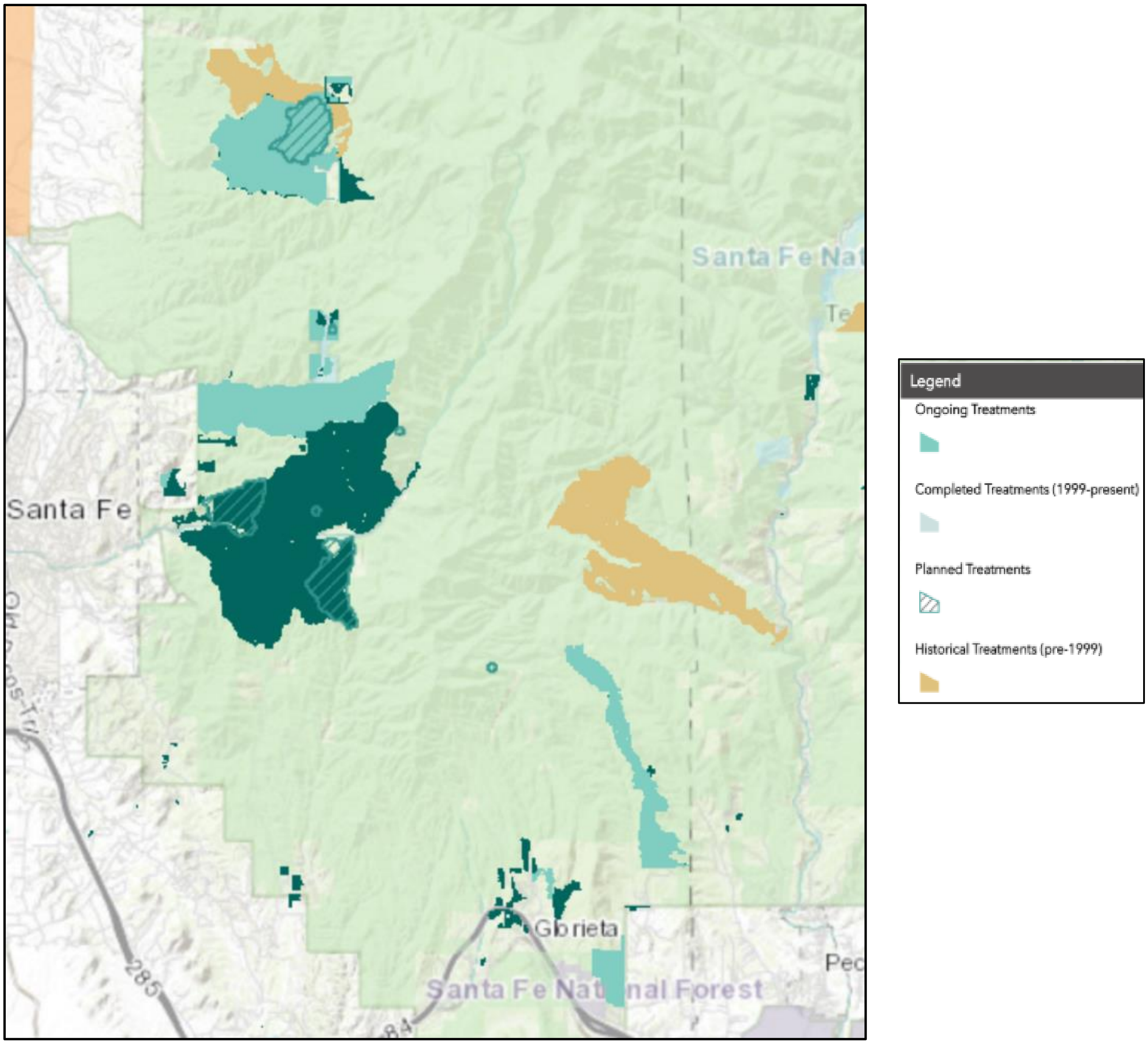

Figure 44. New Mexico Vegetation Treatment Mapping System Display of Southern Santa Fe Mountains Vegetation Treatments.

Consistency with Relevant Laws, Regulations, and Policy

Forest Service Policy

The Santa Fe National Forest Land and Resource Management Plan (LMRP) and projects are required to implement these policies:

Fuels

FSM 5140 – Hazardous Fuels Management and Prescribed Fire. FSM 5140 Provides direction on mitigating hazardous fuels and using fire to achieve desired landscape conditions and attain Land and Resource Management Plan objectives.

The LMRP implements FSM 5140 policy direction for hazardous fuels management and prescribed fire. The LRMP serves as the document to initiate, analyze, and provide the basis for implementing hazardous fuels management and prescribed fire projects to meet resource management objectives.

