Chapter 3. Affected Environment and Environmental Consequences

This chapter summarizes the physical, biological, social, and economic environments of the project area and the effects of implementing each alternative on that environment. It presents the assumptions and methodologies used to analyze the effects of the alternatives, which is the scientific and analytical basis for comparing the alternatives. Only summaries are provided here for each resource area. All specialist reports in their entirety are incorporated by reference and are available on the 4FRI Rim Country webpage at: www.fs.usda.gov/goto/4FRIRimCountry.

Law, Regulation, and Policy

Applicable laws, regulations, policies, and executive orders, as well as Forest Service manual and handbook guidance, memoranda of understanding, conservation strategies, and programmatic agreements, are listed here by resource area. For more information on these, forest plan direction, and other guidance, see the individual resource specialist reports. The relevant documents are available on the Forest Service website (http://www.fs.fed.us/publications/) and from Forest Service offices.

All

- Organic Administration Act of 1897 (at 16 U.S.C. 475, 551)
- Multiple-Use Sustained-Yield Act of 1960 (16 U.S.C. 528-531)
- National Environmental Policy Act of 1969 (16 U.S.C. 4321 et seq.)
- Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, as amended by the National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1600-1614, 472a)
- 40 CFR 1500 Council on Environmental Quality

Watershed and Soils

- Organic Administration Act of 1897
- Weeks Law of 1911
- Knutson-Vandenberg Act of 1930
- Bankhead-Jones Farm Tenant Act of July 22, 1937
- Federal-State Cooperation for Soil Conservation Act of December 22, 1944
- Anderson-Mansfield Reforestation and Revegetation Joint Resolution Act of 1949
- Granger-Thye Act of 1950
- Watershed Protection and Flood Prevention Act of August 4, 1954
- Sikes Act (Fish and Wildlife Conservation) of September 15, 1960
- Joint Surveys of Watershed Areas Act of September 5, 1962
- Land and Water Conservation Fund Act of September 3, 1964
- Federal Water Project Recreation Act of July 9, 1965
- Water Resources Planning Act of July 22, 1965
- Water Quality Improvement Act of April 3, 1970

- Clean Water Act of 1948 (as amended in 1972 (Federal Water Pollution Control Act) and 1987)
- Federal Land Policy and Management Act of October 21, 1976
- Surface Mining Control and Reclamation Act of August 3, 1977
- Soil and Water Resources Conservation Act of November 18, 1977
- Safe Drinking Water Amendments of November 18, 1977
- Emergency Flood Prevention (Agricultural Credit Act) Act of August 4, 1978
- North American Wetland Conservation Act of 1989
- 33 CFR 323 Permits for Discharges of Dredged or Fill Material into Waters of the United States
- 40 CFR 121-135 Water Programs
- EO 11988 Floodplain Management, 1977
- EO 11990 Protection of Wetlands, 1977
- FSM 2500 – Watershed and Air Management
- FSH 2500 – Watershed and Air Management

Vegetation

- Weeks Law of 1911, as amended (at 16 U.S.C. 515, 552)
- Knutson-Vandenberg Act of 1930 (16 U.S.C. at 576b)
- Anderson-Mansfield Reforestation and Revegetation Joint Resolution Act of 1949 (at 16 U.S.C. 581j and 581 j(note))
- Granger-Thye Act of 1950 (16 U.S.C. at 580g-h)
- Surface Resources Act of 1955 (30 U.S.C. 611-614)
- Healthy Forests Restoration Act (HFRA) of 2003 (16 U.S.C. at 1611-6591)
- Stewardship End Result Contracting Projects (16 U.S.C. 2104 (note))
- Tribal Forest Protection Act of 2004 (P.L. 108-278, 118 Stat. 868; 25 U.S.C. 3115a)
- Omnibus Public Land Management Act of 2009 (Title IV – Forest Landscape Restoration of PL 111-11)
- Collaborative Forest Landscape Restoration Act (CFLRA) of 2009
- National Forest Resource Management: Forest Service Manual (FSM) 2000—Chapter 2020— Ecological Restoration and Resilience
- Silvicultural Practices Handbook (FSH 2409.17), Silvicultural Examination and Prescription Handbook (FSH 2409.26d)

Fire Ecology

- Federal Wildland Fire Policy of 1995 (Updated in 2001)
- Guidance for Implementation of Federal Wildland Fire Management Policy, February 2009
- Federal Land Assistance, Management and Enhancement (FLAME) Act of 2009
- FSM 5100

Air Quality

- Clean Air Act (CAA), as amended 1977 and 1990
- 40 CFR 51 300-308 Federal Regional Haze Rule
- National Ambient Air Quality Standards (NAAQS)

Terrestrial Wildlife and Plants

- Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), as amended
- Bald and Golden Eagle Protection Act of 1940, as amended
- Migratory Bird Treaty Act of 1918 (as amended)
- Executive Order 13186 (migratory birds)
- FSM and FSH, Chapters 2620 and 2670
- FSM Chapter 2070, Regional Native Plant Policies

Aquatic Species and Habitat

- Endangered Species Act of 1973
- Clean Water Act of 1948 (as amended in 1972 (Federal Water Pollution Control Act) and 1987)
- FSM 2600 re: fish and wildlife management
- FSH 2600 re: fish and wildlife management
- Executive Order 12898 Environmental Justice, February 11, 1994
- Executive Order 13112 Invasive Species, February 3, 1999

Noxious or Invasive Weeds

- Environmental Justice, EO 12898 of February 11, 1994
- Invasive Species, EO 13112 of February 3, 1999 and amendment EO 13751 of December 2016, Safe guarding the Nation from the Impacts of Invasive Species.
- FSM 2370 (Special Recreation Designations), Part 2672 (Areas Designated Administratively) (RNAs and Botanical Areas) and Forest Service Manual, FSM 2372, 2372. 01, 2372. 02 and 2372. 05
- FSM 2620, 2630, 2670, 2672 re: sensitive species
- FSMs 2900 and 2150 and Regional Supplement No. 2100-98-1, re: noxious weed control
- FSMs 2080 and 2150 and Regional Supplement No. 2100-98-1 re: noxious weed management

Heritage Resources/Tribal Interests

- National Historic Preservation Act of 1966 (NHPA), as amended (16 U.S.C. 470), and its implementing regulation 36 CFR 800
- Indian Financing Act of 1974
- Cooperative Funds and Deposits Act of 1975
- Forest and Rangeland Renewable Resources Research Act of 1978
- Archaeological Resources Protection Act of 1979 (ARPA), as amended (16 U.S.C. 47Oaa et seq.), as implemented by 36 CFR part 296

- American Indian Religious Freedom Act (AIRFA)
- Federal Technology Transfer Act of 1986
- Native American Graves Protection and Repatriation Act of 1990 (NAGPRA), as amended (25 U.S.C. 3001), as implemented by 43 CFR Part 10, Subpart B—Human Remains, Funerary Objects, Sacred Objects, or Objects of Cultural Patrimony From Federal or Tribal Lands
- Department of Interior, Environment, and Related Agencies Appropriations Act of 1992
- The Religious Freedom Restoration Act of 1993 (RFRA)
- Tribal Forest Protection Act of 2004 (TFPA)
- Culture and Heritage Cooperative Authority of 2008 (CHCA)
- Wyden Amendment (Public Law 109-54, Section 434)
- Executive Orders 11593 (Protection of the Cultural Environment), 13007 (Indian Sacred Sites), 13175 (Tribal Consultations), and 13287 (Preserve America).
- Programmatic Agreement (PA) between the Southwestern Region of the Forest Service; the Arizona, New Mexico, Texas, and Oklahoma State Historic Preservation Offices; and the Advisory Council on Historic Preservation (USDA 2003)
- FSM 2300, Chapter 2360, Heritage Program Management

▪ Recreation and Scenery

- National Forest Roads and Trails Act of 1964
- Wilderness Act of 1964
- Wild and Scenic Rivers Act of 1968
- National Trails System Act of 1968 (16 USC 1241)
- Environmental Quality Act of 1970
- The Forest and Rangeland Renewable Resources Planning Act of 1974
- Federal Cave Resources Protection Act of 1988 (16 U.S.C. 4301–4309)
- FSH 1909.13.13a, Chapter 10 re: the Scenery Management System (SMS)
- FSH 1909.13.2.3; FSM 2380.61 re: landscape aesthetics guidance
- FSM 2310 re: use of Recreation Opportunity Spectrum
- FSM 2350 re: trail, river, and similar recreation opportunities
- FSM 2370 re: special recreation designations
- FSM 2380 re: managing landscape aesthetics and scenery

▪ Socioeconomics

- Civil Rights Act of 1964
- Environmental Justice, EO 12898 of February 11, 1994

▪ Lands and Minerals

- Act of 1866, General Mining Law
- An Act to Repeal Timber-Culture Laws, 1891
- Occupancy Permits Act (March 4, 1915)

- The Act of March 4, 1915, as amended July 28, 1956, (16 U.S.C. 497) authorizes term permits for structures or facilities on National Forest System land
- Bankhead-Jones Farm Tenant Act of 1937, Section 31-33
- Highway Act of August 27, 1958, (23 U.S.C. 317), supplemented by the Act of October 15, 1966 (49 U.S.C. 1651)
- Land and Water Conservation Fund Act of September 3, 1964
- National Forest Roads & Trails Act 1964
- Telecommunications Act of 1996 (Public Law 104-104)
- The Act of November 16, 1973, (30 U.S.C. 185) authorizes the Forest Service to issue authorizations for oil and gas pipelines and related facilities
- Mineral Leasing Act of 1920, as amended on November 16, 1973, (30 U.S.C. 185(1))
- Oil and Gas Pipeline amendment to the Mineral Leasing Act, Section 28
- Term Permit Act of March 4, 1915, amended July 28, 1956
- Federal Land Policy and Management Act of 1976
- National Forest Townsite Act of July 31, 1958 (72 Stat. 483; 7 U.S.C. 1012a; 16 U.S.C. 478a) as amended by Section 213 of the Federal Land Policy and Management Act of 1976 (90 Stat. 2760)
- Alaska National Interest Lands Conservation Act, 1980
- Small Tracts Act of January 12, 1983 (96 Stat. 2535; 16 U.S.C. 521c-i)
- Water Conveyance Act of 1986
- Colorado Ditch Act of 1986 (FLPMA amendment)
- Telecommunications Act of 1996 (Public Law 104-104)
- Forest Service Facilities Realignment Act of 2005 (119 Stat 559-563; 16 U.S.C. 580d, as amended).
- Energy Policy Act of 2005
- Executive Order 11990 (Wetlands) and Executive Order 11988 (Floodplains)
- Forest Service Handbook 2709.11 Special Uses Management
- Forest Service Manual 2700 Special Uses Management

▪ Range

- Forest and Rangeland Renewable Resources Planning Act of 1974
- Federal Land Policy and Management Act of 1976
- National Forest Management Act of 1976
- 36 CFR 222: Subpart A – Graving and Livestock Use on the National Forest System, Subpart B – Management of Wild Free-roaming Horses and Burros, and Subpart C – Grazing Fees
- Forest Service Manual (FSM) 2200 – Range Management
- Forest Service Handbook (FSH) 2209.13 – Grazing Permit Administration Handbook

Transportation

- National Forest Roads and Trails Act of October 13, 1964, as amended (16 U.S.C. 532-538)
- Highway Safety Act of 1966 (23 U.S.C. 402)
- Organic Administration Act of 1897 (16 U.S.C. 551)
- Revegetation – Forest and Rangeland Renewable Resources Planning Act of 1974 (16 U.S.C. 1601, Pub. L. 93-378) as amended by the national Forest Management Act of 1976 (16 U.S.C. 1608, Pub. L. 94-588).
- Title 36, Code of Federal Regulations, Part 212 (36 CFR 212) re: administration of the forest transportation system
- Travel Management (36 CFR Part 212, Subpart A)
- Prohibitions (36 CFR Part 261, Subpart A) re: prohibitions on forest transportation system roads
- Sale and Disposal of National Forest System Timber (36 CFR Part 223 Subpart B) re: revegetation of temporary roads
- Forest Service Manual (FSM) 7700- Transportation System

Assumptions and Methodology

To facilitate landscape analysis and strategic planning in the Southwest, the Forest Service has developed a framework of ecosystem types referred to as Ecological Response Units (ERUs). In the Southwestern Region of the Forest Service, these ERUs provide the foundational unit for analysis of vegetative attributes and associated ecosystem services at the landscape and strategic planning scales (USDAFS 2017). Reference conditions and desired conditions are described for each ERU. The desired conditions correspond with the final regional vegetation desired conditions that are carried forward in forest plans revised after this framework was developed. Of the three forest plans tiered to in the Rim Country EIS, only the 2018 Coconino Revised Forest Plan uses ERUs. The 2015 Apache-Sitgreaves Revised Forest Plan used Potential Natural Vegetation Types (PNVTs) in its analysis, and the 1996 amended Tonto Forest Plan incorporated the earlier Terrestrial Ecological Unit Inventory (TEUI).

The forest cover types used for the Rim Country analysis are based on the Ecological Response Units (ERUs) identified in the project area. Each resource area that uses a different forest type classification for analysis includes a crosswalk with ERUs such as in Table 17.

Table 17. Acres by ERUs, Existing Forest Type, Soil Strata Veg Type

Ecological Response Units	Acres	Existing Forest Type	Acres	Soil Strata Veg Type	Acres
Ponderosa Pine Forest	534,667	Ponderosa Pine	523,267	Ponderosa Pine	534,887
Ponderosa Pine – Evergreen Oak	145,354	Ponderosa Pine/Evergreen Oak	148,810	Ponderosa Pine-Evergreen Oak	137,787
				Ponderosa Pine and Wet Mixed Conifer Forest on Steep Slopes	71,373
Mixed Conifer - Frequent Fire	88,577	Mixed Conifer/Frequent Fire	49,760	Dry Mixed Conifer Forest	16,282
Mixed Conifer w/ Aspen	37,498	Mixed Conifer with Aspen	2,562	Dry Mixed Conifer-Ponderosa Pine Transitional Forest	15,544
				Wet Mixed Conifer Forest	25,876
Pinyon-Juniper	72,899	Pinyon-Juniper	122,044	Pinyon-Juniper	100,194
Madrean Pinyon-Oak Woodland	3,551	Madrean Pinyon-Oak	23,535		
Gambel Oak Shrubland	0	Gambel Oak Shrub	30,748		
Riparian Types	12,141	Cottonwood Group	2,161	Riparian Wet Meadows	623
				Streamside Riparian Areas	8,240
Colorado Plateau / Great Basin Grassland	8,250			Great Basin Grasslands	24,158
Montane / Subalpine Grassland	15,180			Montane Meadows	3,231
Herbaceous (wetland)	2,318				
Historic Riparian - Residential/Urban	76				
Interior Chaparral	2,542				
Madrean Encinal Woodland	16,281	Aspen	1,453		
Water	225	(blank)	35,583		1,637
Total	**939,560**		**939,924**		**939,833**

Each resource specialist determined what ecological units and subunits would be best to use for their effects analysis. Most specialists use watersheds as their landscape-scale analysis units, while the finer-scale analysis units differ by resource area. The analysis units used for each resource area are described in the Assumptions and Methodology section of each specialist report and summarized here for each individual resource area. Due to differences in specialists' approaches to rounding when displaying numerical data, sums of table columns may differ slightly from the totals displayed.

Effects Analysis

The Rim Country DEIS includes analysis of the potential direct, indirect, and cumulative effects from treating the number of acres proposed for each specific treatment toward its highest level of openness for that treatment (e.g., IT, SI, and UEA 10-25 at 25 percent; IT, SI, and UEA 55-70 at 70 percent). This level of examination is done to ensure that the maximum potential effects from the activities proposed in each action alternative are analyzed, even though it will give the appearance of more effects than expected. A stand treatment adjusted to a lower intensity during implementation, per the flexible toolbox approach used for this project, may have fewer effects on the environment, depending on the affected resource, than the more open treatments originally proposed for that stand, resulting in slightly different effects than those analyzed in the DEIS.

Cumulative Effects

A summary of past, present, and reasonably foreseeable projects with management activities proposed and completed (see Table 18), as well as past wildfires (see Table 19), in the Rim Country project area and in the 6th HUC watersheds is presented here. This summary is intended to provide a snapshot of those projects and events that have influenced the existing conditions of the project area (in terms of vegetation structure, composition, diversity and function). It also includes a summary of ongoing and reasonably foreseeable projects that may cumulatively affect project area resources. This summary represents the best available information made available to each resource specialist to determine relevancy to their specific resource. Each resource specialist identified the cumulative effects analysis boundary and past, present and reasonable foreseeable projects relevant to their specific resource and used this information, along with the potential direct and indirect effects, to analyze the cumulative effects on their resource area. Cumulative effects analyses are discussed in this chapter by resource area.

Table 18. Past, Current, and Reasonably Foreseeable Projects

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other[1]	Forest	Past	Current	Reasonably Foreseeable
Vegetation Management Projects (Mechanical Thinning and Prescribed Fire)								
Mullen Saw timber and Whitcom Multiproduct Offerings	1990	Group selection, intermediate thin, pre-commercial thin, shelterwood seed cut	Mullen: 1,798/0/0 Whitcom: 1,440/0/0	0 /130/685 wildlife habitat improvement	Apache-Sitgreaves	X		
Jersey Horse Timber Sale	1991	Species habitat improvements, timber sales, forest vegetation improvements, fuel treatments	N/A	1,452/351/0	Apache-Sitgreaves	X		
Amended Elk Timber Sale	1993	Commercial and pre-commercial mechanical thinning	2,589/0/0	834/466/0	Apache-Sitgreaves	X		
Brookbank Multi-Product Timber Sale	1994	Mechanical thinning and prescribed fire	6,177/6,465/0	5,624/4,981/0	Apache-Sitgreaves	X		

1 Acres of implementation may be counted more than once for multiple activities on the same acres.

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Cottonwood Wash Ecosystem Management Area	1995	Mechanical thinning, fuelwood sales, prescribed fire	3,493/10,896/0	516/2,447/0	Apache-Sitgreaves	X		
Blue Ridge-Morgan	1997	Commercial mechanical thinning, fuelwood sales, broadcast burning	8,280/7,618/0	14,471/14,552/0	Apache-Sitgreaves	X		
Gentry	1997	Thinning, fire	7,718	451/191/ 0	Apache-Sitgreaves	X		
Sundown Ecosystem Management Area	1997	Salvage cut intermediate treatment, regen, fire	7,607	2,075/24/170 range vegetation control, 1,830 range veg manipulation and type conversion, 3,463 tree encroachment control, 1,560 tree release and weed	Apache-Sitgreaves	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Wiggins Analysis Area	1998	Group selection, intermediate thinning, pre-commercial thinning, broadcast burning	5,935/3,385	0/4,224/0	Apache-Sitgreaves	X		
Show Low South (#22297)	1999	Prescribed fire, construction/ maintenance of defensible space	N/A	0/2,696/0	Apache-Sitgreaves	X		
Larson Rx Burn	2001	Prescribed fire	0/2,500/0	0/3,015/0	Apache-Sitgreaves	X		
Treatment of Dead Trees in the Rodeo-Chediski Fire (#20740)	2002	Treat dead trees for trail management, facility and road maintenance, utility line safety	N/A	5,730/1,880/15 fuels compaction	Apache-Sitgreaves	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Heber-Overgaard WUI	2003	Mechanical thinning, prescribed fire	3,593/489/0	5,089/686/571 fuels chipping, 541 range forage improvement, 96 special products removal	Apache-Sitgreaves	X		
Hidden Lake Rx Burn	2003	Prescribed fire	0/2,000/0	0/2,828/0	Apache-Sitgreaves	X		
Camp Tatiyee / Camp Grace Fuel Reduction	2004	Pile Burning	340/340/0	0/172/0	Apache-Sitgreaves	X		
Country Club Escape Route	2004	Commercial thinning, fire	0/975/0	524/1,848 burning/915 range cover manipulation	Apache-Sitgreaves	X		
High Value Ponderosa Pine Tree Protection	2004	Mechanical thinning, insecticide treatment	698/0/698	985/826/203 insect control and prevention	Apache-Sitgreaves	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Rodeo-Chediski Fire Salvage	2004	Mechanical thinning, fuel treatments	47,467/0/0	25,913/ 626/1,256 fuel breaks, 411 planting/ regeneration site prep	Apache-Sitgreaves	X		
Forest Lakes WUI Treatment	2005	Mechanical thinning, hand thinning, piling, pile burning	N/A	1,691/1,645/0	Apache-Sitgreaves	X		
Rim Top Rx Burn (formerly Woods Canyon Fuel Treatment)	2005	Prescribed fire	0/665/0	0/665/0	Apache-Sitgreaves	X		
Show Low South (#4456)	2005	Thinning, fuels treatments	N/A	10/585/0	Apache-Sitgreaves	X		
Dye Thinning	2006	Mechanical thinning	250/250/0	247/0/0	Apache-Sitgreaves	X		
Hilltop WUI	2006	Mechanical thinning, mastication, prescribed fire	1,544/1,544/0	1,534/45/616 range forage improvement	Apache-Sitgreaves	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Bruno Thinning and Slash	2009	Hand thinning, piling, pile burning	0/86/0	0/70/0	Apache-Sitgreaves	X		
Whitcom WUI	2009	Commercial thinning, fire	0	925/0/0	Apache-Sitgreaves	X		
Hilltop II Fuels Reduction	2011	Mechanical thinning, prescribed fire	190/1,544/0	0/799/616 cultural site protection	Apache-Sitgreaves	X		
Rodeo-Chediski Site Prep for Reforestation (#48660)	2016	Mastication, prep for planting	200/0/0	?	Apache-Sitgreaves	X		
Little Springs WUI	2003	Group selection, improvement cut, commercial thin	7,991/0/0	4,376/4,227/ 2,500 range cover manipulation	Apache-Sitgreaves		X	
Nagel	2005	Commercial thin, salvage cut, fire	116,618	19,611/18,231/ 889 range cover manipulation, 1,592 range forage improvement, 321 scarify and seed landings	Apache-Sitgreaves		X	

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Los Burros	2006	WUI thinning, hazardous fuels treatments, woodland stand thinning, thin from below, aspen regeneration treatments	22,224/3,560/0	30,237/13,059/ 29 range cover manipulation	Apache-Sitgreaves		X	
Nutrioso WUI	2006	Commercial thin, salvage cut, fire	28,576/39,356/0	19,476/9,870/ 827 tree planting, 394 control range vegetation, 33 control tree encroachment	Apache-Sitgreaves		X	
Show Low South (#29987)	2011	Commercial thin, group selection, fire	3,739/4,637/0	3,372/0/0	Apache-Sitgreaves		X	
Rodeo-Chediski Fire Rx Burn	2012	Fire, pruning, limbing	0/148,222/0	0/9,506/9,670 range cover manipulation, 5,162 weed & tree release	Apache-Sitgreaves		X	

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Timber Mesa/Vernon WUI	2012	Single tree and group selection, commercial thinning, fire	27,000/as needed/0	18,781/39,760/ 9,911 range cover manipulation, 3,979 control tree encroachment, 6,551 weed & tree release	Apache-Sitgreaves		X	
Rim Lakes Forest Restoration	2013	Selection cut, broadcast burn	23,671/32,954/0	12,483/1,335/ 116 pruning, 6,251 range cover manipulation, 80 weed & tree release	Apache-Sitgreaves		X	
Larson Forest Restoration	2015	Group selection, intermediate thinning, pre-commercial thin, shelterwood seed cut, broadcast burn	25,726/4,906/0	1,867/0/2,513 range cover manipulation, 3 weed & tree release	Apache-Sitgreaves		X	

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Upper Rocky Arroyo Restoration	2016	Mechanical thinning, hand thinning, fire	30,400/as needed/0	696/5,411/ 3,960 wildlife habitat improvement	Apache-Sitgreaves		X	
Section 31 Fuels Reduction	2017	Mechanical thinning	230/0/0	44/0/0	Apache-Sitgreaves		X	
Rodeo-Chediski Mastication (Heber-Overgaard and Ricochet/ Williams Ranch Fuels Reduction)	2018	Mastication, removal of small trees, piling & burning	285/285/0	0/0/0	Apache-Sitgreaves			X
Pocket Baker	2000	Mechanical treatment, prescribed fire	5,200/17,000/0	0/5,450/0	Coconino	X		
Blue Ridge Urban Interface	2001	Pre-commercial thinning, prescribed fire	8,158/10,549/0	416/6,225/ 2325 control range vegetation	Coconino	X		
IMAX	2002		N/A	0/6,008/0	Coconino	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Pack Rat Salvage	2004	Salvage, thinning, pile burning	550/550/0		Coconino	X		
Bald Mesa Fuels Reduction	2005	Mechanical treatment, prescribed fire, fuels reduction	N/A	2,485/5,150/0	Coconino	X		
APS Blue Ridge 69kV Transmission Line	2005	Mechanical treatment, prescribed fire	N/A	0/1,600/0	Coconino	X		
Good/Tule	2006	Thinning, prescribed fire	4,337/8,361/0	1,389/2,025/0	Coconino	X		
Post-Tornado Resource Protection and Recovery	2011	Removing downed wood, thinning	14,776/3,990/0	765/0/0	Coconino	X		
Lake Mary Road ROW Clearing (ADOT)	2016		N/A	788/0/0	Coconino	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Lake Mary Meadows Two Fuel Reduction	2005		N/A	117/10,223/ 803 control range vegetation	Coconino		X	
East Clear Creek Watershed Health Improvement	2006	Mechanical treatment, prescribed fire	10,407/10,497/0	40,020/38,470/ 30,000 weed & tree release, 10,000 control tree encroachment	Coconino		X	
Victorine 10K Area Analysis	2006	Mechanical thinning, prescribed fire	1,293/8,407/0	9,015/29,585/0	Coconino		X	
Upper Beaver Creek Watershed Fuel Reduction	2010	Mechanical thinning, prescribed fire	15,807/75,068/0	20,608/64,000/0	Coconino		X	
Blue Ridge Community Fire Risk Reduction	2012	Mechanical, pile burning	50-75/5/0	0/45,000/0	Coconino		X	
Clints Well Forest Restoration	2013	Mechanical thinning, prescribed fire	12,899/16,444/ 25 rock pit expansion	11/6,639/0	Coconino		X	

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Hutch Mountain Communication Site	2017	Clearing for communication site and solar array, thinning	2.5/0/0	0.5/0/0	Coconino		X	
Cragin WPP	2018	Mechanical thinning, prescribed fire	41,046/63,656/0	0/0/0	Coconino			X
Ridge Analysis Area	1994	Commercial thinning, salvage, vegetation improvements, hazardous fuels reduction	N/A	33,311/0/1,094 control range vegetation	Tonto	X		
Lion Analysis Area	2001	Intermediate thinning, prep cutting, uneven-aged management, wildlife forage areas, prescribed burning	2,455/9,000-10,000/0	5,664/6,900/ 664 weed & tree release	Tonto	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Verde WUI	2004	Thinning, PJ savanna restoration, fuel break construction, prescribed burning	15,471/28,438/1,401 PJ savanna restoration	10,648/48,500/ 5,000 range cover manipulation	Tonto	X		
Parallel Prescribed Burn	2014	Prescribed fire	0/24,089/0	0/4,759/0	Tonto	X		
Pine-Strawberry WUI	2006	Thinning, grassland restoration, fuel break construction, prescribed fire	9,709/40,928/ 7,525 grassland restoration	41,086/19,868/ 200 range cover manipulation	Tonto		X	
Chamberlain Analysis Area	2008	Mechanical thinning, prescribed burning, shaded fuel breaks	8,072/20,050/0	9,044/19,000/ 1,675 control range vegetation	Tonto		X	

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Christopher/Hunter WUI	2009	Thinning, fuel break construction, prescribed burning	32,358/20,550/0	10,763/19,000/ 450 weed & tree release, 489 control range vegetation	Tonto		X	
Cherry Prescribed Burn	2012	Prescribed burning	0/14,700 – 21,000/0	0/6,582/0	Tonto		X	
Myrtle WUI	2012	Fuel breaks, thinning, prescribed fire	16,702/27,131/0	103,891/75,800/1,091 weed & tree release, 744 control range vegetation	Tonto		X	
Flying V&H Prescribed Fire	Decision expected 2018	Prescribed burning, shaded fuel breaks	1,798/59,124/0	0/0/0	Tonto			X
Haigler Fuels Analysis	?	Prescribed burning, shaded fuel breaks	43,435/43,435/0	0/0/0	Tonto			X
Right-of-Way (ROW) Projects with Herbicide Use								
Management of Noxious Weeds and Hazardous	2004	Herbicide treatment of noxious weeds	N/A	25/0/	Tonto	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Vegetation on State Highway ROWs		and hazardous vegetation		11,005 pesticide control of noxious or invasive weeds and hazardous vegetation				
APS-Herbicide Use within Authorized Power Line ROWs on NFS Lands in AZ	Decision expected 2019	Herbicide treatment	0/0/ 2,136 herbicide application	0/0/0	Apache-Sitgreaves Coconino Tonto			X
WAPA Glen Canyon-Rogers 230/345kV Integrated Vegetation Management	Decision expected 2019	Hazard tree removal, herbicide treatment, road repair	13,338/0/0	0/0/0	Coconino Tonto			X
SRP-Herbicide Use within Authorized Power Line ROWs on NFS Lands in AZ	Decision expected 2018 or 2019	Herbicide treatment	0/0/ 7,469 herbicide application	0/0/0	Apache-SitgreavesT onto			X

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Wildlife Habitat Improvement, Grassland Restoration Projects/Allotment Projects								
Park Day Allotment	1994	Mechanical and hand thinning, fuelwood sales, broadcast burning	14,665/250/0	2,193/0/ 701 control range vegetation	Apache-Sitgreaves	X		
Clear Creek Allotment	2000	Species habitat improvement, rangeland vegetation improvement	108	2,397/0/ 949 control tree encroachment, 2,288 range cover manipulation	Apache-Sitgreaves	X		
Wallace Allotment	Unknown			0/0/ 1,586 control tree encroachment, 161 control understory vegetation	Apache-Sitgreaves	X		
Railroad Allotment (Formerly Carlisle Complex Vegetation Treatments)	2007	Mechanical juniper removal	10,000/0/0	2,873/0/ 561 control tree encroachment	Apache-Sitgreaves		X	

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Heber Allotment	?	Mechanical thinning, prescribed fire	0/0/ 39,000 grassland restoration	0/0/0	Apache-Sitgreaves			X
Apache Maid Grassland Restoration	2004			54,528/6,770/0	Coconino	X		
Bar T Bar/Anderson Springs Allotment	2005	Meadow, grassland, wildlife corridor restoration treatment; prescribed fire	32,677/32,677/0	1,304/132,938/ 1,519 control range vegetation, 39,180 control tree encroachment, 652 wildlife habitat improvement	Coconino		X	
Flying V and Flying H Allotment		Juniper removal, seeding native grass, fence construction	10,875/0/ 112 fence construction	0/0/0	Tonto			X
Hardscrabble Allotment Juniper Clearing	?	Cut juniper trees	100/0/0	0/0/0	Tonto			X

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
New Delph Tank & Bear Tank Maintenance		Construct earthen stock tank, maintain existing tank	0/0/ 0.15 acres dredging and berm construction	0/0/0	Tonto			X
Pleasant Valley Northwest Grazing Allotments		Fence construction, juniper removal	N/A	0/0/0	Tonto			X
Red Lake Tanks		Tank construction, shrub removal	0/0/0.8 acres dredging, berm construction, ditch excavation	0/0/0	Tonto			X
Reforestation/Planting Projects								
Bison Reforestation	2003	Site prep, planting	0/0/500	356/312/ 308 tree planting, 275 animal damage control	Apache-Sitgreaves	X		
Clay Springs Reforestation	2004	Site prep, planting	0/0/710	0/0/ 169 tree planting, 169 animal damage control	Apache-Sitgreaves	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Jacques Marsh Elk Proof Fence & Riparian Planting	2006	Exclosure, planting	0/0/10	0/73/0	Apache-Sitgreaves	X		
Pierce Reforestation	2009	Site prep, planting	0/0/1,375	0/0/ 203 tree planting, 203 animal damage control	Apache-Sitgreaves	X		
Rodeo-Chediski Riparian Planting	2010	Planting	0/0/ 1 tree planting	0/0/ 0.6 tree planting	Apache-Sitgreaves	X		
Rodeo-Chediski Reforestation (#18675)	2007	Planting, shade installation, fencing	0/0/3,071	0/150/ 551 tree planting, 303 animal damage control, 202 weed & tree release	Apache-Sitgreaves		X	
AGFD Fairchild Draw Elk Exclosure	2018	Maintain fence	0/0/ 16 fence maintenance	0/0/0	Apache-Sitgreaves			X

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Conifer Weeding for Aspen Enclosure	Unknown	N/A	N/A	65/0/0	Coconino	X		
Spring and Meadow Restoration Projects								
Bill Dick, Foster, and Jones Springs Enhancement	2013	Pond and trough installation, fence installation and maintenance, willow pole planting	0/0/9.3	Unknown	Coconino	X		
Long Valley Work Center Meadow Restoration	2018	Channel reconstruction, tree removal, pond removal, install erosion control matting		0/0/ 16 tree encroachment control	Coconino		X	
Mogollon Rim Spring Restoration Project	2018	Invasive weed removal, planting, install fencing, tree thinning	Unk/Unk/ 5 spring restoration		Coconino			X
Other Projects								

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
ASNF - No NEPA docs found - various activities reported in FACTS but not tied to other named projects	Unknown	Tree planting and replanting, site prep, animal damage control, invasives control, control range vegetation, range cover manipulation, seeding and plating, tree encroachment control, weed & release, habitat improvement.	N/A	42,763/74,202/ 2,158 tree planting, 350 replant trees, 1,720 site prep, 59 animal damage control, 82 invasives control, 497 control range vegetation; 4,297 range cover manipulation, 438 seeding and planting, 5,563 control tree encroachment, 27 weed & tree release, 1,465 habitat improvement	Apache-Sitgreaves		X	
Four Springs Trail Realignment	Decision expected 2018	Trail reroute and rehabilitation	0/0/4.5 miles	0/0/0	Apache-Sitgreaves			X

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Heber-Overgaard Non-motorized Trail System		Creation of trail system		0/0/0	Apache-Sitgreaves			X
Navopache Electric Cooperative Trunk Line Addition		Add new trunk line		0/0/0	Apache-Sitgreaves			X
Grapevine Interconnect (Grapevine Canyon Wind Project)	2012	Installation of powerline and switchyard	24/0/0		Coconino	X		
APS Line Maintenance	Unknown			87/0/0	Coconino	X		

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
COF - No NEPA docs found - various activities reported in FACTS but not tied to other named projects	Unknown	N/A	N/A	16,049/15,175/ 15 biocontrol of invasives, 20 pesticide control of invasives, 3,921 control range vegetation, 739 weed & tree release	Coconino	X		
Sixteen Rock Pits and Additional Reclamation	2017	Expansion and reclamation of rock pits	66/0/ 66 excavation, 5 re-contouring, 5 planting	0/0/0	Coconino		X	
Glen Canyon-Pinnacle Peak 345kV Transmission Line Vegetation Management (WAPA)	2014	Mechanical vegetation removal	4,580/0/0		Coconino		X	

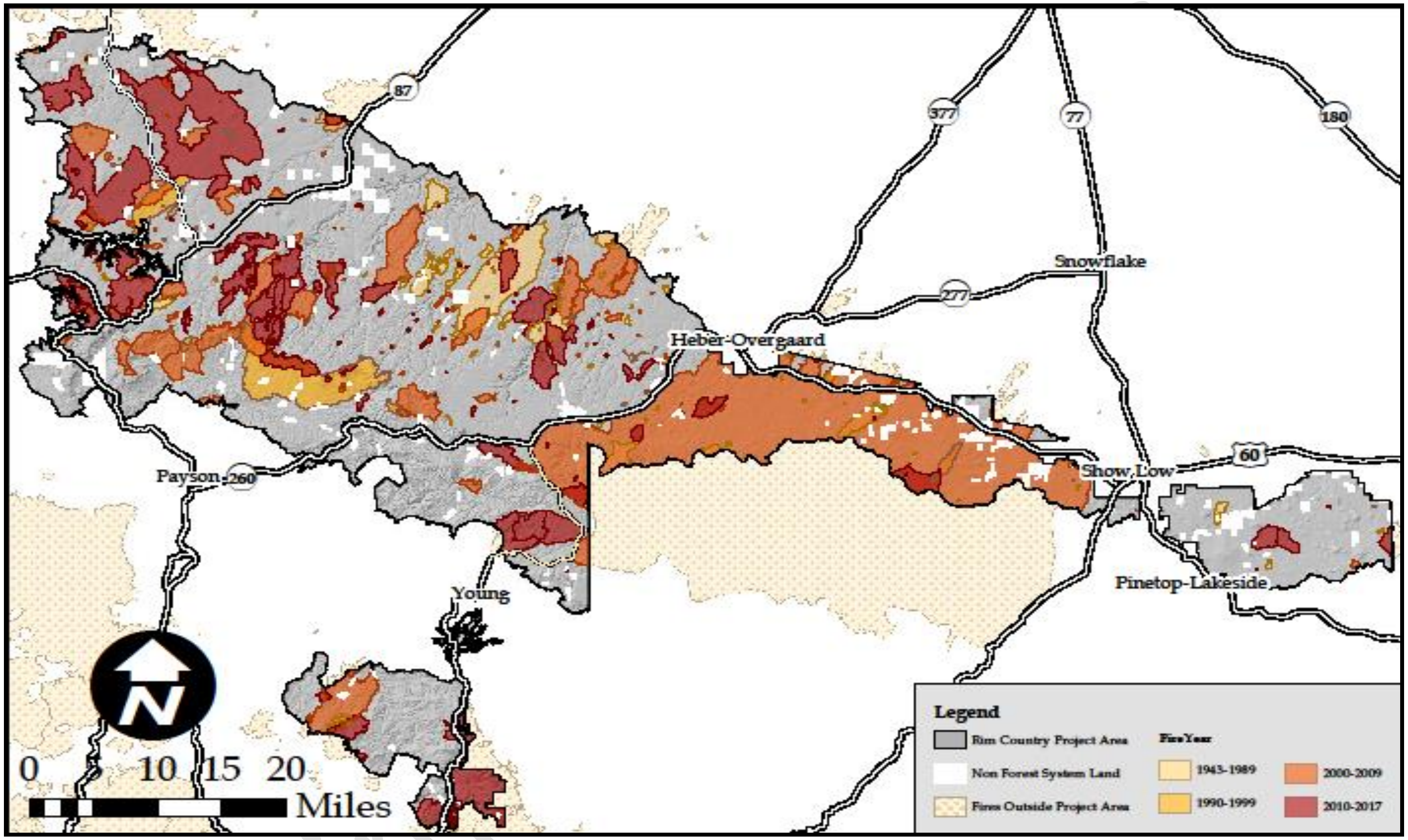
Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
TNF - No NEPA docs found - various activities reported in FACTS but not tied to other named projects	Unknown	N/A	N/A	15,565/26,386/ 260 tree planting, 198 tree re-planting, 4,018 pesticide control of invasives, 21,000 biocontrol of invasives, 6,890 range cover manipulation, 11,345 weed and tree release	Tonto	X		
Noxious Weed Treatment Projects	2005	Noxious weed treatment		61,015/1,008/ 2,021 pesticide control of invasives, 11 biocontrol of invasives	Tonto		X	

Project Name	NEPA Decision Year	Treatment Types	Acres Planned Mechanical/ Prescribed Fire/Other	Acres Implemented Mechanical/ Prescribed Fire /Other1	Forest	Past	Current	Reasonably Foreseeable
Cragin-Payson Water Pipeline and Treatment Plant	2012	Construct, operate, and maintain water transmission pipeline right-of-way	≤ 352/0/ ≤ 352 excavation, construction, and pipeline burial	0/0/0	Tonto			X

Table 19. Wildfire History

Year	Acres
1943-1989	40,994
1990-1999	37,369
2000-2009	262,531
2010-2017	168,583
Total	**509,477**

Figure 16. Wildfire history



○ Water and Riparian

The Water and Riparian Resource Report (Brown 2018) is incorporated by reference. See the specialist report for detailed information.

▪ Affected Environment

• *Water Quality*

Water quality of surface waters has been assessed on 113 miles of streams within the Tonto National Forest portion of the Rim Country project area, primarily within the Salt River and Verde River watersheds. Approximately 161 miles of surface waters have been assessed on the Apache-Sitgreaves and Coconino National Forest's portion of the project primarily within the Little Colorado watershed. In addition, 9 lakes totaling 739 acres were assessed within the Rim Country footprint. Table 20 identifies the water quality status of specific streams, rivers, and lakes that have been assessed by the Arizona Department of Environmental Quality (ADEQ,2016).

Table 20. ADEQ Listed Waterbodies

Water Body	Reach Name	Reach Number	Miles/ Acres Assessed	Assessed Category	Parameters with Exceedances*	Cause of Impairment	Impaired Uses**
Little Colorado River Watersheds							
Barbershop Canyon Creek	Headwaters - East Clear Creek	15020008-0537	14.1 miles	2	Biocriteria		None
Bear Canyon Lake		15020008-0130	59 acres	3	pH		
Billy Creek	Headwaters – Show Low Creek	15020005-019	3.6 miles	2	Dissolved Oxygen		None
Black Canyon Lake		15020010-0180	38 acres	5	Ammonia	High Ammonia	A&Wc
Chevelon Canyon (Downstream of Forest Boundary)	Black Canyon – Little Colorado River	14020010-001	23 miles	2	Dissolved Oxygen		None
Clear Creek (Downstream of Forest Boundary)	Sand Draw-Little Colorado	15020008-006	0.0 miles	3			None
East Clear Creek	Yeager Canyon – Willow Creek	15020008-008	17.4 miles	2	Biocriteria		None

Water Body	Reach Name	Reach Number	Miles/ Acres Assessed	Assessed Category	Parameters with Exceedances*	Cause of Impairment	Impaired Uses**
Knoll Lake		15020008-0750	59 acres	3	Lead		None
Show Low Creek	Headwaters – Linden Wash	15020005-12	4.3 miles	2	SSC, Biocriteria		None
Walnut Creek	Pine Lake – Billy Creek	15020005-238	0.2 miles	3	DO, pH, SSC		None
Willow Springs Lake		15020010-1670	160 acres	3	DO		None
Woods Canyon Creek	Headwaters – Chevelon Creek	15020010-084	10.7 miles	3	DO		None
Woods Canyon Lake		15020010-1700	70 acres	3	DO, Lead		None
Blue Ridge Reservoir		15020008-0200	290 acres	2	pH		None
Salt River Watersheds							
Canyon Creek	Headwaters - White Mtn Apache Reservation Boundary	15060103-014	7.1	2			None
Cherry Creek	Trib at 340509/110560 - Salt River	15060103-015B	0.5	2	E. coli, Lead, phosphorus		None
Workman Creek	Headwaters - Reynolds Creek	15060103-195A	4	2	Dissolved Oxygen		None
Reynolds Creek	Headwaters - Workman Creek	15060103-202	5.4	2	pH, selenium		None
Christopher Creek	Headwaters - Tonto Creek	15060105-353	8	4A/5		E. coli(4A), Dissolved Oxygen (2016)	A&Wc

Water Body	Reach Name	Reach Number	Miles/ Acres Assessed	Assessed Category	Parameters with Exceedances*	Cause of Impairment	Impaired Uses**
Tonto Creek (TON)	Headwaters - Trib at 341810/1110414	15060105-13A	8.0	4A		E coli (4A)	A&Wc
Tonto Creek (TON)	Trib at 341810/1110414 - Haigler Creek	15060105-013B	2	4A/5		Mercury in fish (EPA 2010) (5) E.coli (4A)	EPA FC[3]
Gordon Canyon Creek	Headwaters - Hog Canyon	15060105-336A	9.8	3	Insufficient data to assess		None
Haigler Creek	Headwaters - Trib at 341223/1110011	15060105-012A	15.3	2	Copper		None
Haigler Creek	Trib at 341223.1/1110011-Tonto Creek	15060105-012B	0.4	2	E. coli		None
Thompson Draw	Headwaters - Tonto Creek	15060105-378	6.6	3	E. coli		None
Trib to Thompson Draw	Headwaters - Thompson Draw	15060105-379	0.2	3	Insufficient data to assess		None
Big Canyon above Tonto Creek	Headwaters - Tonto Creek	15060105-373	4.4	3	Insufficient data to assess		None
Verde River Watersheds							
East Verde River	Headwaters - Ellison Creek	15060203-22A	7.8 miles	2	E. coli, biocriteria		None
Patton Spring Draw	Headwaters - Webber Creek	15060203-506	2.2 miles	3	Insufficient data to assess		None
Webber Creek	Headwaters - East Verde River	15060203-058	7.6 miles	2	E. coli		None

Water Body	Reach Name	Reach Number	Miles/ Acres Assessed	Assessed Category	Parameters with Exceedances*	Cause of Impairment	Impaired Uses**
Ellison Creek	Headwaters - East Verde River	15060203-459	9.2 miles	2	E. coli		None
Pine Creek	Headwaters – Pine Ck at 342150.85/1112648.56	15060203-049A	7.3 miles	1			None
Sycamore Creek (SYH)	Headwaters	15060203-055	2.8 miles	2	Arsenic DO		
Stoneman Lake		15060202-1490	125 acres	4A	pH		AGI, AGL, A&Wc, FBC

* Assessment Category: Category 1 assessed as "attaining all uses, Category 2 assessed as "attaining some uses", Category 3 assessed as "inconclusive", 4 A**.** **-** A Total Maximum Daily Load (TMDL) has already been completed and approved by EPA but the water quality standards are not yet attained, Category 5 - assessed as "impaired"
**Designated uses: FBC – Full Body Contact, AGI – Agriculture Irrigation, AGL – Agriculture Livestock Watering, A&Wc – Aquatic and Wildlife (cold water).

Within the Salt River and Verde River Basins, primarily on the Tonto National Forest, water quality is attaining all uses in 13.8 miles (12 percent), attaining some uses in 48 miles (42 percent), is inconclusive in 32.8 miles (29 percent) streams and is not attaining/impaired in 18.2 miles (16 percent) of assessed streams. Within the Little Colorado Basin, primarily on the Apache-Sitgreaves NFs and Coconino NFs, water quality is attaining some uses on 108 miles (67 percent) and inconclusive on 53.3 miles (33 percent) of assessed streams. In addition, nine lakes within the project area were assessed with two (totaling 149 acres) attaining some uses, four (totaling 387 acres) were inconclusive, one (111 acres) was not attaining some uses, and two (totaling 91 acres) were impaired.

The impaired lakes (Bear Canyon and Black Canyon) have a moderate priority for additional sampling that may indicate the need for initiating a total maximum daily load (TMDL) analysis to determine causative factors and to develop appropriate pollutant mitigation strategies. Some streams have had samples that exceed state water quality standards, however, most of the water bodies lack sufficient data to either remove or recommend impairment as there are state statutes dictating minimum data quality and quantity levels. The completion of a total maximum daily load assessment on impaired water bodies may result in developing additional water quality improvement strategies and mitigation of effects within associated watersheds.

The Upper Tonto Creek watershed includes stream reaches that are impaired for Nitrogen, Phosphorous, Low Dissolved Oxygen (D.O.), and E. coli. TMDL assessments were completed for Nitrogen and E. coli bacteria in 2006. Sources of contamination were identified as inadequate septic systems and recreational sources. ADEQ has approved Water Quality Improvement Grants (grants that allocate funds from the US EPA for implementing nonpoint source pollution control projects) for improving septic systems at R-Bar-C Boy Scout Camp (2007), Tonto Baptist Camp (2008), and to Gila County (2006). The Forest Service has constructed new bathrooms, restricted vehicle access to maintain a buffer for the creek, and converted portions of the area from overnight camping to day-use only. A TMDL for Phosphorous has not yet been scheduled and is identified as a low priority for development by ADEQ.

The Upper Tonto Creek watershed is identified as one of Arizona's Targeted Watersheds. These watersheds are a priority in the state for Clean Water Act (CWA) Section 319 Water Quality Improvement Grants and other strategies to restore and/or protect water quality conditions. Development of a TMDL for Low Dissolved Oxygen impairment in the Headwaters of Tonto Creek is identified as a low priority by ADEQ. (http://www.azdeq.gov/environ/water/assessment/download/Appendix_G_Priority_Ranking.pdf)

Implementation of site specific Best Management Practices (BMPs) have been shown to be effective in mitigating impacts to water quality, and the development, implementation and monitoring of BMPs are FS responsibility as described within the Memorandum of Understanding between the State of Arizona, Department of Environmental Quality and USFS Southwestern Region (USFS, 2013). The completion of a total maximum daily load assessment on impaired water bodies may result in developing additional water quality improvement strategies and mitigation of effects within associated watersheds.

- *Stream Courses*

Stream courses within the project area are generally low-gradient ephemeral and intermittent streams with dendritic drainage patterns, except in areas with very steep terrain such as mountains (i.e., extinct volcanoes) and cinder cones, which typically have radial drainage patterns with high-gradient ephemeral and intermittent drainages flowing in all directions from upper slopes. Approximately 4,047 miles of occur within the analysis area, of which approximately 385 (10.5 percent) miles exhibit perennial flow.

- *Riparian and Stream Condition*

In the Southwest, the Forest Service uses a system of ecosystem types, "ecological response units" (ERUs), to facilitate landscape analysis and strategic planning. ERUs have been built from plant associations and ecosystem units that have been identified through Terrestrial Ecological Unit Inventory (Wahlberg et. al. 2013). Within the project area, there are approximately 21,330 acres identified as riparian by the Region 3 ecological response unit ERU map (Treipke 2014a and b). Table 21 shows the percentages of each ERU within the project area. Of this total, the largest proportion consists of Narrowleaf Cottonwood/ Shrub with 35.6 percent, follow by Ponderosa Pine / Willow and Herbaceous (wetland) with 26.3 and 20.0 percent, respectively. Willow –Thinleaf Alder contributed 7.6 percent and each remaining unit comprised less than 5 percent of the total.

Table 21. Acres and Percent of Riparian ERUs

ERU	Acres	Proportion
Arizona Alder - Willow	228	1.1%
Arizona Walnut	68	0.3%
Fremont Cottonwood - Conifer	169	0.8%
Fremont Cottonwood / Shrub	539	2.5%
Herbaceous (wetland)	4270	20.0%
Historic Riparian - Residential/Urban	298	1.4%
Narrowleaf Cottonwood / Shrub	7584	35.6%
Ponderosa Pine / Willow	5607	26.3%
Sycamore - Fremont Cottonwood	946	4.4%
Willow - Thinleaf Alder	1617	7.6%
Total	**21,326**	**100%**

Riparian areas have distinctly different vegetative species composition, diversity, and abundance depending on the type of drainage segment in which they occur. The most robust riparian vegetation occurs in association with perennial and intermittent stream systems. However, some transitional ephemeral drainages do support isolated pockets of riparian woody vegetation because of the presence of shallow subsurface water. The following is a description of the occurrence and characteristics of riparian vegetation associated with the three stream types within the project area:

Ephemeral Drainages: in steeper, headwater reaches of drainages these drainages function solely to collect and transmit water off the uplands, hence, they contain primarily vegetation of the same species and stature as the upland vegetation. As moisture runs off before any substantial amount can be stored, there is no immediate beneficial effect to vegetation. In ephemeral reaches with lower gradients and wider valley widths, where water slows and moisture is stored in deeper alluvial soils, upland vegetation takes advantage of the greater residence time of water to grow larger and denser than what grows in the uplands or in ephemeral reaches. Tree species such as oaks grow to large trunk diameters with impressive spreading crowns while shrubby species easily attain twice the height found on adjacent uplands. Although vegetation is typically not obligate riparian in these reaches, some pockets of riparian woody vegetation do occur were shallow ground water is available for roots to tap into.

Riparian-Intermittent Drainages: found where obligate riparian species occur intermittently along the reach due to sporadic presence of water from spring sources or from subsurface flows; also includes areas such as isolated springs. Presence of surface water is dependent upon subterranean bedrock configuration that allows water retention at relatively shallow depths or actual surfacing of low flows along intermittent sections of the stream course. The presence of a shallow water table allows obligate riparian species to sustain themselves during dry periods.

Riparian-Perennial Drainages: found where there is perennial surface and ground water and riparian-obligate vegetation is fairly continual along the reach. Generally, perennial reaches are located at the mouths of fairly sizable watersheds, which are required to supply sufficient and continual discharge to sustain surface flows throughout the year.

The three forests surveyed riparian condition using different assessment methods. Therefore, for necessity of this analysis all the forest data was cross-walked into a single protocol for display and reporting. The protocol selected is the Proper Functioning Condition (PFC) (Dichard et al. 2015). Proper functioning condition of perennial and intermittent streams includes the seventeen critical elements found in standard lotic PFC assessments, which encompasses hydrology, vegetation, and geomorphology. Reaches meeting PFC criteria are also in satisfactory riparian condition in terms of Forest Plan standards. Channel morphology (drainage configuration) is typically too variable in ephemeral reaches to allow applying any sort of standard or expectation.

Riparian condition was either documented or estimated on a total of 876 miles of intermittent and perennial streams since the late 1990's. A compilation of condition information across the three forest three forests within the project area is presented in table 22. A total of 257 miles (29 percent) were to be at PFC, with 475 miles (54 percent) at Functional at Risk and 145 miles (17 percent) rated nonfunctional.

The PFC summary data for the Tonto NF displays estimated riparian conditions developed during the Watershed Condition classification analysis completed in March 2011. Twenty four miles of riparian areas have been inventoried. The remaining stream channel condition classes were derived from gathering all existing riparian and stream information within each HUC12 watershed using the guidance found in the National Watershed Classification Technical Guide, Indicator #5 for Riparian/Wetland Vegetation Condition.

Table 22. PFC Assessment Summary

Subwatershed	6th Code	Miles of Surveyed Riparian		
		PFC	FAR	NF
Apache-Sitgreaves NF				
Alder Canyon	150200100106		16.4	3.7
Bagnal Draw-Show Low Creek	150200050107			2.5
Bear Canyon-Black Canyon	150200100203		6.3	
Billy Creek	150200050101	3.1	2.3	
Buckskin Wash	150200100202		2.9	
Cabin Draw	150200080308	2.5		
Dalton Tank-Cottonwood Wash	150200050305			0.1
Dodson Wash	150200050309			1.2
Durfee Draw-Chevelon Canyon	150200100110	7.8		
East Clear Creek-Clear Creek	150200080311	#	#	#
Echinique Draw-Clear Creek	150200080403	1.5		
Fools Hollow	150200050103		1.7	
Gentry Canyon	150200080305		12.7	12.4
Leonard Canyon	150200080307	#	#	#
Long Tom Canyon-Chevelon Canyon	150200100102	8.2	3.6	0.5
Lower Brookbank Canyon	150200100209			0.9
Lower Willow Creek	150200080310	11.1	2.2	
Mortensen Wash	150200050308	0.9	15.4	3.6
Ortega Draw	150200050201			
Porter Creek	150200050102	2.7	0.5	0.4
Pulcifer Creek	150200020401			
Sepulveda Creek	150200020403	2.2		
Stinson Wash	150200050301			

Subwatershed	6th Code	Miles of Surveyed Riparian		
		PFC	FAR	NF
Town Draw	150200050306			
Upper Brookbank Canyon	150200100205			12.0
Upper Brown Creek	150200050202		2.9	
Upper Chevelon Canyon-Chevelon Canyon Lake	150200100104	3.0	2.7	3.8
Upper Day Wash	150200050303			
Upper Phoenix Park Wash	150200080102	1.5	5.2	
Upper Pierce Wash	150200100204		6.9	
Upper Rocky Arroyo	150200050205		0.5	
Upper West Chevelon Canyon	150200100107			
Upper Wildcat Canyon	150200100103	13.3		
Upper Willow Creek	150200080306	0.3	21.8	4.2
West Fork Black Canyon	150200100201		1.0	
West Fork Cottonwood Wash-Cottonwood Wash	150200050302		4.0	4.8
Wilkins Canyon	150200080309		2.1	14.2
Woods Canyon and Willow Springs Canyon	150200100101	2.3	1.4	2.9
Windsor Valley	150200020406			
A-S Total		60.2	112.8	67.3
Coconino NF				
Miller Canyon	150200080301			
Bear Canyon	150200080302	17	6	5.2
East Clear Creek-Blue Ridge Reservoir	150200080303	4.8	10.9	8.8
Barbershop Canyon	150200080304	17.3	14.3	
Leonard Canyon	150200080307	34	2.9	6.1
East Clear Creek-Clear Creek	150200080311	40.7	1.3	1.1

Subwatershed	6th Code	Miles of Surveyed Riparian		
		PFC	FAR	NF
Echinique Draw-Clear Creek	150200080403	1.5		
Windmill Draw-Jacks Canyon	150200080501			
Tremaine Lake	150200080502			
Double Cabin Park-Jacks Canyon	150602020603	2.1	6.6	
Brady Canyon	150602020604		4.2	
Rattlesnake Canyon	150602020605			
Red Tank Draw	150602020610		3.4	
Upper Willow Valley	150602030101			
Long Valley Draw	150602030102			
Toms Creek	150602030103		1.4	1.9
Clover Creek	150602030104		0.5	
Lower Willow Valley	150602030105	2.4	1.2	
Webber Creek	150602030203			
Coconino Total		119.8	52.7	23.1
Tonto NF				
Canyon Creek Headwaters	150601030302		14.8	
Upper Canyon Creek	150601030304		1.2	
Gentry Canyon	150601030305		9.2	
Ellison Creek	150601030306		0.5	
Parallel Canyon-Cherry Creek	150601030401		17.4	
Crouch Creek	150601030403		1.4	
Gruwell Canyon-Cherry Creek	150601030404			16.4
Walnut Creek-Cherry Creek	150601030406			4.5
P B Creek-Cherry Creek	150601030407			3.5
Reynolds Creek	150601030801	9.4		

Subwatershed	6th Code	Miles of Surveyed Riparian		
		PFC	FAR	NF
Workman Creek	150601030802	13.1		
Upper Salome Creek	150601030803		28.0	
Buzzard Roost Canyon	150601050101		20.1	
Rock Creek	150601050102		11.2	
Upper Spring Creek	150601050103		11.3	
Middle Spring Creek	150601050105		1.1	
Marsh Creek	150601050201		5.0	
Gordon Canyon	150601050202		18.4	
Christopher Creek	150601050203		21.0	
Horton Creek-Tonto Creek	150601050204		23.9	
Haigler Creek	150601050205		31.9	
Bull Tank Canyon-Tonto Creek	150601050206			15.9
Green Valley Creek	150601050301		8.1	
Houston Creek	150601050304			0.8
Gun Creek	150601050401		8.7	
Greenback Creek	150601050408		1.2	
Ellison Creek	150602030201	54.2		
East Verde River Headwaters	150602030202		32.7	
Webber Creek	150602030203		26.4	
Upper East Verde River	150602030205		5.1	
Pine Creek	150602030206			13.2
Rock Creek	150602030208		.05	
Hardscrabble Creek	150602030306		10.6	
Tonto Total		**76.7**	**309.3**	**54.3**

Sources: Springs Institute, Apache-Sitgreaves NFs and Coconino NF Reference Spatial Databases Tonto NF Riparian Area survey was based on the Tonto Stream and Riparian

Inventory methodology. # See Coconino shared Riparian area. Note: PFC is Proper Functioning Condition, FAC is Functional-at-Risk, and NF is Nonfunctional.

The principle force behind the structure and function of riparian ecosystems is streamflow. Riparian systems are primarily initiated and maintained by erosion, transport, and deposition of sediments by flowing water. Streamflow characteristics in the southwest have been highly altered over the past century, affecting riparian conditions (Baker et al. 2004). Human effects such as legacy excessive grazing, channelization, fire suppression, flow diversions, stream impoundments, and flow diversions have disrupted overall water availability, induced streamflow variability, altered seasonal patterns, and modified the sediment regimes. Currently riparian systems are drier, with reduced extent, structure complexity, density, and diversity than they have been historically. Research predicts that as climate changes, water inputs are expected to decline due to reduced precipitation, consequently reducing water in riparian zones. Water losses are also likely to increase due to elevated evapotranspiration rates at higher temperatures and greater run-off losses associated with increased frequencies of high intensity convectional storms. Furthermore, lowered water availability will stress riparian plants and increase the ecosystem susceptibility to invasion by nonnative plants, such as salt cedar and Russian olive, which in turn will disrupt the natural wildlife community (USDA 2010).

Many of streams within the project area exhibit legacy effects from past land management, such as poor logging practices, poor road locations, and overgrazing, among others. The effects of these practices include entrenchment of stream channels, increased gradient, decreased sinuosity and subsequent decrease of the streams available floodplain. Superimposed on these conditions are the effects of recent (past 30 years) of uncharacteristic wildfires. Approximately 31 percent of the project area has experienced wildfire over the past 30 years. The Rodeo-Chediski wildfire burned through a large portion of the Rim Country analysis area. Other fires, such as the Dude wildfire in 1990, still may exhibit residual effects from the change in cover density and type. Effects to the riparian systems from these fires include but were not limited to burning of the vegetation overstory, increased peak flows, increased bank erosion and sediment transport and deposition. PFC assessments conducted in 2004, two years after the Rodeo-Chediski wildfire, recorded substantial post-fire effects including downcutting, eroded banks, and direct loss (burning) of riparian vegetation.

- *Wetlands and Springs*

There are approximately 1,000 natural lakes, reservoirs, and natural wetland depressions within the project boundary that impound water for a sufficient duration to exhibit some wetland characteristics and are therefore listed in the U.S. Fish and Wildlife Service National Wetlands Inventory database.

Approximately 360 springs have been inventoried by the Spring Stewardship Institute within the Rim Country Project analysis area. Of these 360 springs, 214 have survey information, 138 are unverified, and 8 were verified. Information regarding historic flow or water quality from these springs is minimal. Most springs within the project area are either rheocrene- meaning they flow directly from the ground resulting in a small stream, helocrene- they emerge from low gradient wetlands, or hillslope – they emerge from confined or unconfined aquifers on a hillslope (typically 30 to 60 degrees); often with indistinct or multiple sources.

Several springs within the project area are currently being assessed using the Spring Ecosystem Assessment Protocol (SEAP) (Stevens et al. 2011) with at least one objective being that to see document effects of thinning treatments, such as those proposed by landscape- level restoration efforts like the Rim Country Project, on spring discharge. Eighty springs have been assessed using the SEAP protocol within the Rim Country project boundary. All these assessed springs are located on the Coconino NF. Eight percent of the springs were identified to be at moderate or greater risk. Many springs within the project area have been adversely affected by human activities including flow regulation through installation of spring boxes and piping of discharge to off-site locations, recreational impacts, urbanization and other construction activities, and grazing by domestic livestock and wildlife herbivores.

- *Watersheds and Watershed Condition*

The Rim Country Project lies within 141 sixth-level, or 12-digit, hydrologic units (i.e., sub-watersheds), 28 10-digit (watersheds) and 11 eight-digit (sub-basins).

A watershed condition assessment was initially completed in 2011 for all sub-watersheds in the project area as part of an agency-level assessment of watershed conditions for each forest Watershed condition information is also included in the Soil and Watershed Specialist's Report. Some of the sub-watersheds have very limited areal extent within the project and will not be analyzed further in detail.

The result of the analysis of all watersheds in the project area indicate 20 (15 percent) were rated as Functioning Properly, 111 (83 percent) were rated as Functioning at Risk, and 2 (2 percent) were rated as Impaired. This information is presented in appendix B. Many of these conditions could be improved over time with implementation of an ecosystem restoration project such as the proposed action.

Across the project area, the following indicators have the most effect on the overall watershed score. Most of the functioning at risk and impaired watersheds have fair or poor ratings for these indicators.

1. Water quantity – accounts for changes to the magnitude, duration, or timing of the natural streamflow hydrograph. Watersheds with dams, diversions, major impoundments or significant retention structures, groundwater pumping that affects stream base flows, effluent discharge, poor range conditions, recent fires, or urbanized areas affected this rating.
2. Aquatic habitat – accounts for habitat fragmentation, large woody debris, and channel shape and function. This rating was affected by road crossings that serve as fish barriers, the condition of riparian vegetation along stream channels that controls recruitment of large woody debris and the condition of stream channels (data for approximately 170 stream channel reaches within the Rim Country project area on the Tonto NF exists to assess channel conditions).
3. Aquatic biota – accounts for distribution, structure, and density of native and introduced aquatic fauna. Most of the perennial streams on the Tonto NF support populations of non-native fish and invertebrate species (including crayfish and bullfrogs).
4. Riparian/Wetland vegetation – accounts for function and condition of riparian vegetation along streams, water bodies, and wetlands. Photo points, riparian surveys, and channel condition surveys were used to assess riparian conditions on the National Forest System lands.
5. Roads and trails – accounts for density, location, distribution and maintenance of the road and trail network. This indicator was influenced by low frequency of maintenance on

Level 2 roads (high clearance, native surface roads), location of roads in close proximity to stream channels, and to a lesser extent by road density.

6. Soil condition – accounts for soil productivity, erosion, and chemical contamination. The Region 3 Soil Condition Class Rating Guide (Reference) that rates soils as satisfactory, impaired of unsatisfactory was used for this indicator.

Watershed condition information can be found in the online Watershed Condition Class and Prioritization Map at: https://apps.fs.usda.gov/wcatt/

A substantial number of watershed have functioning at risk or impaired ratings based on other indicators, such as fire regime and rangeland vegetation, but these indicators only have a small effect on the overall watershed condition rating due to the low weight assigned to them in the assessment process.

Watersheds that are identified as Class II or III (Functioning-at-risk or Impaired rating) are a result of, in large part, overly dense forests with fire regime condition classes of 2 or 3 (moderately or highly departed from reference conditions), a high-density road network that can alter hydrology with many in close proximity to stream courses, a riparian condition rating (PFC) of Functioning-at-risk and Non-functioning condition, and lack of native fisheries or aquatic species in watersheds with perennial streams. Current conditions are dominated by overly dense forests that lead to high fuel loads with the potential of uncharacteristic wildfires. Uncharacteristic wildfires in many cases result in soils with high burn severities that pose risk to watershed function, soil productivity, and water quality following storm events. High burn severity results in water-repellent soils, loss of protective vegetative ground cover and, following storm events, accelerated erosion and sediment delivery to connected stream courses that may degrade water quality. Consequently, accelerated erosion and sediment delivery into connected stream courses leads to loss of soil productivity and watershed function.

The distribution of ratings for these indicators in the Rim Country project area are displayed in Table 23. Overall, ratings indicate that water quality was the highest of the three indicators, with 70 percent of watershed at a good rating. This is followed by 48 percent of the water quality ratings as Good. Riparian/Wetland condition was the lowest with most ratings at 'Fair' condition and a greater percentage of 'Poor' ratings than 'Good'. This suggests that the Riparian /Wetland indicator is most departed from desired conditions and is critical to address for restoration.

Table 23. Distribution of Ratings for Water Quality, Water Quantity, and Riparian/Wetland Condition Indicators within Rim Country

Indicator	Poor	Fair	Good
Riparian/Wetland Condition	27%	58%	15%
Water Quality Condition	6%	23%	70%
Water Quantity Condition	15%	37%	48%

Priority watersheds are the designated watersheds where restoration activities will concentrate on the explicit goal of maintaining or improving watershed condition with watershed condition framework process (USDA 2011).

The table below shows the four priority watersheds inside the Rim Country boundary. The two watersheds located on the Apache-Sitgreaves NF are rated as Functioning Properly. The other watersheds, located on the Coconino and Tonto NFs, are rated as Functional at Risk.

Table 24. Priority Watersheds within the Rim Country Project Area

Hydrologic Unit Number (HUC12)	Subwatershed Name	National Forest	Percent Within Rim Country	Condition Class
150200100103	Upper Wildcat Canyon	Apache-Sitgreaves	99.9%	Functioning Properly
150200100102	Long Tom Canyon-Chevelon Canyon	Apache-Sitgreaves	99.9%	Functioning Properly
150200080303	East Clear Creek-Blue Ridge Reservoir	Coconino	100.0%	Functioning at Risk
150601030401	Parallel Canyon-Cherry Creek	Tonto	94.4%	Functioning at Risk

- *Municipal Watersheds*

The city of Pine Municipal Watershed is approximately 7,611 acres in size. Located on both the Tonto and the Coconino National Forests, the Pine Creek reservoir serves approximately 500 residents in Pine, Arizona. The Municipal watershed is entirely located in the Pine Creek subwatershed, Hydrologic Unit Number (HUC12) 150602030206.

The C.C. Cragin Management area occurs in the southeastern portion of the Coconino NF and adjoins the East Clear Creek and Long Valley Management Areas, as well as Tonto NF. It is accessed by forest roads that join Highway 87 and is characterized by C.C. Cragin Reservoir and Forest Road 300 along the Mogollon Rim. C.C. Cragin supplies water via a pipeline for the Town of Payson and other communities in northern Gila County. The subwatersheds (HUC12) that support the C.C. Cragin Reservoir are: Bear Canyon 150200080302, Miller Canyon 150200080301, and East Clear-Blue Ridge 150200080303. C.C. Cragin reservoir also provides water-based recreation.

Assumptions and Methodology

Analyses for environmental consequences to water quality and riparian areas that may result from implementation of each alternative were conducted using information contained in the Ecological Response Unit (ERU) inventory maps (Triepke et al. 2014a and b), the Watershed Condition Framework, the revised Apache-Sitgreaves National Forest Plan, (2015), the Revised Coconino National Forest Land Management Plan (2018), and the Tonto National Forest Plan (1985), information obtained from other Apache-Sitgreaves NF, Coconino NF, and Tonto, NF resource specialists, the Arizona Department of Environmental Quality (ADEQ), other agency reports, available literature, and input from collaborators and cooperators. Geospatial analysis was used to quantitatively and qualitatively assess hydrology, riparian resources using Geographic Information Systems (GIS) data obtained from a variety of sources.

- *Water Quality*

Effects on water quality are assessed qualitatively by alternative by comparing predicted direct, indirect, and cumulative effects by major land disturbing activities (e.g. forest thinning, prescribed burning, ephemeral channel restoration, and spring protection and restoration) within the project area.

The general classification used for surface water quality by ADEQ is attaining, attaining some uses, inconclusive/not assessed, not-attaining, and impaired for the identified uses. The classification designates each waterbody in one of five categories:

Category 1- Surface waters assessed as “attaining all uses.” All designated uses are assessed as “attaining.”

Category 2 - Surface waters assessed as “attaining some uses.” Each designated use is assessed as either “attaining,” “inconclusive,” or “threatened.”

Category 3 - Surface waters assessed as “inconclusive.” All designated uses are assessed as “inconclusive” due to insufficient data to assess any designated use (e.g., insufficient samples or core parameters). By default, this category would include waters that were “not assessed” for similar reasons

Category 4 - Surface waters assessed as “not attaining.” At least one designated use was assessed as “not attaining” and no uses were assessed as “impaired.” A Total Maximum Daily Load[2] (TMDL) analysis will not be required at this time for one of the following reasons:

4 A. - A TMDL has already been completed and approved by EPA but the water quality standards are not yet attained;

4 B. - Other pollution control requirements are reasonably expected to result in the attainment of water quality standards by the next regularly scheduled listing cycle; or

4 C. - The impairment is not related to a “pollutant” loading but rather due to “pollution” (e.g., hydrologic modification).

Category 5 - Surface waters assessed as “impaired.” At least one designated use was assessed as “impaired” by a pollutant. These waters must be prioritized for TMDL development.

Water quality is assessed by comparing existing conditions (Categories 1 to 5) with desired conditions that are set by Arizona under authority of the Clean Water Act. The Arizona Department of Environmental Quality (ADEQ) is the regulating authority for water quality in Arizona as promulgated by EPA. Waters that are not impaired (those not on 303d[3] list or in category 4 or 5) are providing for beneficial uses identified for that stream or water body and can be considered in a desired condition until further sampling indicates impairment. Those in

2A TMDL is a written analysis that determines the maximum amount of a pollutant that a surface water can assimilate (the “load”), and still attain water quality standards during all conditions. The TMDL allocates the loading capacity of the surface water to point sources and nonpoint sources identified in the watershed, accounting for natural background levels and seasonal variation, with an allocation set aside as a margin of safety.

3 Under section 303(d) of the 1972 Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These impaired waters do not meet water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. (http://www.epa.gov/region9/water/tmdl/303d.html)

category 2 or higher require special attention during site specific project analysis. The ADEQ also interprets its surface water quality standards to apply to "intermittent, non-navigable tributaries." The ADEQ interprets the definition of "surface water" to include tributaries ("the tributary rule") and assigns water quality standards to intermittent surface waters that are not specifically listed by name in Arizona's surface water quality standards rules. ADEQ has determined it is necessary to regulate and protect these types of waters as "waters of the United States" because it is estimated that approximately 95 percent of the surface waters in Arizona are either intermittent or ephemeral.

In the southwestern region, the Forest Service uses a system of ecosystem types, "ecological response units" (ERUs), to facilitate landscape analysis and strategic planning. ERUs have been built from plant associations and ecosystem units that have been identified through Terrestrial Ecological Unit Inventory (Wahlberg et. al. 2013).

- *Water Quantity*

Effects on water yield, peak flows, and stable hydrologic regime will be discussed qualitatively, based on comparison of current activities to projected effects of implementing the alternatives. Generally, reducing forest overstory in vegetation types within higher precipitation zones will generate more runoff, although these may periods may be short lived (Baker 1999; O'Donnell 2016).

- *Stream Reaches*

Effects on riparian resources will be discussed qualitatively, based on comparison of current activities to projected effects of implementing alternatives.

The most common method used to assess riparian area functionality along stream courses is called lotic Proper Functioning Condition assessment (Dickard, 2015). This is the standard protocol to assess lotic riparian conditions by USDA Forest Service. This is a qualitative assessment that requires professional judgment on 17 assessment items that are rated individually to derive a summary rating. Each riparian area is judged against its capability and potential. A riparian area is considered to be in proper functioning condition (PFC) when adequate vegetation, landform, or large woody debris are present to:

- Dissipate stream energy associated with high water flow, thereby reducing erosion and improving water quality.
- Capture sediment and aid floodplain development.
- Improve flood-water retention and ground-water recharge.
- Develop root masses that stabilize streambanks against erosion.
- Maintain channel characteristics.

If a riparian area is not in PFC, it is placed into the following categories:

Functional at Risk-Riparian Areas: These riparian areas are in limited functioning condition; however, existing hydrologic, vegetative, or geomorphic attributes make them susceptible to impairment. Trend toward or away from PFC must be described when a rating of FAR is given. Trend is the direction of change in an attribute(s) over time and can be addressed two ways. If trend is determined using photos, monitoring data, detailed inventories, and any other measurement or documentation to compare past conditions to present conditions, it is defined as "monitored trend." Apparent trend is defined as "an interpretation of trend based on observation and professional judgment at a single point in time" (Society for Range Management 1998) and is described as upward, downward, or not apparent.

Nonfunctional: These riparian areas clearly are not providing adequate vegetation, landform, or woody material to dissipate stream energy associated with moderately high flows, and thus are not reducing erosion, improving water quality, etc.

- *Springs*

Using descriptors from the current Forest Plans, the desired conditions for springs will be the following: " Springs and associated streams and wetlands have the necessary soil, water, and vegetative attributes to be healthy and functioning at or near potential". Water flow patterns, recharge rates, and geochemistry are similar to historic levels and persist over time."

There are a number of various techniques to capture and display spring data. In the southwestern region, the Spring Stewardship Institute has developed a number of protocols that are commonly employed on the three forests with differing inventory variables and levels. Inventories provide data on the distribution, status of resources, processes, values, and aquatic, wetland, riparian, and upland linkages (Stevens et al, 2016). The difference between the two inventory levels are:

1. A Level 1 inventory of the springs in a landscape is used to define the distribution, access, and springs types, as well as flow sampling equipment needed for Level 2 inventories.
2. A Level 2 springs inventory includes an array of measured, observed, or otherwise documented variables related to site and survey description, biota, flow, and the sociocultural-economic conditions of the springs at the time of the survey.

Another protocol, the Spring Ecosystem Assessment Protocol (SEAP) (http://springstewardshipinstitute.org/springs-1) is a process of evaluating the inventory data as well as other external information to generate a condition and risk score in each of the six predefined categories of variables. Risk is interpreted as the potential threat or the "condition inertia" of that variable. In other words, what is the probability of that variable remaining unchanged? The six variable categories are: aquifer and water quality, site geomorphology, habitat and microhabitat array, site biota, human uses and influences, and administrative context under which the spring is managed.

The Spring Ecosystem Assessment Protocol (SEAP) scoring criteria are defined in the following table.

Table 25. SEAP Scores for Risk Categories

Risk Score	Risk Category
0	No risk to site
1	Negligible risk to site
2	Low risk to site
3	Moderate risk to site
4	Serious risk to site

5	Very great risk to site
6	Extreme risk to site
7	Unable to access risk to site

- *Watershed Condition Framework*

A watershed condition assessment was conducted for all sixth-level (HUC12) subwatersheds in the proposed project area as part of a forest-level assessment of watershed condition (Potyondy and Geier, 2010) as part of the Watershed Condition Framework. The Watershed Condition Framework establishes established a new consistent, comparable, and credible process for improving the health of watersheds on national forests and grasslands. This framework will help focus our efforts in a consistent and accountable manner and facilitate new investments in watershed restoration that will provide economic and environmental benefits to local communities.

During the watershed condition assessment, 12 indicators of watershed health were evaluated for each subwatershed. The methodology for the assessment is described in the Watershed Condition Classification Technical Guide (USDA, Forest Service 2011). As described in the guide, indicators are weighted differently based on relative importance to overall watershed condition and tallied to come up with a final rating. Description of the indicators are found in table 26. The indicator ratings are summarized into three classes and are described below.

1. **Indicator Rating 1** is synonymous with "GOOD" condition. It is the expected indicator value in a watershed with high geomorphic, hydrologic, and biotic integrity relative to natural potential condition. The rating suggests that the watershed is functioning properly with respect to that attribute.

2. **Indicator Rating 2** is synonymous with "FAIR" condition. It is the expected indicator value in a watershed with moderate geomorphic, hydrologic, and biotic integrity relative to natural potential condition. The rating suggests that the watershed is functioning at risk with respect to that attribute.

3. **Indicator Rating 3** is synonymous with "POOR" condition. It is the expected indicator value in a watershed with low geomorphic, hydrologic, and biotic integrity relative to natural potential condition. The rating suggests that the watershed is impaired or functioning at unacceptable risk with respect to that attribute.

Table 26. Watershed Condition Indicators in the Watershed Condition Framework (USDAFS 2011, FS-978)

Aquatic Physical Indicators	
Water Quality	This indicator addresses the expressed alteration of physical, chemical and biological components of water quality.
Water Quantity	This indicator addresses changes to the natural flow regime with respect to the magnitude, duration, or timing of natural streamflow hydrograph.

Aquatic Habitat	This indicator addresses aquatic habitat condition with respect to habitat fragmentation, large woody debris, and channel shape and function.
Aquatic Biological Indicators	
Riparian/Wetland Vegetation	This indicator addresses the function and condition of riparian vegetation along streams, water bodies, and wetlands.
Terrestrial Physical Indicators	
Roads and Trails	This indicator addresses changes to the hydrologic and sediment regimes because of the density, location, distribution, and maintenance of the road and trail network.
Soils	This indicator addresses alteration to natural soil condition, including productivity, erosion, and chemical contamination.
Terrestrial Biological Indicators	
Fire Regime or Wildfire	This indicator addresses the potential for altered hydrologic and sediment regimes because of departures from historical ranges of variability in vegetation, fuel composition, fire frequency, fire severity, and fire pattern.
Forest Cover	This indicator addresses the potential for altered hydrologic and sediment regimes because of the loss of forest cover on forest lands.
Rangeland Vegetation	This indicator addresses effects on soil and water because of vegetative health of rangelands.
Forest Health	This indicator addresses forest mortality effects on hydrologic and soil function because of major invasive and native forest insect and disease outbreaks and air pollution.

The results of the Forest Service Watershed Condition Framework planning work are available through a map viewer website where users can view the priority watersheds, read about why the watershed was selected, download the Watershed Restoration Action Plans and learn about other important planning items, including estimated costs and restoration partners. Each watershed on the map also contains information on the overall watershed condition rating and the individual rating of its 12 watershed condition indicators. The interactive watershed condition map can be found online at: Watershed Condition Framework Viewer.

A watershed's condition class integrates the effects of all activities within a watershed, therefore provides an ideal mechanism for interpreting the cumulative effect of a multitude of management actions on soil and hydrologic function (USDA 2011). Although, all these WCF indicators are interrelated to some degree, specific indicators in the Watershed Condition Framework were used to evaluate watershed scale cumulative effects including Water Quality, Water Quantity, and Riparian/Wetland Vegetation condition for this report. Additional watershed cumulative effects analysis is included in the Soils and Watershed specialist report (MacDonald 2018).

It is assumed that the treatments within the proposed action may result in some short-term, localized negative effects from ground disturbance via heavy machinery operations may occur on soils where previously completed projects overlap proposed or future activities in watersheds across the project. However, no long-term cumulative effects from ground disturbance (compaction, topsoil displacement, high soil severity burning etc.) from mechanical operations or prescribed burning outlined in the proposed action are anticipated to occur to a degree or spatial extent that would negatively affect watershed condition. These activities will generally have a positive effect on watershed condition proportion to the extent of the treatments.

- *Climate Variability*

Effects are disclosed based on climate within its normal range of variability. Management during periods when climatic conditions occur outside the normal range of variability are described in regional and forest guidance papers and are considered outside of the effects determination being made.

Environmental Consequences

Water quality and riparian area analysis topics include:

1. Potential for sediment delivery to waterbodies including streams, wetlands, riparian areas, and lakes.
2. Changes in surface runoff, erosion, and sediment delivery to stream courses from road construction, maintenance and obliteration.
3. Changes to channel morphology as a consequence of increased flows caused by removal of upland vegetation resulting in increased storm water runoff.
4. Cumulative effects on water quality, water quantity, and riparian areas, when combined with past, present, and reasonably foreseeable future actions could be significant.

- *Water Quality*

The indicators for water quality includes acres of vegetation (forest, woodland, grassland, riparian) restored by mechanical and prescribed burning, the number of miles of stream channel and number of springs proposed for restoration, the changes in road miles and unauthorized routes, and overall projected changes to water quality, most importantly potential changes with compliance with the Clean Water Act.

Water quality in Arizona is reassessed and reported every 2 to 3 years by the State of Arizona. The latest assessment was documented in the Department of Environmental Quality in 2016 Clean Water Act Assessment (July 1, 2010 to June 30th, 2015) (ADEQ 2016). The findings and recommendations of the report are summarized in the affected environment section.

Most adverse effects on these resources can be minimized or mitigated through appropriate use of resource protection measures such as Soil and Water Conservation Practices (SWCPs) and Best Management Practices (BMPs) as outlined in the Soil and Watershed Conservation Practices Handbook (Forest Service Handbook 2509.22)(USDA 1990). These resource protection measures for the Rim Country Project are included as design features in appendix C. This project will incorporate BMPs, both general and site specific, designed to protect water quality. A memorandum of understanding with the State of Arizona and USDA Forest Service, Region 3 (USDAFS/ADEQ 2013) states ‘Ensure that all project work schedules for project implementation on the ground contain site-specific BMPs, developed through the LRMP implementation process and consider technical, economical, and institutional feasibility and water quality impacts from the proposed activity in selection of the BMP. Monitor BMPs on selective activities to ensure they are implemented and are effective, adjust as necessary.' An important BMP feature is the Aquatic Management Zone (AMZ), which is an area adjacent to a waterbody where activity is restricted or limited to project aquatic and riparian values at risk. The proposed AMZ widths are outlined in the Rim Country design features.

Water Quantity

Water quantity is discussed in terms of stable hydrologic regime, persistence of flow, peak flows, and discharge to waterbodies and springs. Surrogates to analyzing these indicators are similar to those for water quality and include: acres of vegetation treated by mechanical treatments and prescribed burning, miles of roads opened and temporary constructed roads, decommissioned roads and unauthorized routes, and acres of rock pits and in-woods processing areas.

Riparian Resources

The indicators used to assess riparian include the miles of stream restoration, the number of springs proposed for restoration, and the number of acres proposed for vegetation treatments such as mechanical treatments and prescribed burning, including most importantly riparian and wetland areas. Other indicators include the miles of temporary roads constructed and Forest Service system roads reopened, the miles of Forest Service roads and unauthorized routes decommissioned. These are surrogates for assessing potential changes to resource conditions.

The Spring Stewardship Institute provided a spring inventory geodatabase for the project area, including Spring Ecosystem Assessment (SEAP) results for many springs.

Cumulative Effects and the Watershed Condition Framework

As mentioned previously, although all Watershed Condition Framework indicators are interrelated to some degree. Specific indicators such as Water quality, Water Quantity, and Riparian/Wetland Vegetation condition were used to evaluate watershed-scale cumulative effects for water and riparian resources. Other Watershed Condition Framework indicators are addressed in the Soils and Watershed specialist report (MacDonald 2018).

Alternative 1

There would be no direct effects on water and riparian resources as a result of the no action alternative, however there would be indirect effects by not be moving these resources towards desired conditions. Overstocked and dense stands within the project area would not be treated, leaving a less healthy, less vigorous, and under productive forest. Risk of uncharacteristic wildfire would not be reduced. No improvement would be realized in woodlands, savanna, and grassland vegetation types where ground cover conditions are departed from desired conditions. No road decommissioning, rehabilitation of unauthorized routes or stream crossings would occur improving water quality. Stream, wetland, riparian, and spring restoration would not be completed at the scale intended for this project. The project area would not move toward desired conditions, as outlined in the Apache-Sitgreaves, Coconino, and Tonto Forest Plans.

Water Quality and Quantity

Absence of Mechanical Treatments and Prescribed Fire

This alternative would not provide for vegetation conditions that are more resistant to uncharacteristic wildfire. Much of the ponderosa pine forest is in Fire Regime Condition Class 3 and trends indicate that fuel loading would continue to increase in both living biomass and woody detritus through natural forest ingrowth and tree encroachment into existing openings, resulting in increased risk of high severity wildfire. A dense forest litter layer (i.e., duff) has displaced much of the herbaceous vegetation which provides even greater benefits to soil hydrologic function due to fine root turnover, increased fine litter, improved soil porosity and aggregate stability, and increased water holding capacity (NRCS 2001).

The effects on water quality and quantity in the case of wildfires resulting in high soil burn severity are well documented, and can cause heavy sediment and ash inputs to connected stream courses, as well as increased risk of damaging flows to streams, riparian areas and other downstream values at risk. It is likely that under any conditions, a wildfire entering these untreated watersheds under the no action alternative would have considerably greater impacts to water quality and channel stability than wildfire occurring after implementation of the action alternatives. Increased water turbidity, and downstream flooding would be more widespread in an uncontrolled wildfire situation than under prescribed fire conditions where the size and intensity of the fire can be controlled. Haas, 2018 suggests that up to 33 percent of ponderosa pine forest could burn under high burn severity conditions. Therefore, if a 10,000 acre wildfire were to occur within the project area, approximately 1,000 to 3,000 acres of high severity fire would be expected to adversely affect water quality and riparian conditions. Increased sediment loads are the primary physical impacts to surface waters following fire. The bulking effect of sediment and ash in runoff increases the risk to surface water impoundments, infiltration basins, and public water treatment systems. Sediment and debris flows can damage water supply infrastructure. Sedimentation of impoundments can decrease their effective life, resulting in a need for dredging and other mitigation measures.

This alternative would result in no additional acres of ground disturbance from mechanical vegetation treatments, piling of activity-related woody debris, construction and maintenance of temporary roads, road obliteration, fence construction, and the use of prescribed fire. Soils with erosion rates that are exceeding tolerance thresholds would likely continue to erode at current rates. Sediment delivery to streamcourses and waterbodies could continue at current rates or gradually increase from poor upland conditions. In areas where overstory densities are high, little long-term improvement in hydrologic flow regime will occur without mechanical treatment and/or prescribed fire. The soils in these areas have reduced moisture storage and infiltration capacity and are frequently overwhelmed by high intensity summer precipitation events, producing runoff events with relatively large peak flows of short duration. In areas that are overstocked with trees and encroached, water quantity will continue to decline as less water would be available for stream flows due to the closing of the overstory.

- Absence of Riparian, Stream, and Upland Improvements

Riparian vegetation provides many water quality maintenance functions such as reducing surface water temperatures, which promotes high dissolved-oxygen concentrations, by blocking solar radiation. Stabilizing roots reduce the amount of bank cutting and erosion. Uptake by riparian vegetation can effectively remove excess nutrients and pollutants from water. Several stream reaches within the Rim Country Project area are experiencing increased water flows and sediment delivery from the effects of poor upland conditions, some of which are the result of several fires which have occurred over the past 20 years, most notably the Rodeo-Chediski Fire of 2002. These increased flows are causing stream instabilities both vertically and laterally. Stabilizing riparian vegetation has been scoured away causing detachment and movement of channel and bank material impacting sediment concentrations in water bodies. Without active stabilization activities water quality will likely not improve as quickly as with the action alternatives.

- Absence of Roads Activities

This alternative is not anticipated to produce any changes to existing water quality trends in the streams, springs and surface water bodies in or downstream of the project area. Open roads and unauthorized routes being used for motorized travel will continue to discharge runoff and sediment to project area streams, especially where the roads are poorly located in stream bottoms, have inadequate drainage structure, and are hydrologically connected to the stream network (USDA 2010, Orndorff 2017, Berg 1988, Lousier 1990).

There will be no short-term inputs of sediment into waterbodies caused by disturbance associated with the action alternatives.

- Absence of Rock Pits and In-woods Processing Sites

The no action alternative would have slightly more potential of increased sediment yield to downstream perennial waters than the action alternatives because of the use and improvements of FS system roads associated with the rock pits. Increased sediment yield by itself does not constitute an impact on water quality because the sediments leaving the road would have to enter a water body in large enough quantities to cause a change in beneficial uses. Maintaining roads to appropriate standards would be more difficult in this alternative due to the higher haul costs of bringing in rock from elsewhere. Fewer miles of roads surfaced combined with an increase in miles driven compared to the other alternatives would result in continued water quality impacts.

- *Riparian and Wetland Resources*

- Absence of Mechanical Treatments and Prescribed Fire

Under the no action alternative and assuming the absence of wildfire, current trends in condition of riparian areas within the project area would be expected to continue. Riparian condition would not benefit from improving upland watershed conditions to desired conditions with mechanica and prescribed fire treatments. There would be no potential benefit from improvement of the hydrologic flow and altered sediment regime by restoring herbaceous ground cover. Fuel loading would remain high, thus there would be greater risk of high burn severity and subsequent flooding effects, which could negatively affect riparian condition. Tree density and canopy closure within the riparian areas would increase. Current levels of large woody debris would be available to the stream channel both from the riparian and adjacent upland zones. Areas where deciduous woody riparian vegetation is being shaded out by invading conifers would remain in that condition.

This alternative would result in riparian condition improvement at a slower rate than either of the action alternatives as there would be no direct reduction of conifer encroachment via mechanical and prescribed fire to increase the potential for expansion and vigor of riparian vegetation.

- Absence of Riparian, Stream, and Upland Improvements

Many of the stream reaches accessed are not currently at desired conditions and are in less than proper functioning condition. Headcuts and other instabilities can adversely affect riparian vegetation by scouring away soils and stabilizing plants leading to channel entrenchment and subsequent lowering the water table. It is expected that riparian condition of these reaches would continue to decline or, if recovering, recover at a slower rate with the no action alternative than the action alternatives.

- Absence of Roads Activities

Potential effects from construction of temporary roads and opening of closed Forest Service roads, such as increased runoff on disturbed soils and potential increased delivery of sediment to water bodies, would not occur with the no action alternative. Forest service roads and unauthorized roads will not be decommissioned or relocated, therefore resource degradation from these roads will continue, and the improvement to riparian condition will not occur.

- Absence of Rock Pits and In-woods Processing Sites.

The absence of rock pits and in woods processing sites would have no impact on riparian or wetland resources because of the location of these away from these resources. The no action alternative would result in no additional acres of ground disturbance from rock pits and in little to no potential of sediment generation distribution from in-woods processing sites.

- *Effects Common to Both Action Alternatives*

In general, direct and indirect effects on water quality and riparian areas as a result of the action alternatives include:

1. Reduction of the forest canopy would decrease interception (precipitation captured by leaves, branches, and boles) and increase net precipitation reaching the soil surface. Where disturbance is recent, surface runoff could reach waterbodies and affect water quality.
2. Partial removal of the forest overstory would reduce transpiration (water lost from plants to the atmosphere), increasing soil moisture and runoff (Baker 1999, Ffolliott et al. 1989), which may improve riparian conditions.
3. Increased soil moisture and loss of root biomass could reduce slope stability and increase soil erosion resulting in adverse effects on water quality.
4. When young, dense forests with high interception rates (or higher annual transpiration losses) replace mature forests with lower interception rates (or lower transpiration losses), water yield would be reduced until the young forest matures and thins naturally or is thinned in treatments.
5. Impervious surfaces (roads and trails) and altered hillslope contours (cutslopes and fillslopes) would modify water flowpaths, increase overland flow, and deliver overland flow and sediment directly to stream channels.

- *Water Quality and Quantity*

- Upland Mechanical Vegetation and Prescribed Burning Treatments

Water Quality

Fire, including prescribed burning, can disrupt nutrient cycling and cause nutrient volatilization, leaching, and transformations. When vegetation is consumed by fire some of the soil and organic matter nutrients such as calcium, magnesium, and potassium are converted into oxides and accumulated in ash (DeBano et al. 1998). During precipitation events these compounds can be delivered to nearby waterbodies. However, the primary short-term risk to water quality from prescribed fire and mechanical vegetation treatments is from increased sediment input to water bodies from where ground cover has been reduced or eliminated. This risk of is greatest where treatment activities result in soil disturbance or complete removal of vegetative ground cover in close proximity to drainages. Such areas would include designated stream crossings, skid trails, log landings, installed firelines, and areas with higher soil burn severity.

As reported in the Soils and Watershed specialist report (MacDonald 2018), erosion potential is expected to increase on 10 to 15 percent of areas treated mechanically due to removal or displacement of ground cover. However, this erosion would be short term (1 to 5 years) and localized. In the long-term, these treatments will likely increase vegetative ground cover and decrease the potential for high severity fire and substantially more drastic effects from heavy fuel loading. As shown in erosion modeling results, sediment delivery following high to moderate soil burn severity areas is about twice that of low severity areas, which is the predominant severity class resulting from prescribed burning. Where uncharacteristic, or high-severity wildfires have occurred, 36 percent of the TES (Terrestrial Ecosystem Survey) strata exhibited erosion and sediment delivery rates above soil loss tolerance thresholds. Bringing these areas towards desired conditions will promote stability in hydrologic and sediment regimes.

Rainfall-runoff monitoring from a study in New Mexico reported much greater runoff coefficients, total discharge, and sediment yield in pinyon-juniper woodland sites than those areas with higher herbaceous ground cover such as in grasslands (Puttock et al. 2013). Thinning of forest cover on soils currently characterized as unsatisfactory would improve those soils over the long-term by improving soil moisture and allowing greater sunlight penetration to the forest floor, resulting in an increase in forest understory of desired herbaceous species. Vegetative recovery following fuel reduction treatments is generally rapid, with erosion rates typically returning to pre-treatment levels within 1 to 2 years (Elliot 2000). The increased herbaceous vegetation would likely reduce soil erosion and associated sediment delivery rates by providing vegetative and litter ground cover. This cover would intercept rain before it can reach soil surfaces, and detach and entrain soil particles in runoff water, promoting long-term improvement in water quality.

Resource protection measures including BMPs (see design features in Appendix C) are included with this project to protect water quality are effective in preventing long-term degradation of water quality from sediment and point sources of contamination. The use of streamside buffer zones, referred to as aquatic management zones (AMZs) in this project, to increase filtration capacity, have been shown to be capable of reducing sediment entering waterways to non-significant levels (Rashin 2006). These ‘buffer zones’ decrease the velocity of surface runoff that carry sediment and other pollutants from upland areas and trap them prior to entering waterways (Baker et al. 2004).

Adverse effects to water quality from mechanical vegetative and prescribed burning treatments would be mitigated, but not eliminated entirely with implementation of design features. Design features SW001 through SW017 include the use and description of AMZs that are protective of water quality. Additional BMPs addressing spill prevention, and remediation are included in SW001 – SW005, SW020 – SW024, SW110 – SW111, SW104, SW106, and SW108. Other protection measures for water quality associated with mechanical vegetation treatments include design features: SW018, SW032 –SW034, SW037 –SW058, SW061 – SW073, SW076, SW079 –SW080, SW082, SW089-SW092, SW094-SW102, and SW105. Design features related to prescribed burning activities include: SW038, SW074-SW080, SW089, SW091-SW092, SW094, SW096, SW098, SW102, and SW105.

- *Water Quantity*

Departures from historical ranges of variability (HRVs) in vegetation and fire regimes have the potential for alteration of hydrologic regimes. Excessive overland flows can increase channel flow volume and velocity, causing channel erosion and increased deposition downstream. The proposed mechanical treatments and prescribed fire would move portions of the uplands toward desired conditions. The increase in vegetative grass component would improve the ability of the watershed to intercept and retain water inputs (precipitation and snow melt). Herbaceous ground cover, residual plant material, and plant vigor would increase surface roughness, reducing runoff velocities. Soil compaction would start to break up and additional organic material incorporate into the soil, allowing for reduced surface runoff, increased water infiltration, and moisture retention. Overall, these conditions could promote more stable hydrologic flow regimes.

Fuel reduction treatments in forested watersheds, including mechanical treatments and prescribed burning, can result in long-term increases in water yields either on-site or downstream (Brewer 2008; Bosch and Hewlet 1982; Troendle et al. 2003, 2007). Treatment prescriptions that cover most of the project area and remove greater than 20 percent of tree basal area would be needed to generate a detectable change in surface flows. Treatments prescribed in the action alternatives would include leaving groups of trees, which would allow more snow collection in openings and result in greater potential for on-site water storage and yield. This could provide longer periods of flow in intermittent streams within and downstream of the project area (Zou et al. 2009). In high-elevation subalpine spruce-fir stands managed for snowpack redistribution and transpiration reduction, increases in annual water yields from one to three inches could often be expected. Water yields in mixed conifer stands are approximately 25 percent less than those expected in subalpine forests.

In drier ponderosa pine stands, increased yields of one-quarter to one inch would be realistic. A modeling effort presented in Robles et al. (2014) found that runoff in thinned ponderosa pine forests was about 20 percent greater than unthinned forests, regardless if in a drought or wet period. However, these increases were temporary, occurring less than six years following treatment, and were modest (0-3 percent) when compared to total mean runoff from the study watershed. A study by Simonin et al. (2006) found that positive effects on water outflow from thinning in ponderosa pine only occurred in wet winters. Bosch and Hewlet (1982) concluded, and subsequent data (Hornbeck et al. 1997) and modeling (Troendle et al. 2003, 2007), support that removing less than 20 percent of the basal area may also result in a change in flow, but this change will not be detectable. In cases where there is a detectable hydrologic response to fuel management treatments, the observed response would be greatest in wet years and smallest or non-detectable in dry years.

Prescribed fires, when designed and used as a fuel reduction tool alone, are probably less likely to influence water yield than mechanical treatments or a combination of burning with mechanical treatments, because of the smaller reduction in basal area and lack of ground disturbance by heavy machinery. Measures taken to reduce the potential impact of increased peak flows and runoff from too intensive and extensive treatments are included as project design features in appendix C.

Adverse effects to water quantity would be mitigated, but not eliminated entirely with implementation of design features. Most of the AMZ-related design features listed for water quality are applicable to water quantity. Other design features relevant to mechanical vegetation treatments include: SW018, SW026, SW032, SW033, SW037, SW039-SW058, SW061, SW064, SW066-SW073, SW076, SW079-SW080, SW082, SW092, SW094-SW096, SW098-SW101, and SW105. For prescribed fire and other burning activities, the design features listed for water quality are all applicable.

- *Riparian, Wet Meadow, Spring, and Stream Restoration*

Restoration activities described in the Aquatic and Watershed Flexible Toolbox Approach (AWFTA) could promote conditions for desirable water quality and quantity characteristics. Reducing trees encroachment on riparian areas would allow for decreased precipitation interception, improved infiltration and water storage. Riparian vegetation often acts as a mitigating influence on flooding. Riparian vegetation provides instream roughness via large woody debris as well as live vegetation along stream banks. This roughness can reduce stream velocities and dissipate stream energy, resulting in an increased stream stage. The spreading of water out onto a floodplain promotes water entering into storage, further dampens peak flows. Improving conditions in these areas would also promote resiliency during uncharacteristic wildfires, by reducing the potential for high severity burning. High severity burning in riparian areas can reduce shading causing increasing stream temperatures, and destroy stabilizing vegetation resulting in excessive erosion and sediment production.

Long-term water quality would benefit from promotion of soil and channel stability and establishment of riparian vegetation, with improved dissipation of stream energy, water storage, and more stable flow regimes. Riparian vegetation can also maintain cooler temperatures within water bodies by reducing the amount of solar radiation impinging on the water surface. Water quality improvements can also occur from nutrient uptake and storage by riparian vegetation.

Short-term effects to water quality and quantity would be mitigated from riparian, wet meadow, spring, and stream restoration activities, but not eliminated entirely with implementation of design features. BMPs related to riparian restoration that are protective measures for water quality and quantity include those associated with AMZs and spill prevention and remediation (see water quality and quantity BMPs for general mechanical and prescribed burning). BMPs specifically related to thinning activities in and around these resource areas include: SW059, SW060, SW062, SW063-SW064, SW082, SW096, and SW098-SW102. Design features to reduce adverse effects to water quality and quantity associated with AWFTA restoration activities include: SW027-SW031, SW038, SW043, SW069, SW081-SW082, SW087-SW090, SW092-SW101, and SW105.

- *Roads Activities*

Road management-related activities include: road improvements, temporary road construction, decommissioning of system roads and unauthorized routes, and improvement and relocation of system roads.

Approximately 5,682 miles of roads currently in the forest system road network would be needed for the activities proposed in the action alternatives. Of this total mileage, 2,076 would be included from the re-opening of maintenance level 1 (ML1) roads. Temporary roads would also be constructed. It is important to note that not all the ML-1 roads will be opened or temporary roads constructed at the same time across the project area. Only those ML1 and temporary roads required for implementation in a certain area would be opened or constructed. These roads would be properly maintained during implementation and closed or decommissioned, following FS policy and design features (see Transportation specialist Report (Rich 2019)), when they are no longer required for project activities.

Vehicle traffic associated with project implementation, particularly trucks, can pulverize road surface aggregates, resulting in more fine particles that are easily transported in runoff.

Additionally, the pressure of vehicular tires on saturated road surfaces can force fine particles from below the surface to move upward to the surface (Truebe and Evans 1994). Runoff from road surfaces can detach and transport the fine material from road prisms and ditches. Road proximity and connectivity to drainages can strongly influence sediment delivery to watercourses and alter flow regimes in streams. Road and stream intersections are the primary locations where sediments are delivered to stream courses. Sediment production from roads diminishes over time after proper closure and non-use (Beschta 1978). Roads induce surface runoff and can alter subsurface flow on hillslopes, and this could affect the magnitude and timing of surface runoff.

No long-term effect on water quality and quantity is expected from the action alternatives with regards to the proposed road activities. In the short term, it is possible that sediment inputs to area watercourses would increase slightly from re-opened roads, constructed temporary roads, or improved roads in the project area. However, all opened roads and temporary roads would be closed and decommissioned, respectively, when they are no longer needed. Short-term effects on water quality would be minimized by employing design features for road decommissioning and rehabilitation, including BMPs (see appendix C) which are effective in preventing sediment from reaching streams when strictly followed.

A total of approximately 800 miles of existing system roads and unauthorized roads would be decommissioned under both action alternatives. Road decommissioning would entail obliteration whereby road surfaces could be ripped and seeded or mulched, inside ditches filled, road prisms outsloped, culverts and fill materials removed, stream crossings re-contoured, unstable sidecast or cutslopes removed or stabilized, and entrances blocked to prevent future access. These activities would return unproductive acreage to a more stable, productive status over the long term by improving water infiltration, naturalizing water flow, increasing vegetative ground cover, and reducing erosion. Upon completion of road obliteration activities, long-term erosion rates for decommissioned roads would be expected to approach natural erosion rates. Rehabilitation or removal of roads offers benefits including reduced sedimentation and decreased peak flows.

Water quality and quantity protective measures related to transportation activities include design features: SW018, SW083-SW089, SW091, and SW093. Additional design features are included for the Transportation specialist report (Rich 2018).

- *Rock Pits and In-woods Processing Sites*
  - Rock Pits

The action alternatives include the use of 10 existing rock pits on the Coconino NF and 11 existing rock pits on the Apache-Sitgreaves NFs. Since each of the rock pits analyzed is required to be operated so that they have internal drainage, none of the proposed pits or expansion areas would result in sediment outside the boundary of the pit and there would be no direct effect on water bodies. The lower hauling costs associated with having more rock pits closer to activity areas, would result in more miles of roads with better surfacing. This would also limit effects on water quality from roads. Water quality would be expected to remain the same or improve because of the greater number of road miles surfaced and maintained.

The site selection criteria used for rock pits and expansions greatly reduce the potential for effects on waterbodies. Increased truck traffic would create some finer sediment on road surfaces and could increase sediment yield. The main concern with increased sediment yields would be from dust caused by the construction and use of the rock pits and facilities. However, increased sediment yield by itself does not constitute an effect on water quality because the sediments leaving the road would have to enter a water body and in large enough quantities to cause a change in the beneficial uses of that water body.

- In-woods Processing Sites

Twelve processing and storage sites are proposed and analyzed for use in the Rim Country EIS, ranging in size from 4 to 21 acres. These sites were screened so as to be located outside of riparian areas and away from nearby streams where some of the most productive forest soils are found, as well as in relatively flat areas. The siting of processing sites in relatively flat areas would minimize the need for extensive site grading.

In order to facilitate the types of tasks and equipment that may be used at these sites, the sites would typically be required to be cleared and grubbed (i.e., vegetative cover and trees removed), resulting in displacement of top soil and exposure of subsoil. The operation of equipment on these sites would result in compaction of the soil, reducing the ability of soils to infiltrate water. Areas of exposed soil would have to be covered with aggregate to minimize erosion and facilitate use of the site. The aggregate surfacing would cover the surface soil where it is not graded, and would protect soil productivity. Various permits would need to be obtained for fuel storage, industrial site use, and stormwater pollution prevention. These permits would help to minimize effects on soil productivity and function.

Aboveground fuel storage tanks would have to be manufactured, installed, and operated in accordance with federal, state, and local requirements. For example, a permit for installation of an aboveground storage tank would have to be obtained through the Arizona State Fire Marshall's Office. Additionally, the processing sites would likely be regulated as industrial sites subject to permitting under the Arizona Department of Environmental Quality's Multi-Sector General Permit program. This permit program requires that certain industrial facilities, including those involved in the types of activities that would likely occur at the processing sites, implement control measures and develop site-specific stormwater pollution prevention plans to comply with Arizona Pollutant Discharge Elimination System requirements. Among other things, the prevention plan would have to identify best management practices that minimize non-point source water pollution, including measures to minimize or prevent soil erosion and contamination.

Following completion of the use of processing sites and removal of all equipment and materials, site rehabilitation would be accomplished, including but not limited to removal of aggregate, restoration of pre-disturbance site grades, de-compaction of soil for seedbed preparation, tree planting, and seeding and mulching of the site with native grasses and forbs.

The selection for processing sites included the following criteria: flat uplands less than 5 percent slope; more than 200 feet from ephemeral and intermittent stream channels, more than 300 feet from meadows, springs and karst features. These selection criteria considerations, in addition to the Rim Country design features for these sites, should greatly reduce the potential for effects on waterbodies.

Water quality and quantity design features addressing rock pits and in woods processing sites include those for spill prevention and remediation (refer to water quality protective design features for general mechanical vegetation treatments and prescribed burning). Additional design features include: SW103 through SW113.

- *Riparian Resources*
    - Upland Mechanical Vegetation and Prescribed Fire Treatments

Upland mechanical thinning and prescribed burning treatments should reduce the risks to riparian communities and ecosystem integrity from scorching, and damaging peak flows associated with uncharacteristic wildfire. The effects of wildfire and prescribed burning activities on riparian areas are highly dependent on position of fire within the watershed, proximity to riparian areas, and position relative to mainstream channel and tributaries (Dwire et al., 2016). In general, the hotter a watershed burns, the greater the extent of burning within riparian areas.

In addition, the reduction of canopy cover near riparian areas would stimulate the development of understory vegetation including deciduous woody riparian vegetation (e.g., aspens, willows and cottonwoods). Reductions in upland tree density and the long-term maintenance of open stands and forest openings should respond with increased stream flow, and overall water yield (Brewer, 2008), which in turn would provide longer periods of intermittent stream flow. Increased infiltration resulting from the vegetative treatments would move excess moisture into sub-surface storage and groundwater, resulting in a slower release of water. Higher-intensity thinning would likely have the greatest potential for groundwater recharge, and stream and spring discharge, by reducing evapotranspiration rates. Increased water availability would support riparian vegetation abundance and vigor, and for stream channels minimize channel bank and bed instability (Fisher et al. 2008). Overall, the long-term effects of these treatments would likely improve riparian, stream channel, wet meadow, and spring conditions and functionality more quickly than the no action alternative. Adherence to project design features would limit the extent and degree of effects from mechanical thinning and burning activities both in the uplands and riparian areas. Treatments in AMZs would be limited in scope, space, and time to achieve multiple resource management objectives.

Design Features included to reduce adverse effects to riparian resources during mechanical vegetation activities include: SW049, SW059-SW060, SW062-SW064, SW082, SW095-SW096, SW098-SW102, and SW105. For prescribed burning relevant design features include: SW078 (which relates to riparian condition (PFC ratings)), SW098, and SW105. Appendix C contains additional relevant design features.

- Riparian, Wet Meadow, Spring and Stream Restoration

Thinning activities and prescribed burning activities targeted for riparian resources including in around streams, wet meadows, and springs will have effects similar to those described in the prior section on effects to riparian resources from upland mechanical vegetative and prescribed fire treatments. Leaving riparian areas untreated and with higher fuel loading, while treating fuel loading in the uplands can produce high fire severities in these areas (Dwire et al., 2016). These higher severities can reduce riparian vegetation abundance and diversity and take several decades to recovery to pre-fire conditions.

Treatments can also produce other desirable effects such as potentially more groundwater and surface water to be available to promote riparian vegetation abundance and vigor. As stated previously adherence to project design features would limit the extent and degree of effects from mechanical thinning and burning activities both in the uplands and riparian areas. Treatments in AMZs would be limited in scope, space, and time to achieve multiple resource management objectives.

Activities included in the Aquatics and Watershed Flexible Toolbox Approach (AWFTA) would directly improve riparian conditions and functionality associated with stream channels and banks with stabilization techniques, and intensive treatments that modify stream sinuosity, width/depth ratio, and gradient. Grade control structures are useful for reconnecting stream channel and floodplains, reducing degrading stream energy and aggrading entrenched systems. Vertical instabilities such as headcuts can adversely affect riparian vegetation by scouring away of plants and soils and lowering of the water table. Reduction of bank erosion would increase stream stability and moisture-holding capacity of hydric soils, improving conditions for riparian vegetation production. Degraded wet meadows could be restored by transplanting native herbaceous species and reposing steep banks. Upland soil stabilization would be completed at sites where soil conditions are contributing to gully formation. Stabilization techniques would include hand or mechanical installation methods, depending on site needs, access, and other resource concerns. Native vegetation would be expected to reestablish in these areas soon after restoration activities are completed (from one to three years). Additional benefits would include reduced susceptibility of sites to invasion by noxious or invasive weeds with the increased native vegetation recruitment over time. In some areas, riparian vegetation production would be augmented with planting of riparian herbaceous and woody species appropriate to those locations. Protective barriers around riparian areas would reduce the browsing and trampling effects from large ungulates, since continued heavy to extreme use of woody species could limit plants' ability to regenerate (Winward 2000).

Strict adherence to design features in appendix C would minimize potential water quality effects. Protective measures for riparian resources as related to AWFTA activities include design features: SW069, SW082, SW096, SW098, SW100, and SW105.

- *Roads Activities*

Riparian areas, wetlands, stream channels and springs would not be directly affected by temporary road construction as it is prohibited in or near these resources in the project design features (appendix C). Additionally, indirect effects are expected to be minimal. Poorly located roads and unauthorized routes can degrade soil conditions and cause channel instabilities resulting in excess erosion and deposition which may affect riparian diversity, extent, and vigor. Decommissioning of FS system roads and user-created roads could improve functionality of riparian areas, stream channels, wetlands, and springs.

Design features related to roads activities that are protective to riparian resources include: SW018, SW083-SW084, SW086, and SW088.

- *Flood Zones*

Large scale treatments can have an effect on amount and timing of stream flows. Areas within or adjacent to flood zones may be affected by wildfire as loss of vegetation cover reduces the ability of the watershed to effectively hold and release water and sediment.

- *Rock Pits and In-woods Processing Sites*

The selection criteria of processing sites included the following: flat uplands less than 5 percent slope, more than 200 feet from ephemeral and intermittent stream channels, and more than 300 feet from meadows and springs. These considerations, in addition to other relevant design features, should greatly reduce the potential for effects on adjacent riparian resources.

- *Effects Unique to Each Action Alternative and Differences among Them*
    - *Water Quality and Quantity*
        - General Mechanical and Prescribed Fire Treatments

The effects of general mechanical treatments and prescribed fire, including treatments in savannas, to water quality and quantity described in the Effects Common to Both Action Alternatives section, and apply to this section. Acres of mechanical and fire treatments differ between the action alternatives, with 817,870 and 427,786 acres proposed for Alternatives 2 and 3, respectively. This amounts to a 48 percent difference in acres. The difference in acres of mechanical treatment and burning in savanna vegetation types shows an even greater difference, with 54,890 proposed in Alternative 2 and 38,790 proposed in Alternative 3. This is a 28 percent difference in acres. Prescribed fire only acres are also lower in Alternative 3, with 40,630 acres proposed as compared to 54,070 acres in Alternative 2, a 26 percent difference.

For water quality, the short term effects of Alternative 3 as compared to Alternative 2, would be a potential decrease in the amount of sediment reaching waterbodies from ground-disturbing activities, such as from mechanical vegetation treatments and prescribed burning. However, in the long-term, Alternative 3 would likely result in decreased long-term water quality benefits, from decreased upland treatment acres currently not meeting desired conditions due to departures in vegetation and fuel composition. Both alternatives would maintain compliance with the Clean Water Act through strict adherence to design features.

Regarding water quantity, Alternative 2 with more treated acres, could promote increased water yield, more stable hydrologic flow regimes, and increased discharge downstream. Springs would likely received more groundwater recharge, promoting increased discharge.

- *Road Activities*

The difference between the action alternatives is the proposed number of miles of temporary roads. More miles of temporary roads would be needed for Alternative 2 because more acres are proposed for mechanical treatments and prescribed fire. Up to 330 or 170 miles are proposed for implementation of Alternatives 2 and 3, respectively; a 49 percent difference. In the short-term, a greater number of temporary roads over the project area will remove more vegetation, exposing and compacting more bare soil, potentially leading to increased concentrated flows and sediment delivery to waterbodies. It should be noted that a potential increase in the magnitude or duration of effects from a greater number of temporary roads will likely be spread over a larger geographical area, including many additional watersheds, thus in essence spreading out or diluting potential effects. Overall, the effect of temporary road in either action alternative effects will be minimized with the use of road erosion control design features (appendix C). In addition, all temporary roads will be decommissioned through obliteration and rehabilitated as return the road footprint to as natural condition as much as possible upon nonuse, thus mitigating potential long-term effects.

- *Riparian and Wetland Resources*
    - General Mechanical Treatments and Prescribed Fire Including Treatments in Savannas

The general effects of mechanical treatments and prescribed fire, including treatments in savannas, on riparian and wetland resources are described in the Effects Common to Both Action Alternatives section, and apply to this section. Acres of mechanical and fire treatments differ

Alternatives 2 and 3, amounted to a 48 percent difference. The difference in mechanical treatment and burning in grassland and savanna vegetation types acres treated was 28 percent comparing Alternatives 2 to 3.. Prescribed fire only acres between the action alternatives resulted in a 26 percent difference.

As these proposed treatments are primarily upland treatments, direct effects on riparian and wetland resources are not expected. With regards to indirect effects, the additional treatment acres proposed in Alternative 2 as compared with Alternative 3, would bring more acres towards desired conditions. This will reduce the potential for riparian impairment from upland watershed conditions. Alternative 2 would to a greater proportional extent promote longer periods of intermittent stream flow and groundwater recharge available to spring systems by bringing upland tree densities and forest openings to desired conditions. This would in turn support riparian vegetation vigor and wetland functionality.

Road Activities

Regarding roads, the difference between the action alternatives is in the proposed number of miles of temporary roads. More miles of temporary roads are required for Alternative 2 because more acres are proposed for mechanical and prescribed fire treatments. Up to 330 are proposed for implementation of Alternatives 2, a 49 percent increase, as compared to Alternative 3 with proposed 170 miles. With fewer miles of temporary roads proposed, there is likely less potential for negative effects to riparian and wetland resources with Alternative 3. Poorly located and high road densities can concentrate surface flow potentially causing increased peak flows damaging to these resources. The potential effects of temporary roads on riparian, spring, and wetland resources will be minimized with the design features included in appendix C. Specific design features which include the use of aquatic management zones, would be employed to protect these sensitive areas in both action alternatives. No temporary roads are to be located in close proximity (as defined as the AMZ width) to these resources. When no longer required for treatments, temporary roads are to be decommissioned through obliteration, and road footprints rehabilitated as to be returned to as natural condition as possible. The number of miles of Forest Service managed roads would return to pre-implementation numbers or those determined through the travel management rule (TMR) process. Thus, changes in open road density would be temporary, most likely two years or less.

Cumulative Effects Analysis

Watershed Condition Framework

The cumulative effects analysis for water quality and quantity, and riparian/wetland condition was completed at the HUC12 (subwatershed) scale using the Watershed Condition Framework. Watershed condition is defined as the state of the physical and biological characteristics and processes within a watershed that affect the hydrologic and soil functions supporting aquatic ecosystems (USDA Forest Service 2011). As described earlier in the report, watershed condition scores are based on 12 indicators composed of attributes related to watershed processes. This analysis qualitatively describes the potential changes in the relevant indicators and, consequently, the watershed condition scores in relation to: 1) the effects from past, present, and reasonable foreseeable activities in the watersheds, and 2) the effects that would be expected with implementation of the alternatives for the Rim Country Project. Table 27 presents a descriptive, relativistic comparison of effects between the alternaatives. Activities and events which are at a scale and magnitude that could affect watershed condition indicators include but are not limited to: riparian, stream, and spring restoration; road decommissioning; wildfire and prescribed fire; mechanical thinning; and grassland restoration.

Table 27. Summary of Cumulative Effects by Watershed Condition Framework Indicators

TIME PERIOD			
PAST ACTIONS AND EVENTS			
Watershed Condition Indicator	**Effect on Indicators**		
Water Quality and Quantity, Riparian and Wetland Vegetation Condition	Watershed condition indicator ratings originally developed in 2010 incorporating past activities and events, such as wildfire, vegetative treatments, road management, prescribed burning, range management etc. up until2010. Some watershed ratings were updated in 2012.		
PRESENT AND REASONABLY FORESEEABLE ACTIONS			
Water Quality and Quantity, Riparian and Wetland Vegetation Condition	Maintenance or improvement with vegetation treatments, road management, and prescribed burning, springs and wetland restoration, and proper grazing management. Potential declines due to wildfire.		
PROPOSED ACTION AND NO ACTION			
	Alternative 1 No Action	**Alternative 2**	**Alternative 3**
General and Comprehensive Mechanical Forest Vegetative Treatments and Prescribed Burning			
Water Quality, Water Quantity, and Riparian/Wetland Condition	No Benefit or Potential Decline	Greatest Potential for Improvement	Maintenance or Improvement
Riparian and Stream Restoration			
Water Quality, Water Quantity, and Riparian/Wetland Condition	No Benefit or Potential Decline	Greatest Potential for Improvement	Same as alternative 2
Roads improvements- temporary road construction, decommissioning of system roads and unauthorized routes, improvement and relocation of system roads			
Water Quality, Water Quantity, and Riparian/Wetland Condition	No Benefit or Potential Decline	Improvement	Similar to alternative 2

ROCK PITS AND IN WOODS PROCESSING SITES			
Water Quality, Water Quantity, and Riparian/Wetland Condition	Minimal to no change	No change	No change

Past activities and events for a 25-year period ending in 2010 were considered in development of the initial watershed condition ratings in 2010. As discussed in the existing condition section, the majority (58 percent) of HUC12 subwatersheds had Riparian/Wetland Vegetation Condition indicator ratings of “Fair”, 27 percent had “Poor” ratings, and 15 percent had “Good” ratings. For the Water Quality indicator, 70 percent of subwatersheds were rated “Good”, whereas 24 and 6 percent were rated “Fair” and “Poor,” respectively. It should be noted that there are currently no waterbodies within the Rim Country project area that are impaired from excess suspended sediment concentrations, which would be the primary impairment of concern for the activities proposed in the action alternatives. Water Quantity indicator ratings were 15, 37, and 48 percent for “Poor”, “Fair”, and “Good”, respectively.

Past, present, and reasonably foreseeable management activities within Rim Country subwatersheds are presented in table 18. Most of these projects are vegetative treatments involving either burning or thinning restoration treatments.

Present (current/ongoing) activities are those that are currently being planned or implemented. Consistent with past activities, present activities mostly involve mechanical treatments and prescribed burning. Also included are reforestation, spring and meadow restoration, and noxious or invasive weed and vegetative management along transmission lines. Reasonably foreseeable activities include those that are anticipated now and for 25 years into the future and include projects with completed NEPA (planned) and those still in the planning process. Some of the more relevant projects include mechanical thinning in the Cragin Watershed Protection Project, the Rodeo Chediski Mastication Project, and several large prescribed burning projects such as the Haigler Fuels Analysis. Several woodland, grassland, and spring restoration projects are also proposed in the Heber, Pleasant Valley, and Northwest Grazing Allotments analyses and the Mogollon Rim Spring Restoration Project.

A table in the Watershed and Riparian specialist report (Brown 2018) displays the percentages of subwatersheds managed by the Forest Service that are covered (proportional extent) by current and reasonably foreseeable projects and activities. Sixty-nine percent of subwatersheds have up to 25 percent coverage by other projects. Approximately eight percent of subwatersheds are covered from 25 to 50 percent by other activities and projects, and about five percent are covered from 50 to 75 percent. Seventeen percent of Rim Country subwatersheds are covered 75 percent or more by other projects.

Cumulative effects from livestock grazing include minor, generally localized soil compaction, puddling, displacement and erosion from livestock trailing and in areas where animals congregate such as livestock waters and areas where mineral supplements are placed. Livestock trails make up a very small portion of the total project area and therefore have a negligible effect on soils or watershed condition.

These projects, with the exception of travel management, include restoration activities through the use of prescribed fire or mechanical treatments. Coupled with similar fuels reduction and vegetative treatments in the action alternatives for the Rim Country Project, these activities will maintain or potentially improve many of the Water Condition Framework indicators. Other projects in the planning stage include the Apache-Sitgreaves NFs Travel Management Rule (TMR) with an expected decision in 2020. The Tonto NF is also in the process of finishing a TMR EIS. The rule will likely result in reduced road density, in a fewer roads crossing drainages and riparian areas, and in keeping road users in designated areas. These activities would be consistent with the Rim Country Project objects of improving Water Quality, Water Quantity, and Riparian/Wetland Vegetation Condition indicators.

Superimposed on the past, present, and reasonably foreseeable activities are the effects with respect to the full implementation of the action alternatives. A comparison of the proportional extent of subwatersheds (those acres administered by the USFS), is displayed in the Watershed and Riparian specialist report (Brown 2018). Sixty-seven percent of Rim Country subwatersheds could receive up to 25 percent additional mechanical and prescribed fire treatments acres in alternative 2 as compared to alternative 3. Increases between 25 and 50 percent would occur in seventeen percent more subwatersheds in alternative 2. Increases ranging from 50 to 75 percent and 75 to 100 percent would occur in 11 percent and 5 percent of subwatersheds, respectively, with alternative 2 as compared to alternative 3. These numbers suggest that the Water Quality, Water Quantity, and Riparian/Wetland Vegetation Condition indicators would benefit from either alternative, more so with alternative 2, by moving upland vegetation towards desirable vegetation structure and composition and desirable fuel composition, and by restoring natural fire regimes with mechanical treatments and prescribed fire. Bringing stands to desired cover conditions would reduce the risk of crown fire and the resulting undesirable loss of forest and ground cover, while stimulating vigorous herbaceous plant growth and promoting infiltration rates, reduced overland flow, and overall stable hydrologic and sediment regimes. The proper temporal (timing and frequency) and spatial planning, so as not to overlap treated areas still recovering from previous treatments and wildfire, are important factors for reaching desired conditions.

Stream and riparian restoration activities would promote maintenance or improvement of Water Quality, Water Quantity, and Riparian/Wetland Vegetation Conditions indicators by bringing these systems to desired conditions through stream and wetland stabilization, riparian planting and protection. The activities proposed in the Aquatics and Watershed Flexible Toolbox Approach, including stabilization structures, and riparian planting, would improve stream, riparian, and wetland conditions by bringing these systems closer to desired conditions. Improving stream channel functionality would promote stable hydrologic and sediment regimes, improving dissipation of flood energy, bank storage, and geomorphic maintenance. Barriers around riparian areas and springs would improve riparian vegetation survival and vigor, and protect vegetation from browsing and trampling by large ungulates.

The Watershed and Riparian specialist report (Brown 2018) provides a table showing total miles of stream restoration by HUC12 subwatershed. The highest percentage of streams proposed for restoration treatments are in subwatersheds with a Water Quality indicator rating of “Good,” a Water Quantity indicator rating of “Fair,” and a Riparian/Wetland Vegetation Condition indicator rating of “Fair” (table 28). The lowest percentage (seven percent) of streams proposed for restoration are in subwatersheds with Water Quantity and Riparian/Wetland Vegetation indicator ratings of “Good.”

Table 28. Percentage of Proposed Stream Restoration Treatment Miles by Overall Watershed Indicator Ratings

Water Condition Framework Indicators	Percentage of Proposed Stream Restoration Treatments		
	Fair	Good	Poor
Water Quantity	61%	7%	32%
Water Quality	11%	58%	31%
Riparian/Wetland	61%	7%	32%

Wildfires also can have a profound effect on Watershed Condition Framework indicators. Tables in the Watershed and Riparian specialist report (Brown 2018) display wildfires in Rim Country subwatersheds for two time periods: 25 years prior and up to the last re-scoring of the Watershed Condition Framework in 2012, and after that to the present. Over the past 25 years, 54 percent of Rim Country HUC12 subwatersheds burned over less than 25 percent of their total area administered by the USFS. Twenty-one percent of these watersheds burned from 25 to 50 percent of their total area, and 11 percent burned from 50 to 75 percent of their total area. Fourteen percent of the Rim Country subwatersheds burned over 75 percent. Some of the recent larger fires include the Snake Ridge, Juniper, San Juan, and Highline Fires. It should be noted that although wildfires burned over considerable proportions of many watersheds, it is the proportion of high and moderate burn severity, not reflected in these numbers, that is important relative to Watershed Condition Framework indicators. Wildfire is a natural disturbance for forest ecosystems, and frequent fire intervals are expected in most ecotypes within the Rim Country project area. A mosaic of burn intensities that are predominately on the lower end are desirable.

Roads can also affect watershed condition. Too many or poorly located roads can directly or indirectly cause loss effects such as increased surface flows, loss of soil productivity, soil erosion, and increased sediment delivery, which can cause unstable water flow regimes, degrade water quality, and riparian and wetland condition, Although roads can directly affect water quality and quantity, and riparian vegetation condition, they are included as a standalone indicator, the Roads and Trails indicator, in the Watershed Condition Framework. The Roads and Trails indicator only takes into account open system roads and trails and therefore by design would not necessarily be appropriate to capture temporary increases in road density from opening of maintenance level 1 roads and construction of temporary roads. All open roads and their potential effects on Water Quality, Water Quantity, and Riparian/Wetland Vegetation indicators have been built into the current watershed condition indicator scores. The design features in appendix C would restrict the location of temporary roads in order to minimize short-term watershed effects. Although maintenance level 1 roads are opened, there is a reasonable degree of certainty that these roads are not currently causing, nor will into the future cause resource effects. This assumption is in part based on the ongoing Travel Management Rule processes on the three Rim Country forests, with one decision signed and in the implementation phase and the other two pending. The Travel Management Rule process involves analyzing and proposing decommissioning of Forest Service System roads causing resource concerns. Given the number of roads and trails proposed for decommissioning in the Rim Country Project, it is likely that some watershed indicators and overall scores would improve the next time Watershed Condition Framework scores are updated.

Changing a watershed condition class would, in most cases, require changes in a watershed that are substantial in their scope and include treatments for multiple resources. However, all indicator scores are expected to be maintained or improved with the multitude of past, present, and reasonably foreseeable actions combined with the activities proposed in these action alternatives. Although future watershed restoration activities are expected to have long-term benefits to watershed condition, the intensity of coincidental watershed activities (too large a proportion of a watershed over too short a time) could potentially lead to negative effects. Specific design features, SW078 and SW080, for treatments proposed in the Rim Country Project are included in appendix C to avoid negative effects associated with the temporal and spatial intensity of treatments during implementation.

- *Climate*

In 2010, the Southwestern Region of the Forest Service released "Southwestern Region Climate Change – Trends and Forest Planning: A guide for addressing climate change in forest planning on southwestern National Forests and Grasslands. The following information is summarized from excerpts of this publication:

In the Southwest, climate modelers agree there is a drying trend that will continue well into the latter part of 21st century (IPCC 2007; Seager et al. 2008). Climate modelers predict increased precipitation, but believe that the overall balance between precipitation and evaporation would still likely result in an overall decrease in available moisture. Current drought conditions "may very well become the new climatology of the American Southwest within a time frame of years to decades". According to recent model results, the slight warming trend observed during the last 100 years in the Southwest may continue into the next century, with the greatest warming to occur during winter. Climate models predict temperatures to rise approximately 5 to 8 degrees Fahrenheit by the end of the century (IPCC 2007). This trend would likely increase demand on the region's already limited water supplies, as well as increase energy demand, alter fire regimes and ecosystems, create risks for human health, and affect agriculture (Sprigg et al. 2000).

While the region is generally expected to dry, it is possible that extreme weather patterns leading to more frequent destructive flooding would occur. Along with monsoons of higher intensity, hurricanes and other tropical depressions are projected to become more intense overall. Arizona typically receives 10 percent or more of the annual precipitation from storms that begin as tropical depressions in the Pacific Ocean. In fact, some of the largest floods in the Southwest have occurred when remnant tropical storms intersect frontal storms from the north or northwest (Guido 2008). Most global climate models are not yet accurate enough to apply to land management at the ecoregional or national forest scale. This limits regional and forest-specific analysis of the potential effects of climate change.

While the future of climate change and its effects across the Southwest remains uncertain, it is certain that climate variability will continue to occur throughout the region as it has in the past. Forest management activities should therefore strive to promote ecosystem resilience and resistance to impacts of climate change. Forest management activities should focus on maintenance and restoration of native ecosystems, thereby reducing the vulnerability of these ecosystems to variations in climate patterns. Forest management should also consider future climate scenarios that could affect precipitation patterns, changes in vegetative community patterns, and changes to inherent soil properties and changes to surface and groundwater dynamics. Ecological diversity remains an integral component in native ecosystems. Projects should promote connected landscapes and endeavor to restore significantly altered biological communities in a manner that promotes resilience to climate changes.

o Soils

▪ Affected Environment

This section provides information about the existing conditions of the affected environment for soils and watershed resources within the project area of about 1,240,000 (with potential restoration treatment area of 953,130 acres). It also includes an analysis of watershed conditions at the 6th Hydrologic Unit Code (HUC) level. This section establishes the baseline against which the decision maker and the public can compare the effects of all action alternatives.

Appendix A of the Soils and Watershed specialist report displays the Terrestrial Ecosystem Survey (TES) map unit stratification and soil interpretations based on similar soils properties and behavioral characteristics, vegetation communities and management risks, limitations and potentials. Appendix B of the Soils and Watershed specialist report displays the existing and desired conditions, need for change and potential management strategies in tabular format by TES map unit stratum.

Affected environment of riparian resources, water quality, and water quantity is analyzed in the Water and Riparian Resources Specialist Report (Brown, 2018).

There were 186 TES map units from the 3 forests that were aggregated into 30 landscape unit strata. Each stratum has similar soils properties, slopes, climate regimes and vegetation communities. These soils also have similar limitations, hazards, suitabilities for various management activities and production potentials. The strata were used in part to design treatments, analyze effects and are based on the potential plant community and capabilities of the soils.

▪ Assumptions and Methodology

This section describes the methodology and analysis processes used to determine the environmental consequences to soils and watershed resources from implementing the alternatives. Environmental consequences will be described with qualitative and quantitative descriptions supported by past studies and relevant literature.

Analyses for environmental consequences to soils and watershed resources that may result from implementation of each alternative were conducted using information contained in the Terrestrial Ecosystem Survey of the Apache-Sitgreaves National Forest, Coconino National Forest and Tonto National Forest, the Watershed Condition Framework, Ecological Response Unit (ERU) inventory maps (Triepke et al., 2014a and b), Forest Land Management Plans, Arizona Department of Environmental Quality (ADEQ), information obtained from other resource specialists, other agency reports, available literature, and input from collaborators, cooperators, and stakeholders. Geospatial analysis was used to quantitatively and qualitatively assess soils and watershed conditions using Geographic Information Systems (GIS) data obtained from a variety of sources.

▪ Soils and Watershed Indicators

Soils and watershed concerns include:

1. Percent of soil exposure across treatment areas

2. Percent of soil disturbance across the treatment areas
3. Severity of soil disturbance across treatment areas
4. Construction of new roads could increase surface runoff, erosion, and sediment delivery to ephemeral drainages.
5. Construction of fire lines, and piling and burning of activity-related debris could disturb, destabilize, and compact soils and expose them to erosion.
6. Burning of large debris piles can create enough heat to sterilize the underlying soils and create hydrophobic conditions, exposing those sites to erosion for an extended period of time.
7. The amount of vegetation removed through fuels treatments and the use of prescribed fire could increase short-term erosion rates.
8. Potential for soil rutting, compaction, and puddling caused by mechanical fuels treatments and fuelwood gathering.
9. The amount of sediment that reaches ephemeral streams or drainages (displayed as embeddedness) could increase.
10. The amount of sediment, debris, and ash that is introduced to municipal water supplies could adversely affect the quality of water entering public water supply systems
11. Prescribed burning could result in increased ash filling livestock and wildlife waters.
12. Cumulative effects to soils and watershed resources, when combined with past, present, and reasonably foreseeable future actions could be significant.

Soil and Water Resources Condition Indicators

For soil resources, the units of measure of effects to soil resources will be the acres and severity of ground disturbance from equipment use and acres subjected to high soil burn severity. Most adverse effects to soils and water resources can be minimized or mitigated through appropriate use of resource protection measures and design features such as Soil and Water Conservation Practices (SWCPs) and Best Management Practices (BMP's) as outlined in Soil and Watershed Conservation Practices Handbook (Forest Service Handbook 2509.22) (USDA 1990), the National Core BMP Technical Guide (FS990a)(USDA 2012), and other relevant BMP guidance.

For water quality measures, no physical stream measurements will be taken to determine water quality. A narrative description will explain the effects to water quality by Alternatives.

Soils

Soils throughout the project area were mapped as part of the Terrestrial Ecosystem Survey (TES) of each forest. This information is available at the respective Forest Supervisor's Offices.

The TES is the result of the systematic analysis, mapping, classification and interpretation of terrestrial ecosystems, also known as terrestrial ecological units that are delineated and numbered. A TES represents the combined influences of climate, soil and vegetation, and correlates these factors with soil temperature and moisture along an environmental gradient. It is an integrated survey and hierarchical with respect to classification levels and mapping intensities. It is the only seamless mapping of vegetation and soils available across the Rim Country analysis area that includes field visited, validated and correlated sites with a stringent

Regional and National protocol stemming from decades of work. Major field work for the TES was completed from 1979 through 1986, although some mapping and classification is ongoing on the Tonto National Forest.

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

The TES follows National Cooperative Soil Survey Standards similar to Soil Surveys conducted by the Natural Resource Conservation Service (NRCS). There has therefore been strict quality assurance including Project Leader field reviews, Regional Office reviews, and annual progressive and final field reviews to approve map unit design and mapping.

Soil taxonomic classification information is included in Appendix A of the Soils and Watershed Specialist's Report.

The TES is used to evaluate and adjust land uses to the limitations and potentials of natural resources and the environment. It presents important properties pertaining to the natural, physical, and behavioral characteristics of the terrestrial ecosystems and provides the background for making interpretations. Interpretations based upon TES incorporate 1) soil physical and chemical properties, 2) climatic considerations, 3) topographic position and slope, 4) vegetation and anthropogenic influences as well as animal effects, 5) productive and successional potentials, and 6) geologic influences. As such the TES can form the ecological basis for describing existing conditions for resource areas including watershed, wildlife, fire, and timber.

A need for change matrix (Appendix B, Soils and Watershed Specialist's Report) has been developed to disclose the existing and desired condition for soils by strata and the need for change and potential management strategies. The following is a summary of existing condition.

Soil condition is based on the primary soil functions of soil hydrology, soil stability, and nutrient cycling.

- *Erosion Modeling*

Soil erosion and sediment delivery rates for undisturbed forest, forest thinning, prescribed fire, wildfire, and road use were modeled using FS WEPP Interfaces. The FS WEPP interface allows users to easily describe numerous disturbed forest erosion conditions. The interfaces present the results as a summary and extended WEPP outputs, and also present the probability of a given level of erosion occurring the year following a disturbance. Values for predicted soil erosion rates by water movement are determined from rainfall simulations and field research of natural rainfall effects conducted by scientists within the USDA and other organizations (Elliot and Foltz 2001). The WEPP model has been further validated for use in the Southwest (i.e., Arizona and New Mexico) through research on hydrologic processes to predict responses of soils to disturbances (Bolton et al. 1991, Paige et al. 2003).

The Erosion Risk Management Tool (ERMiT) was used to model predicted erosion and sediment delivery from low, moderate, and high severity fire conditions in order to cover the range of possible soil burn severitiesfrom both wildfire and prescribed fire. Sediment yield rates for forest thinning treatments were modeled for each soil stratum using the WEPP Fuel Management (FuME) model. The WEPP FuME tool was developed to estimate sediment generated by fuel management activities. WEPP FuME estimates sediment generated for 12 fuel-related conditions from a single input. These conditions include: undisturbed forest, wildfire, prescribed fire, forest thinning, and p roads. The tool is designed to be used by erosion specialists for detailed analysis of effects of proposed fuel treatments, or by fuel management specialists for a quick estimate of potential sedimentation effects from a given stand treatment. Erosion rates for constructed forest roads were also modeled using the WEPP:Road interface. WEPP:Road is an interface to the WEPP soil erosion model that allows users to easily describe numerous road erosion conditions. WEPP:Road is designed to predict runoff and sediment yield from roads, compacted landings, compacted skid trails, and compacted foot, cattle, or off-road vehicle trails.

- *Watershed Condition Class and Prioritization Information*

It is important to note that the condition class of a watershed integrates the effects of all activities within a watershed, including those of other landowners. The Watershed Condition Framework therefore provides an ideal mechanism for interpreting the cumulative effects of a multitude of management actions on soil and hydrologic function (USDA, 2011).

It is reasonable to expect that treatments resulting from implementation of the proposed action or other action alternatives would result in some short-term, localized negative effects due to soil disturbance caused by use of heavy machinery for mechanical forest restoration treatments (including commercial timber harvests), burning of piled woody debris, and broadcast prescribed fire (Debano 1998, Hungerford et al., 1991). These disturbances would also occur on soils where previously completed projects overlap proposed or future activities in watersheds across the project area, resulting in a cumulative effect to soils and watersheds. However, no long-term, cumulative adverse effects from ground disturbance caused by mechanical thinning or prescribed fire (compaction, topsoil displacement, extensive areas of high soil burn severity, etc.) are anticipated to occur at a severity or spatial extent to negatively affect overall soils and watershed conditions. In general, proposed restoration treatments are expected to result in improvement in overall soils and watershed condition in proportion to the areal extent of the restoration treatments within each watershed.

Proposed processing sites and gravel pits for road surfacing materials are expected to exhibit long term negative effects due to extended use of processing sites and extractive operations in gravel pits, which permanently alter landscapes and soils. Gravel pits constitute an irreversible and irretrievable commitment of natural resources (soils and underlying minerals). With implementation of applicable Best Management Practices, design features and mitigation measures, most adverse effects can be minimized or mitigated, reducing long term degradation of soils or watershed conditions.

Environmental Consequences

This section describes the direct, indirect, and cumulative effects of implementing each alternative on the soil and water resources in the Rim Country Restoration Project analysis area. It presents the scientific and analytical basis for the comparison of the alternatives presented in Alternatives section and establishes the baseline against which the decision maker and the public can evaluate the effects of the action alternatives.