IPFPIPG PMS 484. National Wildfire Coordinating Group, Interagency Prescribed Fire Planning and Implementation Procedures Guide. The guide establishes procedures for the five federal land management agencies.

The Forest is required to follow the guide for all prescribed fire operations.

Air Quality

FSM 2580 – Watershed and Air Management – Air Resource Management. FSM 2580 sets policy for integrating air resource management objectives into all resource planning and management activities and the use of cost effective methods of achieving resource management objectives.

The LMRP implements FSM 2580 policy direction by compliance with all Federal, State, or local air control rules, regulations, and directives by requiring compliance with substantive and procedural requirements imposed by a Federal, State, and local administrative authority.

Climate Change

Considering Climate Change in Land Management Planning (USDA 2009). The policy paper calls for Forest Service projects to consider:

1. Climate change effects include the effects of agency action on global climate change and the effects of climate change on a proposed project.

2. The Agency may propose projects to increase the adaptive capacity of ecosystems it manages, mitigate climate change effects on those ecosystems, or to sequester carbon.

3. It is not currently feasible to quantify the indirect effects of individual or multiple projects on global climate change, and therefore determining significant effects of those projects or project alternatives on global climate change cannot be made at any scale.

4. Some project proposals may present choices based on quantifiable differences in carbon storage and GHG emissions between alternatives.

The SMLARP addresses the impacts of climate change to forest resources by proposing to treat unnaturally overstocked forest stands, surface fuel loadings and ladder fuels with mechanical and prescribed fire treatments. The actions would reduce the potential of wide spread damage from wildfires, increase resiliency to drought and climate change effects to ecosystem functions, and improve forest health. Greenhouse emissions from prescribed burning and equipment use would be minor compared to emissions from other regional, national and international sources.

Land and Resource Management Plan

Fuels and Wildfire Behavior

Santa Fe National Forest Plan, As Amended through Amendment 13 – June, 2010

Management Direction Forest Wide

Protection – Fire

P11 Prescribed fire, using planned and unplanned ignitions, will be used to enhance and accomplish resource objectives, particularly in fire dependent ecosystems.

P12 Activity created fuels and natural fuels will be treated to a level that will allow maximum tolerable loss objectives to be met at the 65th percentile rate-of-spread with the existing fire protection organization. Firewood harvest will be the preferred method of fuel reduction.

P13 Fuels treatment will be coordinated with wildlife habitat needs. Prescribed fire will be utilized to minimize high intensity fire risk in essential T&E habitat. Existing and potential snags needed for wildlife habitat will be protected.

Watershed Management

Select treatment methods for plant control or revegetation projects according to the NEPA process and the following criteria:

2. Prescribed fire may be used:
    a. on areas with suitable fuel types,
    b. on areas where the proper vegetative response can be expected, and
    c. where the fire will not pose a threat to human safety or surrounding property,
    d. on slopes greater than 40 percent, with careful resource consideration.
    e. on soils with moderate or high revegetation potential.
    f. soils with low revegetation potential, as long as 40% of the vegetative cover remains.

Wildlife and Fish

Manage at least 5 logs per acre in various stages of decomposition where consistent with visual quality and fuel loading objectives. Wildlife logs should be the largest diameter available and at least 15 feet in length.

Management Area A

Protection

Fuel treatment methods which are commensurate with protection of the timber base and maintenance of wildlife habitat are acceptable.

Prescribed fire will be used primarily for site preparation, fuels reduction and enhancement of wildlife habitat.

Management Area D

Fuel treatment methods with effects lasting no longer than one year are acceptable.

Fuels reduction will be emphasized around developed sites.

Prescribed fire will be used primarily to maintain visual quality and to maintain or create vegetative diversity in conjunction with other treatments.

Management Area E

Prescribed fire will be used to maintain or develop vegetative diversity for P13 visual and wildlife benefits, fuels reduction, and site preparation.

Management Area L

MANAGEMENT EMPHASIS - Emphasis is on providing semi-primitive non-motorized recreation opportunities. Wildlife, range, and ***fuels management*** may occur where consistent with this emphasis. Timber harvest and road building are not consistent with this emphasis, and none are scheduled within this planning period. These areas will receive priority in dispersed recreation management, trail and trailhead development, and trail maintenance.

Prescribed fire may be utilized as appropriate to develop and maintain vegetative diversity for visual quality and dispersed recreation values.

Management Area O

Prescribed fire may be used to reduce fuels to an acceptable level while protecting watershed values.