- *Alternative 1 – No Action*

The No Action Alternative would result in no changes to current rates of vegetation management, commercial timber harvesting, pre-commercial vegetation treatments, or other mechanical or non-mechanical fuels reduction treatments; no changes to road construction, maintenance, decommissioning or obliteration; and no changes to prescribed fire implementation or wildfires managed for multiple resource benefits within the Rim Country Restoration project area. These activities would continue at the current scale and rate. Planned projects (e.g., Cragin Watershed Protection Project, etc.) would be implemented in accordance with official decisions and available funding. Therefore, there would be no changes to current direct effects to soils, water quality, ephemeral or intermittent stream channels, or watershed condition as a result of the no-action alternative. Other proposed activities such as restoration of springs, riparian habitats, grasslands, and meadows would continue at current rates rather than the accelerated rate proposed in the action alternatives. These important landscape features and wildlife habitats would be expected to remain in degraded or impaired conditions for longer periods than under the action alternatives.

Due to the substantially extended temporal timeframe and reduced scale under which restoration actions would occur under the No Action alternative (i.e., individual projects rather than landscape-scale restoration), it is reasonable to expect that short term adverse effects to soils and watershed conditions that result from mechanical and prescribed fire treatments would also occur at a reduced rate and scale.

- *Absence of Upland Vegetation Treatments and Prescribed Fire*

Since tree basal area or density reduction of currently overstocked stands within the project area would not occur at the same rate as under the action alternatives, increased fuel loading in both living biomass and woody detritus would be expected through natural forest ingrowth and tree encroachment into existing openings followed by forest decadence caused by intraspecific and interspecific competition. Additionally, forest ingrowth would continue to increase "ladder fuels" which allow ground fires to ascend and spread quickly as crown fires. Coarse woody debris would be expected to increase over time as small, medium, and large diameter material begins to fall to soil surfaces and decay. While these conditions may improve soil quality in some regards (organic matter accumulation in subsurface horizons, microhabitat for soil organisms and increased organism populations, increased water holding capacity) they would also result in an increased risk of high severity wildfires where fuel loading becomes excessive.

The location, size and severity of future wildfires cannot be estimated with accuracy, although some generalizations can be made. High severity wildfires tend to occur in areas where fuel loading and fuel distributions are sufficient to carry a fire. Typically, uncontrolled wildfires occur during the drier times of the year, yielding higher severity fires than would occur under prescribed fire conditions. The adverse effects of a high severity wildfire, such as the loss of forest floor organic matter, increased soil erosion and sediment delivery to waterbodies, and changes in soil habitat and biota would be more widespread in an uncontrolled wildfire than under prescribed fire conditions (DeLong et al., 2017, Spigel and Robichaud 2005). The primary effect of high severity wildfire on soil productivity is the removal of understory vegetative cover and surface organic matter (i.e., loss of protective cover and nutrient stores), exposure of soil surfaces to erosion by wind and water, and exposure of soils to solar radiation, which increases soil temperatures and reduces soil moisture. If surface organic matter is reduced (as happens under high-severity, long-duration fire) the cation exchange capacity of the soil is also reduced and the ability of the soils to retain nutrients leached from ash also decreases.

Lata, (2012) suggests that up to 33 percent of ponderosa pine forest could burn under high burn severity conditions. Historically, large stand-replacing wildfires on the Coconino National Forest have resulted in 10-25 percent of the burned acreage exhibiting high severity fire (Schultz Fire BAER Report, 2010; Slide Fire BAER Report, 2014; Tinder Fire BAER Report, 2018). Therefore, if a 10,000 acre wildfire were to occur within the analysis area, approximately 1,000 to as much as 3,300 acres of high severity fire could adversely affect soils and watershed conditions.

There have been many examples of high severity wildfires occurring in the southwestern United States in areas that were originally open, fire-adapted forests. Such events can have profound negative effect to soil properties including: a) decreased soil productivity through loss of nutrient sources b) soil hydrophobicity (i.e. the inability of soils to absorb water following precipitation resulting in increased overland flow, and c) increased susceptibility of soils to erosion by both wind and rainfall (Neary et al., 2012, Youberg et al, 2013).

In the absence of mechanical vegetation and fuels treatments and prescribed fire, a high severity wildfire would very likely result in increased surface runoff and downstream flooding, soil erosion, and sediment delivery to streamcourses as a result of loss of effective ground cover at the soil surface, reduced rainfall interception, and reduced soil water infiltration rates. The infrequent nature of ephemeral stream flow results in the potential for sediment and ash to be stored within these stream channels and then transported during the larger surface runoff events. This, in turn, could pose detrimental effects to surface water quality and water storage capacity in livestock and wildlife waters.

This alternative would result in no additional acres of ground disturbance over current levels from tree felling, piling of activity-related woody debris, use of prescribed fire, temporary road construction, or expansion of gravel pits. Risk of uncharacteristic wildfire would not be reduced at the same rate as the action alternatives. No improvement would be realized in forested areas, woodlands, savannas, and grassland vegetative types where vegetative ground cover conditions are departed from desired conditions. No road decommissioning, or rehabilitation of unauthorized routes or stream crossings would occur above current levels. The project area would therefore not move toward desired conditions as outlined in the Apache -Sitgreaves, Coconino, and Tonto Forest Plans as rapidly as under the Action Alternatives.

Historic land management activities, including livestock grazing and fire suppression have resulted in changing vegetative conditions over the last 100 years. These conditions have produced an uncharacteristic accumulation of fuels and increased forest density within the project area, resulting in increased the risk of high severity wildfire in many areas within the Rim Country Restoration Project and increasing the difficulty and risk of wildfire suppression. Additionally, the resulting loss of natural fire regimes and characteristic fire behavior throughout the analysis area has resulted in drainages and meadow systems that are starved of sediment, meaning the lack of sediment delivery to these areas makes meadow restoration difficult where gullies had channels have formed in meadows.

The No Action alternative would not adequately contribute to reduced forest vegetation densities, desired fire regimes, and forested conditions that would provide resilience against uncharacteristic disturbances such as high severity wildfire, insect and disease outbreaks, and prolonged drought or climate change induced mortality. Currently 37 percent of the Rim Country project area has a Fire Hazard Index of moderate or higher, which presents difficult and dangerous suppression conditions during a wildfire and potential for adverse post fire effects on soils and surface water quality. Four percent of the landscape is in the very high category (Fire Ecology and Air Quality Specialist Report). Under dense forested condition, litterfall has resulted in thick forest floor litter layers that have displaced native plant communities. These native plant communities provided greater benefits to watershed condition and soil hydrologic function than litter alone through improved fine root turnover rates, increased fine litter, improved soil porosity and aggregate stability, increased water holding capacity, and increased organic carbon sequestration.

The effects of high severity wildfires on soils, watershed condition, water quality and water quantity are well understood (DeBano et al. 1976, 1996, 1998, USDA 2005). High severity wildfires can cause damaging flows to streams resulting in high levels of sediment and ash inputs as well as increased risk to riparian areas and other downstream values at risk, including forest infrastructure. It is likely that under any conditions, a wildfire entering these untreated watersheds under the no action alternative would have considerably greater effects to soil productivity, water quality and channel stability than wildfire occurring after implementation of the action alternatives. Increased water turbidity, and downstream flooding would be more widespread in an uncontrolled wildfire situation than under prescribed fire conditions where the size and intensity of the fire can be controlled. The bulking effect of sediment, ash, and debris in runoff increases the risk to surface water impoundments, infiltration basins, and public water treatment systems. Sediment and debris flows can damage water supply infrastructure (Blandon et al., 2014). Sedimentation of impoundments can decrease their effective life, resulting in a need for dredging and other mitigation measures.

In areas of high stand densities, long-term improvement in hydrologic processes will occur in the absence of mechanical treatment and/or prescribed fire. The soils in these areas have reduced moisture storage and infiltration capacity and are easily overwhelmed by high intensity summer monsoon precipitation events, producing runoff with relatively high peak flows of short duration.

Other potential detrimental effects to hydrologic conditions in the project area and downstream locations could include the destabilization of the geomorphic conditions of stream channels due to excessive sediment delivery and debris loading, increased peak flows, and overall increases in average annual water yield resulting from loss of upslope interception, infiltration, and evapotranspiration. Ephemeral stream channels within high burn severity areas would lose their ability to buffer runoff from large rainfall events, resulting in increased channel scour and incision caused by accelerated runoff and erosion from severely burned watershed areas. Increased bedloads in stream channels effectively raises the elevation of stream bottoms, causing flood flows to exceed channel capacities, resulting in overland flooding.

Another effect is sediment and ash deposition in downstream roads, stock tanks and meadows, even if such areas may not have burned. In addition, sediment and ash-laden overland flows may damage low lying roads by eroding road traveled ways and filling culverts and low water crossings with sediment and debris. These are examples of why post-wildfire watershed conditions are significantly different from pre-fire or low-severity prescribed fire conditions.

Additional direct and indirect effects of the No Action alternative include ongoing erosion and sediment delivery to ephemeral channels from roads proposed for obliteration under the Action Alternatives that would not be obliterated under this Alternative. When combined with other activities in the proposed project area, sediment production from these roads could contribute to adverse effects to downstream surface water quality if these roads remain in an unstable, eroding condition.

In the absence of proposed vegetation treatments proposed in Alternative 2, including prescribed fire, approximately 953,130 acres of soils resources and watersheds would not be improved.

In the absence of proposed vegetation treatments proposed in Alternative 3, including prescribed fire, approximately 529,060 acres of soils resources watersheds would not be improved.

- *Absence of Riparian Area, Wet Meadow and Stream Restoration Treatments*

Watershed condition is dependent on the condition of the riparian communities that exist within the watershed. The benefits of riparian areas in the project area cannot be over emphasized. Riparian areas help capture pollutants including sediment and nutrients, contribute to channel stability by providing protective vegetative cover and root biomass that anchors soils, regulate water temperatures by providing shade, provide areas for floodwater storage and dissipation and are important wildlife habitat features. As noted in the Riparian and Water Quality Specialist's Report (Brown 2018), several stream reaches within the Rim Country EIS analysis area are experiencing increased water flows and sediment delivery from the effects of poor upland conditions, some of which are the result of historic wildfires. The increased flows have resulted in vertical and lateral channel instability in many intermittent and perennial stream reaches. Riparian vegetation has either been scoured away or reduced through increased channel incision that has detached riparian communities from adjacent floodplains. Stream channel substrates have been altered through increased runoff and in-channel transport. In the absence of proposed riparian, wet meadow, and stream restoration activities, watershed condition would not be improved on 21,280 acres of riparian areas, wet meadows and stream channels. As a result, these areas will continue to not meet desired conditions as outlined in Forest plans and existing risks to water quality would persist.

- *Absence of Road Decommissioning*

As shown in Table 14, roads are a major contributor to surface water quality degradation and long term loss of soil productivity. Additionally, system (i.e., permanent) roads convert productive soils to a non-productive condition for the long term (i.e., typically greater than fifty years). They therefore constitute an irretrievable, but not irreversible commitment of resources. Irretrievable is a term that applies to the loss of production, harvest or use of natural resources. Irreversible is a term that describes the loss of future options. It applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or those factors, such as soil productivity, that are renewable only over long periods of time. Since soil productivity can be restored through application of remedial measures such as disking, ripping, revegetating, etc., loss of soil productivity is not irreversible. However soil productivity is lost throughout the duration that a road exists on the landscape.

Under the No Action alternative, decommissioning of up to 200 miles of existing system roads on the Coconino and Apache-Sitgreaves NFs, and up to 290 miles on the Tonto NF and 800 mile of unauthorized road would not occur. Based on an average width of 12 feet, there are approximately 1,877 acres of roads planned for decommissioning (713 acres of NFS system roads and 1,164 acres of unauthorized roads). These roads would remain on the landscape as unproductive sites and as chronic sources of sediment to streamcourses. Existing open roads and unauthorized routes would likely continue to be used for motorized travel and would remain as chronic sources of pollution, including sediment to stream channels throughout the Rim Country area, especially where the roads are poorly located in stream bottoms or hydrologically connected to streamcourses or have inadequate stormwater control or drainage.

- *Absence of Rock Pits and In Woods processing sites*

Alternative 1 - No Action would have slightly more potential of increased sediment delivery to waterbodies than the action alternatives since road improvements proposed under the Action Alternatives would not occur. Selection of Alternative 1 would mean that road improvements would continue to occur at existing levels, which are currently insufficient to maintain road infrastructure adequately. Roads would therefore continue to serve as chronic sources of sediment to streamcourses and downstream waterbodies.

Expansion of rock pits under the Action Alternatives constitutes an irreversible and irretrievable commitment of resources since productive land is permanently altered and converted to an unproductive status and soils are permanently altered from their in situ condition through overburden removal and extraction of rock for road surfacing. Irreversible is a term that describes the loss of future options. It applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity, that are renewable only over long periods of time. Irretrievable is a term that applies to the loss of production, harvest, or use of natural resources. Rock extraction limits future options for use of the converted sites and for of the material extracted. The No Action Alternative would mean that 66 acres of rock pit expansion would not occur, thereby eliminating this irreversible and irretrievable commitment of natural resources.

Alternative 1 would eliminate the need for 12 wood processing sites (128 acres). Activities such as drying, debarking, chipping stems and bark, processing and sorting logs to size, scaling and weighing logs and creating poles from suitable sized logs would therefore not occur. These sites constitute an irretrievable commitment of soils and vegetation resources since they remove soils and vegetation from productive status for several years while the sites exist. Selection of Alternative 1 would eliminate the need for this irretrievable commitment of soils and vegetation resources.

- *Effects Common to Both Action Alternatives*
  - *Upland Vegetation Treatments*

Potential effects of the Action Alternatives on soil productivity would include localized soil compaction, puddling, displacement, erosion, loss of soil organic matter, short-term changes in soil moisture content or retention, changes in nutrient cycles, changes in soil fauna, and introduction of noxious or invasive weeds. These effects can result from both mechanical and non-mechanical vegetation treatments (i.e., forest thinning), mechanical and non-mechanical piling of activity-related debris, and road construction and maintenance activities necessary to support mechanical vegetation treatments. Mechanical forest vegetation treatments have the potential to adversely affect water quality through introduction of sediment and additional nutrients from decomposing woody debris, particularly where mechanical vegetation treatments occur in areas adjacent to stream courses. Implementation of design features and BMPs as specified in Appendix F of the Soils and Watershed Specialist's Report would minimize or mitigate adverse effects to soils and water quality from these activities.

Soil compaction, puddling and displacement would primarily be limited to the transportation systems and high traffic areas within mechanical vegetation treatments such as existing National Forest System roads, temporary access roads, skid trails, log landings, debris piling areas, and areas where fireline construction occur. Road closures and curtailment of mechanical vegetation treatments during wet weather conditions and designation of authorized access routes (skid trails and temporary roads) and log landings prior to project implementation would minimize adverse effects to soil productivity caused by these activities. With implementation of applicable design features and BMPs as outlined in Appendix F, of the Soils and Watershed Specialist's Report most adverse effects to soils would be minimized or mitigated, although not totally eliminated. Additionally, natural disturbance of soils caused by seasonal wetting and drying, freezing and thawing, and soil organism activity would naturally ameliorate some adverse effects to soils caused by the proposed Action Alternatives.

The effects of the proposed forest restoration activities on erosion and sediment yields depend on methods and equipment used, skills of the equipment operators and personnel conducting the treatments, site-specific conditions, storm event timing and intensity, and prescribed fire locations and burn severities.

The risk of short-term accelerated soil erosion would be highest in areas where forest thinning and use of prescribed fire results in soil disturbance or complete removal of vegetative ground cover. These areas are expected to include skid trails, log landings, temporary access roads, obliterated roads, installed firelines and fuels treatment areas to support prescribed burning efforts, and National Forest System roads.

The removal of forest cover can decrease raindrop interception and evapotranspiration, which can increase water yields from treated areas (Bosch and Hewlett 1982, Stednick 1996). In areas where the annual precipitation is less than 20 in (500 mm), removal of the forest canopy does not typically increase annual water yields (Bosch and Hewlett 1982). The decrease in interception and transpiration caused by forest thinning is usually offset by the increase in soil evaporative losses, resulting in no net change in runoff as long as factors affecting runoff processes are not changed (for example, soil compaction which causes a shift from subsurface flow to overland flow) (MacDonald and Stednick 2003). Evapotranspiration rapidly recovers with vegetative regrowth in partially thinned forests. Increases in runoff due to thinning operations rarely persist for more than 5 to 10 years (Robles et al. 2014, Cram et al. 2007)..

Thinning of forest cover on soils currently characterized as unsatisfactory would improve soil conditions over the long-term by improving soil moisture and allowing greater sunlight penetration to the forest floor (i.e., sunflecks) resulting in an increase in grasses, forbs and shrubs in the forest understory where litter is currently the dominant soil cover (Griffis et al., 2000). The increased herbaceous vegetation would reduce soil erosion rates by providing vegetative ground cover that would intercept rain before it can reach soil surfaces and detach and entrain soil particles in runoff. Woody debris from forest thinning (i.e., slash) would be lopped and scattered where doing so would not result in excessive fuel loads, further mitigating potential adverse effects to soils and watershed resources. Finer litter and woody debris that is incidental to forest vegetation treatments (i.e., needles, leaves, twigs, cones, bark, etc.) would also remain on the ground following mechanical treatments to protect soil surfaces from wind and water erosion.

- *Prescribed Fire*

Prescribed fire has the potential to affect water quality by increasing sediment, dissolved solids, and nutrients in streams. Dissolved nutrients in stream flow primarily originate from weathering of parent materials and soils, decomposition of plant material and other organic matter, and anthropogenic sources. Vegetative communities accumulate and cycle nutrients (Tiedemann et al. 1979, 1987). Fire can disrupt nutrient cycling and cause nutrient volatilization, leaching, and transformations. When vegetation is consumed by fire, some of the soil and organic matter nutrients such as nitrogen, phosphorus, copper, iron, manganese, and zinc are volatilized and lost from the system, while other nutrients such as calcium, magnesium, and potassium are converted into oxides and accumulate in ash (DeBano et al. 1998).

The mobility and concentration of nutrients in soils determines whether or not nearby water sources are at risk of contamination when prescribed fire is used. Nitrate is highly mobile and is therefore subject to risk of being leached from burned areas and transported to either surface or ground water. Phosphorus adsorbs readily to sediment and organic materials. Thus, phosphorus is usually transported to streams and water bodies through soil erosion. Rates of soil erosion and phosphorus contamination are generally dependent on soil characteristics and topographic relief of the site.

Prescribed fire has the potential to alter short- and long-term soil productivity and moisture content by changing the amount and type of vegetation, the amount of forest floor organic matter, and surface soil texture and wettability(O'Donnell et al., 2014). Prescribed fires typically leave greater amounts of organic matter (duff, forest litter, and large and small woody debris) on soil surfaces than uncontrolled fires. These materials serve as nutrient sinks, prevent soil particle detachment caused by raindrop impact, and capture sediments that would otherwise be transported to stream channels and waterbodies. Following low-intensity prescribed fires, an increase in grasses and other herbaceous vegetation often occurs. This rapid regrowth of ground cover further immobilizes nutrients in plant material.

Prescribed fires that remove large amounts vegetation from a site have potential to alter watershed hydrology. As vegetation is removed, evapotranspiration in the watershed decreases, thus providing greater stream flow and overall water yield within the watershed. Water uptake from trees is species-specific. Conifers, which are the dominant vegetation type throughout the Rim Country analysis area, generally transpire greater quantities of water than hardwoods such as oaks and aspen. Dense foliage and longer growing seasons promote the higher overall water uptake in conifers. Additionally, conifers have relatively dense crowns that intercept rainfall and allow for greater evaporative losses.

Once a site has undergone loss of vegetation and removal of the litter layer, surface water can cause erosion problems and result in higher stream discharges. Fires not only consume portions of the litter layer, but at high temperatures fires can also cause hydrophobic soil conditions (water repellant soils), thus making soils more susceptible to erosion. DeBano and Krammes (1966) and Robichaud (2000) observed that water repellency was dependent on the heating temperatures of the soils. At typical wildfire soil profile temperatures (less than 500°F) when the soil was dry, soil hydrophobicity occurs at shallow depths (less than 1 inch). When soils are moist (i.e. conditions that commonly occur during prescribed fire in the spring and fall), soil hydrophobicity was less pronounced and only occurred after long heating times which would typically only occur during smoldering fires. Therefore, soil hydrophobicity under a prescribed fire scenario would likely be minimal in most cases.

Fire in southwestern ponderosa pine forests has been shown to generally increase soil moisture content (Ryan and Covington 1986, Ower 1985, Haase 1986). In a review of literature, Hungerford and others (1991) reported that burning can kill many kinds of bacteria, fungi and arthropods but the extent of this effect is dependent on the amount of heat generated by the fire and soil moisture content. To what extent these changes result in an impairment or degradation of soil productivity is not clearly understood. Hungerford suggests that low to moderate intensity prescribed fires may have minimal long-term negative effect on soil microorganisms. Kaye and Hart (1998) found that microbial nitrogen transformation rates increased under restored forest conditions, relative to the controls, suggesting higher microbial activity in the restored areas. Neary and others (1999) caution against the adverse effects to soil microorganisms caused by fires that become intense or are too frequent. Researchers have recommended maintaining soil carbon pools to maintain biologic activity (Stark and Hart, 1997), and recommend maintaining heterogeneity in burned areas to provide suitable sites from which the microflora and microfauna can reestablish in burned areas (Moldenke, 1999).

Prescribed fires proposed under the action alternatives are expected to be dominantly low soil burn severity with small areas of medium and high soil burn severity, retaining unburned islands and creating a mosaic of fire effects. Low and medium severity fires burn only a portion of the surface organic matter – leaving adequate soil cover over much of the burned area. In general, low severity prescribed fire does not cause excessive erosion or sediment transport since some soil cover is retained in a discontinuous pattern across the landscape. This type of prescribed fire would not have a long-term adverse affect on soil moisture content or biota. The increase in understory vegetation would improve long term soil structure and porosity through increased fine root volume and vegetative litter, which are important habitat components for soil fauna that then incorporate organic matter into soil profiles and facilitate nutrient cycling.

Installation of firelines where they do not currently exist would expose soil surfaces, increasing the risk of erosion by both wind and rain. Areas of high severity fire may consume forest floor organic matter, leaving soil surfaces hydrophobic (i.e., repellant to water) and susceptible to erosion. Initially, the greatest risk of soil erosion would be expected to occur in areas where prescribed fire is implemented prior to forest thinning treatments. This is due to greater amounts of woody debris on the ground, higher stand densities and crown bulk densities at these locations, resulting in increased risk of high severity fire. Rehabilitation of firelines installed during prescribed burning would minimize adverse affects to soil productivity from fireline installation. Implementing prescribed burning under conditions that would minimize high severity fire would minimize areas where soil organic matter is totally consumed and prevent hydrophobic soil conditions.

Piling of activity-related debris (slash) would disturb soil surfaces, exposing them to direct raindrop impact and wind. On steep terrain this would increase localized, short-term erosion rates in areas where pile burning is conducted. These areas would constitute a very small percentage of overall treatment area (i.e., 10 to 15 percent), so these effects are expected to be minor. Use of appropriate design features and BMPs as outlined in Appendix F would mitigate most adverse effects from piling of woody debris created during forest thinning operations. Additionally, use of excavators with hydraulic bucket thumb attachments would minimize soil disturbance resulting from machine piling more effectively than dozer piling.

Burning of slash piles has been shown to negatively affect soil biotic and chemical properties due to intense soil heating (Korb et al, 2004 and Seymour and Tecle, 2004). It can result in soil sterilization, increased erosion risk and an increased risk of noxious or invasive weeds that displace native vegetation. Pile burning sites would constitute a very small portion of the project area (i.e., less than 10 percent). Employing piling techniques that would minimize soil burn severity (e.g., rack-and-pile technique) whereby the pile is elevated on a grid of logs would reduce soil of these sites for the presence of noxious or invasive weeds following pile burning, and treatment of any infestations found would mitigate most adverse effects to soils caused by pile burning of slash.

Soil organic matter serves as the long-term nutrient supply for all vegetation occupying a site. It also provides microhabitat for most soil organisms and improves soil chemical and physical properties including soil aggregate stability, increased porosity, improved water holding capacity, lower bulk densities, and nutrient cycling. Initially, there would be an expected short-term increase in soil organic matter as a result of mechanical vegetation treatments as fine litter and woody debris are deposited on soil surfaces during treatments. Forest thinning would also allow greater light penetration to soil surfaces resulting in warmer soil temperatures. The reduction in tree vegetative cover as a result of forest thinning would decrease overall evapotranspiration rates from trees, but this is typically offset by increased evapotranspiation of understory herbaceous vegetation within a few years following treatment. Warmer soil temperatures would result in increased soil biological activity. Increased soil biological activity results in a proportional decrease in soil organic matter as organisms consume soil detritus. The eventual increase in understory vegetation would result in increased litterfall and deposition of organic matter onto soil surfaces. Broadcast prescribed fire would result in rapid oxidation of surface organic matter and living understory biomass, causing a release or transformation of some soil nutrients. Over time, a balance would occur between soil organism activity and soil organic matter content. This balance is readjusted whenever fire is reintroduced. Low severity fire typically results in beneficial relationships between soil organism populations and soil organic matter content.

Runoff from road surfaces can detach and transport the fine material from road prisms and ditches. Sediment delivery directly from road surfaces to water courses is difficult to estimate since it occurs as non-point runoff. Sediments delivered to streams from roadside ditches may have originated from sheet or rill erosion prior to entering road surfaces or drainage ditches. In the absence of vehicle traffic, sediment concentrations in road runoff decreases over time. However, vehicle traffic, particularly trucks, can pulverize road surface aggregates, resulting in more fine particles that are easily transported in runoff. Additionally, the pressure of vehicular tires on saturated road surfaces can force fine particles from below the surface to move upward to the surface (Truebe and Evans 1994). Road proximity and connectivity to drainages can strongly influence sediment delivery to watercourses and peak flows in streams. Roads within the project area intersect numerous ephemeral drainages. These points of intersection occur as both culverted crossings and low-water crossings. Road-stream intersections are the primary location where sediments are delivered to stream courses.

- *Temporary Road Construction and Road Improvements*

Temporary road construction constitutes an irretrievable commitment of soils and vegetation resources to a project. This is because they commit soils to nonproductive status for the duration of the road's existence and for several years afterwards, soil profiles are permanently altered from the *in situ* conditions, and vegetation (timber and forage) is removed from the traveled way. However, temporary roads are not an irreversible commitment of these resources, since soils eventually return to productive status after the road has been decommissioned and vegetation, including trees, typically returns to the road corridor.

Temporary roads are minimum design standard roads and therefore have fewer negative environmental effects that permanent roads. Typically, temporary roads are native surface roads that are simply "bladed" soil surfaces to smooth the soil surface sufficiently for log transport for short distances (i.e., usually less than a mile). Temporary roads usually do not have culverted stream crossings or long segments of fill material.

Both Action Alternatives will require installation of temporary roads. Alternative 2 would require approximately 330 miles of temporary roads in order to access areas for mechanical vegetation treatments, while Alternative 3 would require 170 miles of temporary roads.

Depending on temporary road locations and timing of use, these roads can adversely affect soil productivity for the duration of the road use and for several years following decommissioning and abandonment. Design criteria and BMPs in Appendix F of the Soils and Watershed Specialist's Report would limit adverse effects of temporary roads by preventing them from being located in sensitive areas (Aquatic Management Zones, near spring ecosystems, and in riparian habitats) except where designated stream crossings are necessary. Upon decommissioning, temporary roads would have water control features installed as needed, would be stabilized using logging slash to protect soil surfaces from raindrop impacts, minimize soil erosion, and prevent visitors from using the road for motorized travel.

Temporary roads are therefore expected to have minimal long-term effects to soil productivity, water quality, and vegetation and therefore watershed condition.

Existing system roads may be improved or realigned to provide serviceable and safe access for forest mechanical vegetation and prescribed fire treatments. These improvements will protect soil productivity and surface water quality by: a) preventing roadbed erosion through application of aggregate to provide a more stable and reliable running surface, b) provide road drainage that prevents erosion and sediment delivery to streamcourses, c) reduce effects of stream crossings through improved road stream crossing designs.

- *Road Use*

Approximately 5,682 miles of National Forest System roads would be needed to implement the Action Alternatives. Vehicle traffic associated with project implementation, particularly trucks, tend to pulverize road surface aggregates, resulting in more fine particles that are easily transported in runoff. Road proximity and connectivity to drainages can strongly influence sediment delivery to watercourses and alter flow regimes in streams.

It is likely that traffic associated with mechanical restoration treatments and commercial timber sales would have short term adverse effects to surface water quality through sediment delivery to streamcourses and other water bodies and increases in turbidity. Use of Resource Protection Measures and applicable road BMPs would minimize and mitigate most adverse effects from road use, but would not eliminate them entirely. As previously noted, forest roads are typically one of the major sources of surface water quality degradation from forest operations.

Once mechanical treatments are completed and transportation of forest products and machinery no longer occur on a given road, adverse effects to water quality typically diminish and return to background level proportional to historic road use levels.

- *Road Decommissioning*

Approximately 490 miles of poorly located and infrequently maintained system roads would be decommissioned under the Action Alternatives (200 on the Coconino NF and A-S NF and 290 miles on the TNF). Additionally, approximately 800 miles of unauthorized roads would be decommissioned on the A-S and Coconino NFs.

Road decommissioning actions will vary, depending on road locations, conditions, and effects on other resources (e.g., soils, water quality and watershed conditon), but could include activities such as ripping, seeding, mulching, filling inside ditches, outsloping road prisms, removal of culverts and fill material, re-contouring of stream crossings, removal of unstable sidecast material or cutslope stabilization, and blocking of entrances to prevent future access. These activities would return unproductive or marginally productive soils to a more stable, productive status over the long term by improving water infiltration and vegetative ground cover and reducing erosion hazards. Stream crossings would be returned to a more natural condition, thus reducing runoff and sediment delivery into ephemeral stream channels or intermittent or pernnial waterbodies. Adverse effects to surface water quality caused by stormwater runoff from road surfaces would also be minimized. Modeled erosion rates of roads are, to a large degree, at or above tolerance erosion rates.

Use of residual woody debris from mechanical timber harvest (i.e., slash) or fuels reduction treatments for closing roads is a common practice for road decommissioning. However, this practice rarely improves hydrologic function where roads have interupted or redirected surface flows via ditches and cross drain culverts, road surfaces are severly compacted, or have channelized flow in the existing roadbed. Additionally, slash can be burned in wildfires and prescribed fires, leaving roads essentially reopened to unauthorized use. Slash alone does not appreciably contribute to native plant propagation within retired roadbeds. While slash can be used as a tool to prevent road use, it should be one component in a suite of road decommissioning practices described above that result in a more naturalized condition upon completion of road decommissioning.

Road decommissioning improves watershed condition by reducing open road densities within affected watersheds. Reducing the number of roaded miles per unit area of watershed reduces hydrologic impacts that roads have on that watershed. Hydrologic impacts such as stream crossings and hydrologic diversions that result from road ditches, cross drainages, etc. are therefore reduced. Road decommissioning typically results in improved soil productivity and water quality(Sosa-Perez and MacDonald, 2017). .

- *Rock Pits and Wood Processing Sites*
  - Rock Pits

As previously noted, expansion of rock pits under the Action Alternatives constitutes an irreversible and irretrievable commitment of 27 acres of soils and geologic resources since productive land is permanently altered from its natural condition and converted to an unproductive condition in perpetuity and through the extraction of rock for road surfacing. Irreversible is a term that describes the loss of future options. It applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity, that are renewable only over long periods of time. Irretrievable is a term that applies to the loss of production, harvest, or use of natural resources. Rock pit expansion limits future options for use of the converted sites and rock extraction eliminates future options for use of the extracted material. Both Action Alternatives would mean that 27 acres of rock pit expansion would occur, thereby making an irreversible and irretrievable commitment of natural resources.

  - Wood Processing Sites

The Action Alternatives would include 12 wood processing sites totaling 128 acres. The criteria for selection of sites suitable for wood processing included the following: flat uplands having less than 5% slope, more than 200 feet distance from ephemeral and intermittent stream channels, and more than 300 feet from meadows and springs. These design criteria, in addition to applicable Resource Protection Measures, would reduce the potential for adverse effects to surface water quality, stream channels, riparian resources, and spring ecosystems. However, these sites constitute an irretrievable commitment of soils and vegetation resources since soils would be committed to nonproductive status for the duration of each wood processing site's existence and vegetation removal would be required for establishing sites, reducing the areal extent of available forage or forest cover. The scale of this irretrievable commitment of soils and vegetation resources for the establishment of wood processing sites in the context of the total project area is minimal at 129 acres and would not likely have detectable adverse effects at the watershed scale.

- *Riparian, Spring and Stream Restoration*

Comprehensive restoration activities included in the Action Alternatives and described in the Aquatic and Watershed Flexible Toolbox would directly improve stream channel morphology, riparian and slope wetland conditions, floodplain functionality and spring ecosystems. Restoring stream channel gradients and increasing channel sinuosity, restoring width-to-depth ratios and reconnecting stream channels to their historic floodplains would improve hydrogeological conditions at the watershed level. Surface flows, floodplain water storage, and sediment transport would all be improved. Activities such as installation of grade control structures has been shown to be effective for dissipating runoff energy, improving sediment storage, aggrading incised stream channels and reconnecting them to historic floodplains. Wet meadows would be effectively restored through implementation of these, and similar practices that eliminate single-thread streams and gullies that are drying out these wetlands. Planting native herbaceous riparian species, stabilizing stream banks, reducing bank steepness of entrenched channels and reconstructing riffle and pool formations would contribute to improved hydrologic function of stream channels

Since upland restoration actions (i.e., forest thinning and prescribed fire) could have a cumulative effect on restoration of riparian areas, springs and streams, it is imperative that upland restoration actions are staged in a manner that compliments comprehensive restoration activities. Upland restoration treatments are expected to produce varying levels of runoff and sediment delivery to riparian areas such as wet meadows and riparian stream corridors as well as stream channels themselves. Currently these areas are sediment deprived, meaning historic sediment loads originating from wildfires are absent. This, combined with historic overgrazing has resulted in gully and channel formation in meadows and incision of streamcourses. Conducting comprehensive restoration treatments prior to upland restoration actions would allow for sediment to deposit as alluvium where desired, rather than being transported through the system in a manner that increases surface scour. If staged optimally, upland restoration treatments combinded with comprehensive restoration treatments would provide the greatest benefit to watershed condition torough improved sediment capture and utilization, improved surface water quality through reduced suspended sediment loads, and nutrient storage and filtering in riparian areas.

There would likely be short-term, adverse effects to surface water quality through implementation of these restoration actions since they are often in-channel restoration practices, occur in wetland areas, or are in riparian areas immediately adjacent to stream channels and wetlands. With implementation of Resource Protection Measures and BMPs, adverse effects can be minimized or mitigated. Native riparian and wetland vegetation is expected reestablish in these areas soon after restoration activities are completed (i.e., 1 to 3 years). In some areas, reestablishment of wetland or riparian vegetation would be hastened by planting of appropriate wetland or riparian herbaceous and woody species. Installation of protective exclosures around restored sites would reduce browsing and trampling by both domestic and wildlife ungulates.

- *Effects Unique to Each Action Alternative and Differences among Them*
  - *Mechanical Forest Restoration Treatments (Thinning)*

One of the primary differences between Alternative 2 – Modified Proposed Action and Alternative 3- Focused Restoration is the number of acres and intensity of mechanical forest restoration treatments. Alternative 2 proposes to mechanically thin trees and/or implement prescribed fire on up to 953,130 acres, while Alternative 3 would mechanically treat slightly more than half (55 percent) of those acres at 529,060 acres. Alternative 2 addresses landscape-scale mechanical forest restoration across the majority of the Rim Country analysis area more effectively than Alternative 3. Alternative 3 is designed to focus restoration treatments in areas that exhibit the greatest departure from the natural range of variation (NRV) of ecological conditions, and/or that put communities at risk from undesirable fire behavior and effects. Therefore, Alternative 3 would leave the greatest number of acres that are moderately departed from desired ecological conditions and would benefit from mechanical restoration treatments to restore forest vegetation health and resilience.

- *Alternative 2 - The Modified Proposed Action*

Since Alternative 2 would provide the greatest areal extent of forest mechanical restoration treatments, it would correspondingly result in a higher proportion of acres that are resilient and fire adapted. As a result, Alternative 2 would improve soil and watershed condition to a much larger degree that Alternative 3.

The greater number of acres that would be treated mechanically also means there would be a corresponding increase in short term adverse effects to soils, water quality and watershed condition. With the higher number of acres to be treated mechanically, adverse effects such as soil compaction, puddling, displacement, erosion, loss of soil organic matter, short-term changes in soil moisture content or retention, changes in nutrient cycles, changes in soil fauna, and risk of introduction of noxious or invasive weeds are likely. The extent and locations of such effects cannot be predicted with accuracy, although some generalizations can be made. Mechanical forest vegetation treatments under Alternative 2 would require more disturbance through construction of temporary roads and road use (330 miles of temporary roads under Alternative 2 vs. 170 miles of temporary roads under Alternative 3), and more log landings and skid trails. More frequent road maintenance would be required since there would be substantially more truck traffic under Alternative 2 than Alternative 3.

As previously noted, soil compaction, puddling and displacement would primarily be limited to the transportation systems and high traffic areas within mechanical vegetation treatments such as existing National Forest System roads, temporary access roads, skid trails, log landings, and debris piling areas.

At the watershed scale, it is possible that the greater areal extent of mechanical vegetation treatments under Alternative 2 would result in increased water yield from watersheds where large percentages of the watershed are mechanically treated in a short timeframe. However, any increases in water yield would be short lived (i.e., 5 to 10 years) since understory vegetation would increase and the water uptake by grasses, forbs and shrubs and warmer soil temperatures would soon offset evapotranspiration lost from forest thinning.

Forest thinning on soils currently characterized as unsatisfactory would improve soil conditions over the long-term by improving soil moisture and allowing greater sunlight penetration to the forest floor (i.e., sunflecks) resulting in an increase in grasses, forbs and shrubs in the forest understory where litter is currently the dominant soil cover.

- *Alternative 3 – Focused Restoration*

Alternative 3 would result in substantially fewer acres being treated mechanically. There would therefore be correspondingly fewer acres that would exhibit adverse effects from mechanical forest restoration treatments such as soil compaction, puddling, displacement, erosion, loss of soil organic matter, short-term changes in soil moisture content or retention, changes in nutrient cycles, changes in soil fauna, and risk of introduction of noxious or invasive weeds. Adverse effects to surface water quality would also be reduced under Alternative 3. However, over the long term, there would be a much greater number of acres that would remain departed from vegetation and fuels desired conditions. These areas would likely remain at risk of high severity wildfire due to high fuel load levels.

- *Prescribed Fire*
  - Alternative 2 – Modified Proposed Action

Alternative 2 proposed substantially more acres of prescribed fire than Alternative 3. Prescribed fire has the potential to impact soil productivity and surface water quality by increasing soil erosion rates and delivery of sediment, dissolved solids, and nutrients to streams and other waterbodies. Since more acres would be treated with prescribed fire under Alternative 2, it is reasonable to expect that there would be greater areal extent of short term adverse effects to soil productivity and water quality and therefore watershed condition. However, adverse effects of prescribed fire on soils, water quality and watershed condition would not be nearly as great as an uncontrolled wildfire.

Prescribed fire has the potential to alter short- and long-term soil productivity and moisture content by changing the amount and type of vegetation, the amount of forest floor organic matter, and surface soil texture and wettability. Prescribed fires typically leave greater amounts of organic matter (duff, forest litter, and large and small woody debris) on soil surfaces than uncontrolled fires. These materials serve as nutrient sinks, prevent soil particle detachment caused by raindrop impact, and capture sediments that would otherwise be transported to stream channels and waterbodies. Following low-intensity prescribed fires, an increase in grasses and other herbaceous vegetation often occurs. This rapid regrowth of ground cover further immobilizes nutrients in plant material.

The mobility and concentration of nutrients in soils determines whether or not nearby water sources are at risk of contamination when prescribed fire is used. Fire can disrupt nutrient cycling and cause nutrient volatilization, leaching, and transformations. When vegetation is consumed by fire, some of the soil and organic matter nutrients such as nitrogen, phosphorus, copper, iron, manganese, and zinc are volatilized and lost from the system, while other nutrients such as calcium, magnesium, and potassium are converted into oxides and accumulated in ash (DeBano et al. 1998).

Prescribed fires can adversely affect watershed hydrology. As vegetation is removed, evapotranspiration in the watershed decreases, thus increasing stream flow and overall water yield within the watershed. The increase in water yield may result in a corresponding increase in sediment and nutrient loads in surface waters.

Trends indicate that fuel loading would continue to increase in areas that are not thinned mechanically. Increased fuel loads would be in the form of both living forest vegetation and woody detritus. Ingrown forest conditions would facilitate the existence of ‘ladder fuels’ which allow ground fires to ascend into the canopy and spread quickly as crown fires.

High severity wildfires tend to occur in areas where fuel loading and fuel distributions are sufficient to carry a fire. Typically, uncontrolled wildfires occur during the drier times of the year, yielding higher severity fires than would occur under prescribed fire conditions. The adverse effects of a high severity fire, such as the loss of forest floor organic matter, increased soil erosion, and changes in soil biota would be more widespread in an uncontrolled wildfire than under prescribed fire conditions where the size and intensity of the fire can be controlled. The primary impact of high severity wildfire on soil productivity is the removal of surface organic matter, exposing soils to erosion by wind and rain. If surface organic matter is reduced (as happens with a high severity wildfire) the cation exchange capacity, a measure of soil fertility, is also reduced and the ability of the soil to retain nutrients leached from ash decreases.

Table 35 provides a summary of the cumulative effects to soils and watershed condition from implementing each alternative, including the no action alternative.

▪ Cumulative Effects

Cumulative effects include the impacts on the environment which result from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other action (40 CFR § 1508.7). The geographic setting for the cumulative effects analysis for soils and watersheds includes all of the 6th level (HUC-12) hydrologic unit subwatersheds tht include Rim Country project area, which comprises approximately 137,153 acres. The timeframe for past actions is ten years, based on soil productivity, vegetative response, and coarse woody debris recovery within treated areas. Surface disturbing activities that are older than 20 years are assumed to be contributing negligible or no measurable cumulative effect within the analysis area.

- *Alternative 1 – No Action*

The No Action Alternative would result in no additional mechanical forest vegetation or prescribed fire treatments, no additional road construction, realignment or decommissioning, no additional spring or riparian restoration, no stream channel restoration, no rock pit expansion, and no wood processing site beyond what has been planned under separate NEPA analyses. Therefore, there would be no cumulative effects to soils or watershed condition as a result of the No Action Alternative beyond those already planned or being implemented under separate NEPA decisions. As can be seen in Appendix G of the Soils and Watershed Specialist's Report, the majority of past, present and reasonably foreseeable future actions consist of forest restoration and fuels reduction treatments. Other restoration actions such as grassland and meadow restoration, spring restoration, and fire rehabilitation are occurring, have occurred in the past or may occur in the future. However, land management activities and changing vegetative conditions throughout the last 100 years have produced an uncharacteristic accumulation of fuels and increased trees density throughout much of the project area and restoration actions undertaken to-date have been insufficient to restore conditions to their natural and historic range of variation. These conditions make future high severity wildfires a possibility and suppression very difficult.

A high-severity fire is not certain to occur within the project area during any given timeframe. However, the occurrence of a high-severity wildfire would have an increased potential for profound adverse impacts to hydrologic systems in project area watersheds and downstream locations. As previously discussed, such a fire event would likely result in increased runoff and potential for soil erosion and sediment delivery to intermittent and ephemeral streams as a result of loss of forest interception of rainfall, reduced soil water infiltration rates, and the reduction of effective ground cover at the soil surface. The infrequent nature of ephemeral stream flow results in the potential for sediment and ash to be stored within these stream channels and then transported during surface runoff events. This, in turn, could pose detrimental effects to surface water quality, stream channel morphology and water storage capacity in downstream livestock waters and other impoundments.

Other potential detrimental effects to hydrologic conditions in the project area and downstream locations could include the destabilization of the geomorphic conditions of stream channels due to excessive sediment delivery and debris loading, increased peak flows, and overall increases in average annual water yield resulting from loss of upslope interception, infiltration, and evapotranspiration. Ephemeral stream channels within high burn severity areas would lose their ability to buffer runoff from large rainfall events, resulting in increased channel scour and incision caused by accelerated runoff and erosion from severely burned watershed areas. Increased bedloads in stream channels effectively raises the elevation of stream bottoms, causing flood flows to exceed channel capacities, resulting in overland flooding.

Another effect is sediment and ash deposition in downstream roads, stock tanks and meadows, even if such areas may not have burned. In addition, sediment and ash-laden overland flows may damage low lying roads by eroding road traveled ways and filling culverts and low water crossings with sediment and debris. These are examples of why post-wildfire watershed conditions are significantly different from pre-fire or low-severity prescribed fire conditions.

Additional cumulative effects of the No Action alternative include ongoing erosion and sediment delivery to ephemeral channels from roads proposed for obliteration under the Action Alternatives that would not be obliterated under the No Action Alternative. When combined with other activities in the Rim Country project area, sediment production from these roads could contribute to adverse impacts to downstream surface water quality if these roads remain in an unstable, eroding condition.

When combined with past, present and reasonably foreseeable future actions, the No Action alternative would not contribute to appreciable improvement in soils or watershed conditions in watersheds that encompass the Rim Country analysis area.

- *Alternative 2 – Modified Proposed Action*
    - *Mechanical Forest Restoration Treatments, including Timber Harvesting*

- *Soil Stability and Erosion Processes*

Proposed meadow and riparian restoration and stream channel restoration will improve soil stability and therefore watershed condition.

Poorly located roads proposed for decommissioning are, in some cases acting in a similar manner as gullies, channelizing runoff into ephemeral and intermittent drainages and other waterbodies. Decommissioning of 490 miles of system roads and 800 miles of unauthorized routes will contribute to improved watershed condition at the landscape scale through reduction of roaded miles per unit of land area. When combined with other past, present and reasonably foreseeable future actions, road decommissioning under Alternative 2 would improve watershed condition throughout most of the project area more effectively than is currently occurring under the No Action Alternative or would occur under Alternative 3.

- *Nutrient Cycling*

- *Soil Hydrology*

Historic evidence indicates that existing landings, skid trails, and roads constitute approximately 5 to 10 percent of the total project area. As previously noted, roads proposed for obliteration tend to be compacted and rutted, and are often channelizing surface runoff to surface waters and are not exhibiting substantial recovery. In order to mitigate any additional compaction and displacement of soils, temporary roads, skid trails, and landings would be stabilized using Resource Protection Measures and BMPs, which may include ripping or decompacting and seeding to alleviate reductions in porosity and infiltration capacity. Therefore, it is not expected that the percentage of compacted areas would increase substantially (i.e., beyond an additional 1 to 2 percent over the current condition). Any soil compaction resulting from mechanical vegetation treatments would be ameliorated over time through pedoturbation caused by soil freezing and thawing and wetting and drying cycles, and root elongation.

Areas of water repellency, which form as a result of the prescribed fire use are expected to recover within 1 to 3 years as natural pedoturbation processes described above occur.

- *Watershed Response*

The magnitude of change in water yield resulting from vegetation treatments and prescribed burning is most strongly related to the amount of precipitation and intensity of the treatments.

The hydrologic response of watersheds in the Rim Country area to proposed restoration activities would depend on the summed effect of the changes in evaporation, transpiration, soil moisture storage, and snowpack accumulation and melt processes. This includes the degree to which vegetation treatments influence net precipitation that reaches soil surfaces through reduced canopy interception, changes to soil moisture evaporation rates, and changes to the amount of transpiration and soil water depletion. Changes to streamflow would depend on whether precipitation or snowmelt exceeds the combined evapotranspiration demand, soil moisture holding capacity, and groundwater recharge rates.

Changes in evapotranspiration following vegetation treatments would be the result of reduced soil moisture depletion during the growing season and decreased winter snowfall interception. Precipitation accumulates in the Rim Country area as snowpack, with melting and sublimation occurring during warm phases throughout the winter. Much of the winter precipitation is intercepted by tree canopies. Some of this moisture evaporates or sublimates without contributing to soil moisture, while some is blown off of intercepting vegetation or simply falls off, thus reaching soil surfaces. When the remaining snowpack begins to melt in spring, melt water first recharges the soil by replacing the water that was depleted during the previous growing season. Once soil moisture storage capacity is at its maximum, remaining melt water is available to become stream flow. On north facing slopes, some of the snowpack remains almost continuously from December to April. While the evaporation rate is lower than south facing slopes, the relatively large surface area of snow permits a substantial amount of evaporative loss to occur. In contrast, on south facing slopes, intercepted snow quickly leaves the less dense forest canopy thus allowing less interception loss. For the first 1 to 3 years following vegetation treatments, a slight increase in stormwater runoff is expected since understory vegetation of grasses, forbs and shrubs would not have reached maximum ground cover levels, snowpack interception would be reduced, and there would be fewer trees to create evapotranspirational demand for soil moisture during the growing season.

When combined with other past, present and reasonably foreseeable future projects, Alternative 2 would be beneficial to watershed response. In the absence of maintenance treatments this benefit would decrease over time as a result of forest ingrowth that would increase evapotranspirational demand.

- *Recreational Activities*

Recreational activities within the proposed project area include: hiking, viewing wildlife, hunting, dispersed car-camping, backpack camping, orienteering, horseback riding, photography, picnicking, taking scenic drives, ORV/ATV use, bicycling, shooting, and gathering in family or social groups. Other common uses within the project area include firewood cutting, Christmas tree cutting, collecting boughs and cones, gathering antlers, and collecting food and medicinal resources such as berries, nuts, mushrooms, and medicinal plants. Of these, ORV/ATV use, dispersed camping, firewood collection and Christmas tree cutting have the greatest potential to result in adverse cumulative effects to soils through compaction, puddling, erosion, and displacement. These conditions would be limited to areas where such activities take place. In combination with past, present and reasonably foreseeable recreation activities, Alternative 2 would improve soils and watershed condition throughout the Rim Country analysis area.

- *Livestock Grazing*

Currently, livestock grazing is authorized across most of the analysis area. While grazing results in discontinuous fuel patterns in grass, forb and shrub vegetative communities, it has not effectively reduced the densities in the ponderosa pine stands. As a result, excessive stand densities in the ponderosa pine vegetation type are causing a shift in understory vegetative communities toward more shade tolerant species such as bromes and mountain muhly.

Over the last 15 years, reduced cool season moisture and increased warm season moisture has resulted in a corresponding shift toward dominiance of warm season species. Since increased livestock grazing is not proposed under any alternative, the increased herbaceous understory would provide imporved protection of soil surfaces from erosion during summer monsoon thunderstorms.

Many riparian areas on the CNF have already been fenced to exclude domestic livestock grazing. Riparian conditions continue to improve over time in these areas as soil compaction is naturally reduced through freeze-thaw, wetting-drying cycles and other natural soil disturbances occur.

Since livestock grazing would be excluded from fenced springs and riparian areas, these habitat features would improve over time. Riparian vegetation extent and condition associated with spring ecosystems and wetlands would therefore improve under both Action Alternatives.

Cumulative effects from livestock grazing include minor, generally localized soil compaction, puddling, displacement and erosion from livestock trailing and in areas where animals congregate such as livestock waters and areas where mineral supplements are placed. Livestock trails make up a very small portion of the total project area and therefore have a negligible effect on soils or watershed condition. Livestock grazing is not expected to increase the area of soils characterized as unsatisfactory within the project area. Overall, in combination with ongoing livestock grazing and in the absence of increasing livestock numbers being grazed, Alternative 2 would benefit soils and watershed conditions

- *Invasive or Noxious Weeds*

The cumulative effect of the increased risk of spread on noxious or invasive weeds on soil productivity can only be described in general terms because of the large number of unknown variables. Areas where soil disturbance includes compaction, displacement, erosion, and excessive heating are at the greatest risk of invasion by noxious or invasive weeds. These include temporary roads, areas where concentrated harvesting operations occur and pile burning sites. Monitoring of these areas for the presence of noxious or invasive weeds and treating observed populations in a timely manner would mitigate these adverse effects. To minimize cumulative adverse effects of noxious or invasive weeds, observed infestations would be managed in accordance with the Final Environmental Impact Statement for Integrated Treatment of Noxious or Invasive Weeds Coconino, Kaibab, and Prescott National Forests (2005).

- *Fire Effects*

In low burn severity areas, effects are mainly light ground char where the litter is scorched, charred, or partially consumed. The litter layer, or duff is largely intact, although it may be charred on the surface. Woody debris accumulations are partially scorched, charred, or consumed. Mineral soil properties are not adversely affected. In fact, low severity fire releases nutrients stored in surface organic matter and live vegetation. These nutrients facilitate rapid reestablishment of vegetative ground cover since root to shoot ratios are improved for grasses and forbs that survive fire, resulting in protection of soils from accelerated soil erosion soon after fire has occurred. Evidence of sheet and rill erosion as a result of low severity fire is typically very minor or nonexistent. In forested areas, much of the tree overstory is green with some scorch at the base of the trees and in the lower branches following low severity fire. Most trees survive; however, pockets of seedlings, saplings, and mature trees can be killed or consumed where moderate to high severity fires occur. While most of the shrubs, forbs and grasses are affected under low severity fire conditions, in most cases, much of this vegetation survives. Areas identified as low burn severity may also contain large unburned areas, resulting in a mosaic of burned and unburned conditions across the landscape or within a subwatershed. When combined with other past, present and reasonably foreseeable prescribed fire project, Alternative 2 would have beneficial effects on soils and watershed conditions.

- *Cumulative watershed effects*

In summary, cumulative watershed effects from implementation of the Alternative 2 would include improved soils and watershed condition and restoration of the ecological interrelationships of soils, vegetation, and watersheds throughout the Rim Country project area. Streams, meadows and riparian areas that depend on stable upland soils would be better protected from potential adverse effects of high severity wildfire as a result of restoration treatments. The transportation system would provide necessary access for future management and would be more sustainable than the current transportation system.

- *Alternative 3 – Focused Restoration*

Cumulative effects of Alternative 3 would be similar to those of Alternative 2, but would occur at a substantially reduced areal extent with regard to forest mechanical thinning and prescribed fire treatments. Other restoration actions (stream channel restoration, spring restoration, road decommissioning, etc. would be the same as Alternative 2.

Vegetation

The vegetation analysis is summarized from the Silviculture Report, which is incorporated by reference (Moore 2018).

Affected Environment

The cover types analyzed are limited to Aspen, Grassland/Meadow, Madrean Encinal Woodland, Madrean Pinyon-Oak, Mixed Conifer with Aspen, Mixed Conifer/ Frequent Fire, Pinyon-Juniper Woodland, Ponderosa Pine, and Ponderosa Pine/ Evergreen Oak and riparian for a total of 951,691 acres. For analysis purposes, the Madrean Encinal Woodland and Madrean Pinyon-Oak cover types will be combined into one category called Madrean Woodland due to limited acreage, data availability and similarity.

Of the 1,238,658 acres within the project area:

- Approximately 255,249 acres have been removed from this silvicultural analysis because they are part of an ongoing project or are being analyzed in a separate analysis (Figure 2). Silvicultural treatments and their effects within these areas will not be analyzed in this report.
- Approximately 30,263 acres are either non National Forest System lands, or are non-forested. The remaining 953,131 acres are identified by cover type and Forest in Table 7.
- An additional 1,141 of these acres identified as “Other” in Table 7 were determined to be either surface water, mineral pits, dams or road surface and will not be given a detailed description in this silvicultural analysis.
- The remaining 951,691 acres, considered the analysis area, will be analyzed in this report and are identified by forest in Table 3-1.

Table 3-1 describes each 5th Code HUC by the amount of area within the analysis area. These 5th Code HUCs vary widely in size due to the fact that only small portions of some HUCs are in the project area (Figure 3-2). Due to their limited size, the data summarizing some of the smaller HUCs such as Corduroy Creek, Salt River-Theodore Roosevelt Lake, and Upper North Fork White River HUCs may not be considered as representative of the entire watershed during analysis.

Table 3-1. Existing Condition - 5th Code HUC watersheds in the analysis area

5th HUC Name	5th HUC Code	Acres
Beaver Creek	1506020206	9,986
Black Canyon	1502001002	69,584
Canyon Creek	1506010303	26,040
Canyon Diablo	1502001504	3,232
Carrizo Creek (Local Drainage)	1506010403	3,954
Cherry Creek	1506010304	28,923
Corduroy Creek	1506010401	59
Cottonwood Creek	1502000503	66,489
East Verde River	1506020302	76,611
Fossil Creek-Verde River	1506020303	21,767
Gun Creek-Tonto Creek	1506010504	10,059
Haigler Creek-Tonto Creek	1506010502	83,662

Jacks Canyon	1502000805	71,752
Lower Chevelon Canyon	1502001003	11,108
Lower Clear Creek	1502000804	1,477
Oso Draw	1502000204	9,656
Phoenix Park Wash-Dry Lake	1502000801	19,723
Rye Creek-Tonto Creek	1506010503	4,967
Salome Creek	1506010308	32,946
Salt River-Theodore Roosevelt Lake	1506010309	108
Show Low Creek	1502000501	23,394
Spring Creek	1506010501	31,446
Upper Chevelon Canyon	1502001001	102,820
Upper Clear Creek	1502000803	139,911
Upper North Fork White River	1506010201	327
Upper Silver Creek	1502000502	10,464
Walnut Creek	1502001502	75
West Clear Creek	1506020301	91,151
Grand Total		951,691

The descriptions of the existing condition are organized under the criteria determined to be part of a properly functioning ecosystem. An ecosystem that is properly functioning is thought to be resilient to perturbations in structure, composition, and biological or physical processes. Systems at risk are those that may be degraded beyond the range of resiliency and sustainability. The four ecosystem characteristics discussed below are cover type, composition, structure, pattern, and processes.

Post-European Settlement Era Ecological Changes

Open, frequent fire forest structure has been altered by logging, grazing, and fire suppression and has led to overly dense forest structure and fire regimes highly departed from their desired conditions.

Large, old ponderosa pines and oaks have become underrepresented in some areas. The remaining large, old ponderosa pines are suffering increased mortality rates as a result of competition with small trees, insects and disease, and climate change.

Ponderosa pine forests have increased in density as abundant tree seedlings have regenerated in canopy openings and replaced some open, multiple age class forest structure with a dense and predominately single age class structure. This resulted from logging practices, protection from fire, grazing, and a relatively wet climatic cycle during the early part of the 20th century (Schubert 1974). In other areas, uneven-aged stand structure remains as a result of historical mechanical harvesting as well as natural disturbance.

Frequent low-severity fire regime forests have increased densities from shade tolerant and fire intolerant species. Dry mixed conifer forests are far denser and with a species composition that is not necessarily representative of their NRV.

Competition for moisture and nutrients is intense in currently dense stands, and results in stress that increases vulnerability to attack by insects such as pine bark beetles (*Dendroctonus* spp.) and *Ips* beetles (Kane and Kolb, 2014).

Though the extent of dwarf mistletoe infections have become more widespread with increased negative impacts in some areas due to closed forest conditions, lack of low severity fire, and lack of adequate mitigation management, thereby resulting in reduced forest health and growth, increased risks to insect attacks, accumulated ladder fuels, and negative effects from projected climate change.

Potential fire severity has changed from mostly low severity fire to mixed and high severity. The risk of stand replacing fires has increased.

High severity fires often result in ecosystem conversions, increased soil erosion, loss of hydrologic function, and invasion by nonnative species.

Stand-replacing wildfires within ponderosa pine ecosystems have resulted in conversion from forest to grass or persistent shrub for long periods or dense, even-aged structure. These areas will not again support old-growth forest structure for centuries.

Trees have significantly encroached into historical grasslands and meadows.

Existing Condition

The descriptions of the existing condition are organized under the criteria determined to be part of a properly functioning ecosystem. An ecosystem that is properly functioning is thought to be resilient to perturbations in structure, composition, and biological or physical processes. Systems at risk are those that may be degraded beyond the range of resiliency and sustainability. The four ecosystem characteristics discussed below are cover type, composition, structure, pattern, and processes.

Vegetation Composition

Vegetative composition refers to the vegetation cover types, species present and their relative abundance.

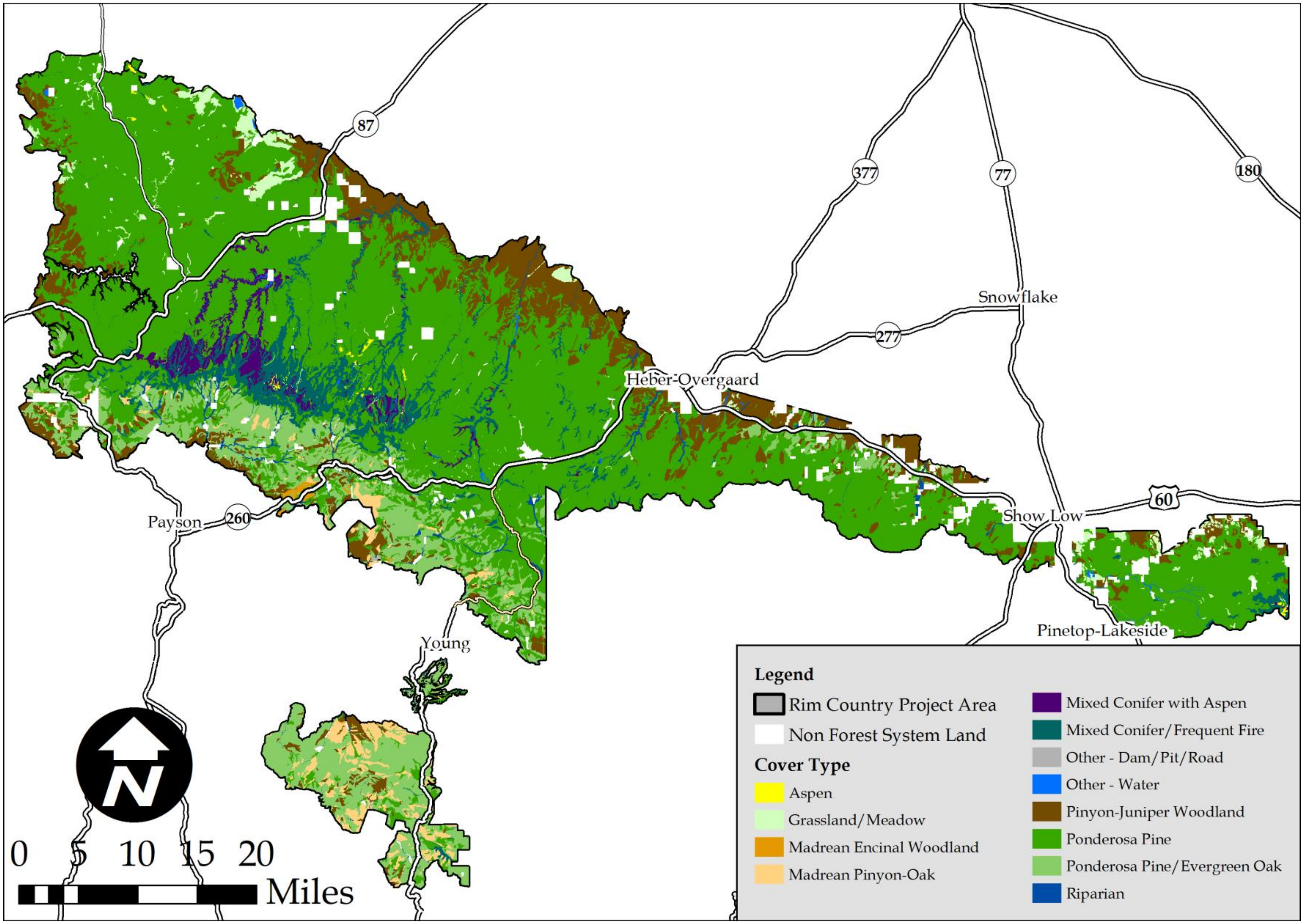


Figure 3-1 – Existing Condition – Cover Type

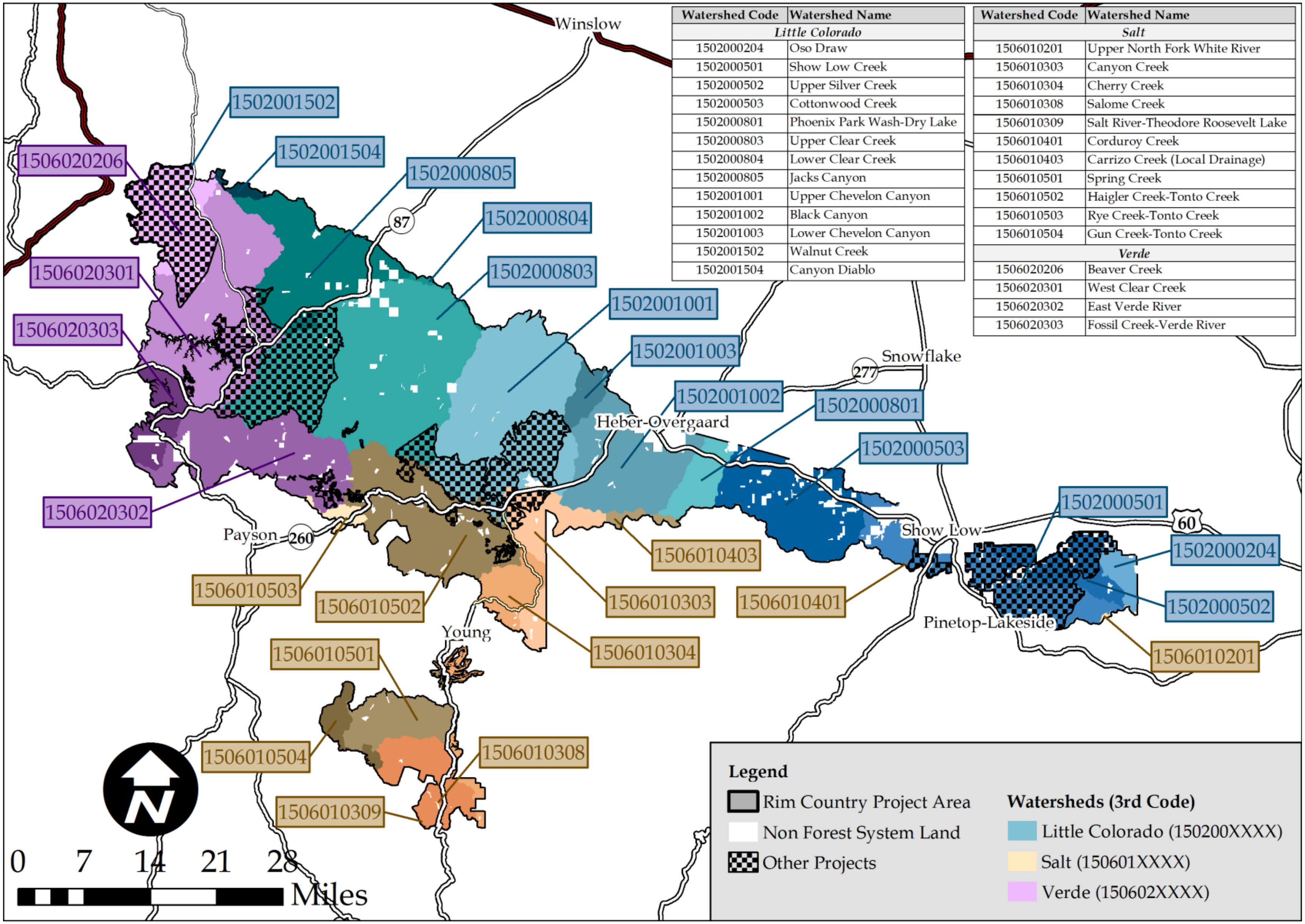


Figure 3-2 – Existing Condition – 5th HUC Watersheds

Table 3-2. Existing Condition - Cover type by Forest

Cover Type	Coconino	Sitgreaves	Tonto	Grand Total
Aspen	635	805		1,440
Grassland/Meadow	12,292	6,526	25	18,843
Madrean Woodland			24,996	24,996
Mixed Conifer with Aspen	1,809	1,311		3,120
Mixed Conifer/Frequent Fire	16,648	21,207	11,444	49,299
Pinyon-Juniper Woodland	29,074	80,027	25,961	135,062
Ponderosa Pine	196,976	281,548	77,779	556,304
Ponderosa Pine/Evergreen Oak	1,824	9,052	137,193	148,069
Riparian	2,716	5,402	6,440	14,558
Grand Total	261,974	405,878	283,839	951,691

Vegetation Structure

Uneven-aged Structure

Structure is a means to express the balance of age and size classes as well as the horizontal and vertical distribution of layers in the forest canopy. In a forested environment, vegetation structure can also include snags, down logs and woody debris, and canopy closure.

Uneven-aged forests are generally described as having three or more distinct age classes of trees (SAF 1998) and is a measure of vertical structure within a forest. Ponderosa pine is composed of trees in structural stages that range from young to old trees and are dominated by ponderosa pine. Forest appearance is variable, but generally uneven-aged and open; occasional areas of even-aged structure are present. It is desired that uneven-aged forest structure occurs on the majority of the acres by cover type. Groups of seedlings and saplings are maintained at sufficient levels to provide a reliable source of replacement as trees grow and progress into succeeding size and age classes and there is a rough balance of areas dominated by young, mid-aged and old structural stages. It is desired to have a forest arrangement in individual trees, small clumps, and groups of trees interspersed within small, variably sized openings of grasses, forbs, and shrubs that are similar to historic patterns and discourage crown fire behavior. Currently, the arrangement of the tree cohorts (groups of trees of a similar age class) or size classes are in conditions conducive to crown fire with extremely dense and continuous overstory canopies in a closed condition and understory canopies acting as ladder fuels supporting a transition from surface fire to crown fire behavior (Tables 3-3 and 3-4).

The current condition in terms of uneven-aged structure appears by 5th HUC watershed in table 3-5. Currently 64 percent of acres across the analysis area can be considered uneven-aged. The Forest Plans as well as the MSO Recovery Plan (USDI 2012) promote the desired condition of forests composed of an uneven-aged structure where groups and clumps of trees of different size and age classes are spatially arranged across the landscape.

A size–class distribution by 5th HUC watershed (Table 3-4) shows that the majority of basal area (63 percent overall) is concentrated in the 5 to 12 inch and 12 to 18 inch size classes.

Table 3-3. Existing Condition – Trees per acre distribution across size classes by 5th HUC watershed

5th HUC Watershed	0-5"	5-12"	12-18"	18-24"	24"+	Total
Beaver Creek	613	86	35	12	3	750
Black Canyon	570	74	20	5	2	670
Canyon Creek	1332	88	22	5	3	1451
Canyon Diablo	1015	105	25	12	2	1159
Carrizo Creek (Local Drainage)	429	57	15	4	2	506
Cherry Creek	1048	149	35	9	3	1244
Corduroy Creek	697	57	16	4	1	775
Cottonwood Creek	632	67	16	3	1	719
East Verde River	1091	119	44	11	5	1271
Fossil Creek-Verde River	908	129	43	8	3	1091
Gun Creek-Tonto Creek	1441	147	36	9	2	1636
Haigler Creek-Tonto Creek	1292	142	42	10	5	1490
Jacks Canyon	431	99	24	6	3	563
Lower Chevelon Canyon	491	120	30	7	3	651
Lower Clear Creek	651	113	26	9	4	803
Oso Draw	1336	108	38	8	2	1492
Phoenix Park Wash-Dry Lake	520	81	20	4	2	627
Rye Creek-Tonto Creek	915	122	37	11	3	1088
Salome Creek	1058	182	40	12	3	1295
Salt River- Roosevelt Lake	1464	105	46	18	7	1640
Show Low Creek	795	80	23	6	1	905
Spring Creek	831	178	41	8	2	1059
Upper Chevelon Canyon	589	121	35	10	4	758
Upper Clear Creek	753	122	37	11	4	927
Upper North Fork White River	1875	106	42	16	4	2044
Upper Silver Creek	905	110	38	8	1	1063
Walnut Creek	59	17	15	11	7	109
West Clear Creek	559	99	41	8	3	710
Overall Average	813	114	35	9	3	973

Density

Overall, basal areas are high for most cover types, especially Aspen, Dry Mixed Conifer, Ponderosa Pine/Evergreen Oak, and Mixed Conifer with Aspen. Average basal area of ponderosa pine cover type across the analysis areas is lower, largely due to the number of ponderosa pine stands that experienced stand replacing fire in the Rodeo-Chediski Fire in 2002 and are now dominated by stands with low basal area.

Table 3-4. Existing Condition – Basal area distribution across size classes by 5th HUC watershed

5th HUC Watershed	0-5"	5-12"	12-18"	18-24"	24"+	Total
Beaver Creek	8	34	42	28	13	124
Black Canyon	11	27	22	11	9	81
Canyon Creek	16	31	25	12	14	99
Canyon Diablo	16	37	29	27	9	118
Carrizo Creek (Local Drainage)	6	22	17	9	6	60
Cherry Creek	14	54	40	19	14	142

Corduroy Creek	15	22	18	10	3	69
Cottonwood Creek	11	25	18	8	4	66
East Verde River	15	45	51	25	25	161
Fossil Creek-Verde River	11	48	49	18	14	140
Gun Creek-Tonto Creek	11	54	41	21	10	138
Haigler Creek-Tonto Creek	17	51	48	24	25	165
Jacks Canyon	6	35	26	14	14	96
Lower Chevelon Canyon	13	44	34	17	14	121
Lower Clear Creek	8	40	31	20	23	121
Oso Draw	16	41	44	18	7	124
Phoenix Park Wash-Dry Lake	9	31	22	10	7	79
Rye Creek-Tonto Creek	12	45	42	24	18	142
Salome Creek	14	67	46	26	13	166
Salt River-Theodore Roosevelt Lake	10	40	54	38	27	170
Show Low Creek	12	30	27	13	6	87
Spring Creek	14	65	47	18	8	152
Upper Chevelon Canyon	12	44	40	22	16	133
Upper Clear Creek	12	45	43	25	18	143
Upper North Fork White River	14	43	50	36	17	160
Upper Silver Creek	14	42	44	17	8	126
Walnut Creek	3	6	19	25	30	82
West Clear Creek	8	39	46	18	11	122
Grand Total	12	42	40	20	15	129

Table 3-5. Existing Condition – Density related indicators of forest structure by 5th HUC watershed

5th HUC Watershed	Basal Area	Stand Density Index	Quadratic Mean Diameter
Beaver Creek	124	270	8
Black Canyon	81	186	5
Canyon Creek	99	251	4
Canyon Diablo	118	288	6
Carrizo Creek (Local Drainage)	60	140	5
Cherry Creek	142	338	5
Corduroy Creek	69	172	4
Cottonwood Creek	66	158	4
East Verde River	161	378	6
Fossil Creek-Verde River	140	325	6
Gun Creek-Tonto Creek	138	346	5
Haigler Creek-Tonto Creek	165	400	5
Jacks Canyon	96	211	8
Lower Chevelon Canyon	121	267	6
Lower Clear Creek	121	274	6
Oso Draw	124	317	5
Phoenix Park Wash-Dry Lake	79	182	5
Rye Creek-Tonto Creek	142	330	6
Salome Creek	166	388	6
Salt River- Roosevelt Lake	170	411	6
Show Low Creek	87	208	5

Spring Creek	152	351	6
Upper Chevelon Canyon	133	293	7
Upper Clear Creek	143	317	7
Upper North Fork White River	160	398	6
Upper Silver Creek	126	298	5
Walnut Creek	82	137	15
West Clear Creek	122	263	8
Grand Total	129	296	6

Large Tree and Old Tree Structure

Ponderosa pine stands of post settlement trees where the quadratic mean diameter of the top 20 percent of trees is greater than 15 inches and the basal area of trees greater that 16 inches is more than 50 square feet of basal area may be considered stands with a preponderance of large young trees (SPLYT stands). These stands occur outside of MSO PACs, MSO Recovery habitat and WUI and are being identified for their distinctive forest structure. Information on SPLYT stands across 5th HUC watershed is shown in Table 3-6.

Table 3-6. Existing Condition - SPLYT statistics by 5th HUC watershed

5th HUC Watershed	Acres	Basal Area >16"	QMD Top 20% of Trees
Beaver Creek	498	81	19
Black Canyon	2,330	71	18
Canyon Creek	10	64	18
Carrizo Creek (Local Drainage)	151	70	20
Cherry Creek	539	74	18
Corduroy Creek	2	66	19
Cottonwood Creek	642	59	19
East Verde River	1,577	92	20
Fossil Creek-Verde River	1,432	70	21
Gun Creek-Tonto Creek	120	65	15
Haigler Creek-Tonto Creek	2,056	67	17
Jacks Canyon	1,545	62	20
Lower Chevelon Canyon	351	65	20
Oso Draw	227	57	18
Phoenix Park Wash-Dry Lake	392	61	17
Rye Creek-Tonto Creek	238	68	18
Salome Creek	594	101	19
Salt River-Theodore Roosevelt Lake	16	109	19
Show Low Creek	229	70	20
Spring Creek	64	68	15
Upper Chevelon Canyon	8,465	84	19
Upper Clear Creek	8,141	82	19
Upper Silver Creek	93	83	18
West Clear Creek	6,554	72	19
Grand Total	36,265	77	19

Forest Process

Insects

A general bark beetle hazard model for southwestern ponderosa pine based exclusively on the tree density relationships developed in a Dendroctonus hazard model was validated by Chojnacky et al. (2000) The model indicates that stands of ponderosa pine within the analysis area with a relative density below 30 percent of SDImax have a low hazard rating and stands between 30 and 40 percent of SDImax have a moderate hazard rating. Using these relative density thresholds, approximately 16 percent of the PP, PP/EO and MC/FF stands area has a low bark beetle hazard rating, while 8 percent of the area has a moderate rating and the remaining 76 percent has a high hazard of beetle attack (Table 3-7).

Table 3-7. Existing Condition - Bark beetle hazard rating and dwarf mistletoe severity rating by 5th HUC watershed

	Beetle Hazard Rating				Dwarf Mistletoe Severity Rating			
5th HUC Watershed	Low	Moderate	High	Grand Total	Low	Moderate	High	Grand Total
Beaver Creek	32%	6%	63%	100%	69%	29%	2%	100%
Black Canyon	41%	8%	51%	100%	81%	19%	0%	100%
Canyon Creek	31%	4%	65%	100%	59%	31%	11%	100%
Canyon Diablo	32%	0%	67%	100%	73%	26%	1%	100%
Carrizo Creek (Local Drainage)	50%	3%	47%	100%	69%	31%	0%	100%
Cherry Creek	2%	8%	90%	100%	51%	45%	4%	100%
Corduroy Creek	59%	0%	41%	100%	75%	25%	0%	100%
Cottonwood Creek	58%	7%	35%	100%	87%	13%	0%	100%
East Verde River	5%	3%	91%	100%	73%	20%	7%	100%
Fossil Creek-Verde River	11%	5%	84%	100%	58%	36%	6%	100%
Gun Creek-Tonto Creek	2%	0%	98%	100%	100%	0%	0%	100%
Haigler Creek-Tonto Creek	4%	1%	95%	100%	55%	38%	7%	100%
Jacks Canyon	35%	19%	46%	100%	97%	3%	0%	100%
Lower Chevelon Canyon	3%	2%	96%	100%	96%	4%	0%	100%
Lower Clear Creek	0%	3%	97%	100%	100%	0%	0%	100%
Oso Draw	14%	3%	83%	100%	66%	33%	1%	100%
Phoenix Park Wash-Dry Lake	43%	12%	45%	100%	74%	26%	0%	100%
Rye Creek-Tonto Creek	32%	8%	59%	100%	96%	4%	0%	100%
Salome Creek	4%	3%	93%	100%	92%	5%	3%	100%
Salt River-Roosevelt Lake	0%	24%	76%	100%	100%	0%	0%	100%
Show Low Creek	48%	3%	49%	100%	78%	22%	0%	100%
Spring Creek	11%	0%	89%	100%	95%	5%	0%	100%
Upper Chevelon Canyon	13%	8%	79%	100%	74%	22%	4%	100%
Upper Clear Creek	6%	5%	90%	100%	64%	27%	9%	100%
Upper North Fork White River	19%	49%	32%	100%	10%	71%	19%	100%
Upper Silver Creek	29%	4%	67%	100%	68%	28%	4%	100%
Walnut Creek	95%	5%	0%	100%	88%	12%	0%	100%
West Clear Creek	16%	16%	68%	100%	78%	20%	2%	100%
Grand Total	19%	7%	74%	100%	75%	22%	4%	100%

	Beetle Hazard Rating				Dwarf Mistletoe Severity Rating			
5th HUC Watershed	Low	Moderate	High	Grand Total	Low	Moderate	High	Grand Total
Beaver Creek	32%	6%	63%	100%	63%	35%	3%	100%
Black Canyon	41%	8%	51%	100%	80%	19%	0%	100%
Canyon Creek	31%	4%	65%	100%	58%	32%	11%	100%
Canyon Diablo	32%	0%	67%	100%	68%	30%	1%	100%
Carrizo Creek (Local Drainage)	50%	3%	47%	100%	69%	31%	0%	100%
Cherry Creek	2%	8%	90%	100%	50%	46%	4%	100%
Corduroy Creek	59%	0%	41%	100%	73%	27%	0%	100%
Cottonwood Creek	58%	7%	35%	100%	85%	15%	0%	100%
East Verde River	5%	3%	91%	100%	70%	22%	7%	100%
Fossil Creek-Verde River	11%	5%	84%	100%	53%	41%	6%	100%
Gun Creek-Tonto Creek	2%	0%	98%	100%	100%	0%	0%	100%
Haigler Creek-Tonto Creek	4%	1%	95%	100%	53%	40%	7%	100%
Jacks Canyon	35%	19%	46%	100%	96%	3%	0%	100%
Lower Chevelon Canyon	3%	2%	96%	100%	95%	4%	0%	100%
Lower Clear Creek	0%	3%	97%	100%	100%	0%	0%	100%
Oso Draw	14%	3%	83%	100%	62%	37%	1%	100%
Phoenix Park Wash-Dry Lake	43%	12%	45%	100%	73%	27%	0%	100%
Rye Creek-Tonto Creek	32%	8%	59%	100%	94%	6%	0%	100%
Salome Creek	4%	3%	93%	100%	91%	6%	3%	100%
Salt River-Theodore Roosevelt Lake	0%	24%	76%	100%	100%	0%	0%	100%
Show Low Creek	48%	3%	49%	100%	73%	27%	0%	100%
Spring Creek	11%	0%	89%	100%	95%	5%	0%	100%
Upper Chevelon Canyon	13%	8%	79%	100%	71%	25%	4%	100%
Upper Clear Creek	6%	5%	90%	100%	64%	28%	9%	100%
Upper North Fork White River	19%	49%	32%	100%	10%	71%	19%	100%
Upper Silver Creek	29%	4%	67%	100%	59%	36%	5%	100%
Walnut Creek	95%	5%	0%	100%	0%	100%	0%	100%
West Clear Creek	16%	16%	68%	100%	77%	21%	2%	100%
Grand Total	19%	7%	74%	100%	72%	23%	4%	100%

Pathogens-Dwarf Mistletoe

Conklin and Fairweather (2010) indicate that stands with less than 20 percent of the ponderosa pine trees infected can be considered a light infection, stands with 20-80 percent can be considered moderately infected while stands with greater than 80 percent of trees infected with dwarf mistletoe are classified as severe. Table 3-7 classifies stands within these categories by 5th HUC watershed. At moderate and severe infection levels there is evidence of decreased tree vigor, increased susceptibility to insect infestations, and stress related mortality (i.e., drought) that accompany a changing climate.

Assumptions and Methodology

The basic unit for characterizing of vegetation conditions is the stand. All lands within the Apache-Sitgreaves, Coconino and Tonto National Forests are delineated into stands based on similar characteristics such as vegetation cover type, slope, aspect, species composition, aerial photo interpretation signatures, and management history. Stands vary in size depending upon their uniformity; within the Rim Country Project this is from less than one acre up to 1,324 acres. Spatial and general vegetation information about each stand is stored in the stand database for each forest within the Forest Service Field Sampled Vegetation (FSVeg) database.

Data Rounding

Data is typically reported to the nearest acre, mile, or percentage. Most values have been rounded from their actual decimal values. Totals were calculated before any values were rounded in order to give the most accurate sum. Any apparent inconsistency between the total values reported in a table and a sum resulting from adding up individual values in a table typically accounts for a discrepancy of about 1 percent in the case of rounding percentages or miles, and less than 2 acres in the case of acres.

In an attempt to avoid confusion over these kinds of inconsistencies, minor adjustments to the numbers in the EIS document were made to allow for numbers in tables to add up correctly as displayed. As a result, some numbers may not be exactly the same in the EIS document as compared to this report. The numbers in this report are the most accurate and any differences do not alter any determination of effects.

Stand Data and Modeling

Stand exam data is an average characterization of the area within the stand boundaries. It is limited by sampling intensity and the variability within the sampled area.

Comprehensive tree data has been collected on a subset of the stands within the analysis area over the last 25 years. Within each sampled stand, tree characteristics were measured at sample points, using both variable basal area factor plot and fixed plot designs. Specific tree data collected includes species, class, diameter, height, age, growth, damage and disease. Other data sometimes collected depending on design included surface fuels and plant association (USDA 2013). This stand data is currently stored in the FSVeg database which is a nationally supported database used to store field sampled data in a common format. A thorough review of the stand data was done for the analysis area to ensure validity.

Modeling Assumptions

The following is a list of general modeling assumptions.

- All tree data was grown to the common year of 2019 and is considered to represent the existing condition.
- Beginning in the year 2019, using the Climate-FVS extension (N.L. Crookston 2014), the effects of climate change were incorporated in the data analysis using the Ensemble_rcp60 scenario
- All tree cutting and removal was modeled in the year 2019 as 2019 is the earliest anticipated first year of treatments
- Two prescribed burns were modeled, post-mechanical treatment in the year 2024, and then again in 2034 with the exception of the aspen treatment which modeled one prescribed burn in the year 2024, post-mechanical treatment.
- After treatment, the tree growth data was simulated to the common year of 2029 and 2039 and is considered to represent the post treatment condition.
- The tree data does not indicate tree age. Simulations initially use diameter as a surrogate for age based on the vegetative structural stage definitions. We acknowledge that there are trees on the landscape where age class overlaps size class. For example there may be: young trees that are larger than 11.9 inches; or mid-aged trees that are larger than 17.9 inches; or mature trees that are less than 18".

- Within this project area, the majority of trees that meet the old tree definition are greater than or equal to 18”. On the ground cutting prescriptions will follow the Old Tree Implementation Plan (OTIP) and trees larger than 18” that do not meet the OTIP criteria may be cut during implementation.

- All cutting simulations assume 15 percent of the cut stems are left on site and 10 percent of the branchwood from the cut and removed stems are left on site. All other biomass resulting from the cutting is assumed to be removed.

- Snags and coarse wood amounts are based on the inventory or default parameters within the model if they were not inventoried. Snag fall rates and changes in surface fuels are based on default parameters.

- Stand exam data is an average characterization of the area within the stand boundaries. It is limited by sampling intensity and the variability within the sampled area.

- Default parameters within the model were used to predict tree growth, mortality, and dwarf mistletoe infection intensification.

- Dwarf mistletoe infections are nearly impossible to detect from remote imagery. Therefore, any nearest neighbor imputation process may impute stand data showing mistletoe infections to stands that are not infected and visa-versa.

- FVS is a distance-independent growth model. It is not spatially explicit and cannot model tree groups and interspaces together. The modeling results are an average approximation of the desired forested structure at the stand level and all results are interpreted as “attribute values” per acre. Output from the FVS model used in this analysis is a characterization of the existing condition and absolute conditions are neither intended nor implied.

Discussions on Stand Metrics

Measures of stand density used in this analysis are Basal Area (BA), Trees per Acre (TPA) and Stand Density Index (SDI). Basal area is the cross-sectional area of all trees, measured in square feet per acre measured at 4.5 feet above the ground. Trees per acre (TPA) is simply a count of the total number of trees on an acre. Stand Density Index is a measure of the relative stand density within forest stands.

Density

Stand density, a measure of the degree of crowding within stocked areas (SAF 1998), is the dominant factor affecting the health and vigor of conifer forests in the western United States (Foresters 2005) and high stand densities leads to reduced ecosystem resilience (Reynolds et al 2013. One of the major factors affecting forest structure and development, specifically the rate at which individual trees grow and advance through successional stages, is inter-tree competition. Competition refers to density-related scarcity of one or more environmental factors necessary for growth (e.g., moisture, nutrients, and sunlight). Early in stand development, and prior to competition between trees, individual trees are growing at their full potential. As stand development advances, relative densities increase as the size of individual trees increase and the competition begins to increase. Individual trees begin to experience some competitive interaction with other trees and self-pruning of lower branches begins. At this stage in stand development, individual trees begin to exhibit height growth differentiation due to genetics, microsite differences, and damage caused by biotic and abiotic factors. As stands continue to develop, competition between trees continues to increase as trees increase in size. Growth rates for individual trees decrease as competition increases. Eventually, stands near the point of full site occupancy and self-thinning occurs due to density-based competition mortality. At this stage of stand development, trees are growing at much less than full potential.

Trees per Acre

Trees per acre is simply a count of the number of stems per acre of an individual species or all species combined regardless of size. Trees per acre is much more informative when considered with an additional stand metric such as quadratic mean diameter or basal area. This additional information provides insight into the forest processes that may be occurring within a stand.

Basal Area

Basal area is the cross-sectional of all stems of a species or all stems in a stand measured at breast height (4.5 feet above the ground) and expressed as square feet per acre. This analysis uses basal area as a key measure of density. Higher basal areas can be indicators of increased competition, risk to insect outbreaks, and density-dependent mortality as well as closed canopy conditions.

Stand Density Index

Stand Density Index (SDI) is a measure of relative stand density based on the number of trees per acre and the mean diameter (Reineke 1933). Percent SDIMax expresses the actual density in a stand relative to a theoretical maximum density possible for trees of that diameter and species. SDI is a good indicator of how site resources are being used by taking both tree size (DBH) and numbers (TPA) into account.

Those who use SDI, or any index of stand density, as an estimate of growing stock, must assume that the index is proportional to site utilization (Long and Smith 1984). Since the contribution of individual stand components to both total SDI and total site utilization is additive, SDI can be used to assess control of growing stock in uneven-aged stands as well as even-aged stands (Long and Smith 1984). Although SDI and the maximum size-density relationship were originally described for pure, even-aged stands, Long and Daniel (1990) have proposed extension of its utility to uneven-aged and multi-aged situations.

Long (1985) divided SDI percentages into four zones which consider the percent of a stand occupied by trees. Based upon established forest density/vigor relationships, density-related mortality from competition begins to occur once the forest reaches 45-50 percent of maximum stand density (zone 3), and mortality is likely at density levels of 60 percent+ of maximum stand density (zone 4).

High forest densities result in increased inter-tree competition, decreased tree health, decreased growth and vigor, decreased regeneration of shade intolerant species, stagnation of structural stage progression, increased insect and disease-related mortality especially in older age classes, decreased horizontal and vertical heterogeneity, decreased understory productivity and diversity, and increased risk of high severity fire. Based on these forest density relationships, a variety of stand and tree characteristics will develop by varying the timing, scale, and intensity of density management.

Openness

A key characteristic of historical ponderosa pine and mixed conifer forests was the grass-forb-shrub interspersed among tree groups; defined as interspace. This interspace typically comprised a large portion of the landscape. The term openness as used in this analysis conveys the percentage of the forested area that is grass-forb-shrub interspace.

Determining openness is best accomplished thru aerial imagery analysis. At present, this sort of analysis is only available for a small portion of the project area. In the absence of a detailed aerial imagery analysis we determined that stand-level inventory data was appropriate to classify the canopy conditions that currently exist within the project area. See the implementation Plan (Appendix C) for guidance in meeting openness objectives.

Issues/Indicators/Analysis Topics

Issues

Issues are statements of cause and effect, linking environmental effects to proposed activities. Comments from the public, the 4FRI Stakeholder Group, other agencies, tribes, and FS personnel were used to formulate issues concerning the proposed action. All comments received were reviewed and analyzed by the interdisciplinary team to "…identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review…" (Council on Environmental Quality, Sec. 1506.3; 40 CFR 1501.7(a) (3)).

The public comments received during the scoping period from June 27 to August 11, 2016 presented 10 issues that are points of intense debate or dispute, inside the scope of the Proposed Action, and relevant to the decision to be made for the 4FRI Rim Country Project. These key issues are used to formulate the alternatives for the Rim Country analysis.

Issue 3 – Large Tree Retention

The Proposed Action may cause the loss of large trees which may significantly affect old growth recruitment. Commenters requested that proposed management actions in old growth, future old growth (large young trees), and high-canopy patches be very explicit, and that no old growth trees be cut.

How Issue 3 is addressed:

This issue will be addressed in the effects analysis for all alternatives. Large trees will be addressed with treatment design and location, design features, mitigation measures, and BMPs to manage for desirable distributions of old trees and groups of large trees in all action alternatives. The Old Growth Implementation Plan and Large Tree Implementation Plan (OTIP/LTIP) were developed for the Rim Country to be responsive to these issues while also being appropriate to the specific ecology and existing conditions in this project area.

Indicators/Measures:

- Number of acres of stands meeting criteria for SPLYT designation.

Significant Issues Responded to in Alternatives to the Proposed Action

Issue 4 – Dwarf Mistletoe Mitigation

The Proposed Action includes dwarf mistletoe treatments that may remove the largest trees in some stands. There is also a concern that more dwarf mistletoe mitigation is needed to improve forest vigor, overall health, and resiliency to climate change. Commenters requested that the scale and intensity of mistletoe mitigation be more clearly defined as far as scale, that where it occurs at natural levels it be allowed to remain to provide essential food and occupancy needs to wildlife, and that the mitigation treatments not focus on removing the largest trees.

How Issue 4 is addressed:

This issue will be addressed in the effects analysis for all alternatives. Dwarf mistletoe mitigation will be addressed with treatment design and location, design features, mitigation measures, and BMPs to retain some dwarf mistletoe as a natural component for wildlife and place limits on removal of large infected trees. The alternatives will propose a range of mitigation treatments.

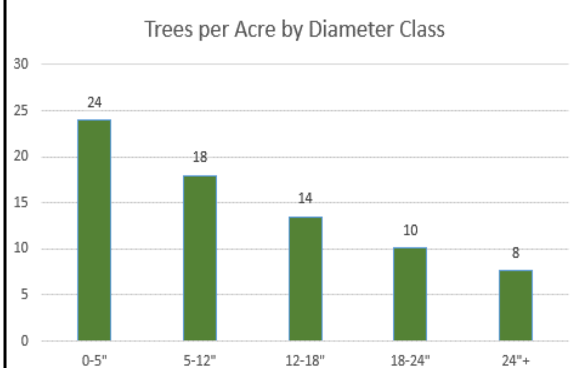
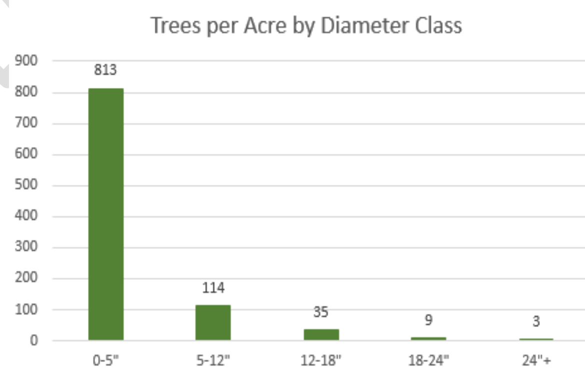
Indicators/Measures:

- Acres of severe dwarf mistletoe mitigation proposed
- Percent of acres in dwarf mistletoe severity rating classes

Environmental Consequences

In order to conduct a site-specific analysis, data from individual stands was used to calculate stand metrics. In order to scale these metrics up to a landscape level analysis, stand data was aggregated up to the 5th HUC watershed and then to the analysis area. The effects analysis period modeled is from 2019 to 2039.

Table 3-8. Desired and existing conditions for the project area.

	Desired Condition	Existing Condition
Structure - Pattern	The majority of stands are in an open condition. Forest arrangement is in individual trees, small clumps, and groups of trees or randomly spaced trees interspersed within variably sized openings of grasses, forbs, and shrubs that are similar to historic patterns. Most forest stands in uneven-aged condition to meet forest resilience and sustainability goals while maintaining wildlife habitat.	The majority of stands are in a closed condition and lacking groups and clumps of trees or randomly spaced trees. Grasses, forbs and shrubs are underrepresented compared to historic patterns. This is departed from desired conditions consisting of a matrix of groups, clumps and individual randomly spaced trees with interspaces,
Structure - Trees per acre	Trees are distributed across size classes with total number of trees per acre between 10 and 250. Below is an idealized tree distribution across size classes totalling 74 trees per acre and carrying 90 ft^2 of basal area  	Total trees per acre is higher than the desired condition and are overrepresented in the smaller diameter classes and underrepresented in the larger classes 
Basal Area	Generally less than 90 square feet per acre to meet forest resilience goals. while maintaining wildlife habitat desired conditions. For MSO protected and nest/roost replacement habitat 110 to 120 square feet per acre is the minimum.	The current average basal area within the analysis area is 129 square feet per acre. High densities in terms of basal area make trees more susceptible to mortality from insects, disease, and competition and increase crown fire risk.
Stand Density Index	Maintain forest density between 25% and 45% of SDImax to maintain forest health and tree growth. For ponderosa pine this SDI range is between 112.5 and 202.5. For MSO protected and Nest/Roost replacement habitat, desired	Currently the average stand density index across the analysis area is 66% of MaxSDI. 21 percent of stands meet the desired condition for SDI. High densities in terms of stand density index make trees more susceptible to mortality

	forest density is between 45% and 60% of SDImax or between 202.5 and 270.	from insects, disease, and competition and increase crown fire risk.
Forest Insects	Stands in the analysis area are in the Low or Moderate hazard for bark beetles	Currently 74% of acreage have a high bark beetle hazard rating. The remaining 26% of stands meet the desired condition for insect hazard.
Forest Disease	Stands in the analysis area have Low to Moderate dwarf mistletoe infection severity (Less than 20% of trees infected)	Currently 75% of acreage has a low dwarf mistletoe infection rating,. 22 percent of acres have a moderate rating and 4 percent have a severe infection rating. 5% of the analysis area meets the desired condition for mistletoe infection severity

Project Scale Area

Alternative 1 – No Action

During the analysis period (2019-2039) the number of trees per acre would decrease across the analysis area, while basal area and SDI would increase somewhat. The number of trees per acre and basal area and SDI would move further away from the desired condition. The number of trees per acre, and basal area are outside of Desired Conditions over much of the analysis area and under the no action alternative, this trend would be expected to continue. The balance of even-aged structure and uneven-aged structure would remain relatively unchanged.

The increase in basal area would likely be skewed toward the larger size classes as larger trees continue to shade out and suppress smaller trees. Suppression and density-dependent mortality would like occur in the smaller size classes. Coarse woody debris, down logs, and snags would all likely increase as a result of continued tree mortality. The amount of basal area in trees greater than 16” would increase and additional stands would meet SPLYT criteria. More acres of forested stands would continue to grow in closed conditions and susceptibility to crown fire would increase. Bark beetle hazard as well as dwarf mistletoe infection severity would continue to increase. Without disturbance, the stands within the analysis area would continue to accrue more biomass during the analysis period. However, as fire hazard, insect hazard, and dwarf mistletoe severity increase, so would the potential for large-scale disturbances that would result in large-scale loss of biomass.

Under the no action alternative, it would be possible for lightening ignited wildfires to be managed for resource benefits across the analysis area. Management of naturally-caused fires for resource benefit could result in changes to forest structure or reductions in small trees that would move some areas to desired conditions for density, and in some rare circumstances could burn at moderate or high severity to improve forest structure in some patches. However, management of naturally-ignited fires on the landscape for resource benefits may be difficult over large areas given that the current condition of the landscape can more easily facilitate a fire growing from low severity to high severity. Thus, the use of this tool to move vegetation conditions toward desired conditions by killing small trees and creating small openings would be limited to circumstances where the risk of high severity fire is low. Additional information on the use of naturally ignited fire can be found in the Fire Ecology Specialist Report (USDA 2019x).

Alternative 2 – Proposed Action

During the analysis period, the number of trees per acre, basal area, and SDI would decrease considerably as a result of the thinning and prescribed fire activities. These indicators would trend toward our desired conditions. In general, stands would move toward a more uneven-aged size class distribution across the landscape as smaller trees are removed and larger trees grow into larger size classes. The protection of the majority of large and old trees, may produce even-aged stands in some cases. However, as treatments are applied on the ground, the use of the large and old tree implementation plans in accordance with an uneven-aged thinning strategy would be able to produce uneven-aged conditions across much of the landscape.

Modeling indicates that the amount of basal area in trees greater than 16" would increase as a result of the proposed action, though not as rapidly as in the no action alternative. With design features in place during implementation, large trees meeting the large and old tree implementation plan criteria would be retained, resulting in more large trees being left at the expense of smaller tree sizes. This would allow the acreage of stands meeting SPLYT criteria to increase. The majority of stands would be classified as open with susceptibility to crown fire being reduced, meeting the desired condition. Bark beetle hazard as well as dwarf mistletoe infection severity would be significantly reduced, meeting or approaching the desired condition. Fire hazard and insect hazard would be reduced as well as the potential for large scale disturbances, creating additional stability and resilience in the forested system.

With the increased heterogeneity of the forest structure created by implementing the proposed action within the forest stands (i.e., reduced tree densities, more uneven-aged conditions, more acreage of trees configured into groups and clumps), resilience to fire, drought, and insects would be improved over the existing condition, meeting the project purpose and need, and trending towards desired conditions.

Alternative 3 – Focused Alternative

In general, the effects of the focused alternative would be similar to the effects of the modified proposed action, with a muted effect due to the fewer number of acres treated. During the analysis period, the number of trees per acre, basal area, and SDI would decrease as a result of the thinning and prescribed fire activities. These indicators would generally trend toward our desired conditions and within NRV, but only in the stands treated. In general, treated stands would move toward a more uneven-aged size class distribution across the landscape as smaller trees are removed and larger trees grow into larger size classes. The protection of the majority of large and old trees, may produce even-aged stands in some cases. However, as treatments are applied on the ground, the use of the large and old tree implementation plans in accordance with an uneven-aged thinning strategy would be able to produce uneven-aged conditions across much of the landscape. In untreated stands, the balance of even-aged structure and uneven-aged structure would remain relatively unchanged.

Modeling indicates that basal area in trees greater than 16" would increase in treated stands as a result of the Focused Action. With design features in place during implementation, large trees meeting the large and old tree implementation plan criteria would be retained, resulting in more large trees being left at the expense of smaller tree sizes. This would allow the acreage of stands meeting SPLYT criteria to actually increase in treated areas. The portion of stands considered open would increase, approaching the desired condition, and susceptibility to crown fire would be reduced. Bark beetle hazard as well as dwarf mistletoe infection severity would be significantly reduced, meeting or approaching the desired condition, though this effects would only be apparent in treated stands. As fire hazard and insect hazard would be reduced, the potential for large scale disturbances would also be reduced.

Table 3-9. Analysis Area Averages for Density and Structure-related Indicator Measures for all Alternatives

		Basal Area	Stand Density Index	Quadratic Mean Diameter
Alt 1	2019	129	296	6.2
	2029	140	312	6.8
	2039	150	324	7.3
Alt 2	2019	129	296	6.2
	2029	65	116	11.0
	2039	62	103	13.3
Alt 3	2019	129	296	6.2
	2029	87	172	9.8
	2039	89	170	11.5

Table 3-10. Distribution of trees per acre across size classes for all alternatives

		0-5"	5-12"	12-18"	18-24"	24"+	Total
Alt 1	2019	813	114	35	9	3	973
	2029	713	117	37	10	4	881
	2039	621	121	39	12	4	797
Alt 2	2019	813	114	35	9	3	973
	2029	97	27	15	8	3	151
	2039	48	18	14	8	4	92
Alt 3	2019	813	114	35	9	3	973
	2029	281	54	21	9	3	368
	2039	222	50	21	9	4	307

Table 3-11. Distribution of basal area across size classes for all alternatives

		0-5"	5-12"	12-18"	18-24"	24"+	Total
Alt 1	2019	12	42	40	20	15	129
	2029	14	43	43	24	17	140
	2039	15	43	46	27	19	150
Alt 2	2019	12	42	40	20	15	129
	2029	2	11	19	18	15	65
	2039	1	8	17	19	18	62
Alt 3	2019	12	42	40	20	15	129
	2029	5	20	25	20	16	87
	2039	6	19	25	21	18	89

Table 3-12. Acres meeting criteria for identification as a Stand with a Preponderance of Large Young Trees (SPLYT) for all alternatives

		Acres	BA >16"	QMD Top 20%
Alt 1	2019	36,265	77	19
	2029	51,855	80	19
	2039	80,139	80	19
Alt 2	2019	36,265	77	19
	2029	47,828	69	23
	2039	64,774	70	24
Alt 3	2019	36,265	77	19
	2029	50,961	71	22
	2039	72,424	72	22

Table 3-14. Analysis Area Averages for Forest Health Related Indicator Measures for all Alternatives

		Beetle Hazard Rating			Dwarf Mistletoe Severity		
		Low	Mod	High	Low	Mod	High
Alt 1	2019	19%	7%	74%	75%	22%	4%
	2029	16%	6%	78%	67%	26%	6%
	2039	13%	6%	82%	66%	25%	9%
Alt 2	2019	19%	7%	74%	75%	22%	4%
	2029	77%	12%	11%	69%	30%	2%
	2039	83%	9%	8%	66%	31%	3%
Alt 3	2019	19%	7%	74%	75%	22%	4%
	2029	49%	12%	39%	68%	30%	2%
	2039	50%	10%	40%	66%	30%	4%

Alternative 1 – No Action

Direct and Indirect Effects

Under Alternative 1 no acres would receive either prescribed cutting or prescribed fire treatment. Although this alternative does appear to meet some of the desired conditions identified in the Forest Plan concerning forest structure, it would not move the forest forward in initiating the re-establishment of a fire-adapted, resilient, diverse, and sustainable forest ecosystem. For example, based on a broad array of research, current stand conditions would continue to develop so that the overabundance of trees in the smaller size classes (0-5 and 5-12 inch size classes) at the landscape scale, but they would likely develop at a slower rate due to increased competition and water stress. At the same time, the slow transition of intermediate and mature forests would lead to an increasing lack of young, developing forests. In the likely case of one or more large disturbance events (e.g., wildfire, drought, insects), the result would be an over-abundance of young forests. For a more thorough analysis of the effects of larges disturbance such as uncharacteristically large or severe wildfires, consult the Fire Ecology Specialist Report (USDA 2019).

Without treatment, stands in the analysis area would be much less resilient to disturbances such as multi-year drought, insects and disease such as bark beetle and mistletoe, and wildfire (Abella, et al., 2007). Increased drought stress and insect attacks are often associated with increased tree density, altered tree spatial arrangement, and shifted forest composition that have resulted from fire exclusion, grazing, and past logging. These changes in forest structure may exacerbate tree mortality due to increased competition among trees (Kane, Kolb, & McMillin, 2014, p. 171). At the fine scale, these disturbances would likely result in a greater mortality rate for areas with dense forest, which include groups and clumps of large trees (Zhang, Ritchie, Maguire, & Oliver, 2013).

Composition

Forest composition is not expected to change dramatically under this alternative if there are no large-scale disturbances such as wildfire or epidemic-level insect outbreaks. Ponderosa pine would still be the dominant cover type within the analysis area. Mixed conifer would make up a moderate proportion of the analysis area, though the composition of shade tolerant species such as white fir may increase considerably in this forest type. Juniper, grasslands, and other hardwoods would continue to make up a minor part of the analysis area. Without wildfire or other types of disturbance, aspen would continue to decline, as normal succession pressures continue to favor conifer establishment. This continued encroachment may result in the loss of aspen from parts or all of the analysis area. Climatic models for the southwestern U.S. predict continued warming, greater variability in precipitation, and increased severity and longevity of drought. These climatic changes would likely contribute to continued and perhaps increasing tree mortality, which may lead to large shifts and contractions in the range of dominant trees throughout much of the region (Kane, Kolb, & McMillin, 2014).

In general, overstory density would increase and understory species richness would decline significantly (Korb & Springer, 2003). Without treatment, understory grass vigor would be expected to be reduced. Less sunlight would reach the forest floor. As a result, understory diversity would decrease, which would reduce the overall biodiversity found in frequent-fire forests.

Structure

Uneven-aged Structure

Uneven-aged forest structure is the Desired Condition. Under this alternative, there is little change to forest structure (Figure 3-3). Some trees will grow into larger size classes, but the overall the portion of stands that can be considered uneven-aged remains unchanged. The uncharacteristically high number of trees in the smaller and medium size classes provide excessive competition with larger trees in the stand, slowing growth and limiting diameter growth of the largest trees in the stand. While this meets the Desired Condition, it provides little improvement over the Existing Condition into the future.

While this indicator meets the desired conditions for uneven-aged structure in the forest plans, this does not account for the possibility of an uncharacteristic wildfire or other substantial disturbance event, such as a beetle outbreak or long-term drought. There are an abundance of small diameter trees across the analysis area, far above historic conditions. Because of the current structure, including overstocked forests and ladder fuels created when smaller trees grow directly beneath the canopy of larger trees, the current landscape would be less resilient if a catastrophic event were to occur. Many, if not most, of the trees would be killed, resulting in large areas lacking live trees. Natural regeneration or reforestation planting would create large even-aged, young forests, with little structural diversity for the foreseeable future.

Density

Measure of density in this analysis include trees per acre, basal area and stand density index. The overall tree density continues to remain very high under this alternative, averaging nearly 1,000 trees per acre through much of the area (Table 3-10). All 5th HUC watersheds currently do not meet the desired condition for trees per acre. In general trees are overrepresented in the smaller size classes and underrepresented in the larger size classes. Smaller trees and their aggregated spatial pattern on the landscape has resulted in dense thickets of “dog-haired” pine. While there would be some density-related mortality in the smaller trees as time goes by, this trend of “dog-haired” thickets of pine is expected to continue into the foreseeable future under this alternative. Across the analysis area, forested stands would continue to be dominated by small diameter trees into the future. This tree density would result in reduced tree growth and increased mortality, especially in older trees, stagnated nutrient cycles, decreased herbaceous and shrub forage quality and quantity (Covington & Moore, 1994a). Without cutting or fire disturbances, tree regeneration would be inhibited and the trend would be a shift to the larger size classes maintaining extremely dense conditions that are not resilient to disturbances such as fire, insects, and climate.

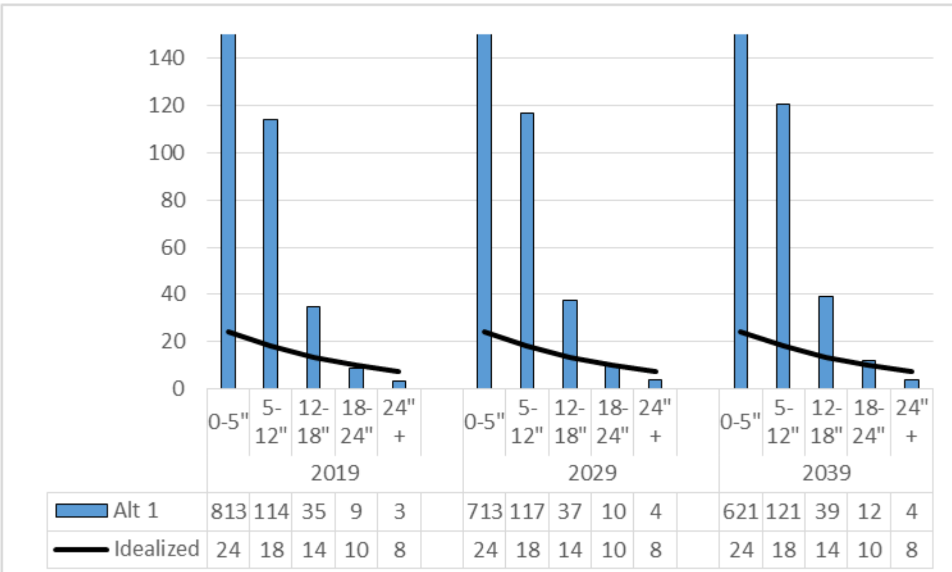


Figure 3-3. Alternative 1 – No Action – Distribution of trees per acres across size classes across the analysis area as well as an idealized distribution of trees per acre

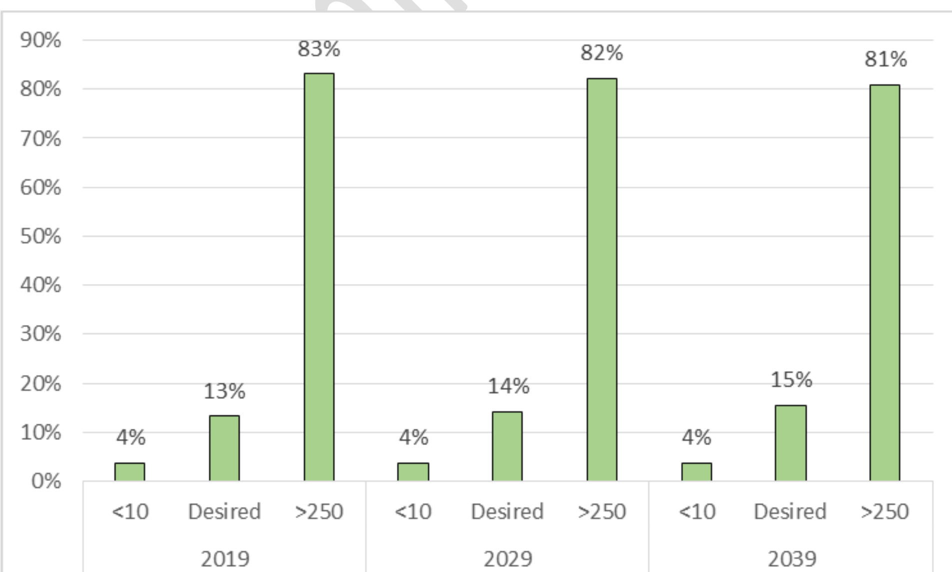


Figure 3-4. Alternative 1 – No Action – Percent of acres meeting desired condition for trees per acre across the analysis area

The desired condition is to retain a basal area of between 30 and 90 square feet per acre across most habitat types outside of MSO habitat. For a more thorough analysis of the effects of this alternative within MSO habitat as well as northern goshawk habitat, consult the Wildlife Specialist Report (USDA 2019). While the Forest Plans provide a desired condition with a range of basal areas ranging from 20 to 180 square feet per acre depending on cover type, for this analysis, at the project level, for ease of comparison of effects between alternatives, 30 to 90 square feet per acre is the breakpoint for the resource measure. For both mixed conifer and ponderosa pine cover types it is desired to maintain basal area at less than 90 square feet per acre, though exceptions exist to provide heterogeneity across the landscape as well as specific wildlife needs for dense and closed canopy forest conditions. For a thorough description of these considerations consult the Implementation Plan (Appendix C).

Under the No Action alternative, basal areas across the analysis area would average 129 square feet per acre, ranging from 60 square feet per acre in the Carrizo Creek watershed, which has experienced a considerable amount of uncharacteristic severity wildfire, to 166 square feet per acre in the Salome watershed, and Haigler Creek-Tonto Creek watershed, dominated by dense ponderosa pine evergreen oak cover type. This excessive stocking is expected to increase to, on average, 150 square feet per acre by 2039. Currently only 19 percent of acreage meets the desired condition for basal area. The percentage of stands that meet the desired condition would be reduced to 12 percent by 2039 under the No Action alternative.

Continuous tree growth would allow for forest stand densities to depart further from the desired condition. This would result in increasing competition for limited resources (water, light, growing space, and soil nutrients). Competition-induced mortality and growth stagnation would continue to increase, along with susceptibility to potential insect and disease outbreaks. The current conditions and effects of no action over the next thirty years support a shift away from frequent, low severity surface fires to increasingly larger high severity intensity crown fires (Cooper, 1960) (Swetnam, 1990) (Covington & Moore, 1994a) (Kolb, Wagner, & Covington, 1994) (Swetnam & Baisan, 1996). For more information consunt the Fire Ecology Specialist Report (USDA 2019). These conditions would not meet the purpose and need for fire-adapted, resilient, diverse, and sustainable forest ecosystems.

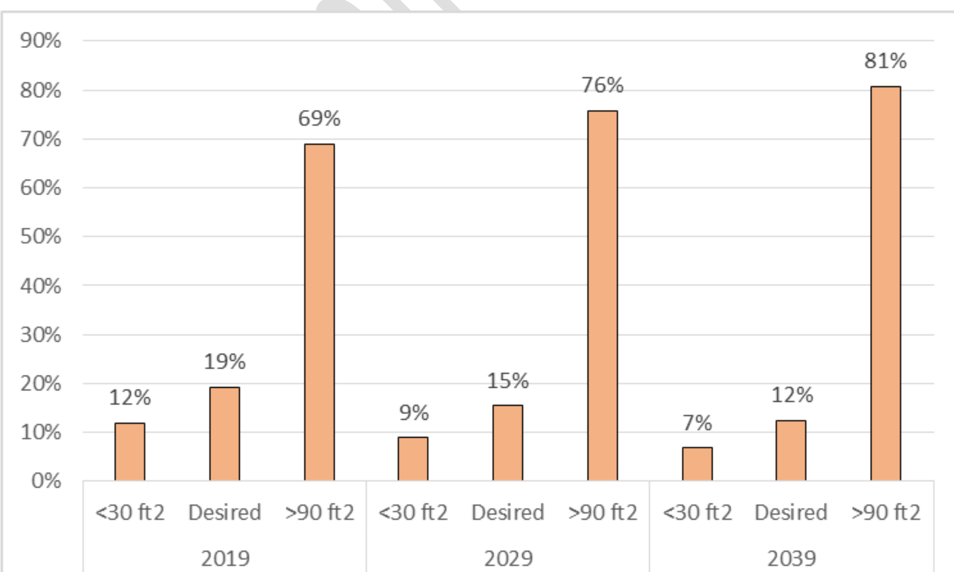


Figure 3-5. Alternative 1 - No Action – Percent of acres meeting desired condition for basal area across the analysis area.

Stand Density Index (SDI) is a measure of relative stand density based on the number of trees per acre and the mean diameter (Long 1995). Percent SDImax expresses the actual density in a stand relative to a theoretical maximum density possible for trees of that diameter and species (SDIMax is 450 for this analysi). SDI is a good indicator of how site resources are being used by taking both average tree size and trees per acre into account. SDImax represents an empirically-based estimate of the maximum combination of quadratic mean diameter and density which can exist for any stand of a particular forest type.

Currently across the analysis area, SDI averages 296 or 66 percent of SDImax and is considered in the zone where density related mortality is prominent and approaching the zone where imminent mortality will occur. Values range from 140 in the Carrizo Creek watershed, which has experienced a considerable amount of uncharacteristically severe wildfire to 400 in the Haigler Creek-Tonto Creek watershed which has a substantial amount of the ponderosa pine evergreen oak cover type. Overall, SDI and its relation to SDImax continues to increase to 324 or 70 percent of SDImax by 2039. In relation the desired condition, currently 15 percent of acres within the analysis area meet desired condition for SDI. This number would decrease to 11 percent by 2039.

Over time, with no action, continuous tree growth will allow forest stand densities to remain high and extremely high on the majority of acres (Das et al. 2001). This would result in increased susceptibility to insect epidemics, particularly bark beetles and intense individual tree competition and competition-induced mortality, decreased individual tree diameter growth and stand volume, and forage production over time and further departure from the desired condition.

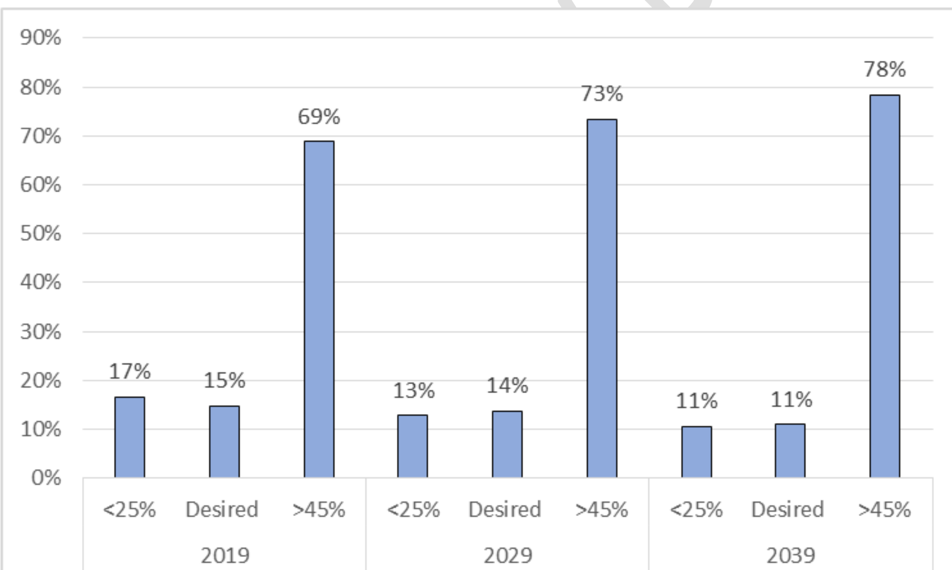


Figure 3-6. Alternative 1 - No Action – Percent of stands meeting the desired condition for stand density index

Large Tree and Old Tree Structure

Stands of post settlement trees where the quadratic mean diameter of the top 20 percent of trees is greater than 15”and the basal area of trees greater that 16” is more than 50 feet of basal area can be considered stands with a preponderance of large young trees (SPLYT stands). These stands occur outside of MSO PACs, MSO Recovery habitat and WUI and are being identified for their distinctive forest structure.

Under this alternative, no trees would be removed through cutting. Therefore, all large and old trees are expected to remain, except they are likely to be more susceptible to mortality from drought, pests, and disease as well as wildfire (Das et al. 2011, Ritchie et al, 2008). Across all 5th HUC watersheds in the analysis area the number of acres meeting SPLYT criteria is currently estimated to be 36,265 acres with a QMD of the top 20 percent of trees to be 19 inches. This number would increase to 80,139 acres by 2039 with a QMD of the top 20 percent of trees remaining at 19 inches. This is the result of current trees continuing to increase in diameter growth and does not take into account the potential mortality from drought, insects, disease and wildfire.

This alternative would also result in higher risk of mortality, especially for larger trees, because of an increasing risk of infection from pests or disease (Fischer et al, 2010), high severity or uncharacteristic wildfire (Coop et al, 2016) (Fiedler et al, 2010), or increased drought stress from competition (Erickson & Waring, 2014). A number of studies have found that higher forest density leaves large and old trees more susceptible to mortality. Erickson and Waring (2014) concluded that, "treatments removing small, neighboring trees may be critical in maintaining old ponderosa in the landscape, particularly under future climate change and increasing drought frequency in the western USA." Modifying forest conditions to facilitate low severity fire on the landscape has been identified as a key condition to preventing increased mortality of large and old trees over the next several decades (Fiedler et al. 2007, Kolb et. al. 2007, Ritchie et. al. 2008). Thus, while this alternative may increase the amount of large and old trees based on model results, these results do not account for the likely substantial loss of old and large trees as a result of various forest disturbances (such as uncharacteristically severe wildfire), which would decrease the amount of old and large trees in the analysis area.

Under this alternative it is possible that one or more naturally caused wildfires will be managed to benefit forest resources. Depending on the ability to manage one or more naturally caused fires based on values at risk, fuel, and weather conditions under this alternative some wildfires could result in small openings that decrease areas of intermediate aged trees, which would then contribute to establishment of a new young cohort of trees. Management of naturally caused fires under this alternative may also have the effect of reducing basal area and SDI by killing small trees or groups of small and/or intermediate aged trees. These fires could also result in mortality of some large and old trees or large patches of high severity mortality. Based on those areas in recent wildfires that have been managed for resource benefits, this effect may be very limited across the landscape. The current condition of the Forest would limit the ability to manage naturally-occurring wildfires in the analysis area at low to moderate-intensity levels without potential unacceptable effects on values at risk.

Forest Process

Insects

Under the No Action Alternative the proportion of acreage with a high hazard rating for bark beetles would increase from 74 percent to 82 percent, a considerable majority of the landscape. The proportion of acreage with a low or moderate hazard rating would decrease. Some large watersheds such as Upper Clear Creek, Haigler Creek-Tonto Creek and East Verde River are currently over 90 percent high hazard for bark beetles. The existing condition is departed from the desired condition and would further depart between 2019 and 2039 as basal area and SDI continue to increase beyond the Desired Condition.

Drought, coupled with high tree densities, can lower resistance to beetle attacks. Bark beetle population dynamics suggest that homogenous, dense, even-aged stands are highly susceptible to beetle outbreaks. Susceptibility to western pine beetle would slowly increase over time. Areas with the greatest likelihood of infestation are those stands with densities greater than 120 square feet of basal area and average stand diameters greater than 12 inches dbh. Susceptibility to Ips would continue to increase with activity most likely occurring in response to a drought or a snow or ice event that creates fresh pine debris.

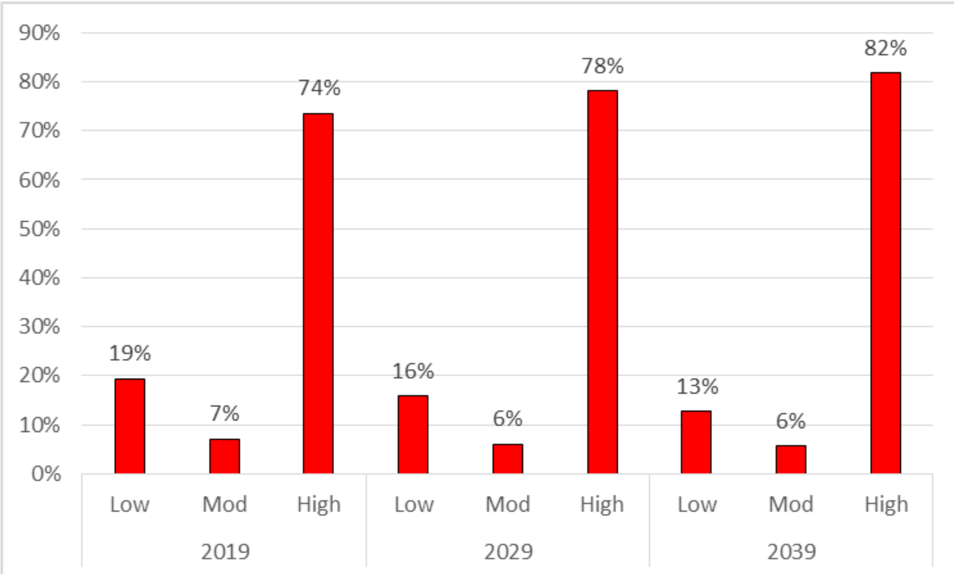


Figure 3-7. Alternative 1 - No Action Alternative – Distribution of Bark Beetle Hazard Rating classes across the analysis area.

Disease

Across the analysis area, approximately 75 percent of the area is not infected or has a low infection level, 22 percent has a moderate severity rating and 4 percent has a high severity rating. This distribution shifts to higher severity ratings over time; by 2039, 25 percent of acres are classified as moderate and 9 percent of acres are classified as severe by 2039. This is an indication that mistletoe infection is intensifying and spreading over time. Dwarf mistletoe infections would not be reduced and may intensify in infected trees and the surrounding trees, reducing the growth, vigor, and longevity of ponderosa pine. Though most of the analysis area meets the desired condition of having a low or no dwarf mistletoe severity, 34 percent of the analysis area would have a moderate or severe dwarf mistletoe severity rating by 2039 and would not meet the desired condition. Stands would further depart from the desired condition over time as infected stands intensify their infections and infect adjacent areas (Conklin and Fairweather 2010).

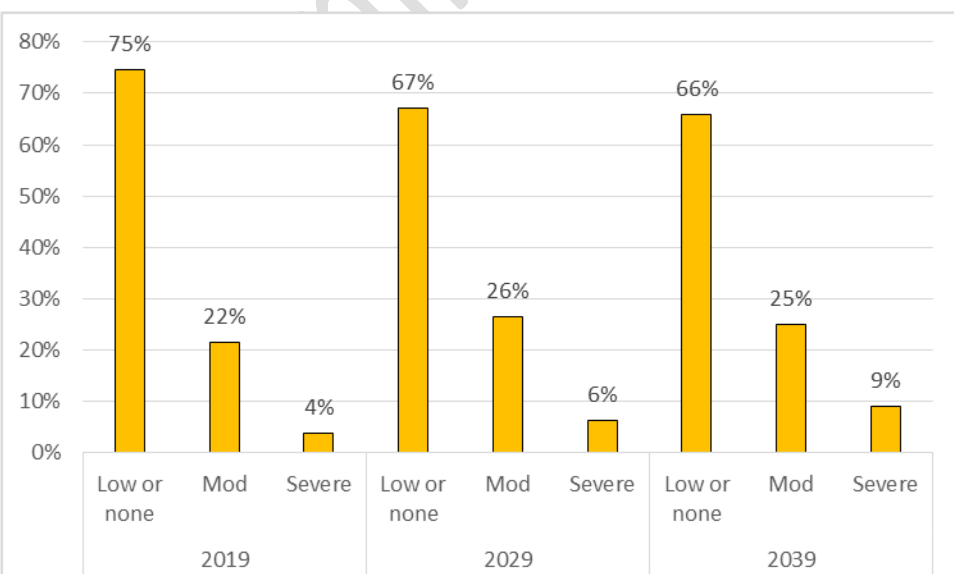


Figure 3-8. Alternative 1 - No Action Alternative – Dwarf Mistletoe Severity Rating classes across the analysis area

Fire Adaptation

For a more thorough discussion of this alternative in terms of fire adaptation, consult the Fire Ecology Specialist Report (USDA 2019). In general, this alternative does not support the purpose and need to develop or return to a forest ecosystem that is fire-adapted, resilient, diverse, and sustainable. This alternative would continue to support the current shift away from frequent, low severity surface fires to conditions that are more likely to support increasingly larger high severity crown fires (Cooper 1960) (Swetnam 1990) (Covington and Moore, 1994a) (Kolb et al 1994) (Swetnam and Baisan, 1996). The current forest structure is quite different from conditions from the NRV of the native microbes, plants, and animals living in western ponderosa pine and dry mixed conifer forests (Covington and Moore 1994a, Reynolds et al 2013). As a result, this project area would remain susceptible to undesirable fire behavior and effect, and other disturbance agents, such as bark beetles and disease, over time.

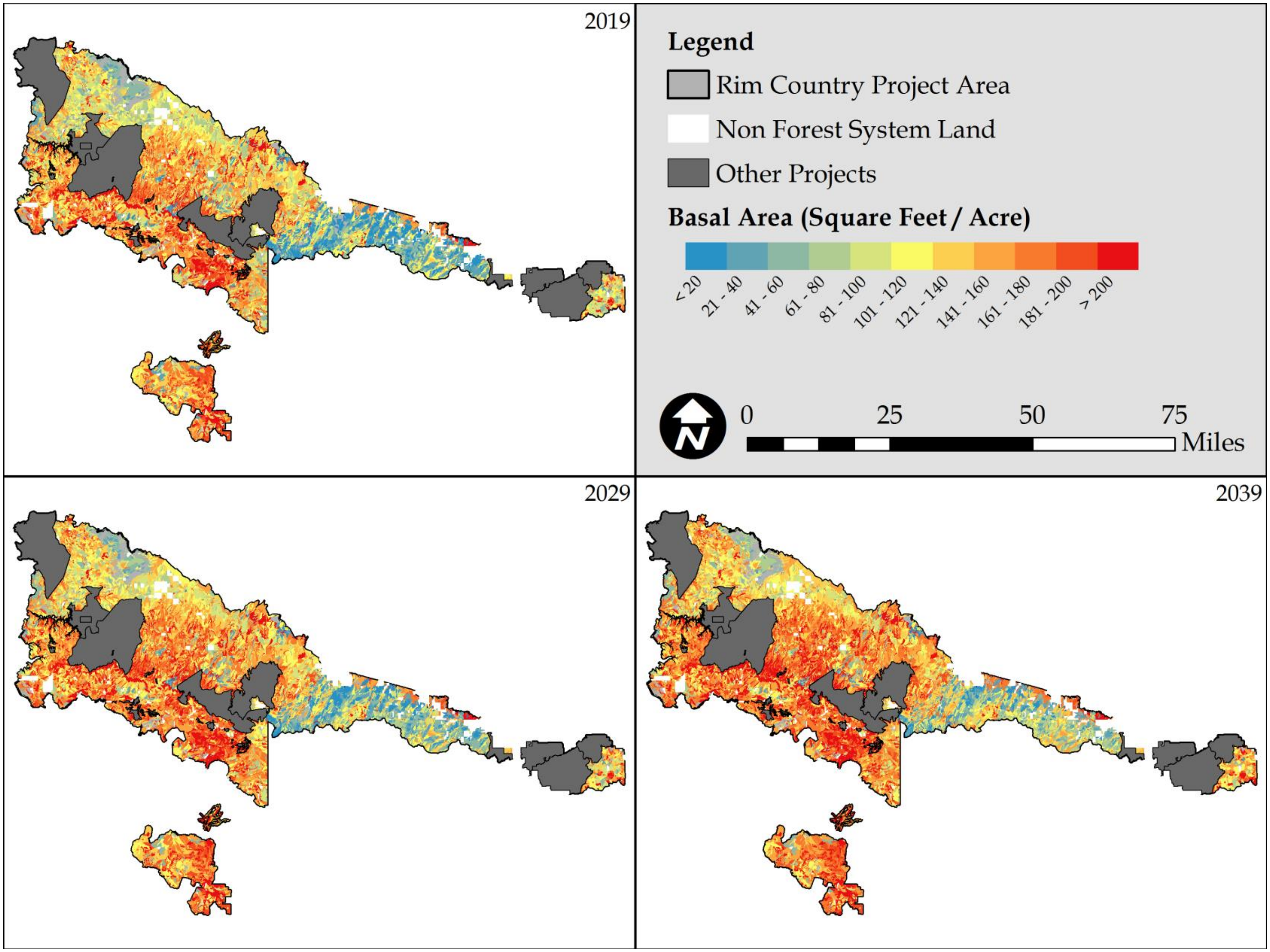


Figure 3-9. Alternative 1 – Basal Area

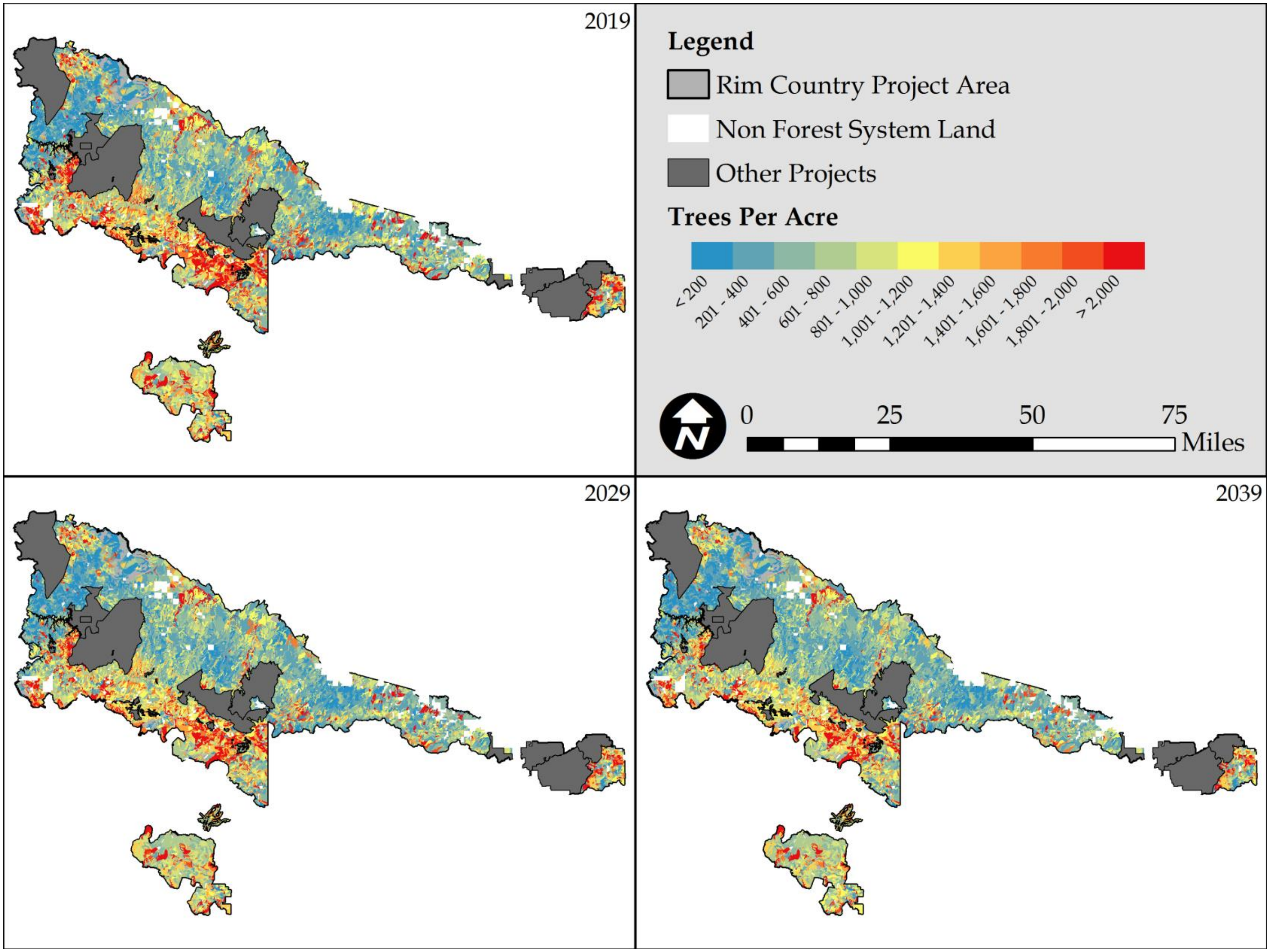


Figure 3-10. Alternative 1 –Trees per Acre

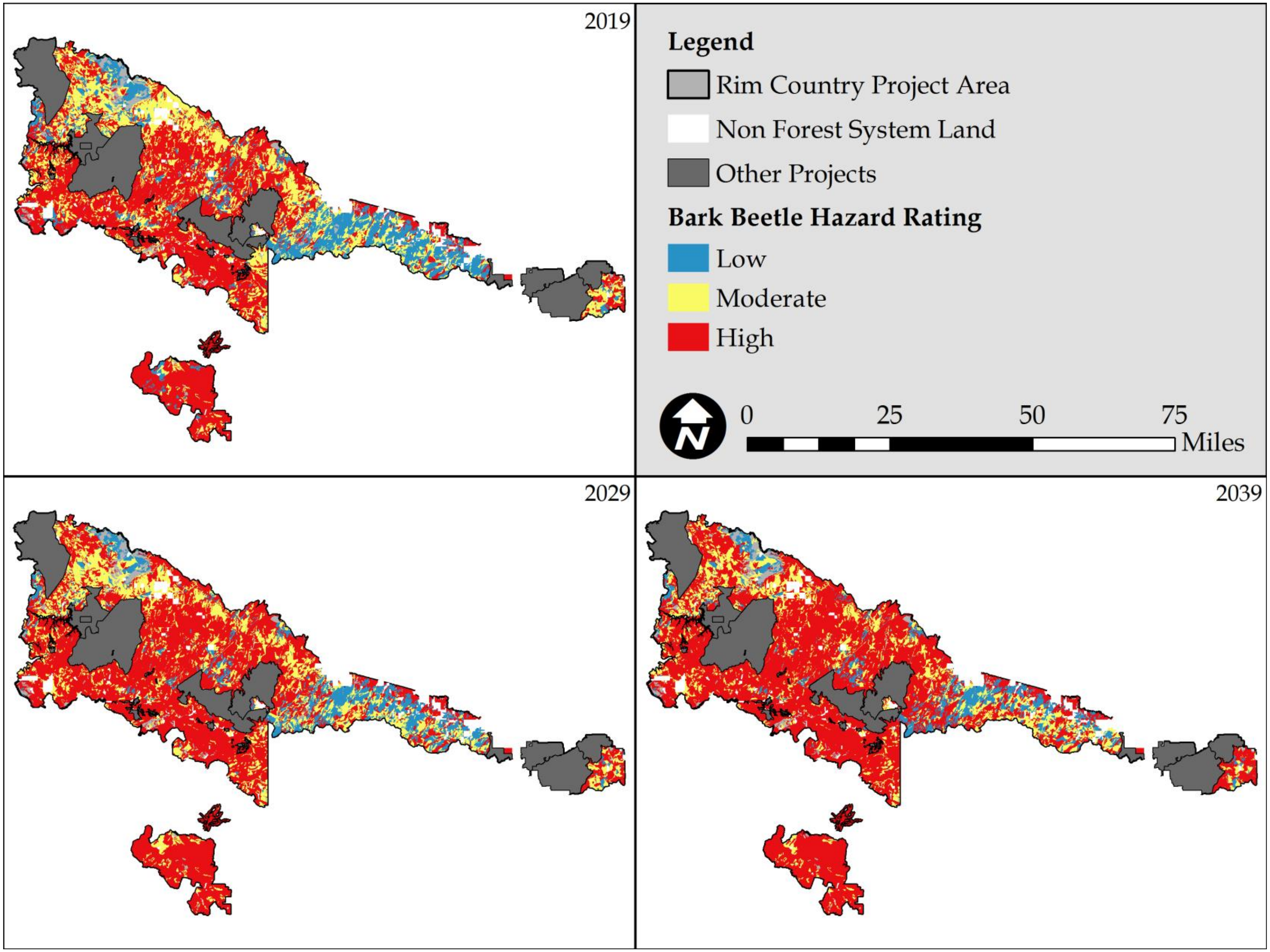


Figure 3-11. Alternative 1 – Bark Beetle Hazard Rating

Alternative 2 – Proposed Action

Direct and Indirect Effects

Under Alternative 2, prescribed cutting and/or prescribed fire treatment would be applied in order to move towards or meet the desired conditions. This alternative meets or moves the project area toward the desired conditions identified in the Forest Plans and moves the project area forward in initiating the re-establishment of a fire-adapted, resilient, diverse, and sustainable forest ecosystem. The distribution of trees across size classes is more representative of a historic size class distribution as many trees in the smaller size classes have been removed or burned. At a landscape scale forest composition, structure, pattern, and process would all be improved. For a more thorough analysis of the effects of this alternative on the wildfire hazard, consult the Fire Ecology Specialist Report (USDA 2019).