Air Quality

Santa Fe National Forest Plan, As Amended through Amendment 13 – June, 2010

Forest Goals - Wilderness - Protect air quality related values in Class I wilderness areas.

Management Direction Forest Wide

Watershed Management

F04 Management activities will be planned so that air quality will meet applicable Federal, state, and local regulations.

Protection – Fire

P09 Fires which exceed the suppression objectives are considered escape fires and appropriate response will be determined by an escape fire situation analysis. The analysis will consider at least the following:

4. Effects on air quality and watershed.

Other Relevant Law, Regulation, or Policy

Federal Law – Air Quality

Federal Clean Air Act (CAA) of 1955 as amended in 1967, 1970, 1977, and 1990; Clean Air Act. 42 USC §§ 7409, 7410, and 7502-7514

The act is a legal mandate designed to protect public health and welfare from air pollution. Although this policy creates the foundation for air quality regulation, states and counties are often responsible for implementation of the air quality standards. The Clean Air Act establishes human health and welfare standards for air quality and affords Class I wilderness areas protection from air pollution. EPA and Federal Land Managers (FLM) work closely with state air regulators to protect air quality for the benefit of human health and the natural environment. The task of identifying NAAQS is assigned by the Clean

Air Act to the EPA. The EPA evaluates and updates these standards every 5 years. The Act and requires geographic areas within a state to be designated as attainment, nonattainment, or unclassifiable based on NAAQS monitoring data. It also requires States to prepare State Implementation Plans (SIP's) for assuring that the NAAQS are met. Further, the Act requires Federal agencies to comply with General Conformity rules. Under General Conformity, Federal actions must not interfere with goals of the SIP. Federal oversight of the law is provided by the U.S. Environmental Protection Agency (EPA).

In New Mexico the CAA is administered by the New Mexico Environment Department, Air Quality Bureau. The CAA is implemented at the Santa Fe National Forest level when activities under the control of the Forest are required to comply with state law and air quality regulations.

National Ambient Air Quality Standards

The CAA requires the Environmental Protection Agency to set the NAAQS for ambient concentrations of criteria air pollutants that are considered harmful to public health and the environment. The NAAQS has two forms: primary and secondary. The primary standard sets limits for the protection of public health, including the health of sensitive populations, like asthmatics, children, and the elderly. The secondary standard sets limits for the protection of public welfare, including visibility impairment and damage to animals, crops, vegetation, and buildings. Criteria pollutants for both forms of the NAAQS include: particulate matter (PM10 and PM2.5), ozone (O3), nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon monoxide (CO), and lead (Pb). Geographic areas not meeting the NAAQS are designated as nonattainment based on the ambient criteria pollutant concentration.

An exceedance of a NAAQS is defined in 40 CFR 50.1 as "one occurrence of a measured or modeled concentration that exceeds the specified concentration level of such standard for the averaging period specified by the standard." A violation of the NAAQS consists of one or more exceedances of a NAAQS. The precise number of exceedances necessary to cause a violation depend on the form of the standard and other factors, including data quality, defined in federal rules such as 40 CFR 50.

The New Mexico Environment Department, Air Quality Bureau is the state agency having jurisdictional authority over air pollution control and sets guidelines to attain and maintain the national and state ambient air quality standards within the state of New Mexico. The Bureau enforces the New Mexico Ambient Air Quality Standards (NMAAQS). NMAAQS also include standards for total suspended particulate matter, hydrogen sulfide, and total reduced sulfur for which there are no national standards.

Nonattainment and Maintenance Areas

Nonattainment Areas are designated by EPA based upon air quality monitoring data or modeling studies that indicate an area violates, or contributes to violations of the NAAQS. States are required to submit a State Implement Plan (SIP), which defines the strategies used to control air pollution in order to bring air quality into attainment. After air quality improves and no longer violates the NAAQS, EPA may re-designate the area as attainment and these areas are known as maintenance areas. The CAA and EPA regulations impose requirements for Federal agencies to work with State and local governments in nonattainment and maintenance areas to ensure that federal actions conform to the initiatives established in the applicable SIP. These regulations are defined under the CAA General Conformity Rule.

There are no nonattainment areas in the Santa Fe National Forest area.