Stand and landscape resilience to disturbances such as multi-year drought, pests, and disease such as bark beetle and mistletoe, and undesirable fire effects would increase (Abella, et al. 2007) as density would be reduced under this alternative. Drought stress and insect attacks associated with increased tree density, altered tree spatial arrangement, would be reduced. These changes in forest structure would reduce tree mortality due to decreased competition among trees (Kane et al, 2014). At the fine scale, forest structure and pattern would be improved as vegetation management activities would maintain or improve the level of tree aggregation (groups and clumps of trees) as existing groups are maintained and new groups are created (Zhang et al, 2013).

Composition

Forest composition would improve under this alternative. Ponderosa pine would still be the dominant forest cover type. Mixed conifer would continue to make up a moderate proportion of the analysis area. As a result of prescribed cutting and prescribed fire, prevalence of later seral species such as white fir and corkbark fir in forested stands would be reduced and would better represent their role in the NRV. Pinyon juniper woodlands and oak species would continue to make up a considerable part of the analysis area. The treatment of conifer encroached grasslands would expand their range to more fully represent the Desired Condition to reestablish their historical extent. The protection and improvement of aspen stands would promote regeneration and reduce inter-tree competition and improve their condition under this alternative; however aspen is one of the species predicted to be most affected by a changing climate. The condition of less common but important species such as maple and Emory oak would be improved through the cutting of other species such as juniper and other species.

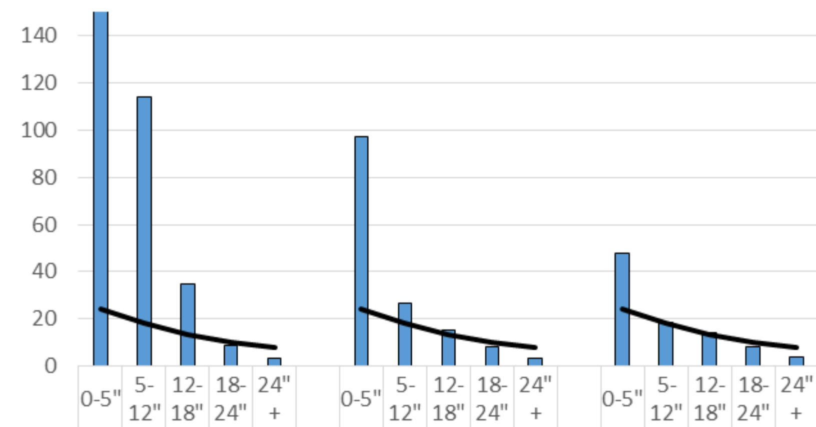
This analysis has considered the effects of a changing climate. Though this alternative would result in a landscape more resilient to climate change, climatic models for the southwestern U.S. predict continued warming, greater variability in precipitation, and increased drought. These climatic changes would likely contribute to some level of tree mortality; however, considerably less than the No Action Alternative. A changing climate may lead to large shifts and contractions in the range of dominant trees throughout much of the region (Kane et al, 2014).

Structure

Uneven-aged Structure

Uneven-aged forest are defined as forests composed of three or more distinct age classes of trees, either intimately mixed or in small groups. The Desired Condition is for uneven-aged forest structure to occur on a majority of acres. Under this alternative, there is considerable change to forest structure (Figure 3-12). Across the project, evenaged structure would dominate the landscape with a balance of trees in smaller, medium and larger size classes. The proportion of stands with uneven-ageed structure would increase into the future. This alternative would meet the Desired Condition for uneven-aged structure in the Forest Plans and forest structure would more closely resemble the NRV. Modeling indicates that some stands would move towards more even-aged conditions in the dominant cover types proposed for treatment as a result of removal of trees from the smaller size classes and retention of trees in the larger size classes. Modeling the most intense extent of the range of the prescribed treatment, combined with the protection of large and old trees, produced even-aged stands of larger trees in some cases. However, as treatments are applied on the ground, the use of the large and old tree implementation plans, in accordance with an uneven-aged thinning strategy, would be able to produce uneven-aged conditions across much of the landscape. Individual tree growth would increase and trees would move into larger size classes as a result of a reduction in individual tree competition. Naturally-occurring regeneration would provide additional vertical structure over time.

An additional, and potentially more substantial, benefit to forest structure would be a reduction in the possibility of an uncharacteristic wildfire or other substantial disturbance event, such as a beetle outbreak or long-term drought. Under this alternative stands would be more resistant to uncharacteristic fire and insect outbreaks and more resilient to drought. The balance of size classes and uneven-aged structure would provide conditions favorable to restoration of a natural fire regime.



	2019					2029					2039				
	0-5"	5-12"	12-18"	18-24"	24"+	0-5"	5-12"	12-18"	18-24"	24"+	0-5"	5-12"	12-18"	18-24"	24"+
Alt 2	813	114	35	9	3	97	27	15	8	3	48	18	14	8	4
Desired	24	18	14	10	8	24	18	14	10	8	24	18	14	10	8

Figure 3-12. Alternative 2 – Proposed Action – Distribution of trees per acres across size classes across the analysis area

Density

Measure of density in this analysis include trees per acre, basal area and stand density index. With prescribed thinning and fire, there would be considerable change to the size class distribution in the near future. The Proposed Action would effectively meet the desired condition for trees per acre with a balance across size classes. The overall tree density would decrease considerably under this alternative, from 973 in 2019 to 151 in 2029 and 92 by 2039 (Table 3-10).

While the initial reduction in trees per acre would result from a combination of mechanical and prescribed fire activities, the reduction after 2029 can be attributed to the recurring prescribed fires over time. Prescribed fires with higher or lower severity (e.g., burning under hotter or cooler and/or wetter conditions) from 2029 to 2039 could be implemented to maintain a higher or lower number of trees per acre in the smaller size classes if desired. The reduction in tree density would increase individual tree growth and reduce density dependent tree mortality. Understory grasses, forbs herbs and shrubs would increase in quantity (Covington & Moore 1994a).

The desired condition is to retain a basal area of between 30 to 90 square feet per acre across most habitat types outside of MSO PACs. While the Forest Plans provide a desired condition with a range of basal areas ranging from 20 to 180 square feet per acre depending on cover type, for this analysis, at the project level, for ease of comparison of effects between alternatives, 90 square feet per acre is the breakpoint for the resource measure across the analysis area. For both mixed conifer and ponderosa pine cover types it is desired to maintain basal area at less than 90 square feet per acre though exceptions exist to provide heterogeneity across the landscape as well as specific wildlife needs for dense and closed canopy forest conditions. For a more thorough analysis of the effects of this alternative within MSO and Northern goshawk habitat, consult the Wildlife Specialist Report (USDA 2019).

Under the Proposed Action alternative, basal areas across the analysis area would average 65 square feet in 2029 and 62 square feet in 2039. While currently only 19 percent of stands meet the desired condition, by the year 2029, 58 percent of stands would have met the desired condition, and by 2039, over 56 percent of stands would meet the desired condition. This would result in decreased inter-tree competition for resources such as water, light, growing space, and nutrients. Individual tree growth would increase and density dependent mortality would be dramatically reduced along with susceptibility to potential insect and disease outbreaks. These conditions would indicate a shift from the current larger and higher severity crown fires that the forest would currently experience to cooler, higher frequency, lower severity surface fires (Cooper 1960) (Swetnam 1990) (Covington & Moore, 1994a) (Kolb et al 1994) (Swetnam and Baisan 1996) that persisted prior to European settlement. The reductions in basal area would meet the desired condition and purpose and need for fire-adapted, resilient, diverse, and sustainable forest ecosystems at the landscape and watershed scales.

While all watersheds would have their average basal areas reduced to within the desired condition, some watersheds such as Gun Creek-Tonto Creek and Rye Creek-Tonto Creek would experience considerable additional mortality as a result of prescribed fire between 2029 and 2039. Prescribed fires with lower severity effects (e.g., burning under cooler and/or wetter conditions) in 2029-2039 could be implemented to maintain the desired basal area and continue to meet the desired condition.

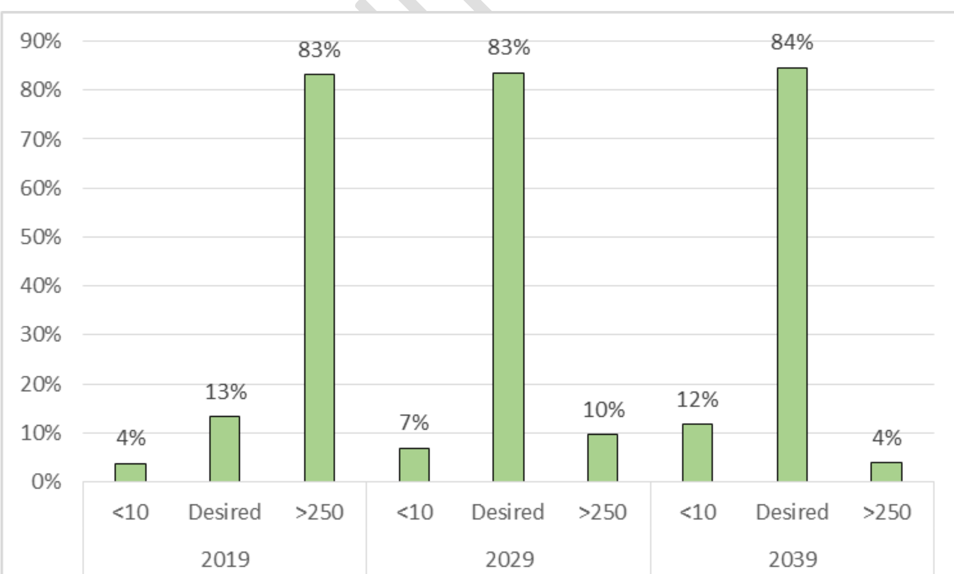


Figure 3-13. Alternative 2 – Proposed Action – Percent of acres meeting desired condition for trees per acre across the analysis area

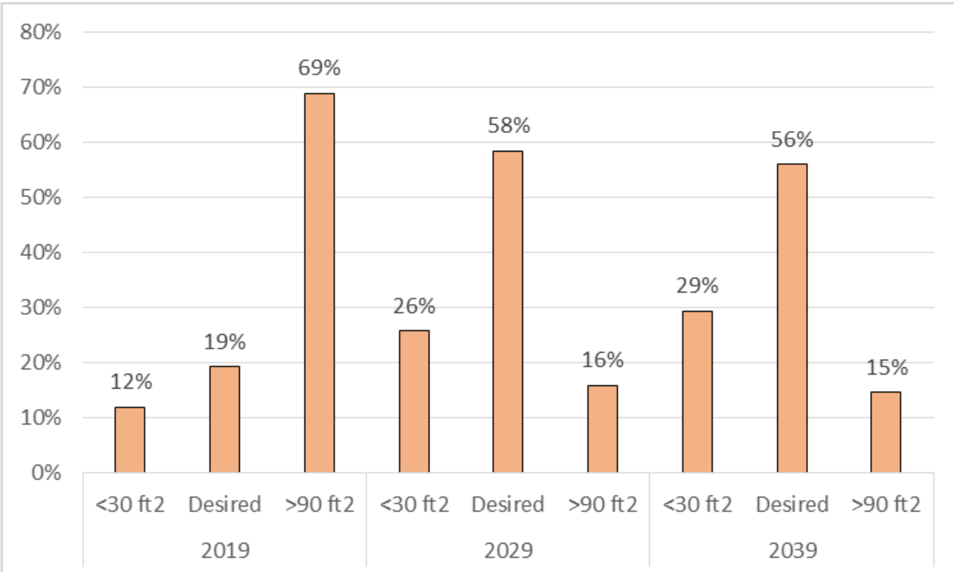


Figure 3-14. Alternative 2 - Proposed Action – Percent of acres meeting desired condition for basal area across the analysis area.

Stand Density Index (SDI) is a measure of relative stand density based on the number of trees per acre and the mean diameter (Reineke 1933, Long 1995). Percent SDImax expresses the actual density in a stand relative to a theoretical maximum density possible for trees of that diameter and species. SDI is a good indicator of how site resources are being used by taking both average tree size and trees per acre into account. SDImax represents an empirically-based estimate of the maximum combination of quadratic mean diameter and density which can exist for any stand of a particular forest type.

The desired condition for SDI is to be between 25 and 45 percent of SDIMax or between 112.5 and 202.5. Currently across the analysis area, SDI averages 296 or 66 percent of SDImax and is considered extremely high. As a result of the proposed action, SDI would be reduced to 116 or 26 percent of SDIMax by 2029 and 103 or 23 percent of SDIMax by 2039. While the proportion of acres meeting desired condition in 2019 is 15 percent, the proportion meeting the desired condition would increase to 27 percent in 2029 and to 21 percent by 2039. Prescribed fires with lower severity effects (e.g., burning under and/or wetter conditions) from 2029 to 2039 could be implemented to maintain a higher or SDI if desired. SDI values between 25 percent and 45 percent of SDIMax are associated with high understory production and intermediate levels of individual tree diameter growth as overall stand growth is concentrated on fewer number of trees than in more dense forests. Depending on the level of tree aggregation, little inter-tree competition would be occurring. Competition could still be occurring within dense tree groups.

Over time, with the proposed action, stand densities should stabilize as the reintroduction of fire returns natural disturbance processes to the landscape. This would result in reduced susceptibility to insect epidemics, particularly bark beetles, as well as reduced density dependent mortality, increased individual tree diameter growth and forage production over time, and continued attainment of the desired condition.

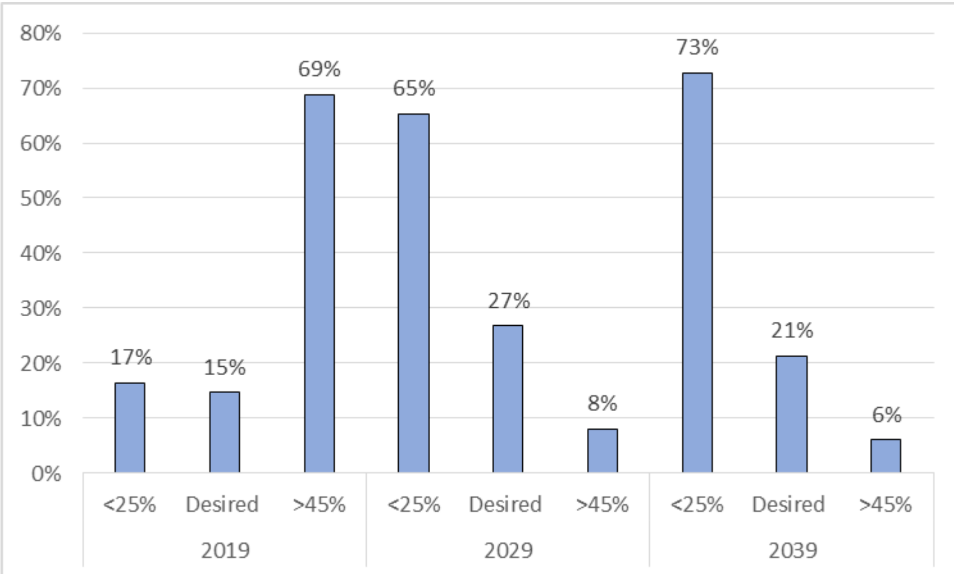


Figure 3-15. Alternative 2 - Proposed Action – Percent of stands meeting the desired condition for stand density index

Large Tree and Old Tree Structure

Stands of post settlement trees where the quadratic mean diameter of the top 20 percent of trees is greater than 15"and the basal area of trees greater that 16" is more than 50 feet of basal area can be considered stands with a preponderance of large young trees (SPLYT stands). These stands occur outside of MSO PACs, MSO Recovery habitat and WUI and are being identified for their distinctive forest structure.

Across all 5th HUC watersheds in the project area, the average number of acres currently meeting SPLYT criteria is 36,325 with a QMD of the top 20 percent of trees being 19 inches. Under the proposed action, this number would increase to 64,774 acres with a QMD of the top 20 percent of trees being 24 inches. While this acreage is lower than the acres meeting SPLYT criteria in 2039 for the no action alternative it does not take into the account the potential large scale mortality of trees as a result of a large fire or insect outbreak. Under this alternative, prescribed cutting and prescribed burning would occur over much of the landscape. Modeling indicates that the number of acres meeting SPLYT criteria would increase as a result of the proposed action, but at a slower rate than the Proposed Action. With design features in place during implementation, large trees meeting the large and old growth tree implementation plan criteria would be retained, resulting in more large trees being left at the expense of smaller tree sizes. This would allow the number of SPLYT acres to increase over time. During implementation, some large trees would be cut in accordance with the large and old growth tree implementation plans. Remaining larger trees would be less susceptible to mortality from drought, insects, disease, and wildlife (Das et al. 2011, Ritchie et al, 2008). This reduction in the number of SPLYT acres over the no action alternative does not take into account the application of the LTIP that would effectively increase the number of large trees remaining across the landscape.

This alternative would result in a lower risk of mortality, especially for larger trees, because of a decreasing risk of infection from pests or disease (Fischer, Waring, Hofstetter, & and Kolb, 2010), high severity or uncharacteristic wildfire (Coop et al, 2016) (Fiedler et al, 2010), or increased drought stress from competition (Erickson & Waring, 2014). A number of studies have found that lower forest density leaves large and old trees less susceptible to mortality as a result of these factors. Erickson and Waring (2014) concluded that, “treatments removing small, neighboring trees may be critical in maintaining old ponderosa in the landscape, particularly under future climate change and increasing drought frequency in the western USA.” Modifying forest conditions to facilitate low severity fire on the landscape has been identified as a key condition to preventing increased mortality of large and old trees over the next several decades (Fiedler et al. 2007, Kolb et. al. 2007, Ritchie et. al. 2008). While this alternative may increase the amount of SPLYT acres at a slower rate than the No Action Alternative, the resulting forest would be far less likely to experience substantial loss of old and large trees as a result of various forest disturbances (such as uncharacteristic wildfire). A potential result of this alternative would be additional SPLYT acres than the No Action alternative in the presence of large scale disturbances.

Under this alternative, Forests would be able to manage more acres of naturally occurring wildfires for resource benefit. Forest structure, including openings, interspace, and groups and clumps of trees would allow for low to moderate fire severity that would maintain openings and have little potential effect on the vegetation resource except for trees in the smaller size classes. For a more thorough description of post treatment fire behavior consult the Fire Ecology Specialist Report in the project record.

Forest Process

Insects

Under the Proposed Action Alternative, the proportion of acreage with a high hazard rating for bark beetles would decrease from 74 percent to 111 percent in 2029 and to 8 percent by 2039. Stands with a low or moderate beetle hazard rating, the desired condition, would increase from 26 percent in 2019 to 89 percent in 2029 and then 92 per cent by 2039. This demonstrates a considerable shift towards the desired condition for this indicator. While the proportion of acreage with a moderate rating would change only slightly, the proportion of acreage with a low hazard rating would increase considerably as the analysis area approaches desired condition for this indicator.

Stands with lower tree densities and basal area are more resilient to drought and beetle attacks. Bark beetle population dynamics suggests that homogenous, dense stands are highly susceptible to beetle outbreaks. The proposed action would create heterogeneous, open, uneven-aged stands that would dramatically reduce susceptibility and maintain that reduced susceptibility over time. Susceptibility to western pine beetle would decrease over time with mechanical treatment and reintroduction of low severity surface fire. Areas with the greatest likelihood of infestation from bark beetles are areas treated at a low intensity as to not considerably affect beetle hazard rating. Additionally, areas with large amounts of slash remaining post treatment are at risk for Ips beetles. Some susceptibility to Ips would continue to increase, with activity most likely occurring in response to a drought or a snow or ice event that creates fresh pine debris.

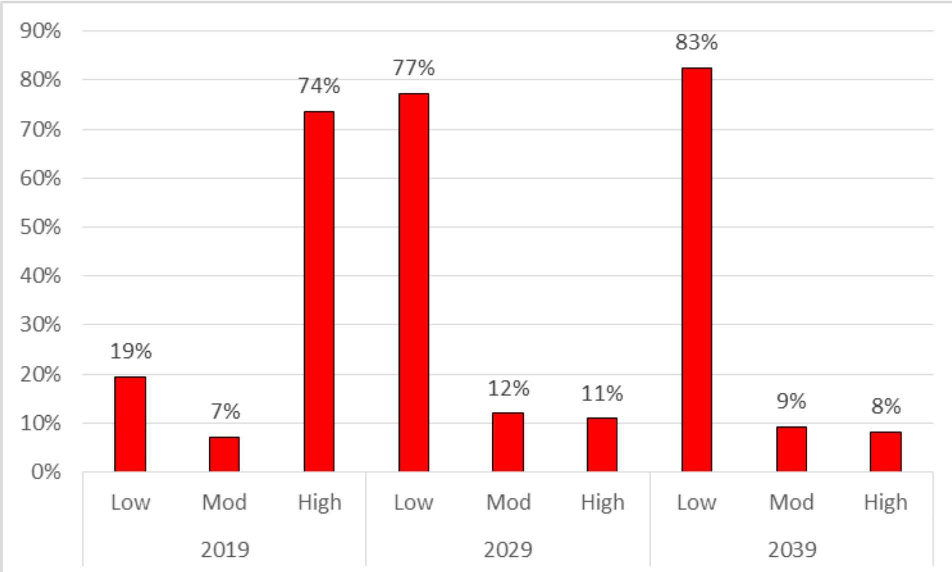


Figure 3-16. Alternative 2 - Proposed Action – Distribution of Bark Beetle Hazard Rating classes across the analysis area.

Disease

Across the analysis area, approximately 75 percent of the area would not be infected or have a low infection level, 22 percent would have a moderate severity rating, and 4 percent, or 36,058 acres, would have a high severity rating. As a result of the Proposed Action, stands with a high severity rating would drop to 2 percent and stands with a Low or None rating drop to 69 percent. Acres with a moderate rating would increase to 31 percent as infection intensification and spread occur even after mechanical treatment. Dwarf mistletoe infections may be reduced as a result of the Proposed Action but may intensify in remaining or latent infected trees, surrounding trees, and infected residual overstory trees, reducing the growth, vigor and longevity of ponderosa pine (Conklin and Fairweather 2010). However, across the analysis area, growth, longevity, and vigor of ponderosa pine trees would be increased. Though most of the analysis area would meet the desired condition of having low or no dwarf mistletoe severity, 34 percent of the analysis area would have a moderate or severe dwarf mistletoe severity rating by 2039 and would not meet the desired condition. This would be an improvement in dwarf mistletoe severity rating over the No Action Alternative by the year 2039.

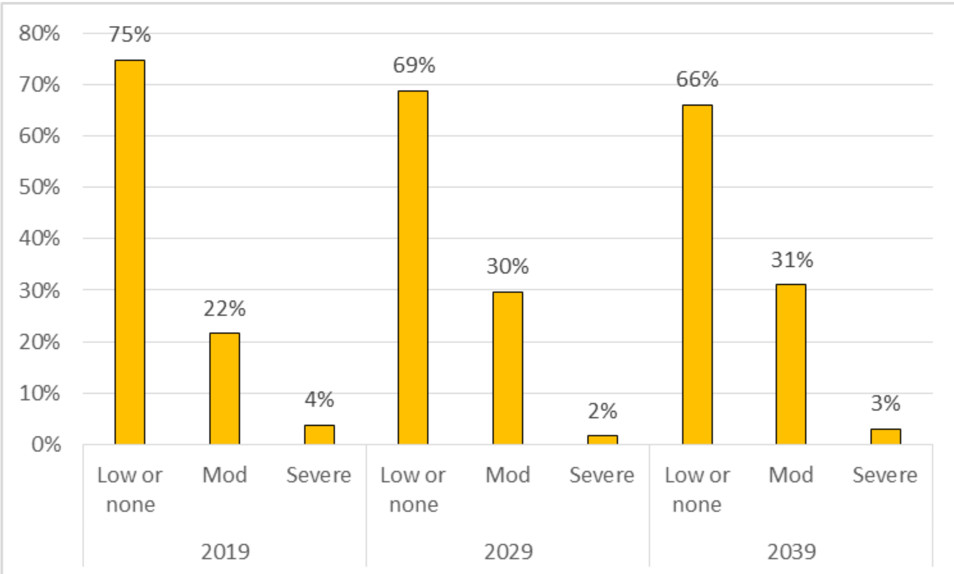


Figure 3-17. Alternative 2 - Proposed Action – Dwarf Mistletoe Severity Rating classes across the analysis area

Fire Adaptation

For a more thorough discussion of this alternative in terms of fire adaptation, consult the Fire Ecology Specialist Report (USDA 2019). In general, this alternative would support the purpose and need to develop or return to a forest ecosystem that is fire-adapted, resilient, diverse, and sustainable. This alternative would support the shift away from larger high severity crown fires to conditions that are more likely to support increasingly frequent, low severity surface fires (Cooper 1960) (Swetnam 1990) (Covington and Moore, 1994a) (Kolb et al 1994) (Swetnam and Baisan, 1996). Over time this alternative would create conditions that resemble the NRV of the native microbes, plants, and animals living in western ponderosa pine and dry mixed conifer forests (Covington and Moore 1994a, Reynolds et al 2013). As a result, the analysis area would have reduced susceptibility to undesirable fire behavior and effects as well as other disturbance agents, such as bark beetles and disease, over time.

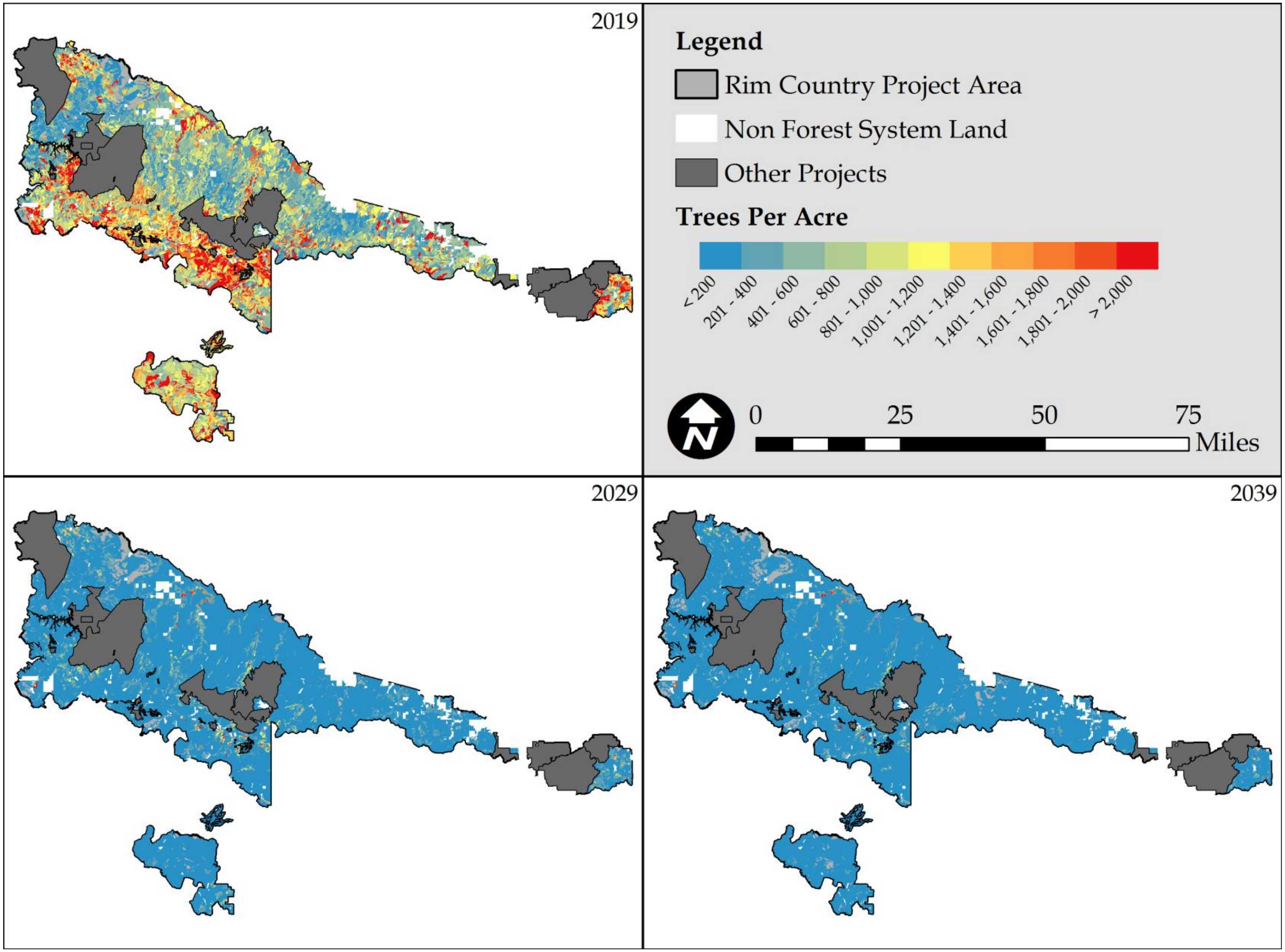


Figure 3-18. Alternative 2 – Trees per Acre

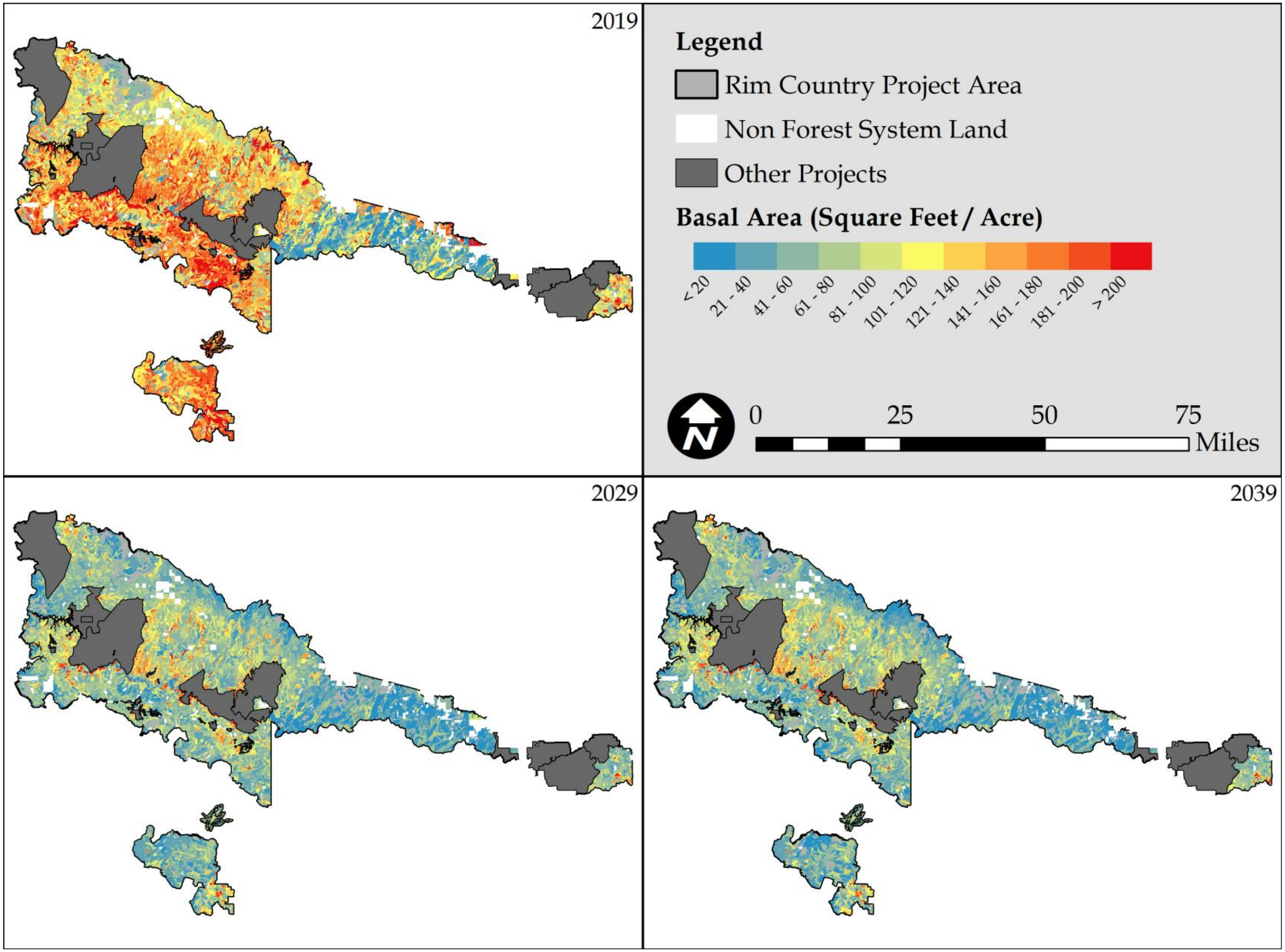


Figure 3-19. Alternative 2 – Basal Area

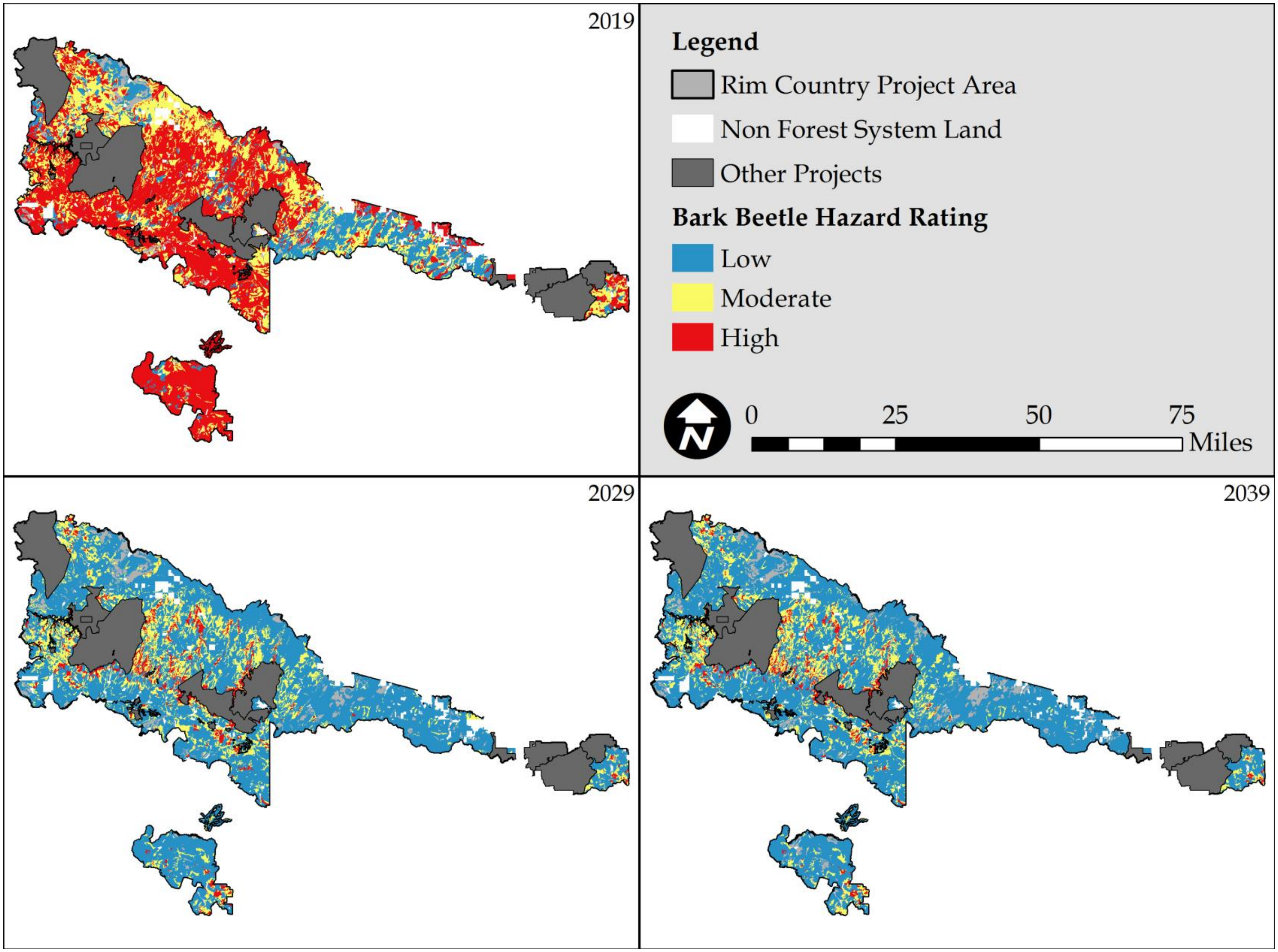


Figure 3-20. Alternative 2 – Bark Beetle Hazard Rating

Alternative 3 – Focused Alternative

Direct and Indirect Effects

In general, many of the direct and indirect effects of Alternative 3 would fall somewhere between those of the Alternative 1 and Alternative 2 or similar to Alternative 2 with somewhat muted effects due to the limited number of acres treated. Under Alternative 3, prescribed cutting and/or prescribed fire treatment would be applied over a portion of the analysis area in order to move towards or meet the desired conditions. This alternative meets or moves the project area toward the desired conditions identified in the Forest Plans and moves the project area forward in initiating the re-establishment of a fire-adapted, resilient, diverse, and sustainable forest ecosystem over the portion of the project area that would be treated. For a more thorough analysis of the effects of this alternative on the wildfire hazard, consult the Fire Ecology Specialist Report (USDA 2019). Many other areas that did not receive treatment would not move toward the desired conditions identified for this project. The distribution of trees across size classes is more representative of a historic size class distribution as many trees in the smaller size classes have been removed or burned. At a landscape scale, forest composition, structure, pattern, and process would all be improved, but to a lesser extent than the Proposed Action.

Stand and landscape resilience to disturbances such as multi-year drought, pests and disease such as bark beetle and mistletoe, and wildfire would increase (Abella, et al. 2007), although to a lesser extent than with the Proposed Action. Drought stress and insect attacks associated with increased tree density, altered tree spatial arrangement, would be reduced. These changes in forest structure would reduce tree mortality due to decreased competition among trees in stands that were treated (Kane et al 2014). At the fine scale, forest structure and pattern would be improved in treated areas as vegetation management activities would maintain or improve the level of tree aggregation (groups and clumps of trees), and as existing groups are maintained and new groups are created (Zhang et al 2013).

Composition

Forest composition would improve under this alternative, although to a lesser extent than the Proposed Action. Ponderosa pine would still be the dominant forest cover type. Mixed conifer would continue to make up a moderate proportion of the analysis area, however shade tolerant species such as white fir may increase compositionally in untreated stands. As a result of prescribed cutting and prescribed fire in areas proposed for treatment, prevalence of later seral species such as white fir and corkbark fir would be reduced and would better represent their role in the NRV. Pinyon Juniper woodlands and oak species would continue to make up a considerable part of the analysis area. The treatment of encroached grasslands would expand their range to more fully represent the NRV, although to a lesser extent than the Alternative 2. The protection and improvement of aspen stands would promote regeneration and reduce inter-tree competition and improve their condition under this alternative, though it is important to note that aspen is one of the species predicted to be most affected by a changing climate (XXXX cite). The condition of less common but important species such as maple and Emory oak would be improved in treated areas.

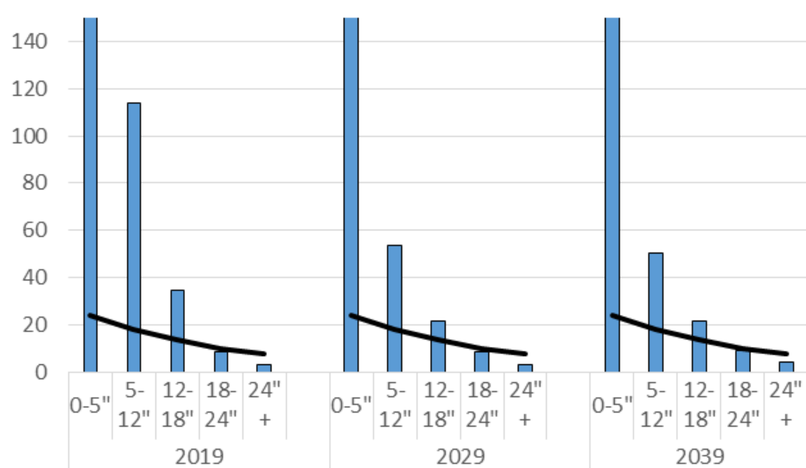
This analysis has considered the effects of a changing climate. Though this alternative would result in a landscape more resilient to climate change than the No Action Alternative, climatic models for the southwestern U.S. predict continued warming, greater variability in precipitation, and increased drought. These climatic changes would likely contribute to some level of tree mortality; however, considerably less than the No Action Alternative. A changing climate may lead to large shifts and contractions in the range of dominant trees throughout much of the region (Kane et al, 2014).

Structure

Uneven-aged Structure

It is desirable for uneven-aged forest structure to occur on a majority of acres. Under this alternative, there would be a change to forest structure (Figure 3-21) on the acres proposed for treatment, however large untreated areas would see little change to existing forest structure. This alternative would meet the Desired Condition for uneven-aged structure in the Forest Plans, however forest structure would more closely resemble NRV in treated stands. Modeling indicates that some stands would move towards more even-aged conditions in the dominant cover types proposed for treatment as a result of removal of trees from the smaller size classes and retention of trees in the larger size classes. However, as treatments are applied on the ground, the use of the large and old tree implementation plans, in accordance with an uneven-aged thinning strategy, would be able to produce uneven-aged conditions across much of the landscape. In treated stands, individual tree growth would increase and trees would move into larger size classes as a result of a reduction in individual tree competition. Naturally-occurring regeneration would provide additional vertical structure over time.

An additional, and potentially more substantial, benefit to forest structure would be a reduction in the possibility of an uncharacteristic wildfire or other substantial disturbance event, such as a beetle outbreak or long-term drought. Under this alternative, treated stands would be more resistant to uncharacteristic fire and insect outbreaks and more resilient to drought. The balance of size classes and uneven-aged structure would provide conditions favorable to restoration of a natural fire regime in the areas proposed for treatment. In areas of untreated stands, the potential for uncharacteristic fire or other substantial disturbances would persist as well as their associated effects on forest structure.



	2019					2029					2039				
	0-5"	5-12"	12-18"	18-24"	24"+	0-5"	5-12"	12-18"	18-24"	24"+	0-5"	5-12"	12-18"	18-24"	24"+
Alt 3	813	114	35	9	3	281	54	21	9	3	222	50	21	9	4
Desired	24	18	14	10	8	24	18	14	10	8	24	18	14	10	8

Figure 3-21. Alternative 3 – Focused Alternative – Distribution of trees per acres across size classes across the analysis area

Density

Measure of density in this analysis include trees per acre, basal area and stand density index. On a portion of the project area prescribed fire and thinning would change the size class distribution of trees.

Alternative 3 would meet the desired condition on a smaller portion of acres as compared to the Proposed Action. The overall tree density would decrease under this alternative, with 973 trees per acre in 2019, 368 in 2029 and 307 trees per acre in 2039. While the initial reduction in trees per acre would result from a combination of mechanical and prescribed fire activities, the reduction after 2029 can be attributed to the recurring prescribed fire over time. Prescribed fire could more likely be used to balance the size classes at the lower end of the VSS distribution and move the landscape toward the desired condition. For example, prescribed fires with higher severity effects (e.g., burning under hotter and/or dryer conditions) from 2029 to 2039 could be implemented to maintain the desired size class distribution at the lower end and better meet the desired condition.

Similar to the Proposed Action, the reduction in tree density would increase individual tree growth and reduce density dependent tree mortality. Understory grasses, forbs, herbs, and shrubs would increase in quantity in treated areas (Covington & Moore, 1994a).

Like many of the other indicator measures, the effects of the Focused Alternative on trees per acres would resemble those of the Proposed Action, only to a lesser degree. It is important to note that this is because fewer acres would be treated compared to the Proposed Action; however those acres that would be treated would still be treated at the same intensity as the Proposed Action.

The desired condition is to retain a basal area of between 30 and 90 ft^2 per acre across most habitat types outside of MSO PACs. While the Forest Plans provide a desired condition with a range of basal areas ranging from 20 to 180 ft^2 depending on cover type, for this analysis, at the project level, for ease of comparison of effects between alternatives, 90 ft^2 is the breakpoint for the resource measure across the analysis area For both mixed conifer and ponderosa pine cover types it is desired to maintain basal area at less than 90 ft^2 though exceptions exist to provide heterogeneity across the landscape as well as specific wildlife needs for dense and closed canopy forest conditions. For a more thorough analysis of the effects of this alternative within MSO and Northern goshawk habitat, consult the Wildlife Specialist Report (USDA 2019).

Under the Focused alternative, basal areas across the analysis area average would be reduced to 87 square feet per acre in 2029 and 89square feet per acre in 2039. While currently only 13 percent of stands meet the desired condition, by the year 2029 52 percent of stands would meet the desired condition and by 2039, 55 percent of stands would meet the desired condition. This will result in decreased inter-tree competition for resources such as water, light, growing space and nutrients in treated areas. Individual tree growth will increase and density dependent mortality would be dramatically reduced along with susceptibility to potential insect and disease outbreaks. These conditions would indicate a shift from the current larger and higher intensity fires that the forest would currently experience to cooler, higher frequency, lower severity surface fires (Cooper, 1960) (Swetnam, 1990) (Covington & Moore, 1994a) (Kolb, Wagner, & Covington, 1994) (Swetnam & Baisan, 1996) that persisted prior to European settlement.

While some effects such as increased diameter growth and reduced competition would be reduced only in treated stands, other effects, such as landscape level insect hazard and fire severity, may extend to untreated areas. The reductions in basal area would allow the treated areas to meet the desired conditions and purpose and need for fire-adapted, resilient, diverse, and sustainable forest ecosystems at the landscape and watershed scales.

While some watersheds would have their average basal areas reduced to within the desired condition as a result of proposed activities, some watersheds such as Rye Creek-Tonto Creek would experience considerable additional mortality as a result of prescribed fire between 2029 and 2039. This is a similar effect as with the Proposed Action and is a result of the intensity of the prescribed fire modeled, as well as the fact that most of the acres proposed for treatment in Alternative 2 were also proposed for treatment in the Focused Alternative. Prescribed fires with lower severity effects (e.g., burning under cooler and/or wetter conditions) from 2029 to 2039 could be implemented to maintain the desired basal area and continue to meet the desired condition in some watersheds.

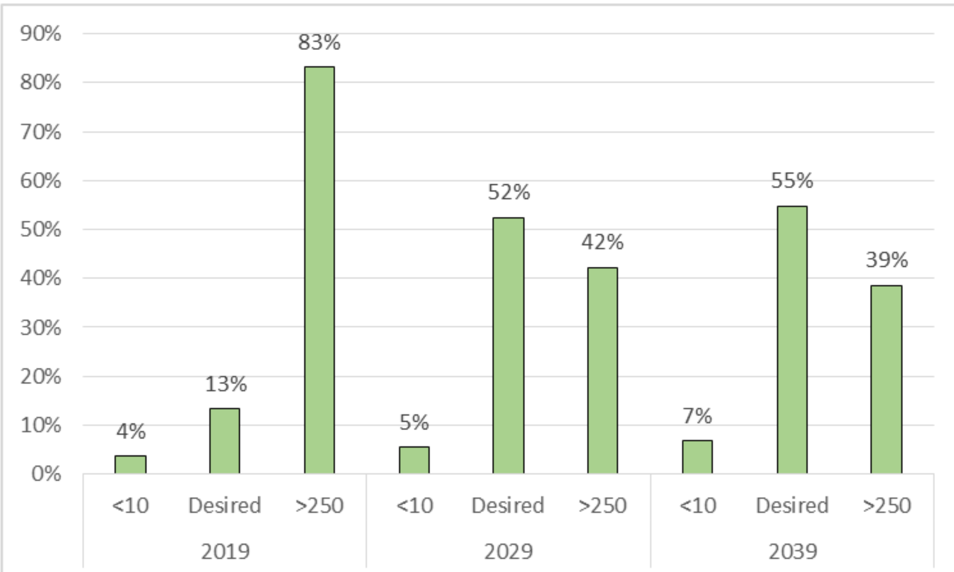


Figure 3-22. Alternative 3 – Focused Alternative – Percent of acres meeting desired condition for trees per acre across the analysis area

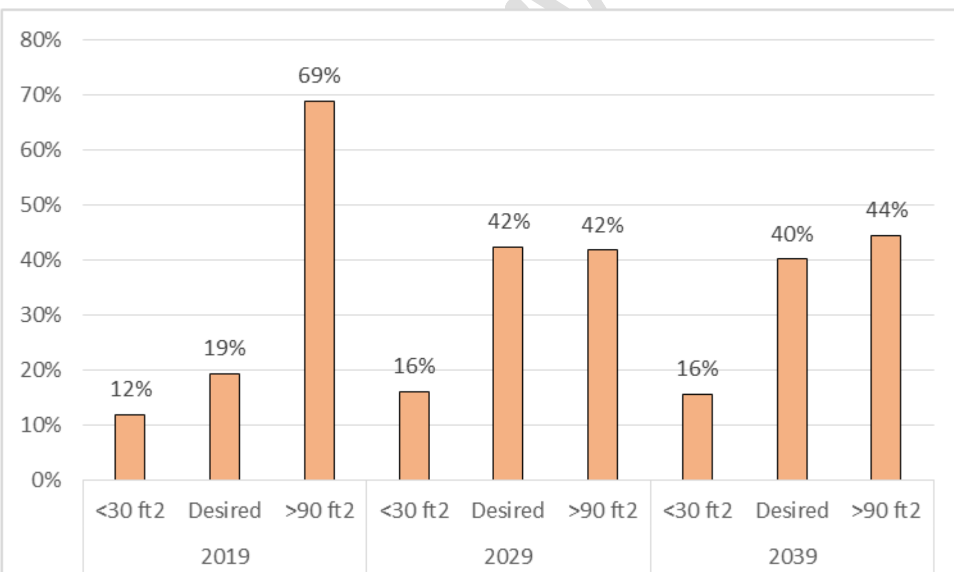


Figure 3-23. Alternative 3 – Focused Alternative – Percent of acres meeting desired condition for basal area across the analysis area

Stand Density Index (SDI) is a measure of relative stand density based on the number of trees per acre and the mean diameter (Long 1995). Percent SDImax expresses the actual density in a stand relative to a theoretical maximum density possible for trees of that diameter and species. SDI is a good indicator of how site resources are being used by taking both average tree size and trees per acre into account. SDImax represents an empirically-based estimate of the maximum combination of quadratic mean diameter and density which can exist for any stand of a particular forest type.

The desired condition for SDI is to be between 25 percent and 45 percent of SDIMax or between 112.5 and 202.5. Currently across the analysis area, SDI averages 296 or 66 percent of SDImax and is considered extremely high. As a result of Alternative 3, SDI would be reduced to 172 or 38 percent of SDIMax by 2029 and 170 or 38 percent of SDIMax by 2039. While currently 15 percent of the acres in the analysis area meet the desired condition, as a result of the Focused Alternative, 27 percent would meet the desired condition and 21 percent would in 2039.

SDI values between 25 percent and 45 percent of SDIMax are associated with maximum understory production and maximum individual tree diameter growth as overall stand growth is concentrated on fewer trees. Depending on the level of tree aggregation, little inter-tree competition would be occurring. Competition may still be occurring within dense tree groups regardless of stand level SDI values.

Over time with the Focused Alternative, stand densities should stabilize in treated areas as the reintroduction of fire returns natural disturbance processes to the landscape. This would result in reduced susceptibility to insect epidemics, particularly bark beetles as well as reduced density dependent mortality, increased individual tree diameter growth, and forage production over time and continued attainment of the desired condition.

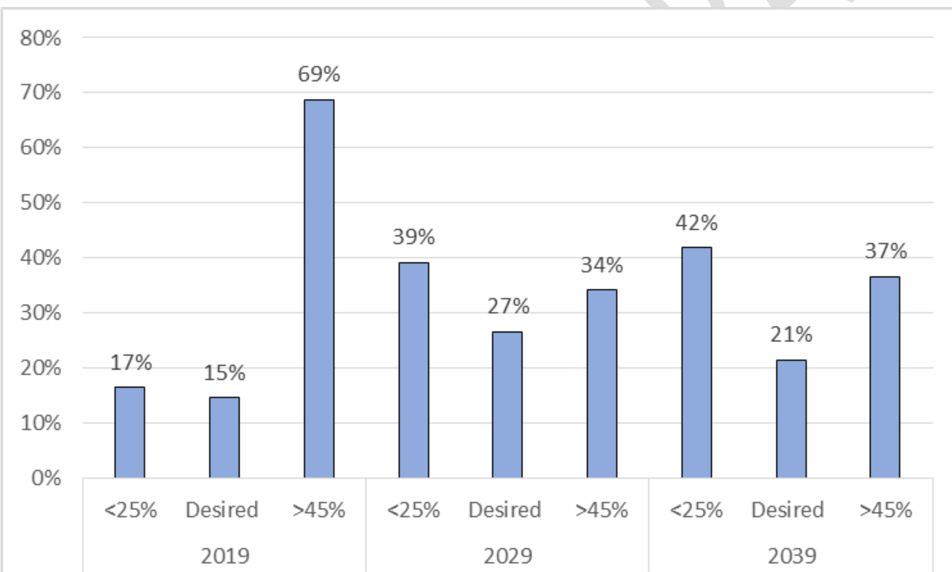


Figure 3-24. Alternative 3 – Focused Alternative – Percent of stands meeting the desired condition for stand density index

Large Tree and Old Tree Structure

Stands of post settlement trees where the quadratic mean diameter of the top 20 percent of trees is greater than 15 inches and the basal area of trees greater that 16 inches is more than 50 feet of basal area can be considered stands with a preponderance of large young trees (SPLYT stands). These stands occur outside of MSO PACs, MSO Recovery habitat and WUI and are being identified for their distinctive forest structure.

Currently, across all 5th HUC watersheds in the analysis area the number of acres meeting SPLYT criteria is 36,325 a QMD of the top 20 percent of trees being 19 inches. Under the focused alternative, this number would increase to 72,424 by 2039 with a QMD of the top 20 percent of trees being 22 inches. The number of acres meeting SPLYT criteria would increase as a result of the Focused Alternative, but at a slower rate than the Proposed Action. With design features in place during implementation, large trees meeting the large and old growth tree implementation plan criteria would be retained, resulting in more large trees being left at the expense of smaller tree sizes. This would allow the proportion of stands meeting desired condition for large trees to actually increase over time. During implementation, some large trees would be cut in accordance with the large and old growth tree implementation plans in order to meet the desired condition. In treated areas, remaining larger trees would be less susceptible to mortality from drought, insects, disease, and wildlife. (Das et al. 2011, Ritchie et al 2008), whereas in untreated areas, susceptibility to these disturbance agents would continue to increase. This slower rate of SPLYT acre recruitment does not take into account the application of the Large Tree Implementation Plan that would effectively increase the number of SPLYT across the landscape at the expense of trees in the smaller size classes.

This alternative would result in a lower risk of mortality in the stands that were treated, especially for larger trees, because of a decreasing risk of infection from pests or disease (Fischer et al, 2010), high-severity or uncharacteristic wildfire (Coop et al, 2016) (Fiedler et al, 2010), and drought stress from competition (Erickson & Waring, 2014). A number of studies have found that lower forest density leaves large and old trees less susceptible to mortality as a result of these factors. Erickson and Waring (2014) concluded that, “treatments removing small, neighboring trees may be critical in maintaining old ponderosa in the landscape, particularly under future climate change and increasing drought frequency in the western USA.” While this alternative may increase the amount of acres meeting SPLYT criteria as a slower rate than the No Action Alternative, the acres proposed for treatment would be far less likely to experience substantial loss of old and large trees as a result of various forest disturbances (such as uncharacteristic wildfire).

In untreated areas, the effects would be similar to the no action alternative and would result in a higher risk of mortality, especially for larger trees, because of an increasing risk of infection from pests or disease (Fischer et al, 2010), high-intensity or uncharacteristic wildfire (Coop et al, 2016) (Fiedler et al, 2010) or increased drought stress from competition (Erickson & Waring, 2014). While this alternative may increase, on untreated areas, the amount of SPLYT acreage based on model results, these results do not account for the likely substantial loss of old and large trees as a result of various forest disturbances (such as uncharacteristic wildfire), which would decrease the amount of old and large trees and SPLYT acreage in the analysis area..

Forests would have the ability to manage more acres of naturally occurring wildfires to benefit forest resources, mainly within watersheds that have a considerable portion proposed for treatment. In treated areas, forest structure, including openings, interspace, and groups and clumps of trees would allow for low to moderate fire severity that would maintain opening and have little potential effect on the vegetation resource except for trees in the smaller size classes.

Under this alternative, on untreated acres where wildfires are managed for resource benefit, they may have the effect of reducing basal area and SDI by killing small trees or groups of small and/or intermediate aged trees. These fires could also result in mortality of some large and old trees. Based on those areas of recent wildfires that were managed for resource benefits, this effect would be very limited across the landscape in untreated areas. For a more thorough description of post treatment fire behavior consult the Fire Ecology Specialist Report in the project record.

Forest Process

Insects

Under this alternative, the proportion of acreage with a high hazard rating for bark beetles would decrease from 74 percent to 39 percent in 2029 and to 40 percent by 2039. The majority of acres that would remain with a high hazard rating are as a result of a lot of acres remaining untreated. While the proportion of acreage with a moderate rating would change only slightly, the proportion of acreage with a low hazard rating would increase considerably as the analysis areas approaches desired condition for this indicator. Stands with a low or moderate bark beetle rating, the desired condition, would increase from 26 percent in 2019 to 61 percent in 2039 and 60 percent by 2039

Stands with lower tree densities and basal area are more resilient to drought and beetle attacks. Bark beetle population dynamics suggests that homogenous, dense stands are highly susceptible to beetle outbreaks. The proposed action would create heterogeneous, open, uneven-aged stands that would dramatically reduce susceptibility and maintain that reduced susceptibility over time. Susceptibility to western pine beetle would decrease over time with mechanical treatment and reintroduction of low severity surface fire. Areas with the greatest likelihood of infestation from bark beetles are areas treated at a low intensity as to not considerably affect beetle hazard rating. Additionally, areas with large amounts of slash remaining post treatment are at risk for Ips beetles. Some susceptibility to Ips would continue to increase with activity most likely occurring in response to a drought or a snow or ice event that creates fresh pine debris.

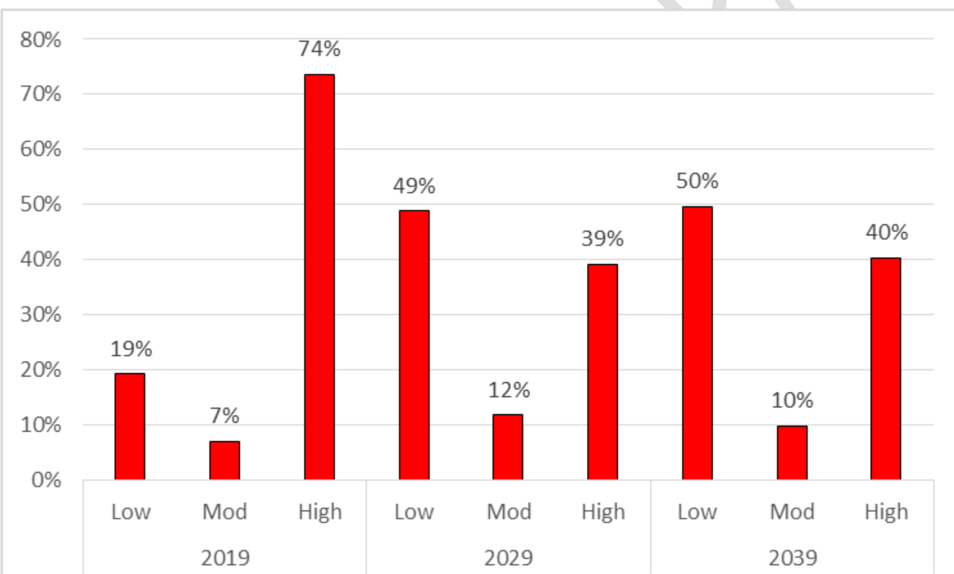


Figure 3-25. Alternative 3 – Focused Alternative – Distribution of Bark Beetle Hazard Rating classes across the analysis area

Disease

Currently, across the analysis area, approximately 75 percent of the area is not infected or has a low infection level, 22 percent has a moderate severity rating and 4 percent has a high severity rating. Initially, as a result of the Focused Alternative, stands with a high severity rating would drop to 2 percent and stands with a Low or None rating would increase to 84 percent by the year 2029. The effects of the mechanical treatment and prescribed fire would diminish over time as acres with a severe rating increase to 4 percent and acres with a Low or None rating decrease to 66 percent by 2039, as a result of infection intensification and spread occurring even after treatment over some of the analysis area. With the exception of the change in severe infection, this result would be similar to the effects from the Proposed Action.

In areas not treated under this alternative, dwarf mistletoe infections may intensify and spread to surrounding trees, reducing the growth, vigor, and longevity of ponderosa pine (Conklin and Fairweather 2010). However, across the analysis area, growth, longevity, and vigor of ponderosa pine trees would be increased, approaching the desired condition. This is an improvement in dwarf mistletoe severity rating over the No Action Alternative by the year 2039, as the reduction in severely infected stands substantially affects forest health, growth, and vigor. In the untreated and severely infected stands, mistletoe infection would intensify and spread over time. Dwarf mistletoe infections would not be reduced in these areas and may intensify in infected trees and the surrounding trees, reducing the growth, vigor, and longevity of ponderosa pine. These stands would further depart from the desired condition over time as infected stands intensify their infections and infect adjacent areas (Conklin and Fairweather 2010).

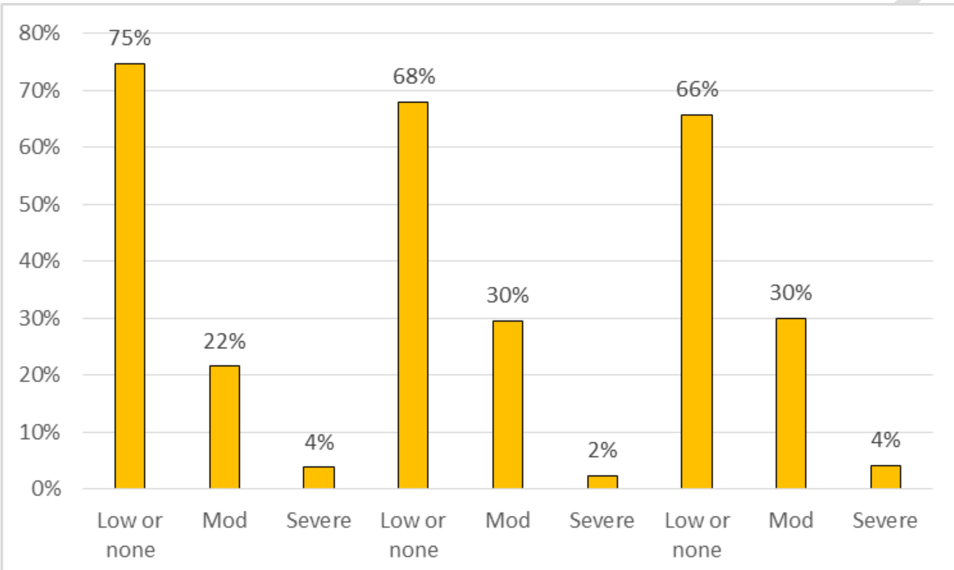


Figure 3-26. Alternative 3 – Focused Alternative – Dwarf Mistletoe Severity Rating classes across the analysis area

Fire Adaptation

For a more thorough discussion of this alternative in terms of fire adaptation, consult the Fire Ecology Specialist Report (USDA 2019). In general, this alternative does support the purpose and need to develop or return to a forest ecosystem that is fire-adapted, resilient, diverse, and sustainable. In areas where treated, this alternative would support the shift away from larger high severity fires to conditions that are more likely to support increasingly frequent, low severity surface fires (Cooper 1960) (Swetnam 1990) (Covington and Moore, 1994a) (Kolb et al 1994) (Swetnam and Baisan, 1996). Over time this alternative would create conditions that resemble the NRV of plants and animals living in western ponderosa pine and dry mixed conifer forests (Covington and Moore 1994a, Reynolds et al 2013). As a result, in areas where treated, this alternative would reduce the susceptibility to uncharacteristically severe fires and other disturbance agents, such as bark beetles and disease, over time. Many areas not treated would remain susceptible to uncharacteristically severe fires and increase in vulnerability to other disturbance agents, such as bark beetles and disease, over time.

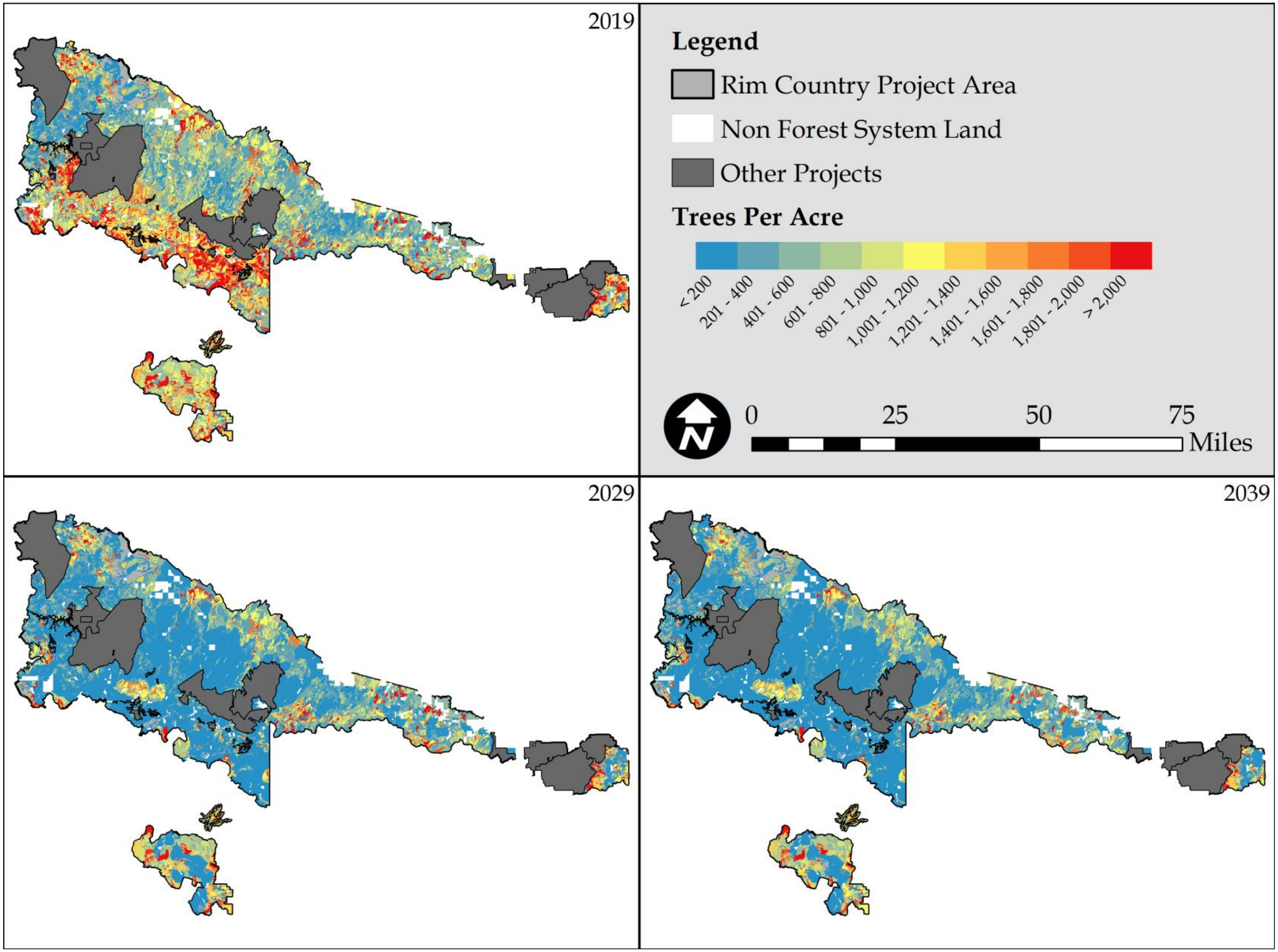


Figure 3-27. Alternative 3 – Trees per Acre -

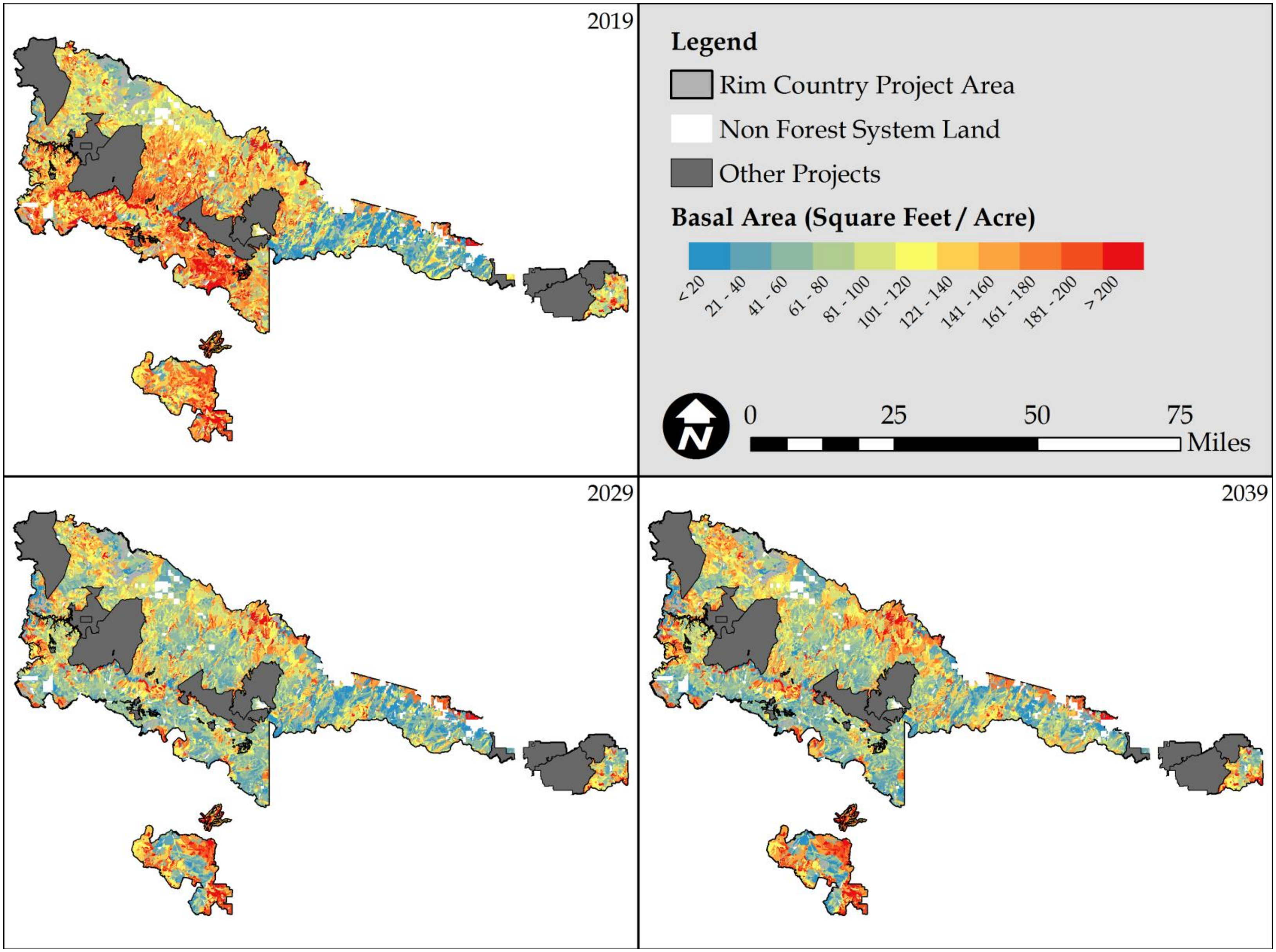


Figure 3-28. Alternative 3 – Basal Area

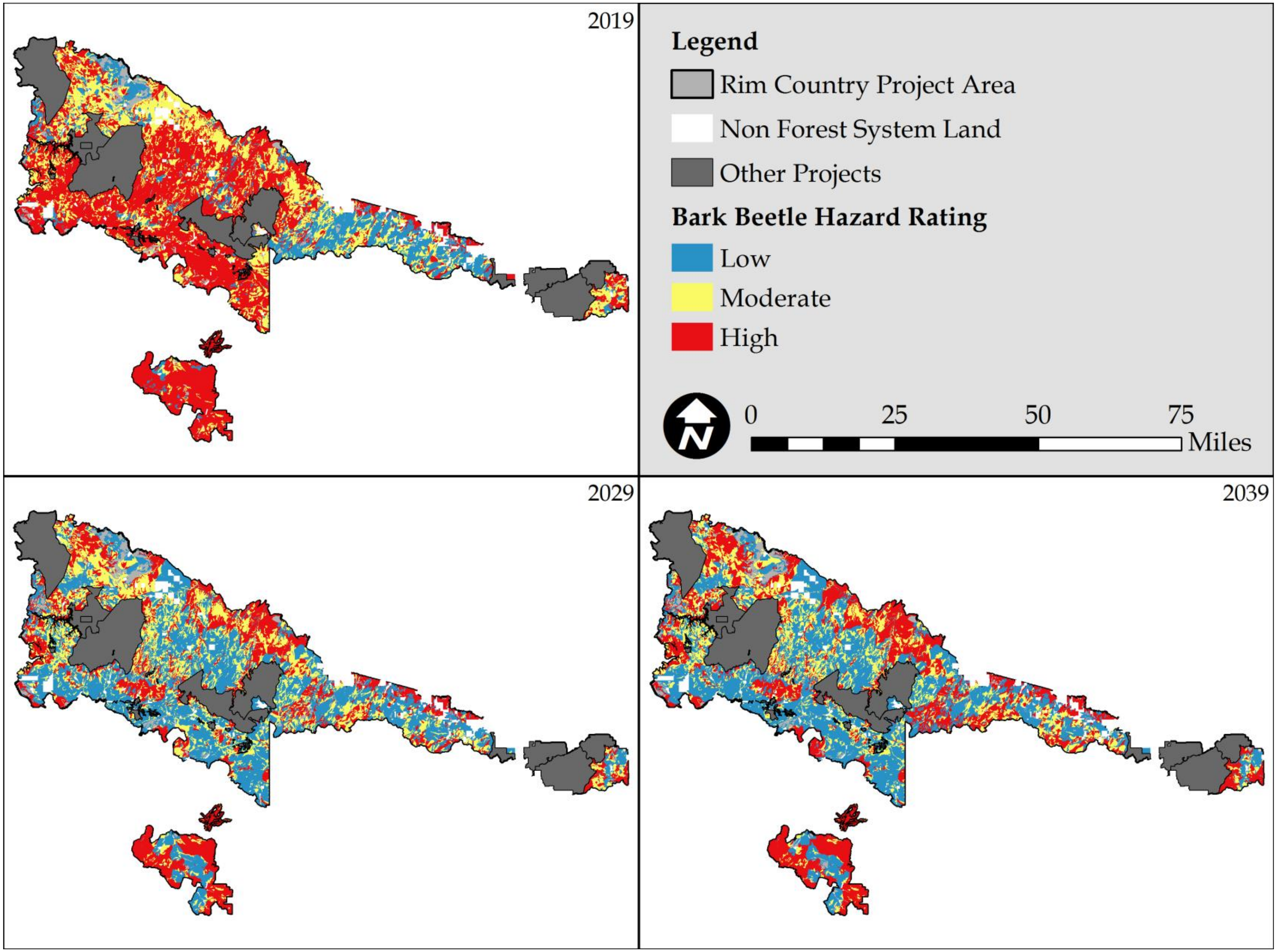


Figure 3-29. Alternative 3 – Bark Beetle Hazard Rating

Effects Common to All Alternatives

In-woods Processing and Storage Sites (Processing Sites)

Alternative 2 and 3 propose the use of wood processing sites for wood storage, log merchandising, and chipping in order to improve the costs of removing wood and biomass from the Rim Country analysis area (Crandall et al, 2017). Twelve sites ranging from 4 to 21 acres as well as 8 additional site from within the Cragin Watershed Protection Project ranging from 5 to 15 acres have been identified for the potential use as processing sites for the Rim Country Project. A total of 20 sites totaling 207 acres were considered in this analysis

Sites were proposed base on terrain, road access, utilities, and potential impacts to resources. On these sites, most existing trees other than those that meet the large and old tree implementation plan would be removed. There will be a short term loss of productivity of forest resources such as tree volume, and forage, for about 20 years until wood processing operations are ended and sites are reclaimed and returned to timber production via natural and artificial reforestation. The processing sites have populations of merchantable timber and fuelwood species, but with the small acreage affected and with design features in place; effects to forest product resources would be temporary until revegetation occurs on the compacted soil. For additional information on the use of in woods processing sites, consult Chapter 2 of the EIS.

Table 3-15. In-woods processing and storage sites within Rim Country Project area considered for use in this analysis.

Site Name	Acres
FR 117, 1321	4
FR 139, 9729D	14
FR 145A, 9615X	7
FR 288, 2781	4
FR 294, 294D	19
3238, 512	20
FR 582, Hwy 87	5
FR 609, 1938	7
FR 74, 64	8
FR 81, 81E	7
9364L, FH 3	21
9731 G, Hwy 87	9
Total	128

Table 3-16. In-woods processing and storage sites within Cragin Watershed Protection Project area considered for use in this analysis.

Site Name	Acres
FR 141, 9398	5
FR 147, 6096/6097	5
211 Revised	15
613F	15
9033H	15
FR 95, North 9032C	10
FR 95F/396	9
9729A	5
Total	79

Rock Pits

The Rim Country Project will analyze the effects from the use of several rock pits in the project area. On the Coconino National Forest, the development, expansion, and use of nine rock pits in the Rim Country project area were analyzed in the Rock Pits Environmental Assessment for the Coconino and Kaibab National Forests (June 2016). One additional rock pit, Park Knoll, is currently being developed by Coconino County under permit. The Forest Service will have a reserve of approximately 20,000 cubic yards of material in this pit, so the potential effects from the use of this rock pit will be analyzed in the Rim Country EIS.

On the Apache-Sitgreaves National Forests, two ranger districts are in the Rim Country project area, the Lakeside and Black Mesa Ranger Districts. Surfacing material needs on the Lakeside Ranger District are met by a large county-operated rock pit under special use permit, as well as other commercial sources. On the Black Mesa Ranger District, 11 existing rock pits in the Rim Country project area are proposed for expansion to provide future material for implementation of Rim Country. Each of these rock pits are considered for 30 percent expansion of their current footprint. The potential environmental effects from the anticipated expansion of these rock pits, as well as those from their use, will be analyzed in the Rim Country EIS. The names and proposed acreage of these expanded pits appears in Table 3-17

Table 3-17. Proposed Pit expansion on the Apache-Sitgreaves National Forest under the Rim Country Analysis.

Pit Name	Current Acreage	Possible Increase in Acreage	Possible Future Total Acreage	Maximum pit espansion (feet)
34T	5	2	7	500
213	7	2	9	500
Pias Farm	6	2	8	500
115	7	2	9	500
717E	2	1	3	400
34B	5	2	7	500
Promontory	16	5	21	700
Carr Lake	12	4	16	600
Brookbank	1	1	2	400
Borrow	12	4	16	600
Cottonwoods Wash	6	2	8	500
Total	79	27	106	n/a

On the Tonto National Forest, all road surface material needs will be met by local commercial sources. Therefore, no effects from rock pit use on the Tonto will be analyzed in the Rim Country EIS. Figure 2-9 displays the locations of these rock pits in the Rim Country project area.

This section describes the effects of the No Action Alternative, the Proposed Action Alternative and the Focused Alternative on vegetation. The analysis includes an assessment of the changes to the existing and potential natural vegetation.

No Action Alternative

Direct and Indirect Effects

The No Action Alternative would have no direct effect on the vegetation cover types in the Analysis Area. The No Action Alternative does not propose the development of new pits or expansion of existing ones. Therefore, no vegetation would be removed in the pit areas. Increased hauling activity expected from this alternative would likely not remove any habitat

The No Action Alternative does not propose revegetation of existing pit areas. Over time, this alternative would have less area of natural vegetation when compared to the action alternatives due to the lack of artificial revegetation of existing pit areas.

An indirect effect of this alternative is a slightly lower risk of the spread of invasive species in the Analysis Area as compared to the action Alternatives. The No Action Alternative exposes less soil and disturbs less area which lessens the amount of area suitable for the establishment or spread of invasive plants. The treatment of noxious and invasive species would continue as prescribed by the three forest integrated treatment plan.

Cumulative Effects

The No Action Alternative would have no direct effect on the vegetation cover types in the Analysis Area and therefore would not contribute to the cumulative effects on vegetation across the Rim Country analysis area.

Proposed Action and Focused Alternative

Direct and Indirect Effects

The Proposed Action proposes to expand 11 existing rock pits, continue operations in the existing footprint of 9 rock pits. These actions would require removal of up to 27 acres of existing natural vegetation, primarily within ponderosa pine and pinyon-juniper plant communities that have not been analyzed under previous decisions. Vegetation removal would be dispersed across the Apache-Sitgreaves National Forests and the pit sites with new vegetation removal and would occur at different times over the next twenty years. The largest area of vegetation removal would be at the promontory pit where up to 5 acres of ponderosa pine would be removed. The smallest removal would be at the Brookbank pit site where expansion would require the removal of approximately one acre of existing vegetation. Considering that the pits would include removal of up to 27 acres within a landscape of over 2.5 million acres, the impact would be very small at the landscape scale and dispersed so as not to concentrate affects to any one type of vegetation or species.

The Proposed Action includes plans for reclamation of the pit sites following material extraction. It is likely that reclamation activities will result in establishment of ground cover with grasses and forbs in the first 1-5 years after reclamation activities; however, it will take several decades to re-establish each area with trees, which will affect vegetation in the pits in ponderosa pine vegetation the most.

Combined the effect of this alternative would be to remove vegetation on 27 acres for a period of several years, which will reset the vegetation dynamics on each of these patches of vegetation by several decades. Many of the rock pits naturally lack vegetation due to the existence of surface rock, which prevents vegetation establishment. In addition, the size and placement of proposed and existing rock pits on the landscape would be similar to natural disturbances or features that lack vegetation on the landscape. Rock pit development would occur at the scale of non-ponderosa pine inclusions such as aspen and meadows that naturally occur in northern Arizona forests. This is not to suggest that they would serve a purpose similar to other vegetation types, but the level of disturbance is unlikely to result in fragmentation of prey habitat at a level that would affect prey population levels.

The loss of 27 acres of potential habitat from rock pit development, would also contribute to loss of potential habitat from other activities such as dispersed camping, private land development, transmission line and pipeline constructions and/or maintenance, and trail and temporary road construction.

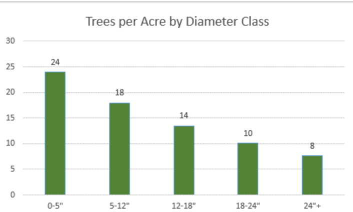
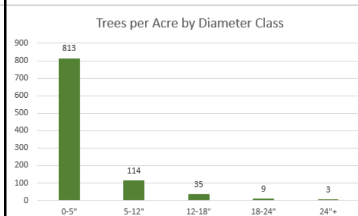
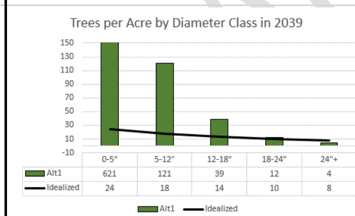
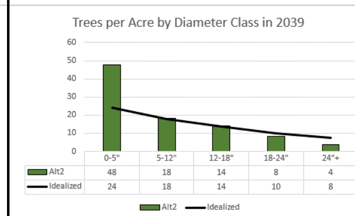
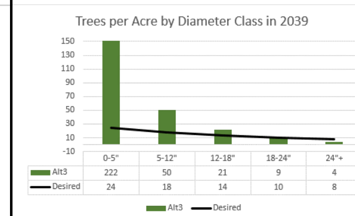
Cumulative Effects

Given the comparatively small area that would be impacted by the proposed activities, this alternative would have only a minor cumulative effect on the vegetation across the Rim Country Project Area. The effect would include the temporary reduction of vegetation cover over the next two decades. This reduction in vegetation cover contributed by the proposed action would affect a very small proportion of the landscape. Many other projects will alter vegetation by reducing the density of forests on the landscape over the next two decades as well. (Table XX 0

This would contribute along with the proposed action to the level of vegetation disturbance and reduction in ground cover at the landscape scale. Other recent management decisions such as the Coconino National Forest Changes to Motor Vehicle Use Designations Project can also contribute cumulatively with this project by cumulatively affecting of vegetation in areas designated for motor vehicle access. The rock pits are designed to connect to the forest road systems, however, none require new access, which would not cumulatively contribute to the road system of each forest.

Cumulative effects would be of greatest intensity where the removal of pit vegetation coincides with treatments that result in similar vegetation removal within the same area and timeframe. None of the proposed pit expansions or existing pits are located in areas where there have been dramatic changes in vegetation cover (e.g. uncharacteristically severe fire, intensive thinning, etc.), thus the cumulative effect of this action would be of greatest relevance at the landscape scale.

Table 3-18. Summarized effects of the Alternatives

	Desired Condition	Existing Condition	Alternative 1 - No Action	Alternative 2 - Proposed Action	Alternative 3 - Focused Alternative
Structure - Pattern	The majority of stands are in an open condition. Forest arrangement is in individual trees, small clumps, and groups of trees or randomly spaced trees interspersed within variably sized openings of grasses, forbs, and shrubs that are similar to historic patterns. Most forest stands in uneven-aged condition to meet forest resilience and sustainability goals while maintaining wildlife habitat. The majority of stands are in an open condition.	The majority of stands are in a closed condition and lacking groups and clumps of trees or randomly spaced trees. Grasses, forbs and shrubs are underrepresented compared to historic patterns. This is departed from historic conditions consisting of a matrix of groups, clumps and individual rendomly spaced trees with interspaces,	Stands would continue to remain in a closed condition, lacking groups and clumps of trees or randoml;y spaced trees. Grasses forbs and shrubs would continue to be underrepresented. Forest structure would continue to be departed from historic conditions.	This alternative would generally meet the desired condition. The majority of stands would be in an open condition. Forest arrangement would be in individual trees, small clumps, and groups of trees or randomly spaced trees that are similar to historic patterns and are as a result of the proposed action Most forest stands in uneven-aged condition to meet forest resilience and sustainability goals while maintaining wildlife habitat.	This alternative would generally meet the desired condition on the acres that were treated, however the acres that were not treated would resemble the conditions described in the no action alternative. Forest arrangement would resemble historic forest structure in some places, while many other areas would not meet the desired condition for forest pattern and structure
Structure - Trees per acre	Trees are distributed across size classes with total number of trees per acre between 10 and 250. Below is an idealized tree distribution across size classes totalling 73 trees per acre and carrying 90 ft^2 of basal area	Total trees per acre is higher then the desired condition and are overrepresented in the smaller diameter classes and underrepresented in the larger classes	Total trees per acre continues to remain above the desired condition. The percentage of acreage in the project within desired condition moves up from 13 percent in 2019 to 15 percent in 2039 as a result of density-dependent mortality. Tree disribution does not approximate the idealized distribution with too many trees in the smaller size classes	The percentage of acreage within desired condition for trees per acre increases dramatically from 13 percent in 2019 to 84 percent in 2049. The distribution of trees across size classes approximates the idealized distribution by 2039 better than any of the other alternatives	The percentage of acreage within desired condition for trees per acre increases from 13 percent in 2019 to 55 percent in 2039. Tree disribution does not approximate the idealized distribution with too many trees in the smaller size classes
					
Basal Area	Generally less than 90 square feet per acre to meet forest resilience goals. while maintaining wildlife habitat desired conditions. For MSO protected and nest/roost replacement habitat 110 to 120 square feet per acre is the minimum.	The current average basal area within the project area is 129 square feet per acre. High densities in terms of basal area make trees more susceptible to mortality from insects, disease, and competition and increase crown fire risk.	Average basal area would continue to increase across the project area from 129 square feet per acre in 2019 to 150 square feet per acre in 2039. The percentage of acres that would meet desired condition decreases from 19 percent in 2019 to 12 percent by 2039.	Average basal area would decrease across the project area from 129 in 2019 to 65 in 2029 and 62 in 2039. The percentage of acres that meet desired condition would increase from 19 percent in 2019 to 58 percent in 2029 and then to 56 percent in 2039	Average basal area would decrease across the project area from 129 in 2019 to 87 in 2029 and 89 in 2039. The percentage of acres that meet desired condition for basal area would increase from 19 percent in 2019 to 42 percent in 2029 and then to 40 percent in 2039
Stand Density Index	Maintain forest density between 25% and 45% of SDImax to maintain forest health and tree growth. For ponderosa pine this is between 112.5 and 202.5. For MSO protected and Nest/Roost replacement habitat, desired forest density is between 45% and 60% of SDImax or between 202.5 and 270.	Currently the average stand density index across the project area is 66% of MaxSDI. 21 percent of stands meet the desired condition for SDI. High densities in terms of stand density index make trees more susceptible to mortality from insects, disease, and competition and increase crown fire risk.	Average stand density index would continue to increase across the project area from 296 in 2019 to 324 in 2039. the percentage of acres that would meet desired condition decreases from 15 percent in 2019 to 11% in 2039	Average stand density index would decrease across the project area from 296 in 2019 to 116 in 2029 and 103 in 2039. The percentage of acres that meet desired condition would increase from 15 percent in 2019 to 27 percent in 2029 and then 21 percent in 2039	Average stand density index would decrease across the project area from 296 in 2019 to 172 in 2029 and 170 in 2039. The percentage of acres that meet desired condition would increase from 15 percent in 2019 to 27 percent in 2029 and then to 21 percent in 2039
Forest Insects	Stands in the project area are in the Low or Moderate hazard for bark beetles	Currently 74% of acreage have a high bark beetle hazard rating. The remaining 26% of stands meet the desired condition for insect hazard.	The proportion of acreage that would meet the desired condition for bark beetle hazard decreases from 26 percent in 2019 to 19 percent in 2039 as a result of increased stocking and lack of disturbance over time.	The proportion of acreage that would meet the desired condition for bark beetle hazard would increase from 26 percent in 2019 to 92 percent in 2039.	The proportion of acreage that meet the desired condition for bark beetle hazard would increase from 26 percent in 2019 to 60 percent in 2039.
Forest Disease	Stands in the project area have Low to Moderate dwarf mistletoe infection severity (Less than 20% of trees infected)	Currently 75% of acreage has a low dwarf mistletoe infection rating,. 22 percent of acres have a moderate rating and 4 percent have a severe infection rating. 5% of the project area meets the desired condition for mistletoe infection severity	The proportion of acreage with a severe dwarf mistletoe rating would increase from 4 percent in 2019 to 9 percent in 2039. The proportion of acreage that meets the desired condition decreases from 96 percent in 2019 to 91 percent in 2039.	The proportion of acreage with a severe dwarf mistletoe rating would decrease from 4 percent in 2019 to 3 percent in 2039. The proportion of acreage that meets the desired condition would increase from 96 percent in 2019 to 97 percent in 2039.	The proportion of acreage with a severe dwarf mistletoe rating remains essentialy unchanged from 4 percent in 2019 to 4 percent in 2039. The proportion of acreage that meets the desired condition also remains unchanged from 96 percent in 2019 and 2039.

Cumulative Effects

For the cumulative effects analysis, the spatial context being considered is the 1,238,658 acre project area. Cumulative effects are discussed in terms of vegetation management and prescribed fire activities as well as the effects of wildfire that have occurred since as early as 1990 and as changes in the existing condition due to present and foreseeable activities, including the effects of the alternative being discussed. The baseline year used for this analysis is the year 2019 as the existing condition. In this analysis, all past activities and events are included in the existing condition description. In the effects discussion, post treatment refers to the time the final activity is accomplished (year 2019), “short-term” effects refers to effects over the 10-year period from the time the final activity was accomplished (year 2029). Beyond 20-years we will be considering effects as “long-term” (year 2049). All Alternatives are compared across forest boundaries (Apache-Sitgreaves, Coconino and Tonto Forests combined).

Vegetation Management Activities and Prescribed Fire

Tables 55 lists approximate acres of the various vegetation management activities, prescribed burning, and other activities that have occurred within the project area as part of vegetation management projects from as early as 1990 to 2017. This includes 469,036 acres of mechanical vegetation management activities that mainly consisted of tree thinning involving heavy equipment and 567,935 acres of prescribed fire. Additionally, 122,264 acres of other activities have occurred in the project areas including 4,645 acres of wildlife habitat improvement, 7,694 acres of range vegetation control, 39,708 acres of range vegetation manipulation, 17,475 acres of tree encroachment control, 45,561 acres of tree release and weed, 15 acres of fuel compaction, 571 acres of fuels chipping, 2,749 acres of range forage improvement, 96 acres of special products removal, 203 acres of insect control and prevention, 1,256 acres of fuel breaks, 1,238 acres of planting, 616 acres of cultural site protection, 321 acres of scarification and seeding of landings and 116 acres of pruning. For additional information on the actions considered in this cumulative effects analysis, see Chapter 3 of this EIS.

Table 55. Approximate acres of vegetation management activities and prescribed fire within and adjacent to the cumulative effects area 1990-2017

Project Name	Year	Mechanical	Prescribed Fire	Other Activities*	Forest
Mullen Saw timber and Whitcom Multiproduct Offerings	1990	0	130	685	Apache-Sitgreaves
Jersey Horse Timber Sale	1991	1,452	351	0	Apache-Sitgreaves
Amended Elk Timber Sale	1993	834	466	0	Apache-Sitgreaves
Brookbank Multi-Product Timber Sale	1994	5,624	4,981	0	Apache-Sitgreaves
Cottonwood Wash Ecosystem Management Area	1995	516	2,447	0	Apache-Sitgreaves
Blue Ridge-Morgan	1997	14,471	14,552	0	Apache-Sitgreaves
Gentry	1997	451	191	0	Apache-Sitgreaves
Sundown Ecosystem Management Area	1997	2,075	24	7,023	Apache-Sitgreaves
Wiggins Analysis Area	1998	0	4,224	0	Apache-Sitgreaves
Show Low South (#22297)	1999	0	2,696	0	Apache-Sitgreaves
Larson Rx Burn	2001	0	3,015	0	Apache-Sitgreaves
Treatment of Dead Trees in the Rodeo-Chediski Fire (#20740)	2002	5,730	1,880	15	Apache-Sitgreaves
Heber-Overgaard WUI	2003	5,089	686	1,208	Apache-Sitgreaves
Hidden Lake Rx Burn	2003	0	2,828	0	Apache-Sitgreaves
Camp Tatiyee / Camp Grace Fuel Reduction	2004	0	172	0	Apache-Sitgreaves
Country Club Escape Route	2004	524	1,848	915	Apache-Sitgreaves
High Value Ponderosa Pine Tree Protection	2004	985	826	203	Apache-Sitgreaves
Rodeo-Chediski Fire Salvage	2004	25,913	626	1,667	Apache-Sitgreaves
Forest Lakes WUI Treatment	2005	1,691	1,645	0	Apache-Sitgreaves
Rim Top Rx Burn (formerly Woods Canyon Fuel Treatment)	2005	0	665	0	Apache-Sitgreaves
Show Low South (#4456)	2005	10	585	0	Apache-Sitgreaves
Dye Thinning	2006	247	0	0	Apache-Sitgreaves
Hilltop WUI	2006	1,534	45	616	Apache-Sitgreaves
Bruno Thinning and Slash	2009	0	70	0	Apache-Sitgreaves
Whitcom WUI	2009	925	0	0	Apache-Sitgreaves
Hilltop II Fuels Reduction	2011	0	799	616	Apache-Sitgreaves
Rodeo-Chediski Site Prep for Reforestation (#48660)	2016	0	0	0	Apache-Sitgreaves
Little Springs WUI	2003	4,376	4,227	2,500	Apache-Sitgreaves
Nagel	2005	19,611	18,231	2,802	Apache-Sitgreaves
Los Burros	2006	30,237	13,059	29	Apache-Sitgreaves
Nutrioso WUI	2006	19,476	9,870	1,254	Apache-Sitgreaves
Show Low South (#29987)	2011	3,372	0	0	Apache-Sitgreaves
Rodeo-Chediski Fire Rx Burn	2012	0	9,506	14,832	Apache-Sitgreaves
Timber Mesa/Vernon WUI	2012	18,781	39,760	20,441	Apache-Sitgreaves
Rim Lakes Forest Restoration	2013	12,483	1,335	6,447	Apache-Sitgreaves
Larson Forest Restoration	2015	1,867	0	2,516	Apache-Sitgreaves
Upper Rocky Arroyo Restoration	2016	696	5,411	3,960	Apache-Sitgreaves
Section 31 Fuels Reduction	2017	44	0	0	Apache-Sitgreaves
Pocket Baker	2000	0	5,450	0	Coconino
Blue Ridge Urban Interface	2001	416	6,225	2,325	Coconino
IMAX	2002	0	6,008	0	Coconino
Pack Rat Salvage	2004	0	0	0	Coconino
Bald Mesa Fuels Reduction	2005	2,485	5,150	0	Coconino
APS Blue Ridge 69kV Transmission Line	2005	0	1,600	0	Coconino
Good/Tule	2006	1,389	2,025	0	Coconino
Post-Tornado Resource Protection and Recovery	2011	765	0	0	Coconino
Lake Mary Road ROW Clearing (ADOT)	2016	788	0	0	Coconino
Lake Mary Meadows Two Fuel Reduction	2005	117	10,223	803	Coconino
East Clear Creek Watershed Health Improvement	2006	40,020	38,470	40,000	Coconino
Victorine 10K Area Analysis	2006	9,015	29,585	0	Coconino
Upper Beaver Creek Watershed Fuel Reduction	2010	20,608	64,000	0	Coconino
Blue Ridge Community Fire Risk Reduction	2012	0	45,000	0	Coconino
Clints Well Forest Restoration	2013	11	6,639	0	Coconino
Hutch Mountain Communication Site	2017	1	0	0	Coconino
Ridge Analysis Area	1994	33,311	0	1,094	Tonto
Lion Analysis Area	2001	5,664	6,900	664	Tonto
Verde WUI	2004	10,648	48,500	5,000	Tonto
Parallel Prescribed Burn	2014	0	4,759	0	Tonto
Pine-Strawberry WUI	2006	41,086	19,868	200	Tonto
Chamberlain Analysis Area	2008	9,044	19,000	1,675	Tonto
Christopher/Hunter WUI	2009	10,763	19,000	939	Tonto
Cherry Prescribed Burn	2012	0	6,582	0	Tonto
Myrtle WUI	2012	103,891	75,800	1,835	Tonto
Grand Total		469,036	567,935	122,264	

*Other activities include but not limited to fuels chipping, range forage improvement or manipulation, range vegetation control, wildlife habitat improvement, tree encroachment control, tree release, fuels compaction, special products removal, insect control and prevention planting, fuel break creation, cultural site protection, scarification and seeding, pruning,

Table 56. Righty of way, habitat improvement, reforestation, spring/meadow and other activities within the cumulative effects area

Project Name	Year	Mechanical	Prescribed Fire	Other Activities*	Forest
Right-of-Way (ROW) Projects with Herbicide Use					
Noxious Weeds and Hazardous Vegetation on State Highway ROWs	2004	25	0	11,005	Tonto
Grand Total for ROW Projects		25	0	11,005	
Wildlife Habitat Improvement, Grassland Restoration Projects/Allotment Projects					
Park Day Allotment	1994	2,193	0	701	Apache-Sitgreaves
Clear Creek Allotment	2000	2,397	0	3,237	Apache-Sitgreaves
Wallace Allotment	Unknown	0	0	1,747	Apache-Sitgreaves
Railroad Allotment (Formerly Carlisle Complex Vegetation Treatments)	2007	2,873	0	561	Apache-Sitgreaves
Apache Maid Grassland Restoration	2004	54,528	6,770	0	Coconino
Bar T Bar/Anderson Springs Allotment	2005	1,304	132,938	41,351	Coconino
Grand Total for Habitat and Grassland Projects		63,295	139,708	47,597	
Reforestation/Planting Projects					
Bison Reforestation	2003	356	312	583	Apache-Sitgreaves
Clay Springs Reforestation	2004	0	0	338	Apache-Sitgreaves
Jacques Marsh Elk Proof Fence & Riparian Planting	2006	0	73	0	Apache-Sitgreaves
Pierce Reforestation	2009	0	0	406	Apache-Sitgreaves
Rodeo-Chediski Riparian Planting	2010	0	0	1	Apache-Sitgreaves
Rodeo-Chediski Reforestation (#18675)	2007	0	150	1,056	Apache-Sitgreaves
Conifer Weeding for Aspen Enclosure	Unknown	65	0	0	Coconino
Grand Total for Reforestation Projects		421	535	2,384	
Spring and Meadow Restoration Projects					
Bill Dick, Foster, and Jones Springs Enhancement	2013	0	0	0	Coconino
Long Valley Work Center Meadow Restoration	2018	0	0	16	Coconino
Grand Total for Spring and Meadow Projects		0	0	16	
Other Projects					
ASNF - No NEPA docs found - various activities reported in FACTS but not tied to other named projects	Unknown	42,763	74,202	16,656	Apache-Sitgreaves
COF - No NEPA docs found - various activities reported in FACTS but not tied to other named projects	Unknown	16,049	15,175	4,695	Coconino
TNF - No NEPA docs found - various activities reported in FACTS but not tied to other named projects	Unknown	15,565	26,386	43,711	Tonto
Grapevine Interconnect (Grapevine Canyon Wind Project)	2012	0	0	0	Coconino
APS Line Maintenance	Unknown	87	0	0	Coconino
Sixteen Rock Pits and Additional Reclamation	2017	0	0	0	Coconino
Glen Canyon-Pinnacle Peak 345kV Transmission Line Vegetation Management	2014	0	0	0	Coconino
Noxious Weed Treatment Projects	2005	61,015	1,008	2,032	Tonto
Grand Total for Other Projects		135,479	116,771	67,094	
Overall Total		199,220	257,014	128,096	

*Other activities include, but not limited to pesticide control of invasives, control of range vegetation, control of tree encroachment, range cover manipulation, control of understory vegetation, wildlife habitat improvement, planting, animal damage control, tree release, site preparation, and biocontrol of invasives,

Table 57. Approximate acres of reasonably foreseeable activities within the cumulative effects area

Project Name	Mechanical	Prescribed Fire	Other Activities*	Forest
Rodeo-Chediski Mastication	301	301	0	Apache-Sitgreaves
Heber-Overgaard Insect and Disease Farm Bill CE	0	0	0	Apache-Sitgreaves
Heber Allotment	0	0	39,000	Apache-Sitgreaves
Pierce Wash Allotment- Section 18 Analysis of Vegetation Treatments	0	0	0	Apache-Sitgreaves
AGFD Fairchild Draw Elk Exclosure	0	0	0	Apache-Sitgreaves
Four Springs Trail Realignment	0	0	0	Apache-Sitgreaves
Heber-Overgaard Non-motorized Trail System	0	0	0	Apache-Sitgreaves
Navopache Electric Cooperative Trunk Line Addition	0	0	0	Apache-Sitgreaves
APS-Herbicide Use within Authorized Power Line ROWs on NFS Lands in AZ	0	0	2,136	Apache-Sitgreaves, Coconino, and Tonto
SRP-Herbicide Use within Authorized Power Line ROWs on NFS Lands in AZ	0	0	7,469	Apache-Sitgreaves, and Tonto
Cragin WPP	41,046	63,656	0	Coconino
Mogollon Rim Spring Restoration Project	0	0	5	Coconino
WAPA Glen Canyon-Rogers 230/345kV Integrated Vegetation Management	13,338	0	0	Coconino, and Tonto
Flying V&H Prescribed Fire	1,798	59,124	0	Tonto
Haigler Fuels Analysis	43,435	43,435	0	Tonto
Flying V and Flying H Allotment	10,875	0	0	Tonto
Hardscrabble Allotment Juniper Clearing	100	0	0	Tonto
New Delph Tank & Bear Tank Maintenance	0	0	0	Tonto
Pleasant Valley Northwest Grazing Allotments	0	0	0	Tonto
Red Lake Tanks	0	0	1	Tonto
Emory Oak Restoration	0	0	0	Tonto
Cragin-Payson Water Pipeline and Treatment Plant	350	0	350	Tonto
Grand Total	111,243	166,516	48,961	

Other activities include, but not limited to pesticide control of invasives, control of range vegetation, control of tree encroachment, range cover manipulation, control of understory vegetation, wildlife habitat improvement, planting, animal damage control, tree release, site preparation, and biocontrol of invasives,

Fire

Wildfires from 1943 to 2017 (Table 58) have burned on approximately 509,447 acres in or adjacent to the project area. Of these acres, it is estimated that the overall average fire severity to the vegetation was 20 percent high severity, 30 percent mixed severity and 50 percent low severity. There is wide variability among these percentages from fire to fire. For more information on the history of wildfires in the project area consult the Fire Ecology Specialist Report (USDA 2019).

Many of the wildfires that burned within the project area in the last 10 years were managed primarily for resource objectives instead of primarily for suppression (Fire Ecology and Air Quality Report), and produced primarily low-severity fire effects. The vast majority of the mechanical thinning projects in the area have decreased the potential for active crown fire and crown fire initiation on acres thinned (469,036 acres from table 55 and 199,220 from Table 56), and the potential for crown fire initiation, and high severity effects from surface fire (567,935 acres from Table 55 and 257,014 acres from Table 56). Past mechanical and prescribed fire treatments decreased the potential for crown fire by breaking up the vertical and horizontal continuity of canopy fuels.

Table 58. Wildfire acres within the project area 1943-2017

Year	Acres
1943-1989	40,994
1990-1999	37,369
2000-2009	262,531
2010-2017	168,583
Total	509,447

Timber Harvest

Past timber harvest practices influenced vegetation structure, pattern, and composition on the majority of the project area. From the late 1880s to the 1940s, logging that facilitated construction of the railroads was conducted by several lumber and timber companies in the areas of Holbrook to Flagstaff (Lightfoot 1978). By 1940, the railroads had removed much of the profitable lumber that could be easily accessed. In terms of vegetation structure, many of the largest and oldest tree sizes larger than 18” DBH were removed from many areas. Extensive regeneration with no large trees interspersed within the younger age classes occupied many of the harvested areas. The pattern on the landscape no longer resembled the Desired Condition outlined in the LRMP.

Past timber sales within the project area such as the Ridge Analysis Area (1994), and Brookbank Multi-product Timber Sale (1994), implemented prior to the Southwestern Region’s 1996 amendment of forest plans, targeted the harvest of medium and large diameter trees. In some cases, all trees over 12 inches in diameter were removed. This affected the presence of pre-settlement trees and old forest structure.

Today, at the landscape (project area) scale, pre-settlement trees are underrepresented in many areas. The focus on even-aged forest management continued until the mid-1990s, leaving the legacy of current forest conditions. Approximately 50 percent of the project area that received some type of regeneration or shelterwood harvest has regenerated. Many stands are even-aged, dense, and lack age class diversity. Today, the majority of acreage can be classified as young and mid-aged forests with a moderately closed to closed tree canopies.

Post 1996 Vegetation Treatments – Uneven-aged Management, Fire Hazard and Restoration

After the region-wide 1996 amendment, vegetation objectives included uneven-aged management (Figure 17) (Table 96 & 97). A review of the Forest Activity Tracking System (FACTS) timber database indicates that treatments designed to promote uneven-aged management began being recorded as early as 1991 on the Apache-Sitgreaves NF, in 1987 on the Coconino NF and 2001 on the Tonto NF. However, acres treated in this category continued to be minor in comparison to acres treated with even-aged methods until about 2005. These acres treated using uneven-aged silviculture systems should today, still be moving these acres towards their desired conditions. Acres still assigned to even-aged silviculture may, or may not, be moving towards desired conditions depending on whether or not the stands can/could be converted to an uneven-aged structure or have been successfully regenerating. Forests in the project area use even-aged management to some extent and the use of this silvicultural system is not precluded in current Forest Plans.

After 1996, the objective of most vegetation projects in the project area was to reduce the risk of high-severity fire, improve forest health (stand and tree resilience and vigor), and improve understory diversity. Retention of snags and managing for coarse woody debris was further enhanced with the 1996 amendment and made part of project requirements. The 1996 forest plan amendment also changed treatments in Gambel oak and the species was recognized for its role in managing for ecological diversity and high quality wildlife habitat.

With the exception of older projects that removed large, old trees and promoted even-aged management, most vegetation projects that contributed to the current condition within the project area occurred from 2000 to 2015. From 2000 to 2015, across the three Rim Country forests, examples of projects designed primarily to address the risk of undesirable fire behavior and effects in the project area include Heber-Overgaard WUI, Camp Tatiyee/Camp Grace Fuel Reduction, Forest Lakes WUI Treatment, Rim Top Rx Burn, Hilltop WUI, Whitcom WUI, Hilltop II Fuels Reduction, Little Springs WUI, Los Burros, Nutrioso WUI, Section 31 Fuels Reduction, Blue Ridge Urban Interface, Bald Mesa Fuels Reduction, Lake Mary Meadows Two Fuels Reduction, Upper Beaver Creek Watershed Fuels Reduction, Verde WUI, Pine Strawberry WUI, Christopher Hunter WUI, Cherry Prescribed Burn, Myrtle WUI and Haigler Fuels Analysis among others (Table XXXX). A variety of other projects have modified vegetation for other objectives such as grassland restoration, wildlife habitat improvement, maintaining rights of way, reforestation, noxious weeds as well as transportation system management (Table 56).

Natural Disturbances – Insect and Disease

Though many of the treatments identified in Table 55 and 56 were designed to reduce hazard of insects and diseases, these natural disturbance mechanisms are still endemic in these forests. Though prescribed fire, or any fire, increases the short-term risks to bark beetle infestations, Mechanical and prescribed fire treatments have worked to reduce insect and disease risk by reducing density in terms of basal area, stand density index and trees per acre. Historic treatments as well as the treatments in the Rim Country analysis have worked together to reduce insect and disease risks. A comprehensive account of insect and disease activity occurring within the project area and cumulative effects area was provided by USDA Forest Health Protection (USDA 2016). Much of the information in that report comes from a combination of the Historical Reports for the three forests (Lynch et al. 2008, 2010, 2015), and aerial detection survey (ADS) data collected every year by Forest Health Protection (FHP) (USDA, Forest Service 2018).

For the Rim Country Project area, ADS indicates that activity of most agents has been relatively low for the past five years. In fact, much of the recent insect activity mapped in the project area occurred during the drought years from 2001-2005. Treatments listed in Table 55 and 56 have maintained these low levels and additional treatments in the Rim Country Project should improve the resilience of these forested systems. More details on the specific agents are discussed within their specific forest type below. We should also note that there are many insects and diseases which cause little damage or tree mortality (Furniss and Carolin 1977). Their effects are not considered extensive and will not be discussed in this cumulative effects analysis.

Generally speaking, current stands of ponderosa pine and mixed conifer are much denser with smaller average diameters than what was historically present prior to European settlement (Covington and Moore 1994). This change in stand structure appears to have favored certain insects and diseases, primarily bark beetles and Southwestern dwarf mistletoe. Details on these are provided below. Root rot pathogens, although not specifically discussed by forest type, are present in all forest types. Root diseases can cause direct tree mortality and are often associated with secondary mortality such as bark beetle attacks (Fairweather et al 2013). Root diseases are often missed during surveys because their deleterious effects are gradual. Some management activities in the cumulative effects area have targeted trees with root rot and reduced its prevalence.

Bark Beetles

The primary two genera found in ponderosa pine, *Dendroctonus* spp. and *Ips,* spp. are capable of causing substantial tree mortality. Historical activity of mountain pine beetle in ponderosa pine in Arizona has been limited to areas on the North Rim of the Grand Canyon (Blackman 1931, Lynch et al. 2008). There are also multiple species of Ips beetles found in the ponderosa pine forests of north central Arizona (Williams et al. 2008).

Historical reports indicate that both the size of bark beetle outbreaks and the beetle species involved in the outbreaks have shifted since the early part of the century. Most tree mortality in the ponderosa pine early in the 1900s was predominately attributed to beetles in the Dendroctonus genus. While periodic Ips attacks were also reported on all three forests, earlier Ips outbreaks were localized events, associated with slash management issues from forest management activities, windthrow, and drought. In contrast, the widespread, landscape-level tree mortality which occurred across the Rim Country Project area in the early 2000’s was primarily attributed to Ips species, and correlated with a widespread drought. Within infected ponderosa pine stands, all three forests experienced substantial tree mortality from this outbreak with stand basal area declining by 32%, 62% and 37% for the Coconino, Tonto, and Apache-Sitgreaves National Forests, respectively (Negrón et al. 2009). Also observed was a reduction in tree density, SDI and average tree diameter. Probability of tree mortality was positively correlated with initial tree density and negatively correlated with elevation and initial average tree diameter (Negrón et al. 2009).

Dwarf Mistletoe

Southwestern dwarf mistletoe incidence has increased on all three Forests, with an estimated 47%, 52% and 32% of commercial acres infected in the 1980s for, the Tonto, Apache-Sitgreaves, and Coconino National Forests, respectively, versus only 19% 41%, and 30%, respectively, in the 1950s (Lynch et al.) High dwarf mistletoe ratings increase tree stress and the likelihood of Ips attacks during drought (Kenaley et al. 2006, 2008). The prevalence of Southwestern dwarf mistletoe seems to be particularly high along the Mogollon Rim. For instance, incidence of mistletoe is higher on the Mogollon Ranger district than on any other district on the Coconino (48% of commercial timber infected) and is higher on the Black Mesa district than on the Lakeside district (Hessburg and Beatty 1985, as reviewed in Lynch et al. 2008, 2010). Denser stand conditions and fire suppression have increased mistletoe abundance in current forest stands, despite the fact that its distribution has likely not changed extensively (Dahms and Geils 1997).

Alternative 1 – No Action

Alternative 1 is the no action alternative as required by 40 CFR 1502.14(c). There would be no changes in current management and the forest plans would continue to be implemented. The effects of 469,036 acres of mechanical vegetation treatments, 567,935 acres of prescribed fire and 122,264 acres of other activities in the form of past and ongoing projects would continue to impact the landscape. Approximately 111,243 acres of vegetation treatments, 166,516 acres of prescribed fire projects, and 48,961 acres of other activities would continue to be implemented in the reasonably foreseeable future within and adjacent to the project area. It is expected that when these actions are completed that these acres will be moving towards the desired conditions. Alternative 1 is the point of reference for assessing action alternatives 2-3. The thinning and prescribed fires treatments in the prior 10-year period were designed to set up the stands to reach their desired conditions according to the then-approved forest plans. In conjunction with mechanical treatments, there were prescribed fire only treatments designed as fuels treatments to reduce surface fuels as well as reduce ladder fuels and crown fire risks. To those ends, the prior treatments will move the acres toward their desired conditions.

Timber Harvest

Past timber harvest practices influenced vegetation structure, pattern, and composition on the majority of the project area. The focus on even-aged forest management continued until the mid-1990s, leaving the legacy of current forest conditions. Approximately 50 percent of the project area that received some type of regeneration or shelterwood harvest has regenerated. Many of these stands are two-aged, dense, and lack age class diversity as a result of these historic practices. Historically, wildfire would have maintained a diverse matrix of age class diversification. Reintroduction of an historical fire return interval will aid in converting, and maintaining, an uneven-aged forest at the landscape level. Currently planned forest treatments should move these stands towards a trajectory for their desired conditions. Untreated stands will continue to move away from desired conditions as densities increase, beetle risks increases and risks of crown fire increase. Under this alternative the potential for uncharacteristically large scale wildfires that dramatically impact the landscape is increased.

The Cragin Watershed Protection Project on the Coconino National Forest was decided in 2018 and will mechanically treat 41,046 acres and use prescribed fire on 63,656 to move stands in that project area towards the desired condition. In most cases, fuels reduction treatments do not necessarily provide adequate change in stand structure and do little to move towards desired conditions. However, fuels treatments following mechanical treatments to balance age classes provide the best chance to set these stands on a trajectory towards desired conditions. The Haigler Fuels Analysis on the Tonto National Forest planned to treat over 43,000 acres with mechanical and prescribed fire, but is still in the scoping phase and no impacts can be assigned other than to say that there is a need to reduce high fuel loadings and return to a natural regime.

Forest Structure

In Alternative 1, the no action alternative, few treatments would be implemented to create a mosaic of interspaces and tree groups. In locations not identified for treatment under other decisions, existing interspace would continue to be reduced by expanding tree crowns and increased tree densities. Understory vegetation response would be suppressed. The risk of undesirable fire ane/or effects would continue to increase. Any large scale tree mortality occurring has the potential to enhance interspace and create tree groups. While the Forests in the project area have an emphasis to favor uneven-aged management, this silvicultural system does not assure interspaces and groups. These Forests have latitude to create openings and groups but have not implemented large areas of openness to date except within WUI treatments. In terms of a mosaic of interspaces and tree groups at the landscape level the prior treatments have not significantly moved the forest towards the desired conditions at this time.

Forest Structure - All age and size classes represented

Prior thinning treatments with restoration objectives were similar to the goshawk habitat and MSO restricted other habitat treatments proposed under the first EIS as well as this project and have resulted in similar diversity in age and size class, and should move these stands towards desired conditions. Uncharacteristically severe wildfires caused large scale mortality across all age and size classes resulting in a non-stocked or single age class representation. Wildfires that burned with a low severity and prescribed burn only treatments had similar effects to forest structure as the post thinning prescribed fires. Restoration treatments and 4FRI treatments are designed to lessen the probability of these uncharacteristically severe wildfires.

The main objective of thinning with a fuels reduction emphasis was to reduce canopy fuels and the potential for crown fire initiation. Generally, this type of treatment focused on removal of trees in the subordinate crown positions and retaining those trees in the dominant and co-dominant crown positions and any pre-settlement trees. This type of treatment resulted in a moderately open canopy, even-aged forest structure with very little age and size class diversity. Prescribed burning and mechanical fuels treatments associated with the above thinning treatments resulted in periodic tree mortality of seedling/sapling size trees and susceptible pre-settlement trees further reducing age class diversity.

Old Forest Structure

Many prior thinning treatments retained pre-settlement trees and the largest post-settlement trees. Sanitation treatments may have removed some old forest structure. Prescribed burning and low severity wildfire resulted in periodic tree mortality of susceptible pre-settlement trees. Mixed and high severity wildfire killed a large proportion of the old forest structure. Powerline treatments removed any old forest structure that was a hazard to the powerline.

Old forest structure has been reduced over many years by past management practices. The change in direction in 1996 to manage more for an uneven-aged stand structure will aid the forest to reach the Desired Conditions over time. The structure of the past and most of the proposed treatments, while planned out as uneven-aged treatments, will have a distinctly different spatial layout than is being planned in this project. Treatments designed in the Rim Country project have identified distinct interspaces of varying sizes with groups of varying sizes as well as randomly spaced trees to aid in forest diversity (horizontal and vertical) while at the same time breaking up areas of continuous canopy to reduce risks to crown fire. Past uneven-aged treatments will have trees more uniformly spaced with more of a closed canopy (moderately closed to closed).

Forest Process

Past thinning treatments resulted in low to moderate stand density index, which is associated with minimum competition between trees, and maximum individual tree growth. This in turn had a beneficial effect of improved forest growth, and reducing the potential for density and bark beetle related mortality. Thinning treatments also removed dwarf mistletoe infected trees reducing the percent of trees infected as well as potentially creating conditions that slowed or inhibited mistletoe spread. Prescribed fire and low severity wildfire also led to localized reduction of forest density and dwarf mistletoe infection. The thinning treatments reduced risks associated with dense forest conditions and improved resilience to the impacts of large scale disturbance under drier and warmer conditions.

Alternatives 2 and 3

Alternative 2 restoration treatments would contribute an additional 953,130 acres toward improving forest health and vegetation diversity/composition, sustaining old forest structure over time, and moving forest structure toward the desired conditions.

Alternative 3 restoration treatments would contribute an additional 529,060 acres toward improving forest health and vegetation diversity/composition, sustaining old forest structure over time, and moving forest structure toward the desired conditions.

Prescribed Fire

Prescribed fire is considered to be an integral component to stand treatments and is a necessary complimentary treatment to mechanical treatments to attain and maintain the desired conditions. Without prescribed fires it would be more difficult to maintain desired conditions or reduce unintended results from uncharacteristically high wildland fire at the landscape level.

Approximately 40,000 acres of prescribed fire would be implemented annually across the analysis area from a combination of this project as well as other projects such as Cragin Watershed Protection Project and the Haigler Fuels Analysis. See Fire Specialist Report for details.

For the analysis period, prescribed fire over the acres (Tables 55 and 56) of broadcast burns reduced fuels, modified fire behavior, and lowered crown fire risks. The majority of these acres occurred since 2004 and many may require reintroduction of a prescribed fire within the next 5 years in order to maintain the benefits of the prior burn. The proposed acres of mechanical treatment and/or prescribed fire of the Rim Country 4FRI project (953,130acres in Alternative 2 and 529,060 acres in Alternative 3), combined with the reasonably foreseeable treatments proposed (Table 57, 166,516 acres) will reduce uncharacteristically severe fire behavior on approximately 1,119,646 acres in Alternative 2 and 695,576 acres in Alternative 3 over the next 20 years. The prior treatments should allow prescribed fire-only treatments, with burns within the same stands as this project, to reduce emissions. The synergy between the prior treatments and the proposed treatments offer some of the best possible outcomes to reduce undesirable fire behavior and/or effects in these treatment areas.

Forest Structure

From the 1970s until 1996 treatments were designed primarily to manage for even-aged stand structure. These stands today are going to be treated to move them towards an uneven-aged structure where possible. Treatments after 1996 had an uneven-aged silviculture emphasis and those treatments would have helped to move those stands towards their desired conditions at the time of treatment. Prior treatments (Tables 55 and 56) have reduced densities within and outside PFAs, but very little treatment has occurred within MSO PACs and Cores. Stands treated prior to 1996 will need treatment within this proposal as the project moves these stands towards an uneven-aged structure and putting them on a trajectory to achieve their Desired Conditions.

Most treatments on the Apache-Sitgreaves, Coconino and Tonto National Forests, with the exception of the 1st 4FRI EIS, left the forest with denser stands when compared to the proposed restoration treatments in this project. Spatially, the prior treatments, until recently, tried to leave a uniform distribution of trees with only natural canopy gaps and meadows for openings. Currently proposed restoration prescriptions will leave a more open forest, post treatment, than was prescribed in past treatments, with distinct interspaces, groups, and regeneration openings of varying sizes as well as randomly spaced trees across the landscape to enhance structural diversity. Planned interspaces will average between 10 to 90% at the stand level from closed forests to open grasslands. The proposed restoration treatments are a departure from past management and have desired conditions for interspaces and groups that will move these stands towards the LMPs Desired Conditions.

Forest Health

Density related mortality -

Stand density is a dominant factor affecting the overall health and vigor of conifer forests in the western US (SAF 2005) and high stand densities leads to reduced ecosystem resilience (Reynolds et al 2013).

Prior treatments have used prescriptions, both even-aged and uneven-aged, to reduce stand densities. Table 55 and 56 lists some of the treatments complete in the analysis area during the analysis period and most all vegetation manipulation treatments were designed to reduce stand densities to some extent. Even with the reduced stand densities some stands were susceptible to the drought period during the early 2000’s. This is probably an indicator of stand behavior at

these treatment densities in context with climate change. Because of these treatments these stands have moved towards the desired conditions.
However, not all were designed as a restoration treatment, especially those implemented earlier in the analysis period. Therefore, these stands may not be moving towards the restoration desired conditions of this project and could be treated again in order to aid in moving them to their desired conditions, or onto a trajectory to achieve the desired conditions.

Proposed treatments in the foreseeable future (Table 57) will be more closely allied with a restoration-based desired condition and prescription. The newly published Forest Plans of the Coconino and Apache-Sitgreaves National Forests clearly spell out the intent to treat widely across the forest with a restoration desired condition. The foreseeable acreages for projects such as Cragin Watershed Protection Project and the Haigler Fuels Analysis show the intent of the forests as they go forward with the Forest Plans. The combined Rim Country treatments (Table 55 and 56) and the foreseeable treatments (Table 57) will move a considerable portion of the landscape towards a desired condition of reduced stand densities with an open grass/forb/shrub matrix in a heterogeneous landscape. These changes will occur in both alternatives, however in alternative 3 the movement toward the desired condition will only occur on the treated acres.

Bark beetle related mortality –
Bark beetles are normal endemic insects in ponderosa pine and mixed conifer communities and the pine type has evolved with such disturbances (Reynolds et al 2013). But when conditions are conducive to beetle outbreaks insects can become a strong determining factor in stand structure and composition that can become even more pronounced during and following extended droughts and under dense stand conditions (Reynolds et al 2013, Negrón 1997). Consult USDA (2014) for a history of epidemic bark beetle infestations within the analysis are from the 50's thru 2014. The current stand structures reflects the occurrences of these epidemic outbreaks.

Prior treatments within the analysis area were completed with a desire to reduce hazardous fuels and reduce stand densities. The drought period from 2000 until now has challenged many stands with bark beetle infestations. The current stand conditions are still dense in many stands as attested to by their high SDIs. Post 1996 treatments were effective in reducing density related mortality. Even with the reduced stand densities some stands were susceptible to the drought period during the early 2000's. Proposed treatments will further restructure stands towards the restoration-based desired condition and this should aid in relieving further stresses. Because bark beetles can fly considerable distances and have multiple generations in one season, treatments outside, and adjacent to, the analysis area have an important influence of beetle activity within the analysis area.

Dwarf mistletoe infection –
Activities identified in Table 55, 56 and 57 treated acres mechanically and with the use of prescribed fire. Many of these treatments had a considerable effect on the distribution, but more importantly, the abundance of dwarf mistletoe. Mitigation strategies for dwarf mistletoe (DM) attempt to reduce stand dwarf mistletoe ratings (DMR) and not individual tree ratings (DMI) (i.e., pruning or fire). Where DM is present, silviculture prescriptions prioritize removal of infected trees (at or above a predetermined infection level). Due to the limited transmissivity of dwarf mistletoe, treatment of stands outside the analysis area do not have as great a potential impact as do stands adjacent to the analysis area. While seeds of the dwarf mistletoe are forcibly ejected the spread of DM is slow by comparison. But infection from outside of the analysis from adjacent stands and into stands within the analysis area is possible. The impact of these outside infections will have little impact to growth or mortality to the overall analysis area.

Prior treatments within the analysis area will have reduced, but not eliminated, DM from the treated stands. The DM infections will continue to slowly intensify. Foreseeable treatments will potentially reduce infection levels further and will benefit the overall analysis area in terms of reduce growth, reduced tree vigor, and reduced bark beetle risks. Where possible, the Rim Country project will target DM infected stands for the more intense treatment levels, and this will lower the infection level. Infected trees can grow at near the rate of uninfected trees on good sites if individual tree infections remain at or below a dwarf mistletoe rate of 3 (Hoffman 2010). Treatments will move most stands towards desired conditions. However, DM is a natural component of the ponderosa pine community and eradication is neither desirable nor possible, and latent infections (those not visible at the time of treatment) will remain within the stands.

Other Direct and Indirect Effects:

Climate change

Risks associated with dense forest conditions would be reduced and resilience to the impacts of large scale disturbance under drier and warmer conditions would be improved by implementing the treatments proposed under alternatives 2 and 3. Prior treatments will benefit the forest by reducing densities and reducing stresses associated with completion. Treated forest will be more resilient to climate change than untreated forest (Kerhoulas et al 2013). Within-forest carbon stocks would be reduced under alternatives 2 and 3, however large scale stand replacing wildfires such as the Rodeo-Chedeski and Wallow fires that emit enormous amounts of carbon dioxide would be less likely to occur. Individual tree growth would improve, resulting in larger average trees size and increased carbon storage over time offsetting short term losses of carbon removed through the mechanical thinning. Some of the carbon biomass removed by mechanical thinning would be sequestered for a considerable period of time in the form of forest products.

Residual Tree Damage

Some damage to residual trees would be expected in Alternatives 2 and 3 with the felling, tractor yarding and piling operations associated with mechanical treatments in ponderosa pine. Damage rates should be similar or less than current silviculture practices due to the more open conditions created. The Proposed Action would result in the most potential damage because of the extensive harvesting in overly dense stands. Damage would be minimized through contract administration, on-site inspections, and proper harvest methods. All piling and/or low-severity burning treatments would reduce understory stocking and reduce inter-tree competition as well as stimulate understory vegetation (shrubs, forbs, grasses). Prescribed fire is expected to damage some residual trees and increases short-term risks to low level bark beetle activity.

Fire Ecology and Air Quality

Only a summary of the fire ecology analysis is presented here. The Fire Ecology and Air Quality Report includes the complete analysis and is incorporated by reference (Haas 2019).

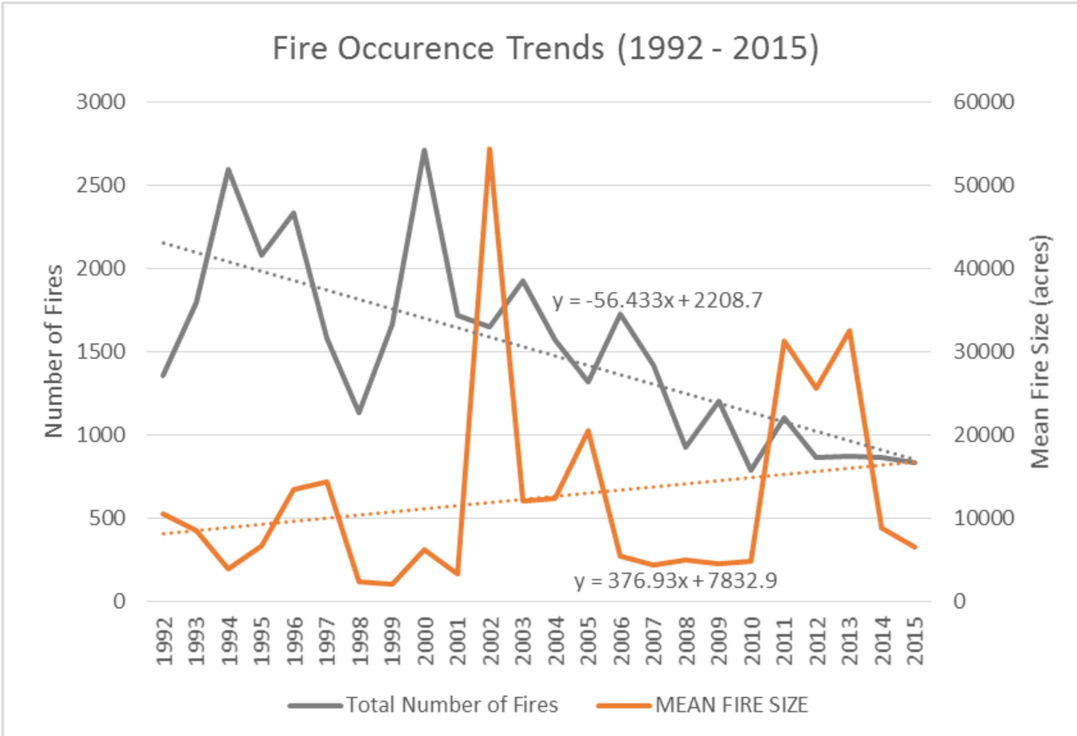


Figure 2: Trends in Mean Fire Size and Total Number of Wildfires from 1992-2015

▪ Affected Environment

• *Background and Historic Conditions*

Across the Rim Country landscape, the disruption of Fire Regimes over the last century is largely responsible for the deteriorating health of the ecosystems in Northern Arizona (Covington 1994). In the latter part of the 19^{th} century, unsustainable practices in fire management, grazing, and logging began to change the structure and composition of landscapes, making them more homogenized. As a result ecological functions are now impaired across the landscape of northern Arizona (Leopold 1924; Covington 1994; Heinlein *et al*. 2005; Rodman *et al*. 2017).

Fire is a keystone process affecting the ecological functions of large areas. As Europeans settled into the area, roads and trails increasingly broke up the continuity of surface fuels and contributed to the reduction of the frequency and size of wildfires (Covington and Moore 1994). Long periods without fire changed the species composition and fuel structure of southwestern ecosystems (Swetnam 1990b; Huffman 2017). There are about 800,000 acres of cover types targeted for restoration in Rim Country that historically were maintained by frequent fires.

Logging removed much of the large tree component across the landscape, allowing younger and smaller trees to survive in unnaturally dense stands (Covington and Moore 1994; Swetnam and Baison 1996). The disruption of historical fire regimes by introduced ungulates has also been well documented for southwestern ecosystems. Montane grasslands were utilized as summer range for large numbers of sheep and cattle (Leopold 1924). Grazing at such intensities removed much of the fine fuels that had competed with pine seedlings for water, nutrients and light, and had also maintained the light, flashy fuels that produced frequent, cool surface fires, with short residence times. This unintentional fire suppression, initiated in the early 19th century through grazing by sheep and cattle, transitioned in the early 1900s to active fire suppression.

- *Fire Occurrence & Fire Regime*

There is little doubt that fires, started by lightning or by Native Americans, were frequent before the arrival of the Europeans and in the early years of settlement. Historically, fires occurred frequently, with return intervals ranging from a few years to a decade or more. These historic fires were typified by low severity. Not until the mid 20th century were a limited number of large scale stand replacing fires recorded (Cooper 1960).

Contemporarily, the number of fires reported in and adjacent to the project area has decreased over the last 25 years (1992 – 2015), while the average size has increased (Figure 4). While fire size is certainly an indicator of the trends in wildfire, it is primarily those areas that burn with uncharacteristic severity that are of concern.

Currently, the number of acres burning with high severity is much larger than historic data indicates was typical of ponderosa pine in the southwest (Weaver 1951; Covington 1994; Swetnam and Betancourt 1998; Westerling *et al.* 2006). Of the annual acres burned by large fires since 1992, about 73 percent burned at low severity on average, and 27 percent burned at moderate to high severity. However, the 2002 Rodeo-Chediski fire, which burned with a much higher percentage of moderate and high severity, serves as an outlier to this pattern. Overall, the annual acres burned by large fires has increased since 1992 (Figure 5), while the proportion of acres burned in each severity class has remained about the same (Figure 6). If these patterns continue into the near future (10 years), the total acres of high severity fire is likely to increase proportional to fire size increases.

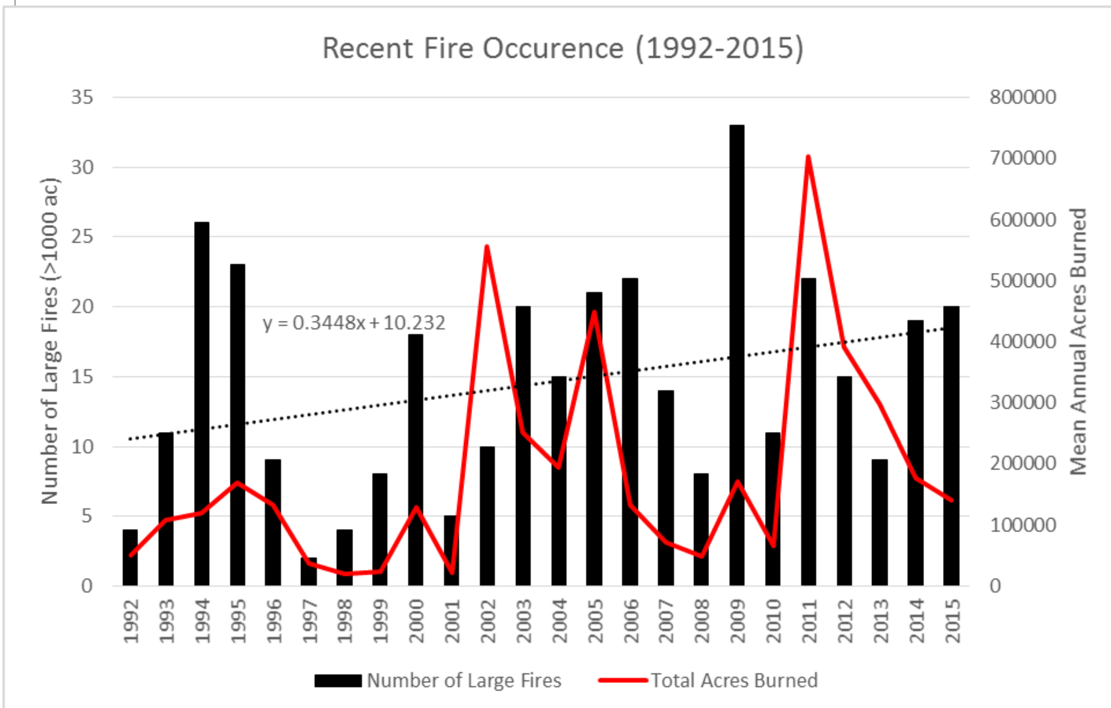


Figure 30: Trends in the Number of Large Fires (>1,000 ac) and Total Acres Burned from 1992 – 2015 within the Arizona/New Mexico Mountains Ecoregion

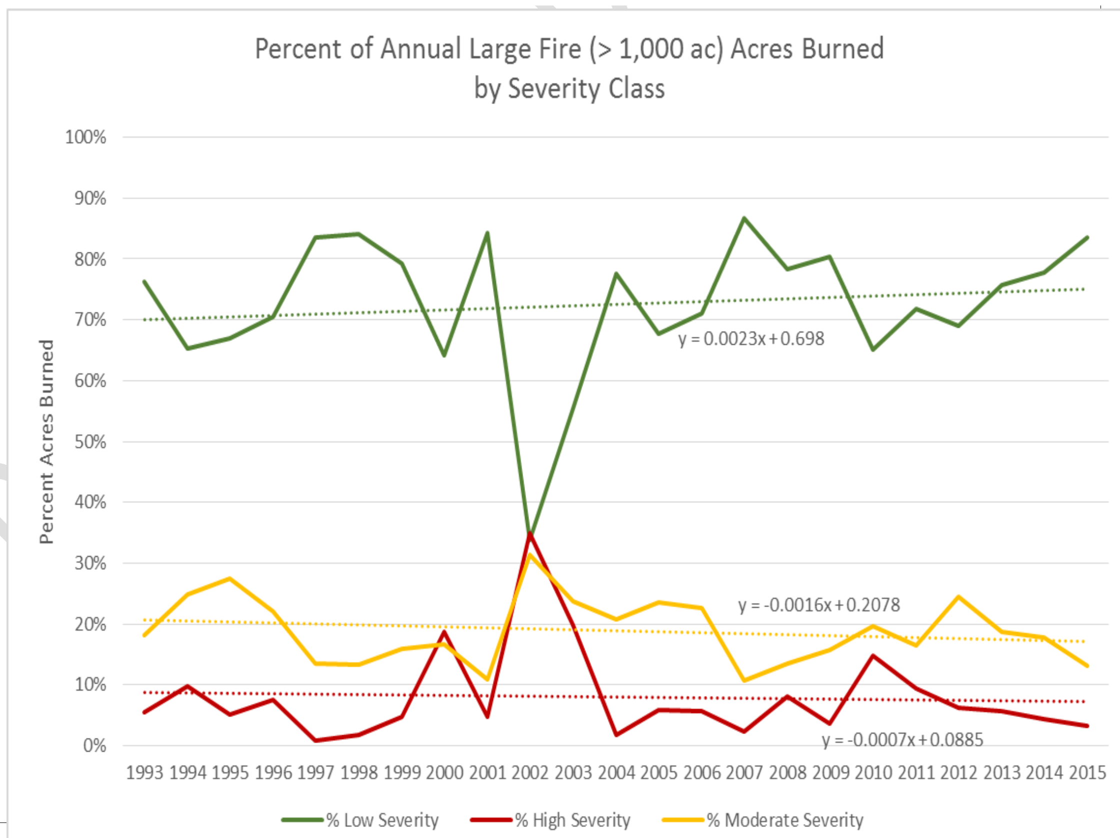


Figure 51: Percent of Annual Large Fires Burned by Severity Class.

Figure 52: Locust dominated area in the Sierra Anchas where the Coon Creek Fire produced high severity effects in 2000.