General Conformity 42 USC 7571-7574

The CAA requires federal agencies to ensure that actions they undertake in nonattainment and maintenance areas are consistent with federally enforceable air quality management plans for those areas. Under the General Conformity Rule, federal agencies must work with State and local governments in nonattainment and maintenance areas to ensure that federal actions conform to the initiatives established in the applicable state implementation plan. General Conformity is typically addressed during the NEPA process. The preamble to EPA's rulemaking on general conformity States that conformity "should be viewed in a manner that fits within a broader view including NEPA activities," and that "EPA expects the conformity analysis to be coupled with the NEPA analysis and, thus, not result in undue delays" (58 FR 63214, November 30, 1993). In addition, the Council on Environmental Quality's NEPA regulations state that Federal agencies shall integrate NEPA requirements for a proposed action with other environmental review and consultation requirements to the fullest extent possible (40 CFR 1502.25(a)). Oversight is provided by the Federal agency responsible for the proposed Federal action. Consistent with the requirements of the Rule, a Federal agency must make its own General Conformity Determination (GCD) indicating that its actions will conform to the appropriate state implementation plan (SIP). However, a GCD is not required for Federal actions that are considered De Minimis or where the total of direct and indirect emissions are below the emissions levels specified under 40 CFR 93.153(b)(1) and (2).

Prescribed burning that is regulated by States having approved smoke management plans complies with the Clean Air Act. In New Mexico the State's smoke management plan regulations are implemented at the state level by the New Mexico Environment Department, Air Quality Bureau. The Forest Service is required to comply with the State's smoke management plan and therefore, prescribed fire projects are presumed to comply with, or "conform" to the federal Clean Air Act's conformity regulations.

1999 Regional Haze Rule 40 CFR Parts 51 and 52 (RHR)

Under the CAA the 1999 RHR mandates that states address control of man-made air pollution that impacts visibility in designated Class I areas. Class I areas include wilderness, national parks and monuments greater than 5000 acres which existed as of August 7, 1977. The goal of the RHR is to return visibility conditions in Class I areas to natural background conditions by the year 2064. EPA defines "regional haze" as visibility impairment produced by sources and activities that emit fine particles and their precursor emissions across a broad geographic area, which can interfere with the scenic vistas integral to our national parks, forests, and wilderness areas.

New Mexico is required to develop and submit to EPA its own regional haze plans by July 31, 2021.

The forest's responsibility with regard to visibility involves coordination with the EPA, and State, county, and tribal air regulatory agencies in managing and mitigating the emissions of air pollutants resulting from Forest Service activities, such as the application of planned fire ignitions. If conditions prescribed by the Regional Haze Rule and the New Mexico regional haze state implementation plan are met, visibility is expected to improve over time in and outside of the Santa Fe.

Prevention of Significant Deterioration (PSD)

The CAA requires federal land managers "…to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, … and other areas of special national or regional natural, recreational, scenic, or historic value." PSD addresses resource protection through the establishment of ceilings on additional amounts of air pollution over base-line levels in "clean" air areas, the protection of the air quality-related values of certain special areas, and additional protection for the visibility values of certain special areas. The PSD Program sets emission limitations for major new or modified stationary sources of air pollution such as coal-fired electrical power generation plants, and sets limits to an increase of pollutants in Class I and Class II areas. A permittee wishing to build a major new (or significantly modify an existing) facility in a clean air region must obtain a prevention of significant deterioration (PSD) permit from the state. Where emissions from new or modified facilities might affect Class I areas, the Federal Land Manager (FLM) must be notified by the air quality regulator having jurisdiction (state or local authorities).

The PSD program is relevant to stationary air polluting sources. The SFMLRP project is an air pollution area source from prescribed burning and is therefore not covered by the PSD Program.

National Forest Management Act

The National Forest Management Act of 1976 (NFMA) requires national forests and grasslands to create land management plans. The law states "National Forests are ecosystems and their management… requires an awareness and consideration of the interrelationships among plants, animals, soil, water, air, and other environmental factors within such ecosystems."

The LMRP meets NFMA air quality requirements by complying with the Clean Air Act.

Wilderness Act

The 1964 Wilderness Act identified management goals for all wilderness areas, both Class I (protected under the Clean Air Act) and Class II. It requires wilderness areas to be administered "for the use of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness." National Forest System Wilderness Implementing Regulations: "Wilderness Resources shall be managed to promote perpetuate and where necessary restore the wilderness character of the land."

The LMRP meets Wilderness Act air quality requirements by complying with the Clean Air Act.

State and Local Law

In New Mexico New Mexico Environment Department, Air Quality Bureau California administers the New Mexico State Smoke Management Program.