Areas of high severity fire can have detrimental impacts that extend far from the actual fire perimeter both temporally and spatially. Many of the areas that burned under high severity have been slow to regenerate and in places are now dominated by herbaceous and shrubby vegetation such as New Mexican Locust (*Robinia neomexicana*). High severity fire, especially over large areas also leaves surface soil layers vulnerable to erosion. Additionally, debris flows and floods associated with severely burned areas may have severe, long term effects on areas downstream, downslope, and adjacent to the burned area. See the soils and watershed specialist report for more detail.

Current conditions inhibit the survival and recruitment of large trees by fueling increasingly extensive high severity fires. These fires have the potential to alter the successional trajectories of post-burn vegetation, creating entirely different communities than those existing before such events (Savage and Mast 2005; Strom and Fulé 2007b; Kuenzi *et al.* 2008). Figure 8 shows dense forest conditions (numerous trees with dense, contiguous canopy fuels) that occur within the project area and would support high severity fire. Even without crown fire, a surface fire burning though this area could do enough damage to trees to cause widespread mortality (Van Wagner 1973).

Of the 349 large fires (> 1,000 acres), 283 were stared by lightning and the remaining 66 were caused by humans (Short 2017). Two of these human caused fires, the Rodeo Chediski (~468,864 acres) fire of 2002 and Wallow (~538,050 acres) of 2011, were some of the most destructive fires in the history of Arizona. The largest lightening ignited fires include the Whitewater Baldy fire (~297,845 acres) of 2012, the Humbolt fire (~248,310 acres) of 2005 and the Silver fire (~234,000 acres) of 2013. These fires mostly burned in ponderosa pine.

Figure 53: Conditions in dry mixed conifer in the project area that could easily support high severity fire

- *Fire Return Interval (FRI)*

Fire Return Interval (FRI) can be used as a coarse indicator of how departed an area is in regards to the fire regime. The FRI calculated for this analysis does not take into account seasonality, severity, size, spatial complexity, or other important characteristics of a fire regime. However, particularly when combined with cover type/s, and severity, it is a useful indicator for evaluating how far an area has departed from a sustainable fire regime.

Fire Return Interval is a component of the fire history of an area. The Mogollon Rim, and the Sierra Anchas areas have a high density of ignitions, both lightning and human. In the past 31 (1987 – 2017) years, 850,215 acres of the 1,238,658 acre project area burned, for a mean annual acres burned of 27,426 acres. In addition to wildfire, 242,028 acres of Rx fire have occurred in the project area from 1995 – 2018 for another 10,084 acres per year. Prescribed fire is often focused on areas strategic to values at risk, and therefore is concentrated on the landscape, rather than distributed throughout (Figure 9). Taken together, the mean fire return interval for the entire project area is 33 years.

For Montane Ponderosa Pine forest types, the recent FRI is 38 years. This is almost double the desired maximum average for maintenance burning in ponderosa pine on the Mogollon Rim. The FRI is 59 years for Ponderosa Pine-Evergreen Oak, 65 years for dry mixed conifer, and 113 for grasslands in the project area. These FRIs represent an average that includes areas that have burned much more frequently and areas that have burned at a much longer frequency. These higher than desired fire return intervals have contributed to the degree of departure from historic conditions that puts over 51% of the area proposed for treatment area at risk of moderate to high severity fire effects based on recent severity proportions.

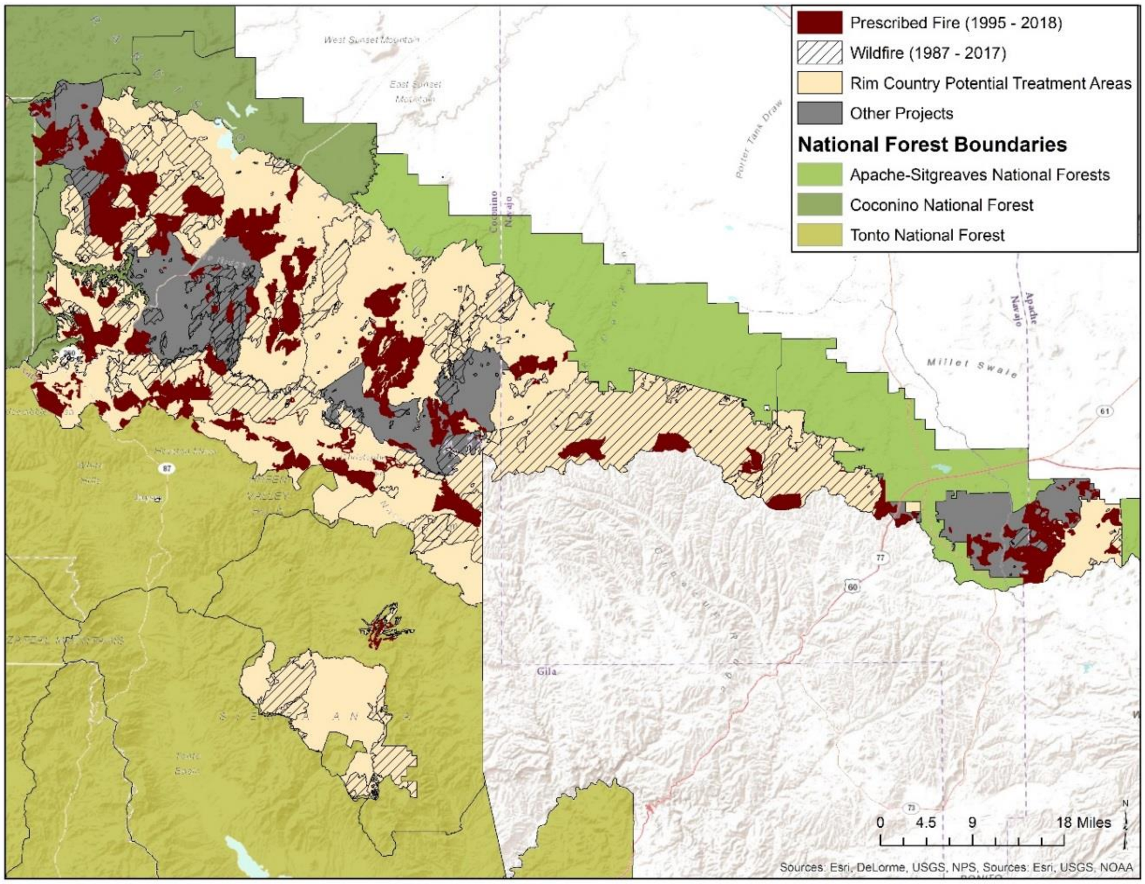


Figure 54: Location of recent Wildfire (1987 – 2017) and Prescribed Fire (1995 – 2018) within the project area.

Table 13: Vegetation cover types targeted for restoration, and their desired and current fire regimes across the project area.

Cover type	Acres of each cover type	Fire Return Interval		High Severity Fire			Average Annual Acres burned +	Average annual acres needed to burn to meet desired conditions
		Desired (average)	Current+	Desired	Recently Burned w/ High Severity++	Expected to Burn with High Severity		
Ponderosa Pine (montane)	543,058	2 – 22 (12)	38	< 20 (<5% active	27% High	23% active crown fire	14,495	~45,000

				crown fire)				
Ponderosa Pine – Evergreen Oak**	146,445	1 – 60 (7)	59	< 25 (with <10% active crown fire)	29% High	36% active crown fire	2,477	~20,000
Dry Mixed Conifer	47,993	2 – 61 (15)	65	< 20 (with <7% active crown fire)	19% High	54% active crown fire	743	~3,200
Aspen	1,436	5 - 150	739	N/A	N/A	17% active crown fire	2	~15
Grasslands	43,000	2 – 40 (12)	113	<10%	12% High	<1% active crown fire	379	3,600
Riparian	9,931	Related to, but not the same as, adjacent cover types.						

+ Average calculated across all stands with that cover type for the past 30 years (1987 – 2017) for wildfire plus the past 24 years (1995 – 2018) for prescribed fire

++Data from Monitoring Trends in Burn Severity from 1992 – 2015

**Evergreen Shrub Subclass included in acres, but not in desired conditionsurface wind speed, which, in turn, affects surface fire intensity and rate of spread. Across the project area, canopies have become much more closed, resulting in elevated potential for crown fire and decreased surface vegetation.

- *Surface fuels*

Wildland fuels are composed of various categories, including live and dead, small and large, and so on. Each plays a different role in fire behavior and associated effects. Coarse Woody Debris (CWD: diameter more than 3 inches) and duff are the highest contributors to total emissions in prescribed fires because prescribed fires are mostly surface fires, and little of the canopy fuels are consumed. Litter is a necessary component of fires in frequent fire systems because, particularly in dry, frequent fire forested systems, litter is what allows a surface fire to spread. Most of the heat produced by fine woody debris (FWD: less than 3 inches in diameter) and litter goes upwards. Duff and CWD can smolder for a long time, transferring excessive heat into the soil, cambiums, and other surface and soil components of an ecosystem than aerial fuels (fuels that are not in contact with the surface. High burn severity (fire effects to soil) is far more likely as the heat transferred to the soil can consume or kill soil biota and other organic matter in soil that is critical to soil function and productivity (Valette *et al.* 1994; Neary *et al.* 2005 (revised 2008); Lata 2006).

Litter and FWD are necessary components of surface fuel loading, providing continuity to carry a fire across the surface. Dry litter combusts relatively quickly during the flaming stage with little smoldering or smoke produced. It is a major component of surface fire intensity and behavior. CWD is an important contributor to healthy forest soils, and many habitat types. It’s common for significant amounts of CWD to be consumed during the smoldering phase, generating more emissions that can impact air quality than fuels burning in the flaming combustion phase. Duff can also be a significant source of emissions and plays a role in feeder root structure. Duff and CWD can smolder for long periods of time, causing temperature impacts to the soil and generating large amounts of low buoyant smoke for weeks (Covington and Sackett 1984).

One of the more difficult problems to address in the restoration of a ponderosa pine forest from which fire has been excluded is the accumulation of litter and duff. Generally, the litter layer contributes to fire *intensity,* while the duff layer contributes to fire *severity,* (Sackett and Haase 1996; Hood 2007).

Historically, fine surface fuel loads were made up primarily of herbaceous material and fire burning though it would move relatively quickly, with a short residence time and a high rate of consumption. Repeated fires would consume coarse woody debris a little at a time, allowing natural recruitment of more from branches or snags to maintain equilibrium based mostly on fire frequency. (Covington and Sackett 1984).

Decades of fire suppression have allowed litter and duff layers to accumulate to levels that cause a multitude of problems that include (but are not limited to) fire behavior, direct and indirect fire effects, fire effects on soil productivity, interception of precipitation, nutrients locked up in organic matter, changes to soil chemistry, emissions, and physical suppression of surface vegetation contributing to a decrease in species diversity (Covington and Sackett 1984; Moir and Dieterich 1988; Neary *et al.* 2005 (revised 2008); Abella *et al.* 2007; Varner *et al.* 2007).

Currently, across much of the project area, surface fuels are dominated by needle litter and duff that has accumulated over years to decades and is more closely packed than herbaceous fuel. Fire burning through these fuels will have a longer residence time than in herbaceous fuels, and the lower layers may smolder for extended periods, transferring more heat to the soil, roots, and boles of trees (Lutes *et al.* 2009, Valette *et al.* 1994; Sackett and Haase 1996). Conversely, litter that has accumulated for just a few years, will burn almost completely, and quickly, with little detrimental impact from heat (Covington and Sackett 1992; Sackett and Haase 1998; Garlough and Keyes 2011).

Litter and duff cones have accumulated around the base of many large and/or old trees in the project area and are likely to cause, or contribute to, undesirable mortality (Egan 2011). Prescribed fire can produce fire behavior that is less likely to cause lethal damage.

These fuel layers cannot be addressed by mechanical means across the entire area proposed for treatment under any of the action alternatives, even if it was ecologically sound to do so. Mechanical treatments may move duff and litter around, creating temporary discontinuities in the surface litter layer, but the biomass remains on site.

- *Wildfire Management*

Initially, and through most of the 20th century, wildfires burning in frequent fire regimes in the Southwest were relatively easy to suppress. Fuels were mostly light and flashy, and forests were open with high canopy base heights, and suppression was a common response. Many areas were increasingly overgrazed to the point where some areas couldn't burn at all and/or fires were easy to suppress. Settlers saw fire as a threat, and actively suppressed it whenever they could. The subsequent accumulation of fuel, through litter-fall, logging debris, and development of ladder fuels that can initiate crown fire (Covington and Moore 1994) made fire suppression more difficult. Surface fuel loading changed from light flashy fuels to compact needle litter, duff, and dead/down woody debris. Forests continued to grow denser, woody species increasingly encroached into non-forested areas, and shrubby species established and matured beneath increasingly dense canopies. This increased the severity of fire's effects, as well as the intensity of fire behavior. As wildfires became more difficult to suppress, firefighting technology, tactics, strategies, equipment and support improved dramatically, allowing suppression forces to succeed in suppressing all but the most intense and extreme fires. Most of the acres that burn now are from fires that have such extreme behavior that they overwhelm firefighting forces.

- *Wildland Urban Interface*

The Wildland Urban Interface (WUI) is the line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels

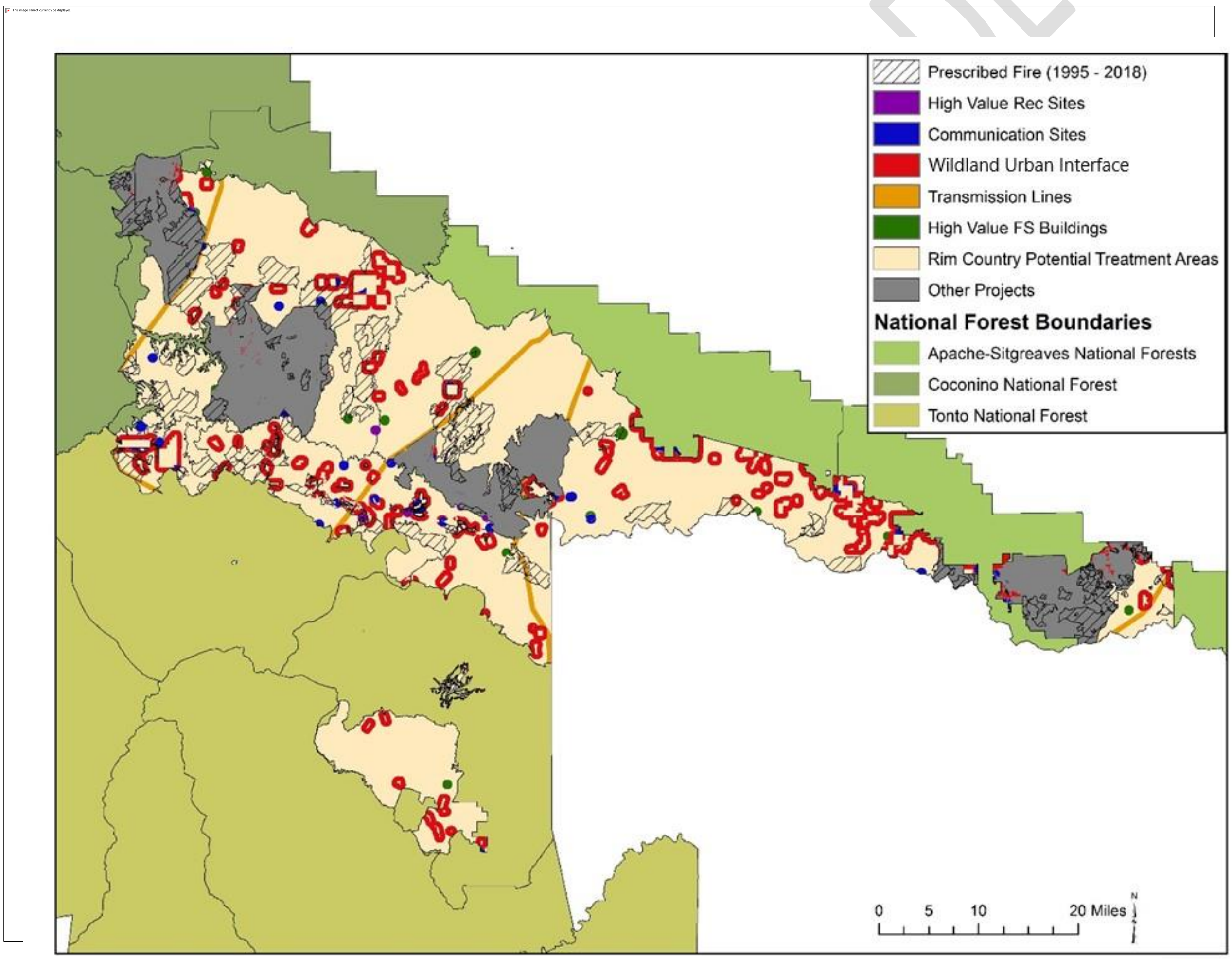


Figure 55: Wildland Urban Interface, as defined and mapped by this project. Recent prescribed fires are shown by hashed polygons.

((NWCG) 2018). It is that portion of the landscape where structures and vegetation are sufficiently close that a wildland fire could spread to structures, or a structure fire could ignite vegetation. WUI areas are scattered across the project area, though areas of the greatest concern are relatively focused around towns or along travelways. For this analysis, the wildland urban interface is defined by a 0.5 mile buffer surrounding non-

Forest Service lands where structures are present (Figure 55). Other critical infrastructure (Transmission Lines and Communication sites) and high value Forest Service Infrastructure (Buildings and Recreation Sites) were also included within the WUI for this project.

Historically, home construction was primarily focused in urban areas. Rural homes and cabins were scattered about the landscape, however most of the population was centered in urban communities.

Large and/or old trees

Large and/or old trees in the project area increase structural diversity, improving habitat for birds, insects, and other animals. Old trees have greater genetic diversity than even-aged groups of young trees, and provide forests a better chance of adapting to changing climate conditions and other environmental stressors (Minard 2002). Large and/or old trees within the project area are threatened by the increasing size and severity of wildfires. Across the west, the increasing severity of wildfires and the ensuing death of large and/or old trees have been linked to fuel accumulation resulting from a century of fire exclusion (Sackett *et al.* 1996; Covington *et al.* 1997c). Some of these fuels are deep duff and organic soil layers at the surface. They often burn with low intensity by smoldering combustion and, although temperatures are lower than in flaming combustion, residence times are much longer so more heat is transferred to cambiums, roots, and soil (Ryan and Frandsen 1991; Hartford and Frandsen 1992; Hood 2010a).

Crown damage is an important factor in the mortality of old trees for which the death is attributed to fire (Fowler and Sieg 2004; Haase and Sackett 2008; Hood 2010b). The proximity of dense young trees and ladder fuels is problematic because it is so wide spread. In the transitional pine areas various species of juniper and oak are components of the forest, often centuries old. The overtopping of these trees by ponderosa pine allows a buildup of needles in the crotches and forks. This can lead to greater mortality and/or damage to very old trees when highly flammable needle accumulations burn than would occur without the needle accumulations.

Vegetation Cover Types

Ponderosa Pine (Montane)

This cover type includes all ponderosa pine other than the ponderosa pine/evergreen oak and transitional pine described in the next section. There are about 543,058 acres of this kind of ponderosa pine forest within the area being considered for restoration treatments.

Fire Ecology

Ponderosa pine forests are widespread in the Southwest occurring at elevations ranging from 6,000-7,500 ft on soils from igneous, metamorphic, and sedimentary parent materials with good aeration and drainage, and across elevational and moisture gradients. The dominant species is Ponderosa pine (*Pinus ponderosa* var. *scopulorum*). Other trees, such as Gambel oak (*Quercus gambelii*), pinyon pine (*Pinus edulis*), and juniper (*Juniperus* spp.) may be present. There is sometimes a shrubby understory mixed with grasses and forbs, although this type sometimes occurs as savannah with extensive grasslands interspersed between widely spaced clumps or individual trees. Canopy cover in the savanna areas is between 10 and 30 percent.

Historically, once fires ignited in ponderosa pine forests, they could burn until extinguished by rain, or until they ran out of fuel, which typically occurred when they reached an area that had recently burned. Fires could burn for months and cover thousands of acres (Swetnam and Betancourt 1990; Swetnam and Baison 1996; Swetnam and Betancourt 1998). Effects from these long burning fires would vary as conditions changed over the weeks or months they burned. As a result, most ponderosa pine in the southwest burned every 2 to 22 years as mostly low-severity, often area-wide fires (Weaver 1951; Cooper 1960; Deterich 1980; Swetnam *et al.* 1990; Swetnam and Baison 1996; Covington *et al.* 1997a; Fulé *et al.* 1997; Heinlein *et al.* 2005; Kaib 2011).

Open stands of ponderosa pine under a frequent fire regime are capable of supporting a contiguous understory of up to 1,600 pounds per acre of herbaceous fuels in frequently burned stands. These high levels are the result of frequent surface fires cycle nutrients, scarify seeds for many species via smoke and/or heat effects, increasing germination (Huffman and Moore 2004; Abella *et al.* 2007; Lata 2015), and reduce competition from woody reproduction. Frequent, surface fires kill small trees, but most grasses and forbs are only top-killed, and mature trees escape damage because of their high crowns and thick bark.

During drier, warmer, windier conditions, fires would have burned at higher intensities, but would still have produced primarily low severity effects in the ponderosa pine forests of the southwest (Swetnam and Baison 1996; Fulé *et al.* 2004; Roccaforte *et al.* 2008) (intensity and severity are discussed on page XX). Ecological processes, including soil types, aspect, topography, and other physical geographic features, contributed to heterogeneous spatial patterns at all scales, with some patterns shifting through time within a natural range of variability (Moore *et al.* 1999; Allen *et al.* 2002b). Numerous documents (Drake 1910; Leopold 1924; Cooper 1960; Brown and Davis 1973; Dahms and Geils 1997) refer to historic ponderosa pine stands as open, park-like, and with a vigorous and abundant herbaceous understory. Captain Sitgreaves in 1854 describes an apparently typical ponderosa pine scene where "the ground was covered with fresh grass and well- timbered with tall pines" (Plummer 1904) (in Dahms et al.1997).

Ponderosa pine has many fire-resistant characteristics. Even seedlings and saplings are often able to withstand fire. The development of insulative bark, meristems shielded by enclosing needles, and thick bud scales contribute to the heat resistance of pole-sized and larger trees. Propagation of fire into the crown of trees pole-sized or greater, growing in relatively open stands (dry sites), is unusual because of three factors. First, the tendency of ponderosa pine to self-prune lower branches keeps the foliage separated from burning surface fuels. Second, the open, loosely arranged foliage does not lend itself to combustion or the propagation of flames (compare this with the dense, foliage of spruce or fir). Third, the thick bark does not easily ignite and does not easily carry fire up the bole or support residual burning. Resin accumulations, however, can make the bark more flammable and may occur if trees have been fighting off insects, or sustained damage such as broken branches or deep abrasions on the bole. Understory ponderosa pine may be more susceptible to fire damage where crowded conditions result in slower diameter growth. Such trees do not develop their protective layer of insulative bark as early as do faster growing trees. They remain vulnerable to cambium damage from surface fires longer than their counterparts in open stands. The thick, overcrowded foliage of young stands or thickets also negates the fire-resisting characteristic of open, discontinuous crown foliage commonly found in this species. Ponderosa pine seedling establishment is favored when fire removes the forest floor litter and grass and exposes mineral soil. Fire resistance of open, park-like stands is enhanced by generally light fuel quantities of flashy fuels. Heavy accumulations of litter at the base of trunks increase the intensity and duration of fire, often resulting in a fire scar or "cat face" when a fire does burn through the area and that part of the bole next to the fuel accumulation is subjected to more heat. New resin ducts develop around wounds to help protect trees although, if the wound doesn't heal before the next fire, the additional flammable resin deposits around wounds can make an individual tree susceptible to fire damage and can enlarge existing fire scars.

The denser and younger stand structures of the historic ponderosa pine forest were the result of special circumstances in the interaction of climate, site, and disturbances. Even though ponderosa pine reproduction was negligible in some years, there were occasional wet cycles as long as 15 to 20 years without fires when ponderosa pine would regenerate (Swetnam and Dieterich 1985). This regeneration cycle required seed production, establishment, and survival to an age at which the young tree could successfully compete and endure surface fires. When single or small groups of trees died and fell, they were inevitably consumed by surface fires, producing severe but localized fire effects that reduced grass competition, and created favorable microsites for seedling establishment (Cooper 1960).

- History

An area now within the Coconino National Forest is described in a U. S. Geological Survey (1904) report as: "A yellow-pine forest, as nearly pure as the one in this region, nearly always has an open growth, but not necessarily as lightly and insufficiently stocked as in the case in this forest reserve. The open character of the yellow-pine forest is due partly to the fact that the yellow pine flourishes best when a considerable distance separates the different trees or groups of trees. " (Dahms and Geils 1997). In a report written in 1910 by Willard M. Drake, Acting Forest Supervisor of the Coconino National Forest wrote: "…Western Yellow Pine, (*Pinus ponderosa*) is the characteristic species generally forming in this type a nearly pure and often very open stand of mature timber with few young trees in the mixture. Only in very scattered areas do the crowns form anything like a continuous cover…"

Although the popular early descriptions of the ponderosa pine forest call attention to the park-like stands, there are some descriptions which refer to areas with dense cover (Woolsey 1911). An accurate picture of the pre-settlement ponderosa pine forest would probably describe a mosaic of mostly open, grass savanna and clumps of large, yellow-bark ponderosa pine and open forest with an occasional dense patches or stringers of small, blackjack pines (young ponderosa pine). Ponderosa pine naturally regenerate infrequently, but when they do, they reproduce with an overabundance of seedlings and a high rate of juvenile mortality (Pearson 1931).

Extensive stand-replacing fires are unreported in the documentary records prior to circa 1950 (Cooper 1960; Allen *et al.* 2002a). Ponderosa pine does not sprout, so crown fire generally produces 100 percent mortality. There are few data available to indicate how much high severity fire was typical across the ponderosa pine in northern Arizona, but simulations suggest that presettlement forest structure would have supported very little crown fire, passive or active (Roccaforte et al. 2008, Covington 2002). Modeled historic conditions in Southwestern ponderosa pine indicate that up to 17% of the area may have supported active crown fire with windspeeds of 43 mph (Roccaforte et al. 2008), with less under conditions close to those modeled for this analysis for montane ponderosa pine.

Historically, passive crown fire produced only small patches of high severity effects. Extrapolating results from Roccaforte et al. (2008) to those conditions used for modeling Rim Country, patches of high severity, mostly in the form of passive crown fire, would generally have been less than 50 acres in size under those conditions modeled for Rim Country. These patches would occur in areas with windthrow, disease/insect infestation, area ecotones between ponderosa pine and mixed conifer or PJ, or other site specific situations that would allow crown fire initiation and spread.

Ponderosa Pine – Evergreen Oak & Transitional pine (PPEO)

The ponderosa pine/evergreen oak (PPEO) cover type in this analysis includes vegetative associations which have been referred to by various classifications and names, including transitional pine, Arizona highlands, Ponderosa Pine/Evergreen Oak ERU, Mogollon highlands, various Madrean fringe types (Fleischner *et al.* 2017; Wahlberg *et al.* 2017 (in draft); Huffman *et al.* 2018). In order to be consistent, this analysis will use the broadest classification, 'Ponderosa Pine/Evergreen Oak' (PPEO) to refer to this broad cover type, with more detailed discussion as needed to include unique characteristics.

PPEO occurs in the mild climate gradients of central and southern Arizona, particularly below the Mogollon Rim, where warm summer seasons and bi-modal precipitation regimes are characteristic. These vegetation types occur at a biogeographic crossroads, contributing to a tremendous ecological diversity in this part of the Rim Country project area. (Fleischner *et al.* 2017). Generally, PPEO occurs from 5,500 –7,200 feet and is dominated by ponderosa pine. PPEO can be distinguished from montane ponderosa pine by well-represented evergreen oaks. It may also include pinyon pine (*Pinus edulis*) and alligator juniper (*Juniperus deppeana*) as co-dominant species (Brown 1994a; Wahlberg *et al.* 2017 (in draft)). In places, ponderosa pine forests co-occur with interior chaparral and Madrean woodland communities (Huffman *et al.* 2018), sometimes as inclusions, and sometimes as more extensive adjacent types, often aspect-driven. Wahlberg *et al.* (2017 (in draft)) describe an 'Evergreen Shrub Subclass' within the PPEO that favors high shrub cover and higher fire severity than in the matrix PPEO forest. These transitional forests commonly occur on xeric sites, and rather than the herbaceous communities typical of montane forests, shrubs presently dominate the understories of many transitional ponderosa pine systems. Much less is known about these ecosystems compared to the montane ponderosa communities, yet transitional forests are important components of biodiversity on southwestern landscapes. Because transitional forests occur at the environmental limits of ponderosa pine, they are vulnerable to rapid changes in terms of tree mortality as the climate warms and periodic droughts become more frequent and severe (Huffman *et al.* 2018).

Fire Ecology

Research in other areas pine/shrub systems found that moderate intensity fires tend to favor pine, while less frequent fire favors the sprouting species. This poses a challenge for management and for proposed restoration treatments.

PPEO forests differ from montane ponderosa pine by site potential, typically favoring high shrub cover, and by higher fire severity, and more even-aged conditions characteristic of mixed-severity fire regimes. Some high-density evergreen shrub patches exhibit infrequent, high severity fire (fire regime IV; stand replacement at 35-200 years). Areas where this pattern was persistent are likely to be identified as Interior Chaparral.

PPEO averages greater fire severity than the montane ponderosa pine forests above the Mogollon Rim, and greater patchiness with less horizontal uniformity and more even-aged conditions. Site potential, fire history, and the importance of perennial grasses versus shrubs in the understory vary, affecting forest structure and the disturbance regime (Wahlberg *et al.* 2017 (in draft)). Understory shrubs include manzanita (*Arctostaphylos* sp.), turbinella oak (*Quercus turbinella*), skunkbush sumac (*Rhus trilobata*), and mountain mahogany (*Cercocarpus montanus*).

- History

It is well understood that 20th century fire exclusion in montane ponderosa pine forests has led to substantial increases in tree establishment and associated changes in ecological function (Covington and Moore 1994; Fulé *et al.* 1997; Moore *et al.* 1999; Savage and Mast 2005; Strom and Fulé 2007a). Much less is known about historical changes associated with modern land use in the PPEO. Some species in the PPEO are often growing at their environmental limits and thus can be under high levels of stress within ecotones, thus these zones where communities intergrade are often dynamic and fluctuate in composition over relatively small spatial and temporal scales. It appears that cover of long-lived sprouting shrubs has increased in many transitional ponderosa pine forests as a result of fire exclusion (Huffman *et al.* 2018).

Historical fire regimes in pine forest communities co-occurring within interior chaparral and Madrean evergreen woodland appear to have been characterized by frequent, low-severity surface fires similar to those widely reported for montane ponderosa pine forests of the Southwest. Frequent fires likely kept forests in open structural conditions and limited establishment and regeneration of sprouting woody species. As was prevalent in other southwestern ecosystems, unregulated livestock grazing in the late 19th and early 20th centuries apparently reduced abundance of herbaceous plants in ecotone communities (e.g., in both ponderosa pine forests and chaparral shrublands), and interrupted fire regimes. Intensive harvesting of ponderosa pine for mining materials in the mid-1800s undoubtedly contributed to later shifts in forest structure at some sites. Fire regime interruption in the Southwest appears to have allowed shrubs as well as young trees to increase in abundance within transitional pine forests. Similarly, less frequent fire in adjacent shrublands allowed ponderosa pine trees to establish and expand into these communities. Active fire suppression beginning in the mid- 1900s likely exacerbated structural shifts of both pine forests and shrublands. The ultimate effect of these anthropogenic influences has been to encourage broader, more complex ecotones, with ponderosa pine trees found overtopping shrubs on both historical forest sites as well as historical shrubland sites. Additionally, research indicates that fire exclusion due to historical intensive livestock grazing and tree harvesting has led to a broadening of ecotone boundaries, with shrubs increasing within pine forests as well as coniferous trees expanding into chaparral and evergreen woodlands. (Huffman *et al.* 2018).

- *Mixed Conifer*

"Mixed Conifer" includes a wide range of vegetation types and fire regimes. Mixed conifer has been classified into warm/dry, or cool/moist (Romme *et al.* 2009; Korb *et al.* 2013; Wahlberg *et al.* 2017 (in draft)), which can also be distinguished by their natural fire regimes (Youtz XXXX). In this analysis, mixed conifer will be referred to as WMC (Mixed Conifer with Aspen, or Wet Mixed Conifer) or DMC (Mixed Conifer - Frequent Fire, or Dry Mixed Conifer).

Historically, mixed conifer in the southwest had highly diverse composition and structure. This diversity was largely driven by topography, with the scale of the mosaic of cover types dependent on the scale of topographic variation. Ridgetops and low elevation sites were (and largely still are) characterized by open stands dominated by ponderosa pine and had frequent surface fires. South and west-facing slopes likely were similar, but were less open and had less ponderosa and more Douglas-fir, aspen and white fir. These stands likely also were characterized by frequent surface fires. North and east-facing slopes were likely more dense and had still less ponderosa and more white fir, as well as Engelmann spruce and subalpine fir, especially at higher elevations. Douglas fir (*Pseudotsuga menziesii*) tends to dominate drier sites where ponderosa pine does well. *Abies concolor* tends to dominate cooler sites, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and north and east-facing slopes which burn somewhat infrequently. *Picea pungens* is most often found in cold, moister locations, often occurring as smaller patches or frost bands within a matrix of other associations. As many as seven conifers can be found growing in the same stand.

Tree species found in mixed conifer forests exhibit a wide range of tolerance to shade and low severity fire; these traits are often related (Strahan *et al.* 2016). Those species adapted to establish and grow in low light conditions below other trees often have thin bark and are easily killed by fire (Evans *et al.* 2011). Conversely, ponderosa pine is well adapted to fire, having thick, insulating bark. On the ground, there is a gradient of biotic and abiotic factors, with some sites being clearly wet or dry mixed conifer, and many sites in a grey area between that can be difficult to identify clearly as one or the other, either in existing condition or historic condition (Figure 11). This is particularly true where the disturbance cycles have been interrupted, and vegetation is significantly departed from historic conditions. Some sites have become so dominated by shade-intolerant species that their classification as DMC was changed to WMC (Margolis and Malevich "Mixed Conifer" includes a wide range of vegetation types and fire regimes. Mixed conifer has been classified into warm/dry, or cool/moist (Romme *et al.* 2009; Korb *et al.* 2013; Wahlberg *et al.* 2017 (in draft)), which can also be distinguished by their natural fire regimes. In this analysis, mixed conifer will be referred to as WMC (Mixed Conifer with Aspen, or Wet Mixed Conifer) or DMC (Mixed Conifer - Frequent Fire, or Dry Mixed Conifer).

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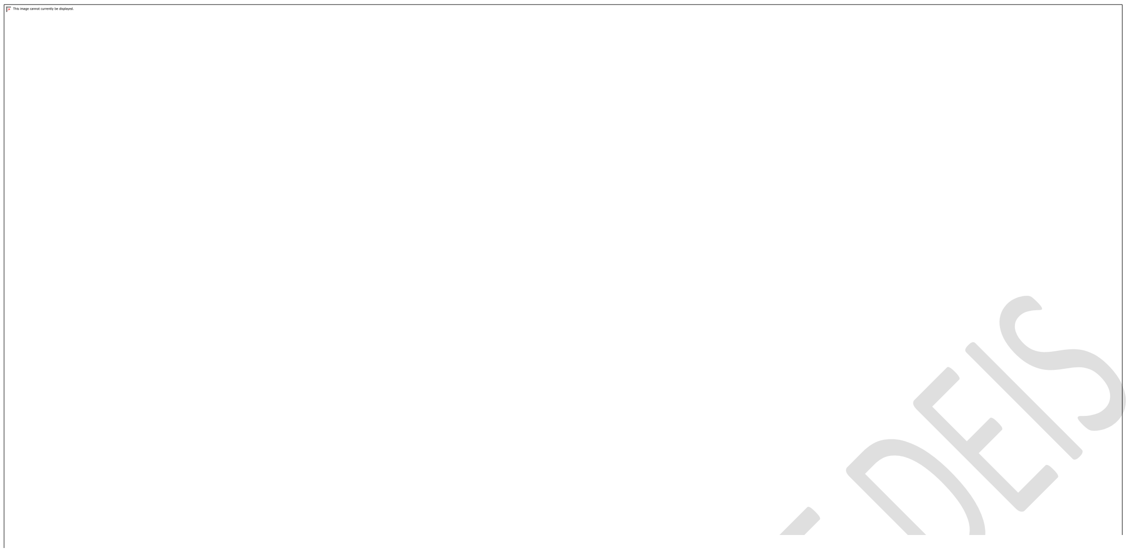

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- *Mixed Conifer with Frequent Fire (Dry Mixed Conifer)*

Dry Mixed Conifer (DMC) covers approximately 63,000 acres within the area proposed for treatment in Rim Country. It generally occurs at elevations between 6,000 and 10,000 feet, with some variability depending on aspect. DMC is generally situated between ponderosa pine or pinyon-juniper woodlands below wetter mixed conifer or and spruce-fir forests above. Historically, DMC was dominated by ponderosa pine (*Pinus ponderosa* var. *scopulorum*) in an open forest structure (Reynolds *et al.* 2013; Rodman *et al.* 2016; Huffman *et al.* 2018), with minor occurrence of aspen (*Populus tremuloides*), Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), and Southwestern white pine (*Pinus strobiformis*). Species vary in relation to elevation and moisture availability and are mainly shade intolerant trees. In lower elevations and drier areas, Douglas-fir, Gambel oak, ponderosa pine, piñon, and juniper may co-dominate. In higher elevations and moister areas, ponderosa pine may co-dominate with Rocky Mountain Douglas-fir, aspen, white fir, southwestern white pine, and Rocky Mountain juniper. The understory can be composed of a wide variety of shrubs, grasses, sedges, rushes, and forbs depending on the soil type, aspect, elevation, disturbance history, and other factors (Wahlberg *et al.* 2017 (in draft)).

Fire Ecology

Historical fire regimes were probably similar to those widely reported for montane ponderosa forests of the Southwest. Frequent surface fires likely kept forests in open structural conditions and limited the abundance of woody understory species. A 2015 study that included areas on the Black Mesa Ranger District of the Apache-Sitgreaves National Forest, fire return intervals ranged from about 2 to 60 years, averaging about 12 (Heinlein *et al.* 2005; Huffman *et al.* 2015). Available evidence in DMC forests suggests that high severity patches would have been generally been less than 60 acres, with the larger patches being less common (Huffman *et al.* 2015; Yocom Kent *et al.* 2015).

History

Tree establishment patterns compared with widespread fire dates did not suggest historical high-severity fires at the site level. Strong evidence of high-severity fire at finer scales was lacking, though spatial locations of ‘young’ plots suggested the possibility of historical high-severity disturbances. The historical fire regime on this landscape was one of high frequency, low-severity fires (Huffman *et al.* 2015). This would have supported a finer grained pattern of vegetation than is currently present. Current conditions show a coarser pattern that would be more consistent with a less frequent, mixed to high severity fire regime, increasing the susceptibility to stand-replacing fire, even where such regimes were uncommon historically (Abella and Springer 2014; Rodman *et al.* 2016). Fire and drought tolerance have decreased since pre-settlement times, driven largely by increases in the relative importance of white fir (*Abies concolor*) and southwestern white pine (*Pinus strobiformis*), but also shifts from shade intolerant species to shade tolerant species (Strahan *et al.* 2016).

Emissions and Air Quality

Wildland fire emissions can cause adverse health effects and/or become a nuisance, but are fundamental to the disturbance ecology associated with healthy ecosystems that are adapted to frequent fire. Fire will occur in the project area in some form, regardless of the decision made based on this EIS, so air quality impacts are evaluated for all the alternatives. Air quality within the project area currently meets EPA air quality standards.

Wildfire vs. Prescribed Fire

Smoke is inevitable in the airsheds of fire adapted ecosystems, such as those of Northern Arizona. Federal land managers have the role of protecting and meeting air quality standards while simultaneously allowing fire, as nearly as possible, to function in its natural role in the ecosystem (USDA and USDOI 1995). Smoke and visibility impairment from wildland fire that closely mimics what would occur naturally is generally viewed as acceptable (Peterson 2001).

Currently, prescribed fires are regulated and their emissions are monitored and regulated in the same manner as emissions sources that are more controllable (such as dust, vehicle emissions, smoke from wood-burning stoves, industrial emissions, etc.), and included in air quality assessments used to approve burn plans. Smoke impacts from wildfire can be more difficult to mitigate than prescribed fire, whether the expected effects of the fire are desirable or not. Among the many factors fire managers and line officers must carefully weigh when deciding how to manage a wildfire, or whether to ignite a prescribed fire is whether the potential benefits of the wildfire outweigh all of the smoke impacts. Prescribed fires and wildfires both create smoke, but differ in the amount, timing, and predictability of these events (Table 7). Most wildfires in the southwest occur between late April and mid-September. Currently, most prescribed fires are implemented in the early spring or late fall.

Fire managers are able to manage smoke impacts to some degree by implementing prescribed fire and when ventilation conditions are favorable. It may be possible to minimize burning and/or hold a fire in check on days when reduced emissions are needed. It can be advantageous to blackline a burn unit well in advance of burning the entire unit to take advantage of burn windows with good ventilation. Various Emissions Reductions Techniques (ERTs) are utilized and documented as a standard part of implementing prescribed fires. (ERTs are listed in the project design features). A 'Daily Burn Accomplishment Form' is completed and submitted for each day a burn is being implemented (see: Design features, Best Management Practices, and Mitigation).

Table 14. Generalized comparison of options for managing fire on federal land

Emission characteristics	Planned ignitions	Unplanned ignitions
Predictability of **when** smoke events occur	Predictable	Somewhat predictable to unpredictable
Predictability of the **severity** (concentration) of smoke impacts	Predictable	Somewhat predictable to unpredictable
Predictability of **where** there will be smoke impacts	Mostly predictable	Somewhat predictable to unpredictable (knowing where a fire will start)
Controllability of smoke	Mostly controllable	Mostly controllable to uncontrollable
Duration of smoke events	Days or weeks	Days, weeks, or months
Frequency of smoke events	Intermittent to frequent and increasing	Intermittent to frequent during the fire season, likely to increase
Severity/desirability of the effects of the fire	Mostly desirable	Mostly desirable to mostly undesirable
Longevity of negative effects	Short to moderate	Short to permanent
Extent of negative effects	Small, unlikely to be more than a few contiguous acres if it occurs	Variable, ranging from less than an acre to hundreds of thousands of acres

Potential for significant negative effects (other than smoke), such as downstream flooding or damage to infrastructure outside the fire perimeter	Low, but present	Low to very high
Threat to human life and property	Low, but present	Low to very high

Activities on prescribed fires and wildfires in an airshed are coordinated between fire managers, working with the Arizona Department of Air Quality, to either spread high emission producing events from multiple wildland fires over several days to reduce the concentration of pollutants, or facilitate these events to occur simultaneously on days with favorable ventilation to move the pollutants up and out of the airshed all at once to reduce the concentration and duration of smoke impacts.

Actual smoke impacts are dependent on numerous factors, some predictable, some less so. Air quality impacts are more closely related to ventilation parameters, live and dead fuel moisture, wind direction and speed, fuel chemistry, firing techniques, timing and duration of ignition, fuel arrangements and loading, atmospheric stability, than the Rim Country Alternatives.

Smoke can travel great distances and affect communities far away from the burn unit, often persisting for a time after the burn has been completed. Fires burning under historic conditions in the vegetation types targeted for restoration treatments in this analysis produce behavior and effects that are mostly low to moderate. Large, uncharacteristically high severity fires usually create more emissions over a longer time that prescribed fires, because of differences in the size and duration of the fires (Hardy *et al.* 2001) and the amount of fuel consumed.

Prescribed burning is implemented only with approved site specific burn plans and with smoke management mitigation and approvals. All burning is conducted according to Arizona Department of Environmental Quality standards and regulations, including the legal limits to smoke emissions from prescribed burns as imposed by Federal and State Law. The Arizona Department of Environmental Quality ADEQ) enforces these laws by regulating acres that are treated based on expected air impacts. These regulations ensure that effects from all burning within the area are mitigated and that Clean Air Act requirements are met. Prescribed fires are initiated under conditions that allow managers to meet both control objectives (fire behavior), and resource objectives (fire effects, including air quality impacts).

- *Meteorological, Climatological and Topographical Effects on Air Quality*

Climatological limits are set by weather and fuel moisture, which profoundly affect fire behavior, fire effects, and the behavior and effects of emissions. As weather varies from year to year, so does the risk of high severity fires and the ability to use prescribed burns and wildfires to achieve resource objectives. Large fluctuations in the number of days of opportunity vary widely from year to year, creating large fluctuations in the number of acres treated with wildland fire. Running averages over many years must be used in order to view trends in fire use or fire effects (Kleindienst 2012).

Topography and weather patterns determine the extent to which airborne particulate matter accumulates within local airsheds. Diurnal temperature changes affect how pollutants in the region are dispersed. Meteorological conditions limit how much smoke an airshed can absorb at any point in time without violating NAAQS (details on page 16) or visibility thresholds. During the warmest days and seasons of the year, air is heated at the surface, and rises, lifting smoke up to heights where transport winds carry it away and disperse it during the daily burn periods. Winds in the project area are predominantly from the south, southwest, and west and, as such, during daytime hours, fire activities within the Rim Country treatment area are most likely to affect smoke sensitive receptors to the north, northeast, and east of fire locations.

The best ‘windows’ for smoke dispersal are when the atmosphere is unstable, allowing smoke to rise up high and disperse. These conditions, when combined with low fuel moistures and high fuel loading, can also lead to undesirable fire behavior and effects. The best dispersal days are often too extreme for prescribed fire. Overnight, winds often become calm, allowing topographic effects to dominate smoke movement. As the temperature decreases, air flows downhill, carrying smoke from smoldering fuels (duff, dead/down wood), which often ‘pools’ in low lying areas until the air warms again the next day. Nighttime settling of residual smoke from fires generates as many concerns and complaints of nuisance smoke as daytime smoke. “Nuisance Smoke” is defined in the State Implementation Plan (page 16) as “Amounts of smoke in the ambient air which interfere with a right or privilege common to members of the public, including the use or enjoyment of public or private resources” (Appendix A-10, pg. 35 of the Arizona State Implementation Plan)

During the winter, weather conditions can trap emissions in a layer of cold surface air (inversion). Under these conditions, particulates can be trapped close the surface in local airsheds, including the communities of Flagstaff, Young, Payson, Pumpkin Center, Roosevelt, St. John, and the Verde Valley. Visibility is also an air quality consideration, and tends to be lowest in the summer due to regional haze and smoke from fires.

- *Emissions and Public Health*

There are six pollutants identified by the Environmental Protection Agency (EPA) that are considered to be ‘fire-related’ pollutants (Hyde *et al.* 2017), are:

1. **Carbon monoxide** (CO) is a colorless, tasteless, odorless gas produced primarily by motor vehicles. Other sources include wood-burning stoves, fireplaces, wildland fires and industries that process metals or manufacture chemicals. High CO concentrations can occur in large urban areas and mountain valleys. CO is poisonous at high levels and can damage the heart and central nervous system.

2. **Lead** in the air exists primarily as particulates. The major source used to be gasoline, but is currently metals processing. Other sources are waste incinerators, utilities, and lead-acid battery manufacturers. Lead particularly affects young children and infants, and is found at high levels in urban and industrial areas. Lead deposits on soil and water, and can harm other animals.

3. **Nitrogen Dioxide** (NO2) has a reddish-orange-brown color and a pungent odor. Nitrogen oxides form when fuel is burned at high temperatures, as in a combustion process. The primary sources are motor vehicles, electric utilities, and other industrial, commercial, and residential operations that burn fuels. Some

nitrogen dioxide is emitted by wildland fires. NO_2 is easily converted to nitrates, a major component of acid rain, contributing to impacts on vegetation, visibility, and soil and water quality. Nitrogen dioxide also impairs human health.

4. **Ozone** is an unstable gas, and has a characteristic odor. Ozone forms when hydrocarbons and nitrogen oxides chemically react in sunlight. Motor vehicle exhaust and industrial emissions, gasoline vapors, chemical solvents and natural sources emit compounds that form ozone. Ozone can trigger a variety of health problems including permanent lung damage after long-term exposure. It can also damage plants and ecosystems.

5. **Particulate Matter** (PM) consists of particles of solid or semi-solid materials in the atmosphere. Most human-made particles are 0.1 to 10 micrometers in diameter. Particulates less than or equal to 10 micrometers (PM_{10}) can cause respiratory problems, while larger particulates settle out of the air. Airborne dust, or particle pollution, causes significant problems with human health and the environment, and should be minimized. Particulates less than or equal to 2.5 micrometers ($PM_{2.5}$) are generally created during combustion and are the major cause of visibility impairment. These fine particles move over long distances by wind and settle on ground or water. High PM concentrations are often associated with large urban areas or mountain valleys where dust, smoke, and emissions are common. Health effects of PM include: respiratory problems, decreased lung function, asthma, chronic bronchitis, irregular heartbeat, nonfatal heart attacks, and premature death in people with heart or lung disease.

6. **Sulfur dioxide** (SO_2) is a colorless gas that easily dissolves in water to form acid. It is a major pollutant throughout the world and potentially carcinogenic. The main source is burning fossil fuels.

The Clean Air Act establishes National Ambient Air Quality Standards (NAAQS) for six principal pollutants that pose health hazards: carbon monoxide (CO), lead, nitrogen dioxide, particulate matter less than 10 microns in size (PM 10), particulate matter less than 2.5 microns in size (PM 2.5), ozone, and sulfur dioxide. All of these pollutants except lead are monitored and reported by the daily Air Quality Index (AQI), which ranging from Good to Hazardous (Figure 13). This index focuses on adverse health effects from exposure to unhealthy air. Each day, monitors record concentrations of the major pollutants at more than a thousand locations across the country. These raw measurements are converted into a separate AQI value for each pollutant (ground-level ozone, particle pollution, carbon monoxide, and sulfur dioxide) using standard formulas developed by EPA. The highest of these AQI values is reported as the AQI value for that day.

AQI Value	Actions to Protect Your Health From Particle Pollution
Good (0 - 50)	None
Moderate (51 - 100*)	Unusually sensitive people should consider reducing prolonged or heavy exertion.
Unhealthy for Sensitive Groups (101 - 150)	The following groups should reduce prolonged or heavy outdoor exertion: - People with heart or lung disease - Children and older adults
Unhealthy (151 - 200)	The following groups should avoid prolonged or heavy exertion: - People with heart or lung disease - Children and older adults Everyone else should reduce prolonged or heavy exertion.
Very Unhealthy (201 - 300)	The following groups should avoid all physical activity outdoors: - People with heart or lung disease - Children and older adults Everyone else should avoid prolonged or heavy exertion.

Figure 58: AQI Table with levels of health concerns. Taken from the Environmental Protection Agency's airnow.gov website: https://airnow.gov/index.cfm?action=aqi_brochure.index

While it is difficult to determine exactly how much emissions from wildfire fires contributes to the overall AQI compared to other polluters such as vehicles, dust and industrial pollutants, trends in AQI can help identify areas with increased need for mitigation of wildfire emissions. The pollutant most directly linked to AQI and wildfires is Particulate Matter (both PM10 and PM2.5)

- *Particulate Matter (PM)*

Air pollutants called particulate matter (PM) include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust. This pollutant is the greatest concern of wildland fire emissions, from wildland fire (Ottmar 2001; Graham 2012-2014), although fire also creates other criteria pollutants and visibility impacts. Particulate matter is defined as tiny particles of solid or semi-solid material suspended in the air. Particles may range in size from less than 0.1 microns to 50 microns. Particles larger than 10 microns tend to settle out of the air quickly and are not likely to affect public health; smaller particles remain airborne, are considered inhalable, and have the greatest health effects. The EPA has used ‘PM10’ since 1987 to refer to particles of 10 micrometers or less in the ambient air. In 1997, the EPA added ‘PM2.5’, which includes only those particles with aerodynamic diameter smaller than 2.5 micrometers.

Studies indicate that 90 percent of smoke particles emitted during wildland fires are PM 10, and about 90 percent of PM10 is PM2.5 (Ward and Hardy 1991). Human health studies on the effects of particulate matter indicate that it is PM2.5 that is largely responsible for health effects (Dockery *et al.* 1993). Because of its small size PM2.5 has an especially long residence time in the atmosphere, penetrating deeply into lungs (Ottmar 2001).

The Clean Air Act defines the NAAQS for PM 2.5 as an annual mean of 15µg/m3, and a 24 hour average of 35µg/m3. At this concentration or above, PM 2.5 is considered to have a detrimental effect on public health. It is important to note that it is not the total amount of emissions from a fire that have effects on human health, but rather how concentrated pollutants in ambient air are for a period of time.

Atmospheric conditions during a fire have a considerable influence on how particulate matter is distributed though the ambient air, and its potential to affect public health. Wind speed and direction, mixing layer height, atmospheric temperature profile upward in the atmosphere, and atmospheric stability all impact where and how well smoke will disperse. Particulate matter can from sources other than fire. In many cases windblown dust and dust kicked up on unpaved roads by vehicle traffic, such as logging trucks, account for much of this fine particulate matter (Kleindienst 2012).

Studies of human populations exposed to high concentrations of particles (sometimes in the presence of SO2) and laboratory studies of animals and humans, indicate there is potential for detrimental effects on human health. These include effects on respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body’s defense systems against foreign materials, damage to lung tissue, carcinogenesis, and premature death. The major subgroups of the population that appear to be most sensitive to the effect of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease of influenza, asthmatics, the elderly and children. Particulate matter also soils and damages materials and is a major cause of visibility impairment, and may soil or damage materials.

- *Fugitive dust*

Heavy equipment used on paved and unpaved roads during the implementation of projects has the potential to create localized impacts from fugitive dust. With high wind events, this fugitive dust has the potential to be carried for several kilometers. Control measures developed for site specific projects can reduce these localized particulate matter emissions, such as reducing travel speeds on unpaved surfaces, ceasing work activities during periods of high winds, applying gravel or soil stabilizers on dust problem areas, covering loads, and covering ground surfaces with water during earth moving activities (BLM 2011).

- *Radioactive emissions*

Radioactive emissions are out of the legal scope of this analysis. However, during the SCOPING periods for the first 4FRI EIS, concerns were raised about the potential for radioactivity in smoke from prescribed fire treatments proposed in 4FRI to contain radioactive substances, so it has been included in this analysis.

During the Cerro Grand fire of 2000, there was also considerable public concern regarding the potential release of radionuclides from fires burning on lands managed by the Los Alamos National Laboratory (LANL). The following risk summary is from "2002 Fact Sheet: Cerro Grand Fire Releases to Air" which may be viewed at:

http://www.nmenv.state.nm.us/OOTS/PR/2011/NMED_Monitoring_Air_Quality_in_Los_Alamos.pdf

"The primary health risks during the Cerro Grande fire were associated with breathing materials released into the air. It was estimated the risk of cancer from breathing any LANL-derived chemical or radioactive material that may have been carried in the smoke plume to be less than 1 chance in 10 million. Potential exposures in the surrounding communities to LANL-derived chemicals that are not carcinogenic were about 10 times lower than acceptable intakes established by the U.S. Environmental Protection Agency (EPA). The risk of cancer from breathing chemicals and radioactive materials in and on the natural vegetation that burned in the Cerro Grande Fire was greater than that from LANL derived materials, but still less than 1 chance in 1 million. The vegetation that burned contained naturally occurring chemicals and radioactive materials and radioactive fallout produced during atmospheric tests of nuclear weapons. These materials and the risks they posed are present during any forest fire. The evidence suggests that some adverse health effects did result from breathing high concentrations of particulate matter in the smoke. Such exposures are associated with any forest fire. Deposition of LANL-derived chemicals and radioactive materials from the smoke plume to the soil was minimal."

Following the Cerro Grande fire that burned the city of Los Alamos and the Los Alamos National Laboratory (LANL) in New Mexico in 2000, the US Environmental Protection Agency (EPA), New Mexico Environment Department (NMED), and LANL partnered with Department of Energy to operate radiological monitoring systems as well as to initiate several studies to assess the impacts of the fire. The results of these efforts with regard to air quality and human health impact indicated that radionuclides originating from the LANL site during the Cerro Grande Fire were restricted to naturally occurring radionuclides.

LANL, the Department of Energy, and NMED monitored radionuclide concentrations in smoke from the Las Conchas fire that burned through the Los Alamos area in the summer of 2011 and reported no significant detection levels (http://www.nmenv.state.nm.us/nmrcb/documents/LasConchasFireAirMonitoring.html).

A study that included Lockett Meadow, within the project area, found levels of radioactive materials in the soil were no different than background levels, and would provide no added human health risk (Ketterer *et al.* ; Graham 2012-2014).

Communication with the EPA (Gerdes 2012 - 2014; Graham 2012-2014), and studies that addressed these emissions (H. *et al.* 2002; Schollnberger *et al.* 2002) indicate that radioactive isotopes and other undesirable chemicals are present in wildfire emissions. Some are naturally occurring chemicals that have always been present at some level in wildfire smoke and some have resulted from the weapons testing that occurred in the mid-20th century. At the level of exposure the public is subjected to, radionuclides do not pose as great a risk as wildfire. Radioactive material that may be carried in the smoke plume carries a risk of human health concerns of less than 1 chance in 10 million (Graham 2012-2014) and NMED 2002 as cited above) and the greatest health risk is from breathing high concentrations of particulate matter in the smoke.

- *Mercury*

Mercury in emissions is out of the legal scope of this analysis. However, during the SCOPING periods for the first 4FRI EIS, concerns were raised about the potential for there to be mercury in smoke from prescribed fire treatments proposed in 4FRI to contain radioactive substances, so it has been included in this analysis.

Mercury is present at some background level around the world, and is sometimes present in emissions from wildland fires (Friedli *et al.* 2003; Biswas *et al.* 2007; Wiedinmeyer and Friedli 2007; Obrist *et al.* 2008; Selin 2009; De Simone *et al.* 2016; Webster *et al.* 2016). However, there is insufficient science to support conclusions about specific effects from the prescribed fires proposed in the Rim Country EIS. General conclusions may be possible, but no valid effects could be presented so, even if we did have the means of providing an estimate of mercury emissions, we would still not know the effects. We were not able to find any information on levels of mercury in the biomass in or near the project area, or in emissions from wildfires or prescribed fires in, or close to the project area. The amount and impact of mercury that is in emissions from a specific fire depends on how much mercury is present in the biomass that is burning; how intensely the fire burns, moisture content of the fuel, how complete the burn is, and wind for the duration of the time there are emissions in the air. There is little question that there would be more mercury in emissions from high intensity wildfires than from the low intensity fires that would typify the prescribed fires proposed by the Rim Country (Friedli *et al.* 2003; Biswas *et al.* 2007; Obrist *et al.* 2008; Lahm 2014; Webster *et al.* 2016). Mercury is not a Criteria Pollutant, that is, it is not one of the six substances for which there are National Ambient Air Quality Standards, because it is not considered an ‘ambient’ substance. Mercury is regulated as a “point source”, meaning emissions are regulated by the specific sources which discharge pollutants into the air from a specific and clearly discernable discharge point, such as a power plant. Additionally, prescribed fires help reduce the intensity of ensuing wildfires for several years, depending on the pre-burn condition of the burn unit (Brennan and Keeley 2015).

- *Smoke Sensitive Areas and Sensitive Receptors*

The Regional Haze State Implementation Plan for Arizona defines ‘sensitive receptors’ as “population centers such as towns and villages, camp grounds and trails, hospitals, nursing homes, schools, roads, airports, mandatory Class I Federal areas, etc. where smoke and air pollutants can adversely affect public health, safety, and welfare” (State Implementation Plan, Appendix A-10 page 36). Several smoke sensitive areas lay within the airsheds of the areas proposed for treatment (Table 8). The list is not inclusive, and we recognize that there are a number of communities within, adjacent, or sometimes downwind of the project that are likely to have some impacts of smoke from Rim Country activities and are not listed. While these areas do not necessarily meet the official definition of smoke sensitive, we are aware of smoke-sensitive populations in airsheds that could be impacted by prescribed fire, and experience has shown that these areas need to be considered when planning and executing prescribed fires.

Table 15. Smoke sensitive areas and sensitive receptors

Area	Proximity to implementation area	Concerns
Verde Valley	Less than 10 miles downslope south and southwest of project area	Hospitals, schools, human habitation, young children, senior citizens,
The Navajo Reservation	Northeast and east of the project area	Hospital, schools, human habitation, young children, elders
Fort Apache Reservation	Adjacent to project area to the south and east	Hospital, schools, human habitation, young children, elders
The Hopi Reservation	Northeast and east of the project area	Hospital, schools, human habitation, young children, elders
Snowflake / Taylor	About 15 miles north of the project area	Human habitation, schools, young children, seniors
Tonto Basin /Roosevelt	About 10 miles south southwest of the project area	Human habitation, schools, young children, senior citizens
Show Low	Project area to the east and west of Show Low	Hospital, human habitation, schools, young children, seniors
Heber Overgaard	Project area is adjacent to town in multiple directions	Human habitation, young children, school, seniors
Strawberry / Pine	Project area is on all sides of the both towns	Human habitation, young children, school, seniors
Blue Ridge	Project area is on all sides of the developed areas	Human habitation, young children, seniors
Pinetop/Lakeside	Project area is on all sides of the project area	Human habitation, young children, school, seniors
Payson	Project area is on all sides of the project area	Hospital, schools, human habitation, young children, seniors

A ‘Class I’ is an area classification that requires the highest level of protection under the Clean Air Act of 1963. Projects which may potentially impact Class I areas must address efforts to minimize smoke impacts on visibility. Class I areas most likely to be impacted by activities in the Rim Country project area are Petrified Forest National Park, Mazatzal Wilderness, and Sierra Anchas Wilderness (Figure 60).

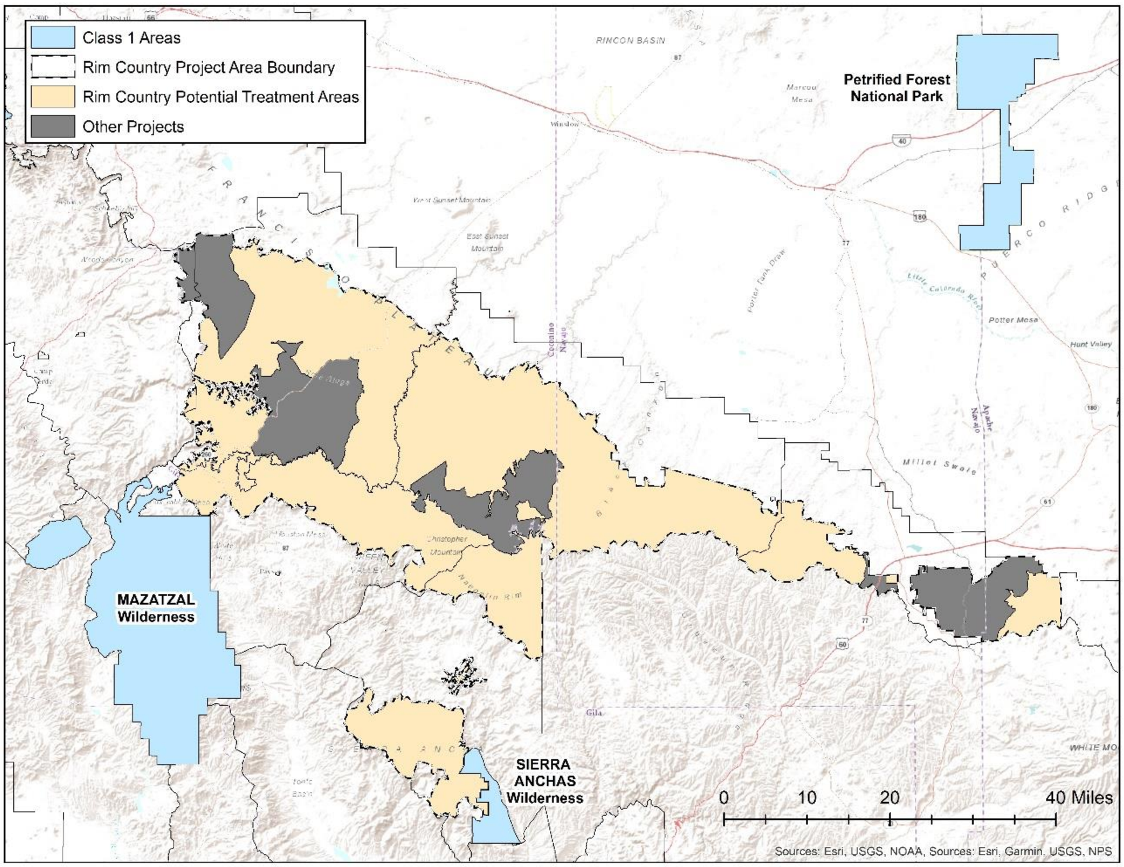

Figure 4: Class 1 areas with greatest potential to be impacted by Rim Country Smoke

The national visibility goal of the Clean Air Act is, “the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I areas in which impairment results from manmade air pollution.” Wildfires are considered to be natural sources of visibility impairment, and generally outside state control or prevention.

The night skies over the Northern Arizona offer professional and amateur astronomers exceptional viewing opportunities. There are several astronomical sites in northern Arizona, but the closest one is over 30 miles mostly west and south from the boundary of the project area, so the impacts would be expected to be minimal.

Non-attainment areas are where air quality has violated one or more of the National Ambient Air Quality Standards (page **Need reference .**). If a project area is within attainment, no additional requirements of the Regional Haze Rule State Implementation Plan administered by the ADEQ apply. The State Implementation Plan (40 CFR

51.309(d) (7)) for Arizona from December 23, 2003 states that “road dust is not a measurable contributor on a regional level to visibility impairment in the 16 Class I areas.”

No NAAQS are in non-attainment over the project area. On rare occasions, pollution from distant, large population centers in California affects the air quality in the area. Huge dust storms that occur in the Phoenix valley can produce large amounts fugitive dust that has also been known to affect air quality in Northern Arizona, but these events are generally limited to a few days a year. Ozone is also a NAAQS pollutant. Levels are increasing, and are trending upward in Northern Arizona (Kleindienst 2012). Natural background ozone concentrations are naturally high in the West; transport from industry and large urban areas in California and other non-local sources also contributes significantly (Tong and Mauzerall 2008; Koo *et al.* 2010). Under current regulations, ozone levels in northern Arizona are largely outside of the regulatory control of the State of Arizona. Spikes seen in ozone levels do not correlate with fire activity although, under certain weather conditions, smoke from fires has the potential to create ozone. As yet, data on how much ozone is created from wildland fire, or prescriptive criteria to deter ozone creation are not available. The airsheds 1, 3, 5 and 6 (Need reference) can be expected to experience the majority of the smoke impacts originating from the proposed treatment area.

Permits are issued by the Arizona Department of Environmental Quality (ADEQ), who help to monitor/manage potential smoke impacts by tracking what is burning at any given time. The ADEQ currently has air quality monitors in Campe Verde, Sedona, Flagstaff, Prescott, Show Low, and Springerville, with additional monitors that can be set up if when there are specific concerns. Outputs of these monitors are available online at: http://www. phoenixvis.net/PPMmain.aspx

Cumulative effects from prescribed fires and from wildfires that are not being actively suppressed in Federal, State, and Tribal lands are largely mitigated through implementation of the Enhanced Smoke Management Program in the Arizona Smoke Implementation Plan (SIP) by the Smoke Management Group. When the Federal land managers actively began prescribed burn programs in the 1970s, they became rapidly aware that a pro-active program for the coordination of prescribed burns would be vital to obtain and continue support of prescribed burning programs by ADEQ and the public. An interagency Smoke Management Group was developed in partnership with the State, and

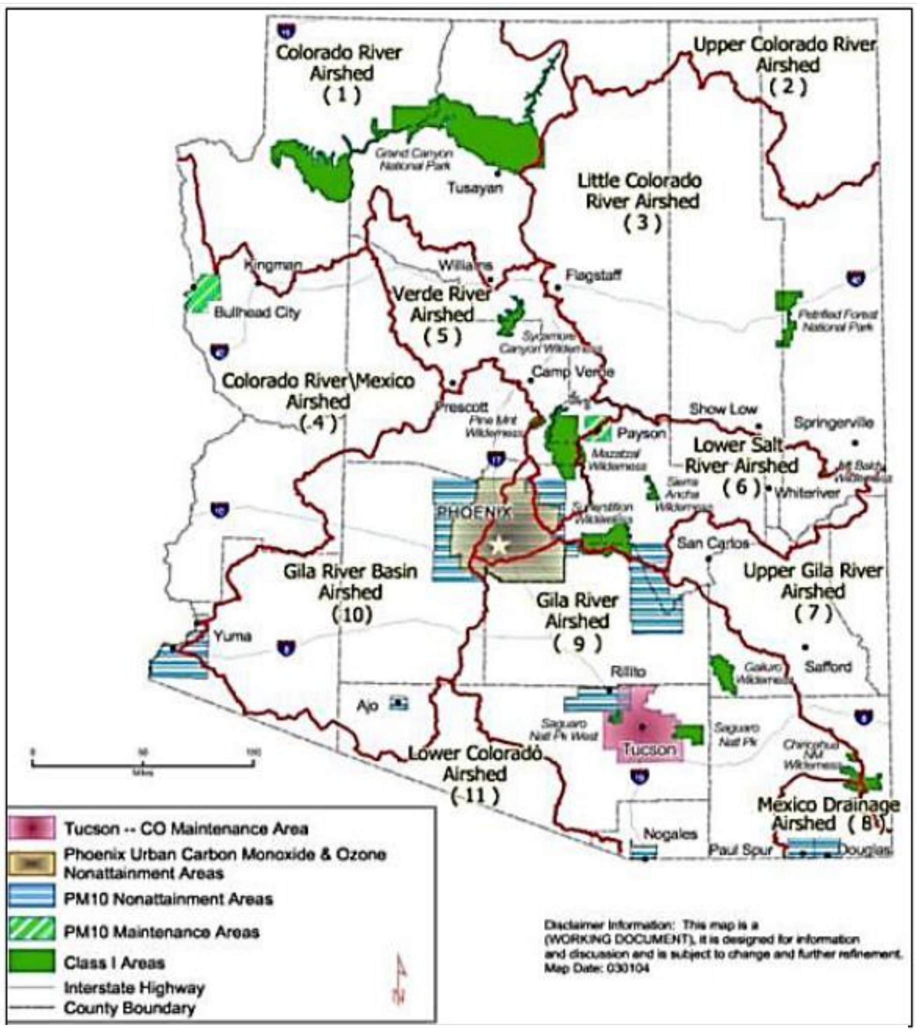

Figure 60: Arizona State Airsheds

housed in the ADEQ offices in Phoenix. The personnel in the group are funded largely by Federal agencies, demonstrating the initiative of the agencies to, in some degree, self-regulate emissions production from prescribed burns, across Federal and State boundaries. This group assists land managers in not exceeding NAAQS or visibility thresholds through the following services:

- Serves as a central collection point for all burn requests from the numerous Federal, State, and Tribal land managers who are all competing to produce smoke that will impact the same airsheds during limited windows of opportunity.
- Evaluates potential emissions from individual and multiple, and determines how meteorological forecasts will affect smoke concentrations both during the burn, and during diurnal settling. The Group considers cross-boundary impacts; and weighs burning decisions against possible health, visibility, and nuisance effects.
- Assists in coordinating activities within and between agencies when potential emissions would likely exceed desired conditions.
- Makes recommendations on the approval or disapproval of each burn request to ADEQ officials.