The Forest Service complies with the New Mexico State Smoke Management Program, which stipulates that all burners must comply with requirements of the Clean Air Act, as well as all city and county ordinances relating to smoke management and vegetative burning practices. Forest Service prescribed burning operations would only be conducted with authorization from the state after air quality meteorologists determine that atmospheric conditions would adequately disperse smoke away from smoke sensitive areas and that air pollutant concentrations would not exceed health standards. The state enforces specific requirements for prescribed fires and wildfires managed for multiple objectives that exceed 10 acres, which include registering the burn, notifying State and nearby population centers of burn date(s), visual tracking, and post-fire activity reports (emissions tracking also applies to wildfires greater than 100 acres that are fully suppressed) (New Mexico Administrative Code Title 20, Environmental Protection; Chapter 2 Air Quality (Statewide); Part 65, Smoke Management).

Conclusion

Issues Addressed

Issue 13: Would the proposed treatments contribute to global climate change?

Implementation of the proposed action would increase ecosystem resistance and resilience to adverse climate change effects. Decreasing risk of significant damage from drought and wildfires outside the natural range of variability would stabilize carbon storage.

The climate impact for the SFMLRP will be related to the additional greenhouse gas emissions it is predicted to emit into the atmosphere. Because local greenhouse gas emissions mix readily into the global pool of greenhouse gases, it is difficult and highly uncertain to assess the indirect effects of emissions from single or multiple projects of this size on global climate. Compared to the estimated annual New Mexico greenhouse gas emissions from prescribed burning the SFMLRP would emit approximately 11-17% of CO2 and 15-22% of CH4 on an annual basis.

Post prescribed burning surface and ground carbon storage would be approximately 248,697 tons. Compared to current Santa Fe National Forest carbon stocks the SFMLRP prescribed burning would reduce forest carbon by 0.3%.

A comparison of no action (2020 existing condition) and proposed action carbon storage in 2070 shows the proposed action would increase carbon storage in thinning treatment units. Total estimated 2020 existing condition carbon storage in the proposed action thinning treatment units is 743,627 tons. Modeling results show that in 2070 carbon storage in the proposed action thinning treatment units would be 770,451 tons.

Compared to forest wide existing condition carbon storage the carbon sequestered in the SFLMRP proposed action thinning treatment units in 2020 represent 0.95% of total forest wide sequestered carbon. Modeling results show that in 2070 the SFLMRP thinning treatment units would sequester 0.98% of existing carbon.

Issue 14: What chemicals are used for ignitions in prescribed burns? What impacts would these chemicals have on human health and the environment?

Prescribed fire aerial ignition may be used in remote areas. Aerial ignition using polystyrene spheres, about the size of ping-pong balls and containing potassium permanganate crystals, are dispensed from a machine mounted in a helicopter. Just prior to release, a small amount of ethylene glycol is automatically injected into each sphere by the dispensing machine. Within 20 to 30 seconds, the sphere ignites on the ground and then ignites surface fuels.

Combustion of the spheres produces carbon dioxide, water vapor and styrene gases in small amounts and are minor compared to overall emissions from prescribed burning. Effects to watershed and aquatic wildlife is presented in the SFMLRP watershed report

Issue 15: Would the proposed prescribed burning treatments impact local air quality?

Wildfire emissions would be reduced and are unlikely to cause smoke impacts that may exceed health standards in smoke sensitive areas or populated communities surrounding the National Forest.

Smoke impacts can be minimized by timing and scheduling the burn to be completed during periods of favorable atmospheric conditions. However, even with favorable atmospheric conditions, residences and other inhabited nearby areas being treated with prescribed fire can experience undesirable levels of smoke for periods lasting several hours.

As night falls, so does the smoke. The smoke then settles more heavily into areas closest to the burn and impacts would be greatest during night time hours when smoke settles into low lying areas – valleys and canyons. Most communities are located in valleys and low lying areas. The Santa Fe River gorge and Pecos River valley funnels night time smoke from fires burning in the Santa Fe Mountains down and into the Santa Fe and Pecos city areas and surrounding communities. Smoke would be heaviest in the early morning hours. As daytime heating increased, smoke would then begin to mix with upper level air flows over a larger area so it does not impact localized areas as heavily. Smoke decreases each day after initial burning, but can last for several weeks after ignitions based on fuel loadings, fuel moistures and precipitation events.

The impact of smoke on local community members and visitors would depend on weather conditions when fires are active and an individual's sensitivity to smoke. The Forest Service would take measures to manage smoke impacts resulting from prescribed fire. Prior to implementing a prescribed fire, a prescribed fire plan would be written to follow the New Mexico Smoke Management Program. Prescribed fires would be carefully evaluated to consider smoke dispersal into nearby communities surrounding the Santa Fe Mountain. As a result, the effects on air quality from prescribed fire would be short term and localized near the prescribed fire area. The duration of the impact would coincide with the duration of prescribed burn activities.

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