- Tracks the use of Best Management Practices and Emission Reduction Techniques used by land managers, to document efforts by land managers to minimize impacts to Air Quality. This information is used promote support from both ADEQ and the public.
- Monitors data gathered from the IMPROVE network to assess visibility impacts in Class I areas, and track progress towards Arizona SIP goals.
- While emissions from wildfires are not regulated, Federal, State, and Tribal land managers understand their responsibility to balance the ecological benefits of wildfires with the social impacts of the smoke they produce. The Smoke Management Group also assists land managers in this area through:
- Limiting prescribed burn approvals during periods when wildfires are already impacting an airshed.
- Making recommendations on the timing, or assisting in the coordination between units, of tactical operations such as burn outs, that will produce large amounts of emissions, so that they are done, when possible, when ventilation conditions are most favorable, or spread out over several burning periods to reduce total emissions when ventilation is not as good.
- Assisting land managers in determining the strategy to take on new wildfires. There may be enough fires burning that suppression on a new start is recommended to reduce cumulative smoke impacts even though all other fire effects would be desirable, and move the area towards desired conditions in the Forest Plan.
- Acting as a sounding board for public complaints. In keeping tabs on the type and number of complaints, the Group is able to provide land managers feedback from beyond their local publics on the state of public smoke tolerance. This is vital in maintaining general public support of allowing wildfires to perform their natural role in the ecosystem under the right circumstances in future windows of opportunity.

Through the services of the Smoke Management Group, cumulative effects from wildland fire that are within the control of Federal and State Land Managers, are thus managed to keep Air Quality across Arizona within desired conditions, including not exceeding NAAQS, protecting visibility in Class I Areas, and additionally promoting general public support of prescribed burn and wildfire management programs.

Over 280 million people visit our nation’s national parks and wildernesses areas every year. Visitors expect to view the scenery through clean fresh air. To protect visibility in these areas of high scenic value, Congress designated all wilderness areas over 5,000 acres and all national parks over 6,000 acres as mandatory federal Class I areas in 1977, subject to the visibility protection requirements in the Clean Air Act.

The Forest Service will continue to adhere to requirements in the Arizona State Implementation Plan to meet natural condition visibility goals. The most sensitive smoke receptor in the State of Arizona is the Verde Valley, which is easily impacted with nuisance smoke from the cumulative burning on the southern part of the KNF, the eastern side of the COF, and the Western side of the Prescott National Forest, as diurnal drainage of smoke from fires settles into this valley. Considerable coordination between Forests takes place when burns and wildfires that can affect the Verde Valley take place, facilitated by the interagency Smoke Management Group housed at ADEQ.

Smoke monitors track emissions concentrations, and other equipment captures images for evaluating visibility. Spikes are found in particulate matter concentrations as smoke from fire activity on the surrounding forests settles into the valley at night, although levels have not, as yet, exceeded NAAQS thresholds in the Verde Valley. Many complaints of nuisance smoke are primarily concerned with the reduced quality of highly valued scenic views.

Visibility is measured in deciviews (dv). A deciviews is a metric of visibility proportional to the logarithm of the atmospheric condition. The deciview haze index corresponds to incremental changes in visual perception from pristine to highly impaired conditions. Visibility conditions are monitored and tracked through the Interagency Monitoring of Protected Visual Environments (IMPROVE) network. The data can be accessed at http://vista.cira.colostate.edu/tss/. This includes data for all Class I areas that have monitors.

- *Public Influence*

Public tolerance for smoke, rather than law, regulation, or policy, effectively sets a social limit to how many acres are treated with wildland fire. The ADEQ and other agencies respond to public inputs by trying to minimize impacts, even when they're well within legal limits. Community public relations and education coupled with pre-burn notification greatly improve public acceptance of fire management programs. The general public will tolerate several days in a row, and several weeks a year, but even the most supportive and educated have tolerance limits (Kleindienst 2012). In order to maintain public support for prescribed burns and the beneficial use of wildfires, land managers must be responsive to the public's tolerance thresholds.

Public acceptance of smoke varies greatly from year to year. Acceptance of smoke from prescribed fires and beneficial wildfires is high following seasons with high profile, high severity events, and during extremely dry years when the threat of large, high severity incidents is elevated. Conversely, acceptance wanes during wetter year when the threat of uncharacteristic fires is low, despite climatology in milder years being more favorable for achieving desired fire effects, especially in areas highly departed from reference conditions (Kleindiest 2012).

- *Ecological effects of smoke*

Fire has historically played an important role in defining the character of ecosystems in Northern Arizona. The cover types in the Rim Country analysis that are targeted for restoration treatments are adapted to frequent fire, often area-wide fires (Cooper 1960; Covington *et al.* 1997b; Kaib 2001; Fulé *et al.* 2003; Huffman 2017), indicating an even more frequent smoke regime. Research in Northern Arizona has shown that the emergence of many species is enhanced by exposure to smoke from ponderosa pine needle litter (Abella 2006; Abella *et al.* 2007; Lata 2015).

From an ecological perspective, smoke effects are important to the germination of many native plants and, in some cases, appear to be more important than heat (Abella 2006; Abella *et al.* 2007; Schwilk and Zavala 2012; Lata 2015; Keeley and Pausas 2016). The composition of surface vegetative communities has shifted with fire suppression and changes to forest structure (Laughlin *et al.* 2011), and some of the changes may be attributable to the lack of smoke, or changes in the timing of smoke exposure (Abella 2006; Abella *et al.* 2007; Lata 2015). Many species with adaptations to smoke occur in the Rim Country project area, including, but not limited to, *Nama dichotomum*, *Heliomersis longifolia*, *Penstemon barbatus*, *Penstemon virgatum*, *Artemisia ludoviciana*, *Erigeron speciosus*, *Linum lewisii*, and *Symphyotrichum falcatum.* Pine needle smoke may also be a natural control for mistletoe and other tree infections (Parmeter and Uhrenholdt 1974; Alexander and Hawksworth 1976; Zimmerman and Laven 1987).

▪ Assumptions and Methodology

In the analysis of this resource the following assumptions were made:

All mechanical treatments were modeled to have occurred in 2019, and all areas proposed for burning were modeled to have burned in 2024 and again in 2034. In reality, treatments would be spread out over years. The specific timing of mechanical treatments would depend on the contract/contractor, road conditions, and numerous factors that are impossible to predict years in advance. Prescribed fire implementation depends on weather conditions, fuel conditions, other fires in the area, available resources, and multiple other variables that are impossible to predict weeks in advance. During the implementation period, untreated areas would be vulnerable to the effects as described in the Existing Condition and/or the Alternative 1 (no action), depending on the applicable time period. Modeling results presented do not include partial treatment, such as would be the case partway through implementation. Details on the treatments modeled can be found in the Silvicultural Specialist report' (Moore, this DEIS).

The prioritization of treatment areas will be a part of the implementation of Rim Country, though broad recommended methodology is presented here. Results were analyzed to compare the effectiveness of each action Alternative Against the "No-Action" Alternative (Alternative 1). Concepts that are necessary for a thorough understanding of this analysis are discussed when they are first presented. Additional information on modeling and concepts may be found in the Fire Ecology and Air Quality Specialist Report, the Silvicultural Specialist Report and the associated appendices.

The discussion of effects assumes that all BMPs, design features, and mitigations described in Appendix XX (page 176) are applied during implementation. Effects discussions are based on modeled fire behavior, modeled emissions, and proposed treatments for which the methods and assumptions are detailed in this section and in Appendices XX, XX, and XX and in the Silviculture Specialists' Report (Moore, this DEIS).

• *Scales of analysis*

The alternatives in this analysis are evaluated at multiple scales to ensure the expected effects are being considered in the appropriate context.

In order of decreasing size, with the largest first:

1. **Rim Country Project Area:** This includes the entire area analyzed for treatment, including comprehensive restoration, at 1,240,000 acres. It includes large areas on which the Rim Country analysis is not recommending treatments. (Figure 1)

2. **Hydrologic Unit Code (HUC):** Proposed treatments will be analyzed and evaluated at the 6th level HUC. In order to be included in this report, at least 30% of the watershed had to

Figure 6: HUC 6 Boundaries. Dark gray areas are those areas within the project area that have current NEPA projects, and are not being fully re-analyzed in this report. Light gray areas are HUC 6 boundaries that fall outside the project area and were not analyzed in this

be within the Rim Country Project Area, resulting in 80 watersheds being analyzed. The watersheds range in size from 7,176 acres to 39,135 acres, with a mean size of 18,465 acres. (Figure 2, Table 1)

- *Metrics & Measures*

Throughout this analysis, there are references to ‘undesirable fire behavior and effects’. Where it is legally and practically possible, ‘desirable’ fire behavior and effects align with reestablishing natural fire regimes, and that is the intent across the majority of the project area. Examples of where it is not possible to restore the natural fire regime include, but are not limited to, the following:

Example 1: Mexican Spotted Owl habitat: Where there are nest cores, in particular, there is a need, legally and biologically, to manage those areas for denser vegetation than would have existed there historically. That means that, in most cases, fire will need to be less frequent than it would have been historically, and there is a desire to prevent high severity fire in those areas.

Example 2: Proximity to infrastructure for certain vegetation types. Some of the ponderosa pine/evergreen oak and adjacent Chaparral/Madrean cover types historically would have had components of high severity fire as part of their natural fire regimes.

Where these cover types occur on steep slopes above vulnerable assets, it may be necessary to manage these areas for lower severity fire.

The metrics used to evaluate the effectiveness of the alternatives in meeting the purpose and need of the project are described in detail below. A comparison of the outputs of these metrics between alternatives is displayed in Table 2.

Table 16: Brief description of the metrics used in this analysis.

Metric	Application	Issue/s Addressed	Assets and Resources Addressed
Fire Type	Indicates potential fire behavior at all scales analyzed. Crown fire is one an indicator of high severity fire.	Landscape and habitat resilience to wildfires burning under extreme conditions, vulnerability of values	Fire Management, Wildland Urban Interface, Old Trees, Vegetation Cover Type, Watershed Response
Fire Hazard Index	See page 301 for details.	Landscape/habitat resilience to wildfires burning under extreme conditions, including both first and second order fire effects, and wildfire suppression difficulty.	Fire Management, Wildland Urban Interface, Vegetation Cover Type, Watershed Response
Total Surface fuel loading (Litter + Duff + Fine Woody Debris + Coarse Woody Debris)	Surface fuel loading is used to indicate potential for surface fire severity and intensity, particularly in areas where there may not be crown fire. It is also an indicator of potential emissions.	Potential for emissions and for high burn severity and high severity effects from both prescribed fire and wildfire from first and second order fire effects.	Old Trees, Vegetation Cover Type, Watershed Response, Air Quality
Emissions	National Ambient Air Quality Standards for six pollutants: Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ozone (O_3), Particle Pollution 2.5 (PM2.5), Particle Pollution 10 (PM10), and Sulfur Dioxide (SO_2) were modeled based on various treatment types, and discussed in context with each alternative.	Air quality concerns; particularly human health and visibility.	Air Quality

The effects of wildfire as quantified by the metrics and measures have direct implications for a variety of highly valued resources and assets. For this report, the resources and assets analyzed will be:

1. Fire management

2. Wildland Urban Interface
3. Old Trees
4. Vegetation Cover Type
5. Air Quality

- *Fire Modeling*

The intent of the fire modeling in this analysis is to identify the areas at greatest risk of undesirable fire behavior and first and second order fire effects, and what the expected effects would be for each of the alternatives.

One of the objectives of the Rim Country EIS is to reduce the likelihood of uncharacteristic wildfires, including large, high severity fires. Modeling fire behavior using conditions under which an uncharacteristic fire is known to have occurred allows for increased accuracy of post-treatment modeling results (McHugh, 2006). This analysis used the Rodeo/Chediski (RC) Fire, which was a large, complex fire that burned in 2002 on the Tonto and Apache-Sitgreaves National Forests, including about 100,000 acres within the Rim Country project area. The Rodeo fire was human caused, and was started on June 18 about 10 miles northeast of Cibecue on the lower slopes of the Mogollon Rim. The Chediski Fire was also human caused June 20 about 12 miles to the west of the Rodeo Fire. The fires merged and became the Rodeo/Chediski Complex which burned 468,638 acres before it was contained on July 6th. The fire effects were high, with 169,043 acres of high severity fire and 657,717 acres of moderate severity fire, in total accounting for 67% of acres burned. Vegetation within the fire perimeter still hasn't recovered in many of the areas that burned with moderate to high severity. The fire also burned 426 structures and homes. Over 30,000 people were evacuated from areas are within, adjacent to, or near the Rim Country Project area.

Conditions under which the RC Fire burned were extreme in regards to temperature, humidity, and fuel moisture. These are conditions that are likely to be more common in coming decades (Brown *et al.* 2004; Westerling *et al.* 2006). Modeled fire behavior assumes that every pixel within the dataset use for this modeling burned under the weather conditions recorded at the Heber RAWS at 1400 hours on June 25^{th}, 2002 (Table 17). In a real wildfire, wind speeds and direction are erratic, and wind speeds recorded at a given point are unlikely to be representative of wind speed or direction across the fire area. Additionally, not all wind gusts are captured by weather stations. The maximum wind gust that occurred over the duration of the Rodeo/Chediski Fire was 36 mph. We used 20 mph in order to preserve the contrast in potential fire behavior as well as wind gusts.

Table 17: The weather conditions during the Rodeo/Chediski Fire (June 25th, 2002), and 97th percentile weather conditions from the Heber RAWS.

Variable	97th percentile weather	Rodeo-Chediski Observed Weather (percentile)	Inputs used for fire modeling (percentile)
Maximum Temperature (°F)	92	89 (94^{th})	89 (94^{th})
Minimum RH (%)	6	3 (99^{th})	8 (95^{th})
Maximum 20' steady wind (mph)	16	4 (<50^{th})	20

Maximum wind gust (mph)	29	6 (<50th) 36 (>99th)	n/a
1 hr fuel moisture (%)	1	n/a	3 (85th)
10 hr fuel moisture (%)	2	n/a	3 (90th)
100 hr fuel moisture (%)	4	n/a	5 (95th)

Data for modeling fire behavior is based on a landscape file with describes the fuel and topographic characteristics of an area, at a 30 square meter (0.22 acre) resolution. The landscape file was created using a combination of Landfire 2014 data (LF1.4.0), Lidar data, USFS stand data (Moore, this report) and satellite imagery (NAIP, USFS Resource Photography). Existing condition fuel models were assigned based on a combination of Landfire Existing Vegetation Type (EVT), canopy cover, canopy height and past disturbance. The predominant Landfire EVT was modified in order to match the FSVeg stand vegetation cover type, while non-burnable surfaces and riparian corridors were left unmodified regardless of stand vegetation cover type. Lidar data was used to create canopy cover and canopy height rasters. Mapped disturbances including mechanical treatments, prescribed fire and wildfire from 2008 – 2017 were used to further modify fuel model assignments. See APPENDIX XX for more detailed information on LCP creation.

Fire behavior for alternative future conditions used outputs from the Forest Vegetation Simulator Fire and Fuels Extension (Dixon 2003; Rebain 2016) to adjust data for modeling the effects of actions, or no actions, proposed in the alternatives. Post-treatment landscape files were modified from the existing conditions using the percent of change to canopy characteristics output from FVS-FFE. The resulting stand characteristics informed the assignation of post-treatment fuel models using the Landfire Total Fuel Change tool (LFTFC v0.160). Details of the process for updating existing conditions and assigning post-treatment fuel models for modeling fire type are included in Appendix XX.

- *Fire Type*

In ponderosa pine and most of its associated vegetative communities, the expected type of fire is a good indicator of the health and resilience of the ecosystem. Crown fire in ponderosa pine is lethal to the tree, therefore the amount and distribution of crown fire activity is an important indicator of the health of a frequent fire forest. Fire types include active crown fire, conditional crown fire, passive crown fire, and surface fire as described below.

1. **Active Crown fire:** A fire that advances from crown to crown in the tops of trees or shrubs (NWCG 2008). Active crown fires generally produce high severity effects and are considered 'stand replacing' because they top-kill, kill and/or consume most of the dominant overstory vegetation. Active crown fire is linked to surface fire, perpetuated by a combination of surface and canopy fuels.

1. **Conditional Crown Fire:** Conditional crown fire is a type of crown fire that moves though the crowns of trees, but is not linked to surface fire. Crown fire must initiate in an adjacent stand and spread through canopy fuels alone. Conditional crown fires burn in areas where canopy base heights are too high for crown fire to initiate within the stand, but there is sufficient horizontal continuity of canopy fuels to carry a crown fire if

initiated. In the fire modeling used, Conditional Crown Fire was combined with Active Crown Fire.

2. **Passive Crown Fire:** Individual trees or groups of trees ‘torch’, as fire moves up into the canopy, ignited by the passing front of a surface fire. The fire climbs up ladder fuels (low branches, shrubs, or herbaceous vegetation that can produce flame lengths long enough to allow a fire to ‘climb’ into the crown of a tree) into the crown of a tree, igniting the crown (‘torching’ it), but does not spread very far into adjacent crowns (NWCG 2008).

3. **Surface Fire:** These are fires that burn in surface fuels only. Such fires consume surface fuels such as litter, duff, dead/down woody fuels, and herbaceous or shrubby fuels that are cured enough to be available fuel. Surface fire can be beneficial or detrimental in ponderosa pine, depending on the fuel loading, and the conditions under which the fire burns.

Passive crown fire is less of a concern than active but, when other variables are close, it is worth considering passive crown fire in the context of both severity and its potential to become active crown fire under worse conditions. Passive crown fire does not produce the same magnitude of negative effects as active crown fire because those areas that are burned with high severity are smaller, discontinuous and, in an ecological context, can help maintain forest structure and spatial patterns across the landscape, or maintain/improve grassland structure.

Fire type was evaluated at the Rim Country project area level and at the 6th level hydrologic unit code (HUC) and in order to facilitate an analysis of specific fire effects in different areas. Watershed impacts from fire increase with the proportion of the watershed burned at high severity (Cannon 2010; Neary 2011). Therefore, fire type is considered at all scales in those areas proposed for thinning and/or prescribed fire.

- *Fire Hazard Index (FHI)*

Five datasets were used to identify areas of high probability for severe fire effects, extreme behavior and a complex fire management environment. These datasets are crown fire potential, fireline intensity, heat per unit area, slope, and soils with high erosion potential.

As a general rule, the amount and size of plants top-killed by fire increases with an increase in either the rate of heat energy released (fire intensity) or total amount of heat energy released (heat/unit/area). Estimates of the rate and amount of this heat release are thus important descriptors of fire behavior (Wade 2013).

Fire intensity is directly related to the suppression strategies, with direct attack becoming less effective as intensity increases. This holds true for both forested and non-forested systems. Therefore, while fire type will only be undesirable for forested landscapes, the FHI can be undesirable on any burnable landscape.

Steep slopes (> 30%) not only increase fire behavior, they are also difficult to thin via mechanical treatments. Fire suppression on these slopes is ineffective and presents additional hazards to the fire fighters.

Soils with high erosion potential have a greater chance of initiating a post fire debris flow, especially when found on steep slopes. With vegetation cover gone following a wildfire, these soils are more likely to erode than those with a lower erosion potential.

The FHI classified the landscape as shown in Table 55 below. Further details are included in Appendix B on page XX.

FHI was evaluated at the Rim Country project area level and at the 6th level hydrologic unit code (HUC) and in order to facilitate an analysis of specific fire effects in different areas. Resource impacts and fire management responses will change with the proportion of the watershed in high hazard classes. Therefore, FHI is considered at all scales in those areas proposed for thinning and/or prescribed fire.

Table 18. Fire Hazard Index scores used to identify the need for treatment for resources, values and assets

Rating	Comments
1 – very low	Conditions are such that expected fire behavior will have minimal negative impacts to resources and suppression efforts, where needed, are expected to be very effective
2 – low	From a fire perspective, areas where crown fire is expected will not pose a threat to soil stability. Areas of high erosion potential are not expected to burn with active crown fires or high intensity conditions. Use of ground resources for suppression efforts becomes increasingly difficult.
3 – Moderate	Either extreme fire behavior resulting in difficult to control fires, or moderate soil severity. Presence of steep highly erodible soils may coincide with crown fire and higher intensity fires. Control of wildfire by suppression efforts will be difficult.
4 – High	These areas have the highest expected levels of all the fire behavior metrics. Control of wildfire by suppression efforts will be difficult and complex.
5 – Very High	These areas have the highest expected levels of all the fire behavior metrics, as well as steep slopes and highly erodible soils, making them prone to adverse second order effects such as debris flows. Control of wildfire by suppression efforts will be difficult and complex.

- *Surface Fuel loadings*

In this analysis, total surface fuel loading includes fine dead woody debris (FWD) ≤ 3 inches in diameter (FWD), dead coarse woody debris (CWD) > 3 inches in diameter, litter, and duff. FWD and litter contribute significantly to fire behavior as well as fire effects, while and CWD and duff are mostly of interest in regards to fire effects (both direct and indirect). All three forest plans provide specific direction on desired conditions for CWD, but are silent or do not quantify any other components of surface fuel loading. As such, in this analysis, CWD, FWD, litter, and duff were combined as "total surface fuel loading" in tons/acre, which is evaluated both qualitatively and quantitatively regarding potential fire effects. Recommended surface fuel loadings are estimates, based on the best available science and expert opinion (Ottmar 2015) on the interaction of surface fuel loading with fire behavior and fire effects

Fuel loadings were evaluated at the Rim Country project area level and the 6th level hydrologic unit code (HUC) and in order to facilitate an analysis of specific fire effects in different areas. Water, soil and wildlife impacts from wildfire are also related to surface fuel loadings. Additionally, fuel loadings have direct influence on wildfire emissions, and therefore will be discussed in those sections as well.

• *Emissions Modeling*

Air impacts are felt, seen, and measured by the concentration of emissions at a given location. There are no reliable methods of predicting concentrations at specific locations years in advance of a prescribed fire. This analysis does not attempt to predict the actual total emissions that would be produced under each alternative. Rather it aims to present a rationale for which alternatives are likely to produce “less” or “more” emissions. It assumes that, over time, there is some degree of correlation between total emission production, and total air quality impacts. Impacts are measured and evaluated based on the concentration of emissions at a specific location, not the total amount of emissions. Though meteorological conditions vary immensely by time of day, time of year, and from one weather system to the next, over the course of years the averaging effect over time of these varying conditions supports a correlation between total emissions and total impacts (Kleindienst 2012).

Smoke/emissions were evaluated both qualitatively and quantitatively by modeled emission quantities in pounds/acre for the most common stand condition under different treatment and non-treatment scenarios using the First Order Fire Effects Model (FOFEM CITATION). Fuel loadings were calculated for a representative Ponderosa Pine stand using FVS. The resulting modeled emissions shows the relative differences that the same piece of ground would be expected to produce before, during and after treatments.

For a landscape analysis, changes in those fuel components which produce the greatest percentages of emissions when they burn were modeled, and mapped using Forest Vegetation Simulator (Moore, this report). The components include litter, duff, FWD and CWD>3 inches (Lutes et al. 2009), which were combined into a single total surface fuel loadings metric in tons per acre. Details may be found in Appendix D (page XX).

The management action that has the greatest potential effect on air quality is prescribed burning. All prescribed fires are expected to achieve the desired conditions for air quality under the action alternatives, and hence, Air Quality is not expected to be a primary driver in selecting one alternative over another.

Some comparison between alternatives can be made by looking at the indirect effects of management activities that reduce the likelihood of active crown fire and heavy surface fuel loading. Active crown fire and heavy surface fuel loading produce large quantities of emissions that may be heavily concentrated. The alternatives that best alter stand structure to promote surface fire over active crown fire and decrease surface fuel loading would have the least negative environmental consequences to Air Quality, and are the focus of comparison between alternatives regarding Air Quality in this report.

▪ Environmental Consequences

Throughout this section, changes directly attributable to proposed actions, such as thinning or prescribed fire, are direct effects. These include changes to shading, canopy continuity, canopy base height, consumption of surface fuel, etc. Changes to the potential behavior and effects of future wildfires that result from the direct effects are considered indirect effects. Effects of proposed actions for stream restoration and roads are discussed separately from those of thinning and prescribed fire.

Alternative 1 – No Action

Under Alternative 1, there would be no changes to current management. Alternative 1 would not meet the purpose and need of this project because most of the ecosystems and natural resources within the treatment area would continue to degrade. The treatment area would not move towards desired conditions. This alternative would not reduce the risk to human lives nor would it result in safe, cost-effective fire management that would protect, maintain, and enhance National Forest System lands, adjacent lands, and lands protected by the Forest Service under cooperative agreements. As required by FSM 5100 (page 9).

This Alternative would not meet direction in Forest Service Manual 5100 (page 9), which includes direction on USFS use of prescribed fire to meet land and resource management goals and objectives. The objectives of fire management on lands managed by the USFS are:

1. Forest Service fire management activities shall always put human life as the single, overriding priority. This Alternative would not fully support incorporation of the highest standards for firefighter and public safety and would not be expected to improve and enhance the safety of the public as it relates to wildland fire.
2. Forest Service fire management activities should result in safe, cost-effective fire management programs that protect, maintain, and enhance National Forest System lands, adjacent lands, and lands protected by the Forest Service under cooperative agreement. This Alternative would not achieve restoration in project area. Under this Alternative fire, when it occurs, would be detrimental to the ecosystems in which it burns as well as areas outside of the burned area. Wildfire in untreated areas is more costly and less efficient to manage in untreated areas than prescribed fire, or wildfire that is managed in areas that have had restoration treatments.

Direct and Indirect Effects

Effects resulting from Alternative 1 are indirect because there would be no new management actions. The effects of implementing Alternative 1 are discussed as follows:

1. Rim Country Project Area and Watershed analysis of measures and metrics
2. Values, Resources and Assets analysis of measures and metrics
    - Wildfire Management
    - WUI
    - Vegetation Cover Types
    - Old Trees
    - Air Quality

This alternative would not meet the purpose and need of Rim Country. Under Alternative 1, all three forest plans would continue to be implemented, but there would be no decrease in undesirable fire behavior and effects, except that resulting from wildfires or other natural disturbances. The direct and indirect effects of Alternative 1 relate to the effects of the continued degradation of surface and canopy fuel conditions, and the effects of the continued interruption of the natural fire regimes. These include the potential for the direct effects of large, high-severity wildfires occurring within the project area. The indirect effects of such burns could also compromise water resources due to post-fire flooding and debris flows. Indirect effects could also include impacts to air quality downwind and downslope of fires. The most likely impacts to air quality being locations northeast of the project area, and in low areas, such as the Verde Valley, Snowflake, and Showlow.

Rim Country Project Area Metrics and Measures

Fire Type

Fires that did occur in the project area would be wildfires; some of which could be beneficial, and some could be catastrophic or detrimental, depending on environmental conditions at the time of the fire, and the condition of the forests at the time they burn. If historic patterns of burn severity were to continue, approximately 73 percent of the area burned in wildfires larger than 1,000 acres would burn with low severity effects that could be beneficial. However, given extreme weather conditions, there would be an increased potential for crown fire compared to the existing conditions. All crown fire types (both active and passive) can be expected across approximately 80% of the project area under extreme weather conditions (Figure 23), up from 73% in the existing conditions. Approximately 33% of the projected area has the potential to burn with active crown fire, up from 31% in the existing conditions.

Post wildfire watershed effects increase with the percentage of the watershed that burns at moderate to high severity (Cannon, 201; Neary 2011). Under Alternative 1, 47 watersheds are expected to burn with active crown fire under extreme weather conditions for over 30% of the watershed, resulting in high severity effects (Figure 64). Thirteen watersheds are have over 50% of the watershed expected to burn with active crown fire. Watersheds 56 (Durfee Draw-Chevelon Canyon) and 7 (Reynolds Creek) have the highest proportion of potential for active crown fire (68% for both). If a wildfire were to burn within these watersheds, detrimental post wildfire effects would be expected.

Fire Hazard Index

The short term (< 20 years) effects of Alternative 1 would include an increased risk of undesirable wildfire behavior and effects. Wildfire behavior and effects could threaten lives, resources, and infrastructure. Forty percent of the project area is within the moderate to extreme FHI, which presents difficult and dangerous suppression conditions during a wildfire and potential for adverse post fire effects on soils and surface water quality, up from 37 percent in the existing conditions (Figure 66).

There are 25 watersheds with over 50 percent of the watershed in the moderate to very high FHI categories (need reference). Watershed 7 (Reynolds Creek, 80 percent) and 107 (Upper Spring Creek, 77 percent) have the highest proportion of FHI in the moderate to very high class. Large wildfires in these watersheds have a high potential to be difficult and dangerous to suppress, and have a high potential for adverse post fire effects.

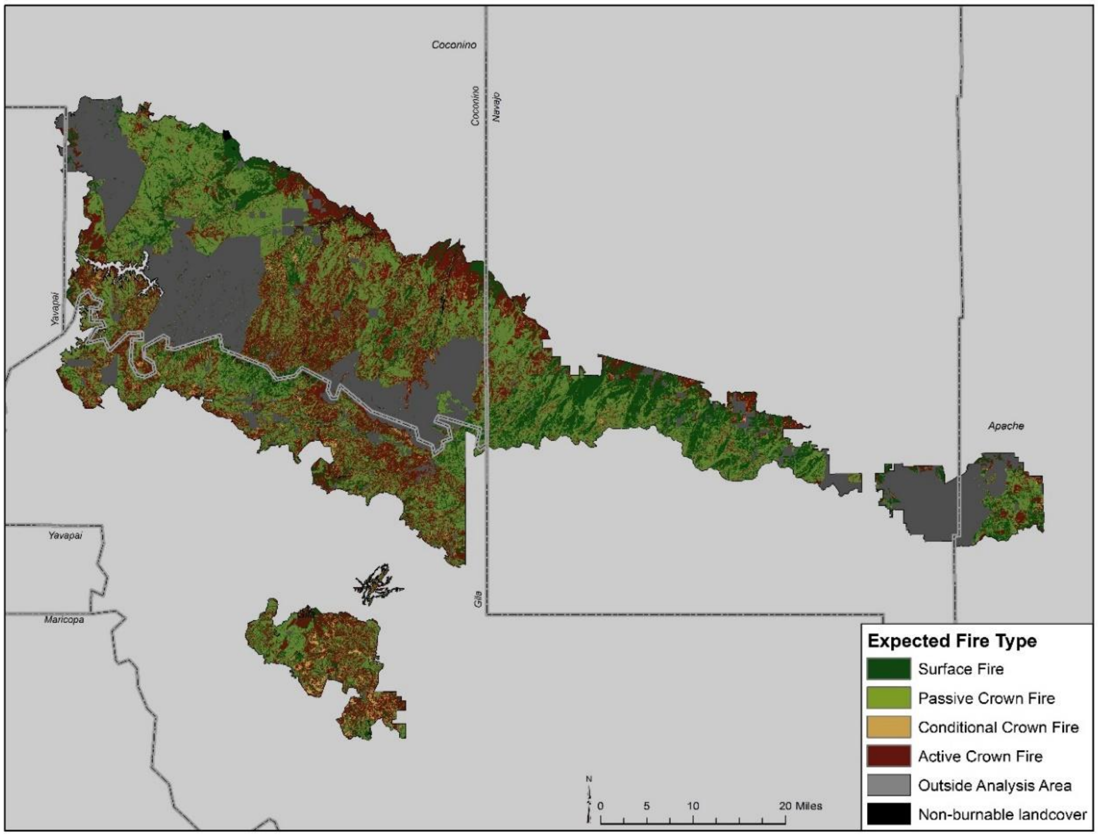

Figure 62: Expected Fire Type for Alternative 1, under modeled weather conditions.

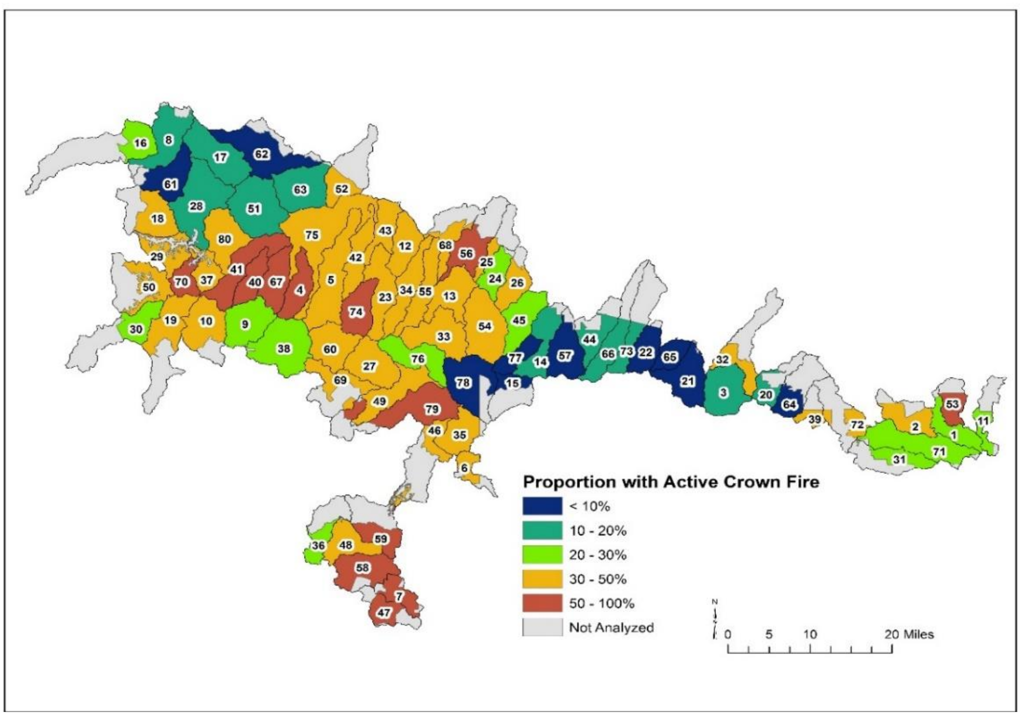

Figure 63: Alternative 1 Proportion of HUC6 watersheds with expected Active Crown Fire, under modeled weather conditions.

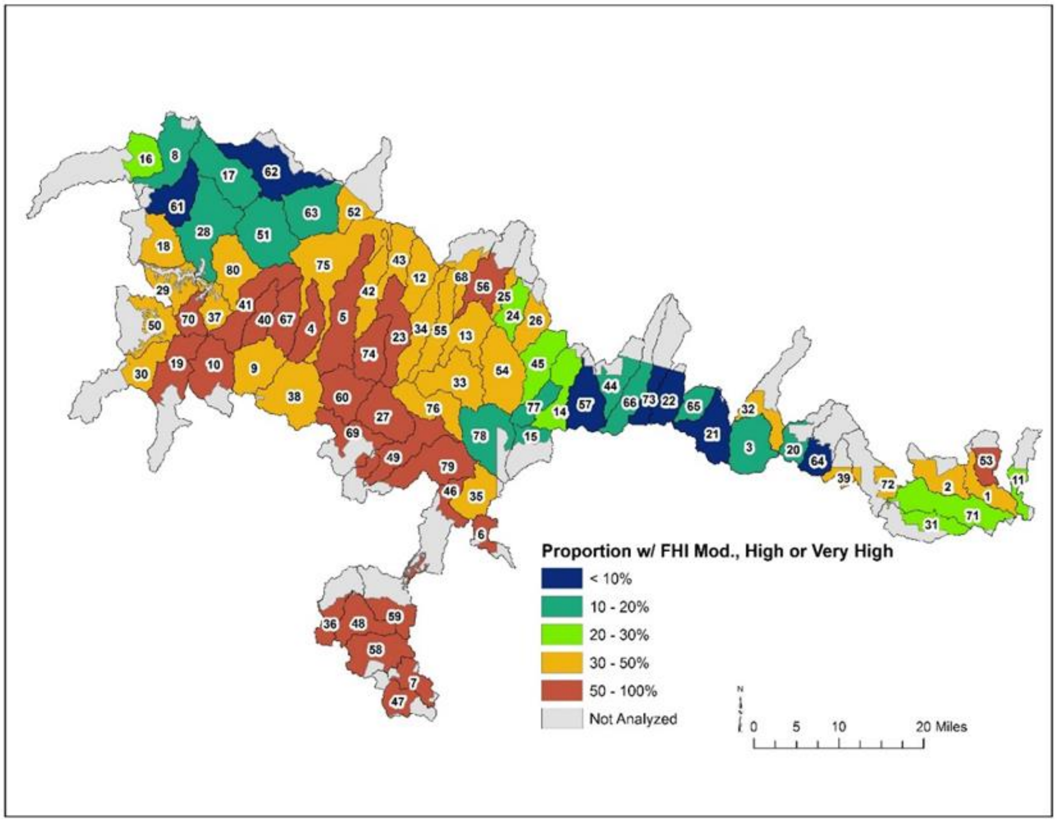

Figure 9. Proportion of each HUC6watershed with FHI in the moderate, high, or very high category for Alternative 1 under modeled fire weather

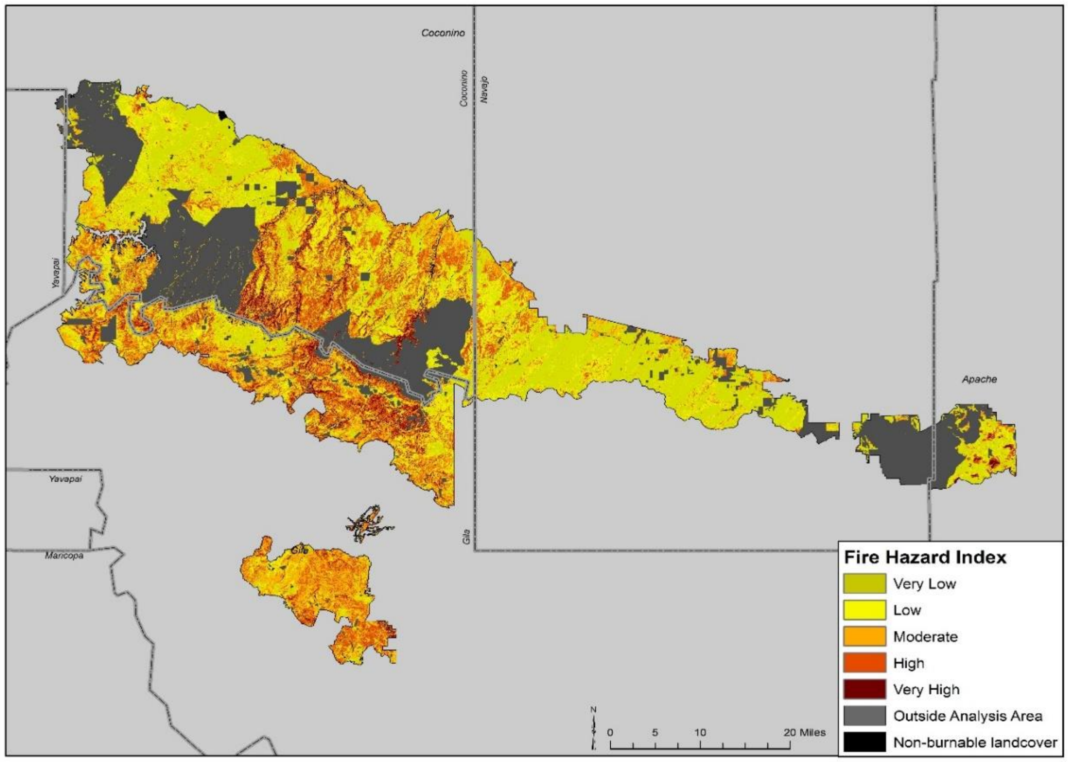

Figure 65: Fire hazard Index for Alternative 1, under modeled fire weather

- WUI

Under the No Action Alternative, WUI areas across the treatment area would be threatened by the increasing extent of high severity of wildfires (**Error! Not a valid bookmark self-reference.**). Active Crown Fire and Fire Hazard Index both increase. The potential for home and asset loss from crown fires, high intensity surface fires and ember lofting would continue to increase.

Table 19: WUI Measures and Metrics for Alternative 1

WUI CLASS	Total Acres	Fire Hazard Index				Fire Type	
		Very Low - Low	moderate	high	very high	Passive & Active Crown Fire	Active Crown Fire
High Value Rec Sites	375	45%	19%	18%	19%	83%	40%
Communication Sites	2074	63%	16%	18%	3%	79%	28%
NonFS Lands w/ structures	22638	63%	17%	18%	3%	73%	29%
Transmission Lines	4083	61%	17%	18%	4%	74%	33%
FS Buildings	1683	49%	14%	29%	9%	85%	43%

- Vegetation Cover Types

In the long term (>20 years), tens of thousands of acres (the actual amount would be a subset of the 334,800 acres in the treatment area that would likely burn with high severity effects) would potentially be converted to non-forested systems as a result of high severity fire, while other acres of non-ponderosa pine would be increasingly encroached upon by pine, including aspen, grasslands, and oak. Aspen stands would continue to decline, and some stands would be likely to disappear. Woody species continue to encroach into grasslands and shrublands, and sprouting shrubby species would increasingly occupy understories in Ponderosa Pine Evergreen Oak. Table 20 shows the metrics for each vegetation cover type.

Table 20: Vegetation Cover Type Measures and Metrics for Alternative 1

ERU	Total Acres	Fire Hazard Index				Fire Type	
		Very Low - Low	moderate	high	very high	All Crown Fire	Active Crown Fire
Ponderosa Pine	556284	75%	7%	16%	3%	81%	22%
PIPO Evergreen Oak	147989	36%	33%	26%	5%	85%	30%
Dry Mixed Conifer	49281	26%	17%	28%	29%	77%	54%
Wet Mixed Conifer	3130	29%	4%	26%	41%	74%	70%
Aspen	1438	95%	1%	3%	2%	6%	5%
Pinyon Juniper	135085	36%	33%	28%	3%	71%	67%
Madrian Pinyon Oak	23318	19%	33%	41%	7%	86%	80%
Grasslands	18851	98%	2%	0%	0%	16%	3%
Riparian Areas	14567	70%	11%	13%	6%	48%	19%

- Large and old trees

Under the No Action Alternative, large and old trees across the treatment area would be threatened by the increasing extent of high severity of wildfires (Swetnam 1990a; Covington and Moore 1994; Swetnam and Betancourt 1998; Westerling *et al.* 2016). In areas where a wildfire would be a first entry burn and there had been no prescribed fire or thinning, there would be a much greater potential for mortality than in treated areas. In this alternative, many old trees would be killed or damaged by wildfire, as well as those trees that die or decline slowly from the cumulative effects of fire and other stressors (Minard 2002).

- Emissions and Air Quality

In this alternative, smoke impacts generated from the proposed treatment area would only come from wildfires. The impacts would be infrequent (a few times a year); more severe when they occur; and the duration, location, and extent of area/s affected would be largely unpredictable. In the absence of wildfire, air quality would remain at current levels. In the short term, there would be no additional impacts on air quality from prescribed fires. Smoke impacts would be from wildfires. Wildfire smoke is less predictable, less frequent, and more concentrated than emissions from prescribed fires.

If the current average annual acres burned by wildfire remained the same (27,426 acres), it is possible that much of the treatment area could burn with wildfire by 2065, and these fires would produce associated air quality impacts. Due to increased potential for crown fire and increased total surface fuel loadings, a wildfire burning under Alternative 1 conditions in 2029 would produce more emissions than one burning under current existing conditions (Figure 67). Wildfire would be the only source of emissions from the treatment area under this alternative. On a per acre basis, emissions increase approximately 17%, due to the increase in surface fuel loadings.

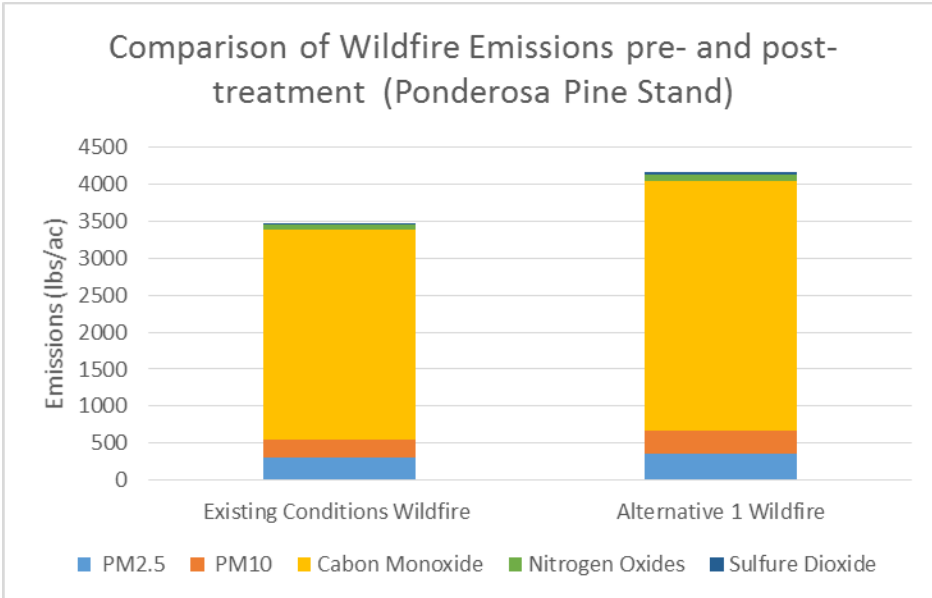

Figure 11: Emissions for Alternative 1

This in combination with the expected increase in annual acres burned will lead to an increase in overall emissions from wildfires.

This alternative would not increase potential smoke impacts during the times of the year when smoke impacts are largely from prescribed fire (pile burning, broadcast burns, and jackpot burning), generally, mid/late fall, winter, and early spring.

The timing and type of smoke effects would change little initially, but as the likelihood of large fires increase so does the potential for air quality levels that exceed National Ambient Air Quality Standards (NAAQS), and nuisance smoke. The likelihood and degree of potential impacts from wildfire smoke would continue to increase as fuel loading increased, since much of the lingering smoke comes from duff, CWD, litter, stumps, and other fuels that can smolder. Watersheds 75 (East Clear Creek-Clear Creek) and 79 (Haigler Creek) have the greatest potential to produce emissions because of surface fuel loading. Under Alternative 1 all watershed increased in total surface fuel loadings, with watershed 58 (Upper Salome Creek) and 37 (Clover Creek) increasing the most (33% increase from existing conditions; Table 66). Watershed 75 (East Clear Creek / Clear Creek) has the highest total surface fuel loadings and therefore has the potential to produce the most emissions should it burn. Watersheds 4 (Barbershop Creek) and 27 (Christopher Creek) have the most dense total surface fuel loading, both with an average of 24 tons/acre.

- *Unavoidable Adverse Effects, Irreversible and Irretrievable Commitment of Resources*

As described above, with no treatment, high severity fire effects would become more widespread, and extreme fire behavior would become more common. In recent years, fires in the area have taken human lives, destroyed homes/property/infrastructure, and produced high severity effects across large areas not adapted to high severity fire including Rodeo/Chediski 2002 (469,000 acres), Wallow 2011 (538,000 acres), and Whitewater 2012 (~297,000 acres). There is broad consensus that such fires will continue to burn in this area if no action taken, though the specific extent and location of the negative effects could not be known until an incident occurs. First order effects would include (but are not limited to): chemical and physical changes to soil, high levels of mortality across ~27% or more of the burned area (assuming ~27% high severity), consumption and/or killing of the seed bank, consumption of organic material in soil, including flora and fauna, conversion of forested habitat to non-forested habitat. Second order fire effects would include (but are not limited to) erosion, flooding, debris flows, destroyed infrastructure, changes in visitation to the forest and the economies of local businesses that depend on visitors and natural resources, and degradation of water resources for wildlife, livestock, and humans. Some of these effects would last just a few days or weeks, some would take much longer. For example, topsoil is critical to healthy surface vegetation and would take centuries to recover though, with climate change, it is unknown exactly what the ecological trajectory would be. The loss of old growth and old trees would require decades to centuries to recover.

- *Effects Common to Both Action Alternatives*

Activities that will effect fire and fuels include mechanical treatments and/or prescribed fire. While the number of acres of prescribed fire and mechanical treatments varies by Alternative, their effects, were implemented, will be the same.

Mechanical treatment alone has the potential to alter fire behavior primarily through a reduction of CBD, but it can also increase surface fuel loadings through the placement of slash on the ground (Carey and Schuman, 2003). Carey and Schumann (2003) further note that the use of mechanical thinning alone has a varied effect on modifying fire behavior, primarily because of the created slash. All of the thinning treatments proposed within this analysis are paired with prescribed burning, therefore, the effects will be a combination of thinning and burning. Various researchers have concluded that the combination of thinning and burning as the most effective way to alter fire behavior (Strom 2005; Graham et al. 2004; Peterson et al. 2005; Cram et al. 2006).

The effectiveness of using prescribed fire as a tool, alone or combined with mechanical treatment, to restore ponderosa pine to a healthier, more sustainable and resilient condition is well documented (Fulé et al. 2001b, Roccaforte et al. 2008, Strom and Fulé 2007, Fulé et al. 2012). Prescribed fire is used as a proxy for wildfires which allows for more control over where and when fire burns and often leads to lower overall severity and emissions.

Most of the effects of the natural role of fire could not be effectively replicated by means other than fire. These effects include nutrient recycling; seed scarification (by both heat and smoke); promotion of a mosaic of seedlings, shrubs, forbs, and grasses; regulating surface fuel loads, changes in soil moisture, changes to albedo, etc.. (Laughlin *et al.* 2008; Pyke *et al.* 2010; Laughlin *et al.* 2011). Over time, prudent use of prescribed burning, particularly when combined with mechanical thinning, would reduce the potential for damage from wildfires, as well as the costs associated with fire suppression (Jaworski 2014). Fire increases structural heterogeneity and diversity and promotes natural regeneration of ponderosa pine, providing favorable seedbeds and enhancing the growing environment for survival (Harrington and Sackett 1992).

The proposed treatments would create a mosaic of interspaces and groups (of ponderosa pine) of various sizes that would be maintained with fire. This mosaic is also a mosaic of crown fire potential, with some groups having potential for crown fire under some circumstances, with the surrounding interspaces causing crown fire to transition back to surface fire.

Post-treatment conditions for the action alternatives would include openings that would be managed to promote regeneration. Prescribed fire would be an important tool for creating receptive seedbeds for successful regeneration by consuming surface fuels, creating bare, mineral soil, allowing seeds better contact with soil. As seedlings and small saplings mature, fire and competition would thin trees, maintaining the desired trajectory for a fire-adapted landscape, so that an appropriate number of seedlings survive to maintain healthy forest conditions.

The longevity of the effects of a prescribed fire depends on the specific effect being evaluated; the condition of the burned area before a burn; the conditions under which it burned, and post-treatment conditions (such as precipitation). For example, a denser forest will accumulate litter faster than a more open forest; soil conditions and moisture affect the rate of decay; the germination and survival of seedlings depends on cone production and environmental conditions for the first 2-3 years.

In the long term, fire would help maintain a shifting, sustainable, resilient mosaic of groups, interspaces, and openings. Without regeneration openings, even with fire, the space occupied by incoming regeneration would begin to fill in the interspaces and, in the long run, as the seedlings mature, it would increase horizontal and vertical canopy continuity so that, if crown fire did initiate, there would be potential for larger areas of high severity effects.

Up to two prescribed fires would be implemented, which may include pile burning months in advance of broadcast burns. Ideally, prescribed fires would occur on an average of every 10 years, depending on yearly fluctuations in climate/weather at different locations within the treatment area. Some areas will have had prescribed fire or wildfire within the last 10 – 15 years, so prescribed fires that are implemented would be maintenance burns (see below). Limitations (wildlife concerns, smoke, funding, resource availability, etc.) may make it difficult to attain an average of a 10 year fire return interval across the proposed treatment area. Burning some areas on a slightly longer return interval may be warranted to reduce smoke in sensitive receptors as mitigation for prescribed fires.

- *Direct and Indirect Effects*

In the short term (<20 years), ***where treatments are implemented***, the potential for undesirable fire behavior and effects would be reduced by breaking up the vertical and horizontal continuity of canopy fuels, decreasing excessive surface fuel loads of litter and duff (direct effects). It would be expected that the growth of light, flashy fuels would be stimulated by post-treatment conditions (second order effects). Wildfire behavior would benefit the ecosystems in which it burned, and would not threaten lives, resources, or infrastructure, except where they are adjacent to, or near areas (such as MSO habitat or Wet Mixed Conifer) that were not treated as intensively as the rest of the treatment area at this time. Air quality impacts (indirect effects) could increase some as prescribed fires are implemented.

In the long term (>20 years), potential for undesirable fire behavior, as assessed by changes to surface and canopy fuels, would remain lower than existing condition for about 37% of the Rim Country area proposed for treatment. Potential for undesirable fire effects, as assessed by changes to canopy and surface fuels, would remain lower than existing condition for about 31% of the ponderosa pine in the treatment area. Impacts to air quality as a result of fire related pollutants emitted as a result of prescribed fire could decrease some as the majority of the treatment area would be in maintenance burn mode, producing fewer emissions per acre. However, since there would be more acres burned, the number of days of air quality impacts could increase.

Thinning, whether or not slash was removed from the site, would give managers more control of the amount and timing of emissions. As thinning and first-entry burns were completed, burn windows would expand for larger areas so more burning could occur when ventilation was good. Fewer and healthier trees, as a result of thinning and would be more fire resistant, and understory and surface vegetation would become established. With lower surface fuel loading, and canopy fuels adapted to fire, burn windows would be broader than for initial entry burns. Decision space for managing unplanned ignitions would expand as Rim Country (and other projects) are implemented.

- *Fire Type*

Decreasing the horizontal and vertical continuity of canopy fuels is a direct effect of the proposed treatments that would allow sunlight to reach the surface, increasing surface temperatures, and decreasing dead fuel moisture content at the surface. This, combined with increased surface winds with fewer trees blocking the wind, could increase surface fire intensity, flame length, and rate of spread even if surface fuels were the same before and after thinning (Omi and Martinson 2004, Scott 2003). Therefore, canopy fuel treatments reduce the potential for crown fire (indirect effect) at the expense of slightly increased surface fire behavior (fireline intensity, flame length, and rate of spread). However, critical levels of fire behavior (limits of manual or mechanical control) are less likely to be reached in stands treated to withstand crown fires, as all crown fires are uncontrollable. Although surface intensity may be increased after treatment, a fire that remains on the surface beneath a timber stand is generally more controllable (Scott 2003). After the first prescribed fire, surface fuels would be lower so, even with the changes described above, the potential fire behavior and effects would be improved following the treatments under Alternatives 2 & 3.

- *Fire Hazard Index*

Some components of the Fire Hazard Index are fixed and not susceptible to changes due to proposed treatments. These components include slope and soil erodibility. While these components are necessary for determining potential fire behavior and/or post fire effects, treatments will not result in changes to these parts. The rest of the components, which relate more directly to fire behavior, will be influenced by proposed treatments in manors consistent with those discussed above in the Fire Type section and below in the Surface Fuels section.

- *Surface fuels*

Mechanical thinning alone can contribute significantly to decreasing the potential for crown fire by breaking up vertical and horizontal canopy fuel continuity, but does little, in the long run, to decrease surface fuel loading. Initial thinning impacts may include temporary fire 'breaks' where there are skid trails, or other surface disturbances, but surface fuels that are not removed from the treatment area remain a potential source of heat and emissions. Effects may be spottier but, where fuels have been pushed into piles or furrows (intentionally or otherwise), they may smolder for days or weeks. Mechanical thinning often increases surface fuel loading by small amounts (Fulé *et al.* 2012).

Litter, Duff, and Coarse Woody Debris greater than 3" diameter contribute more than other fuels to emissions. High surface fuel loading can cause high severity effects, both direct and indirect, to soils, and surface biota (such as roots, seeds, forbs, and other species adapted to low severity fire) (Lata 2006, Neary et al. 2005, Valette et al. 1994), as well as producing air quality impacts. Mechanical thinning alone can contribute significantly to decreasing the potential for crown fire by breaking up vertical and horizontal canopy fuel continuity, but does not decrease surface fuel loading (Fulé et al. 2012). Initial thinning impacts may include temporary fire 'breaks' where there are skid trails, or other surface disturbance, but surface fuels are generally not removed from the treatment area, and remain a potential source of heat and emissions. Surface effects may be spottier following thinning because residual fuels often include jackpots or small piles. Where fuels have been pushed into piles or furrows, by design or happenstance, they may smolder for a long time.

A direct effect of prescribed fires would be the consumption of some CWD and, although more is often produced as an indirect effect of the burn (Waltz et al. 2003, Haase and Sackett 2008, Roccaforte et al. 2012), it may be of a different stage of decay that does not fill the same ecological niche. Surface fuel loading can be managed with fire and felling techniques to increase or decrease woody debris in different size classes. A direct effect of Alternatives 2 and 3 could be that some areas would be deficit in CWD for a few years following treatment but, given the trend shown, it would only be a few years before it met desired conditions again and, with maintenance burning, it should be possible to maintain desired levels.

CWD could be expected to switch from predominantly sound to predominantly rotten debris after about 15 years with no fire, with the highest CWD loading expected from 6 – 12 years after the last fire (Roccaforte *et al.* 2012).

- *Large/old trees*

Ponderosa pine (*Pinus ponderosa* Dougl. ex P. & C. Laws) stands with late-seral features are found infrequently, owing to past management activities throughout western North America. Thus, management objectives often focus on maintaining existing late-seral stands. Observations over a 65 year period of stands with no past history of harvest showed substantial ingrowth in the smaller diameter classes and elevated rates of mortality among the largest mature trees in the stand. Adjacent stands, with combinations of thinning and prescribed fire, had far fewer high-risk mature trees and generally lower rates of mortality aftr treatment. Forecasts using individual-tree diameter growth and mortality models suggest that observed declines in these stands with remaining old trees and a dense understory will contiu=nue in the absence of any treatment. Increased vigor in thinned stands appeared to be offset by an increase in mortality of large trees when thinning was followed by prescribed fire. (Richie *et al.* 2008)

Where site specific mitigation is needed to limit damage or mortality to large or old trees, it is best accomplished by reducing accumulations of fuels within the dripline and in the immediate vicinity of the trees. These fuels may include litter, duff, accumulations of woody fuels, ladder fuels, or any fuel that could produce sufficient heat to lethally damage a tree, whether by high or low intensity fire. This can be accomplished manually, mechanically, or though fire treatments. Potential measures include implementing prescription parameters, ignition techniques, raking, wetting, leafblowing, thinning, or otherwise mitigating fire impacts to the degree necessary to meet burn objectives. Throughout the life of this project, it is likely that some large and/or old trees would be damaged or killed by prescribed fire. It would not be possible to mitigate every large and/or old tree over 40,000 to 60,000 acres of prescribed fire units each year. Data collected from restoration treatments in the White Mountains indicates that mortality of pre-settlement trees increased with thin/burn, or burn only treatments over controls, although those that survived grew significantly faster than those in untreated stands (Fule et al. 2007; Roccaforte et al. 2015). Managers will have to consider tradeoffs between treatment options, and the increasing likelihood of the trees burning in wildfires under conditions that would be more extreme than conditions under which a prescribed fire would be conducted.

Mechanical treatments and prescribed fire would be implemented to help sustain large/old trees across the landscape, and make them more resistant and resilient to natural disturbances such as fire. Throughout the life of this project, it is likely that some large and/or old trees may be damaged or killed by prescribed fire, by direct and/or indirect effects, despite mitigation measures. However, under both alternatives thinning and prescribed fire would decrease potential fire effects in the vicinity of most old and/or large trees, decreasing the likelihood of lethal damage in the event of a wildfire.

Mitigation measures (page XX) are unpredictable, and site specific (Kolb et al. 2007, Hood 2007), and some can have negative effects of their own. Raking, for example, can remove fine, live roots in the surface organic layers, which may compound the effects of additional shallow roots being damaged by fire, though it is unlikely to actually kill the tree (Progar *et al.* 2017). Low intensity fire that causes little crown scorch can stimulate resin production in old trees that may attract bark beetles, increasing tree mortality. Mitigation measures implemented a year or more before a burn, such as thinning or raking, may improve the health of the tree, improving its response to fire.

o *Air Quality and Smoke*

All acres are not equal when it comes to emissions. Open stands support surface fire over crown fire under most conditions, and surface fire produces fewer particulates than crown fire. Stands that have burned more recently and more frequently also produce lower emissions. Figure 30 shows differences in emissions from wildfire or prescribed fires that burn at different stages in burn only and mechanical plus burn treatment cycles.

The management action that has the greatest potential effect on air quality is prescribed burning. All prescribed fires are expected to achieve the desired conditions for air quality under the action alternatives, and hence, Air Quality is not expected to be a primary driver in selecting one alternative over another.

Some comparison between alternatives can be made by looking at the indirect effects of management activities that reduce the likelihood of active crown fire and heavy surface fuel loading. Active crown fire and heavy surface fuel loading produce large quantities of emissions that may be heavily concentrated. The alternatives that best alter stand structure to promote surface fire over active crown fire and decrease surface fuel loading would have the least negative environmental consequences to Air Quality, and are the focus of comparison between alternatives regarding Air Quality in this report.

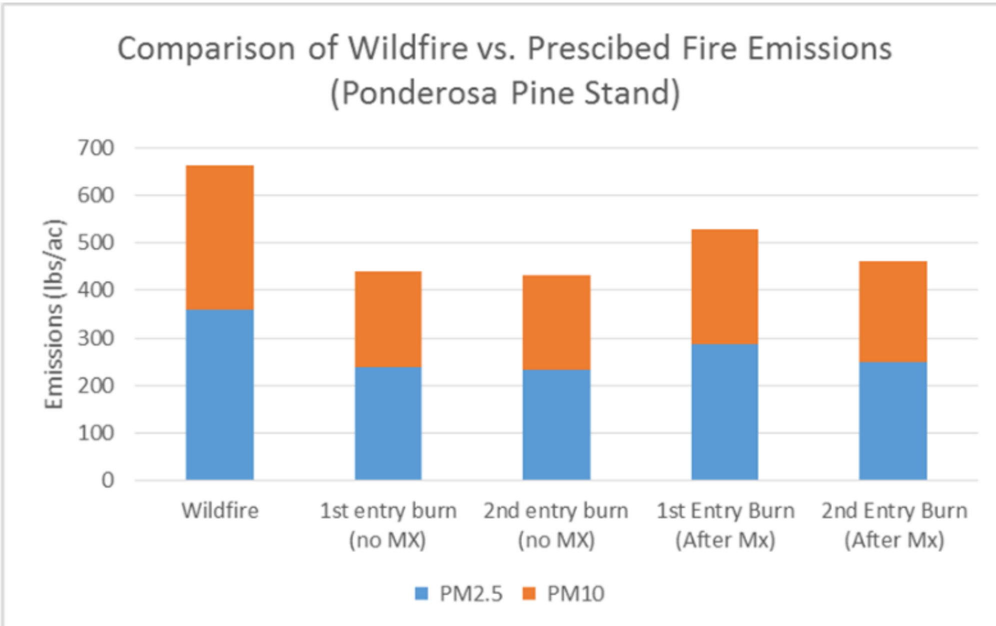

Figure 12. PM 2.5 and PM10 emissions from wildfires vs. prescribed fire at different stages of treatments

Up to two prescribed fires would be implemented, which may include pile burning months in advance of broadcast burns. Ideally, prescribed fires would occur on an average of every 10 years, depending on yearly fluctuations in climate/weather at different locations within the treatment area. Some areas will have had prescribed fire or wildfire within the last 10 – 15 years, so prescribed fires that are implemented would be maintenance burns. Limitations (wildlife concerns, smoke, funding, resource availability, etc.) may make it difficult to attain an average of a 10 year fire return interval across the proposed treatment area. Burning some areas on a slightly longer return interval may be acceptable (drier areas such as Tusayan) and/or may specifically be target to reduce smoke in sensitive receptors as mitigation for prescribed fires.

The combination of prescribed fire and mechanical thinning is the most effective means of limiting emissions from wildland fires by reducing and breaking up fuel continuity. Mechanical treatments proposed by Rim Country would reduce fuels by combinations of cutting and burning. In some cases, thinning would be implemented prior to prescribed burning, allowing higher intensity fire to be used where appropriate, and effectively minimizing potential wildfire emissions by removing some canopy fuels. Thinning generally increases surface fuel loading somewhat because of slash and other debris that break or fall off trees as they are processed, even when the majority of the material is removed from site (Fulé et al. 2012). Disturbance of surface fuels may provide temporary fuel breaks by re-arranging surface fuels where there are skid trails, tire tracks, and other surface disturbances which break up surface fuel continuity while slightly increasing the amount.

In other areas, prescribed fire may precede thinning. This may be appropriate if an area would not be thinned for several years in order to reduce flammability in the interim by beginning the process of reducing surface fuel loads, increasing canopy base height, and decreasing canopy bulk density. It may also occur if there is an opportunity to expand an adjacent burn unit to include part of the treatment area to increase efficiency. It may also facilitate timelier implementation of prescribed fires if there is no need to wait a year or two for the mechanical treatments to be completed. In some cases, it may be preferable to use fire as a thinning agent when the site is too steep or remote to access with mechanical methods.

Air quality provides an example of short- and long-term trade-offs in implementing restoration across large areas. There is a risk of short-term human health impacts from prescribed fire. The emissions from prescribed fires, as opposed to wildfires, can be managed by carefully distributing (prescribed) fire over time and space, as well as under appropriated weather conditions (Cohesive Strategy 2002, page 39). In the long term, once an area has been burned once, there is less fuel and, thus, lower emission potential. The combination of lower fuel loads and larger burn units would allow more acres to be burned without exceeding NAAQS.

In the short term, as ‘1st entry’ burns are implemented, impacts would increase noticeably. Acres with high fuel loading would be burned, in a first step toward restoring the natural fire regime. In the long term, the same acres would produce less smoke, along with maintaining an ecosystem that is resilient to fire, and benefits from it.

Air quality impacts can be predicted from prescribed fire, and the public notified of when and where to expect impacts in advance of a burn. Wildfires are less predictable and, though general patterns of smoke movement on the landscape are known, there is much less surety of where and when there would be impacts.

During the day, when units are ignited, smoke would be expected to travel on prevailing winds, away from sensitive receptors, and dissipate. Most smoke would dissipate, but some may surface. Short-term nighttime nuisance smoke could settle down the drainages into the towns below, particularly during early morning hours. Nighttime smoke would be expected to reside in low areas down slope from the burn units, because night time winds are generally calm. Daytime smoke would be expected to dissipate mostly downwind from the burn unit. Burn plans written for implementation of the proposed prescribed fires would include modeling to determine the most appropriate conditions under which to burn in order to minimize smoke impacts.

Under Alternative 2, air quality impacts would be most likely to those portions of the Little Colorado River Airshed east and northeast of Flagstaff; the Colorado River Airshed north of Williams and including all of the treatment area in RU6; and the Verde River Airshed. There is a small chance that there could be some impact to the northern portions of the Lower Salt River Airshed.

The difference in emissions between the treatments stays roughly the same, with no statistical difference and can generally be attributed the initial difference in fuel loading. The first prescribed fire following a mechanical treatment produced a little over 500 pounds/acre of emissions. The first prescribed fire without thinning produced a little over 400 pounds/acre of emissions. Since stands receiving mechanical treatment prior to prescribed fire start out with more surface fuel than those that are not mechanically treated prior to burning, additional emissions are produced.

▪ Effects Unique to Each Alternatives

• *Alternative 2 – Modified Proposed Action*

Alternative 2 proposes to conduct about 889,344 acres of mechanical and prescribed fire treatments and an additional 63,788 acres of prescribed fire only treatments over about 10 years or until objectives are met. On average, 88,934 acres of vegetation would be mechanically treated annually. On average, 95,313 acres of prescribed fire would be implemented annually across the Forests (within the treatment area). Up to two prescribed fires would be conducted on all acres proposed for burning over the 10-year period.

When analyzed at the scale of the treatment area, Alternative 2 would meet the purpose and need by moving the project area towards the desired condition of having potential for less than 10% active crown fire under extreme weather conditions, lessening post fire detrimental effects and creating a safer and more effective firefighting environment.

This alternative would meet direction in the Forest Service Manual 5100 (page 9) which includes direction on USFS use of prescribed fire to meet land and resource management goals and objectives. Objectives of fire management on lands managed by the USFS include:

Forest Service fire management activities shall always put human life as the single, overriding priority. The proposed actions of the Rim Country fully support incorporation of the highest standards for firefighter and public safety and are expected to improve and enhance the safety of the public as it relates to wildland fire.

Forest Service fire management activities should result in safe, cost-effective fire management programs that protect, maintain, and enhance National Forest System lands, adjacent lands, and lands protected by the Forest Service under cooperative agreement. Rim Country proposes to achieve restoration by restoring ecosystems within the treated area to a condition so that fire, when it occurs, would be beneficial to the ecosystems in which it burns without threatening lives, property, or resources. This would be achieved by fully integrating local industry, mechanical and fire prescriptive treatments, and providing for sustainable supplies of goods, services, and social values though implementation of appropriate fire management activities.

Direct and Indirect Effects

From a fire ecology perspective, direct and indirect effects of Alternative 2 relate primarily to treatments that include mechanical thinning, prescribed fire, or both to meet the purpose and need of the project.

Changes to potential fire behavior are the indirect effects of changes to fuel loading and structure. A direct effect of implementing Alternative 2, would be changes to the horizontal and vertical continuity of canopy fuels. As that continuity is broken up, an indirect effect would be decreased potential for crown fire.

Thinning, whether or not slash was removed from the site, would give managers more control of the amount and timing of emissions. As thinning and first-entry burns were completed, burn windows would expand for larger areas so more burning could occur when ventilation was good. Trees would be more fire resistant, and understory and surface vegetation would become established. With lower surface fuel loading and canopy fuels adapted to fire, burn windows would be broader than for initial entry burns. Decision space for managing unplanned ignitions would expand as Rim Country (and other projects) are implemented.

Fire Type

Once fully implemented, Alternative 2 is expected to reduce the potential for active and conditional crown fire to within desired conditions for all vegetation cover types (see Table 16 below). Over the rim country project area, 12 percent of the area burned under extreme weather conditions would be expected to be active or conditional crown fire, down from 31% given existing conditions (Figure 31). Passive crown fire increases slightly (57% up from 47% EC) under extreme conditions, due to the desired clumpy canopy characteristics of the mechanical treatments. Under less extreme wind conditions (5 MPH instead of 20 MPH), the majority of the landscape (95%) is expected to burn as a surface fire, and only 43,396 acres are expected to burn with passive crown fire, and 270 acres with active or conditional crown fire.

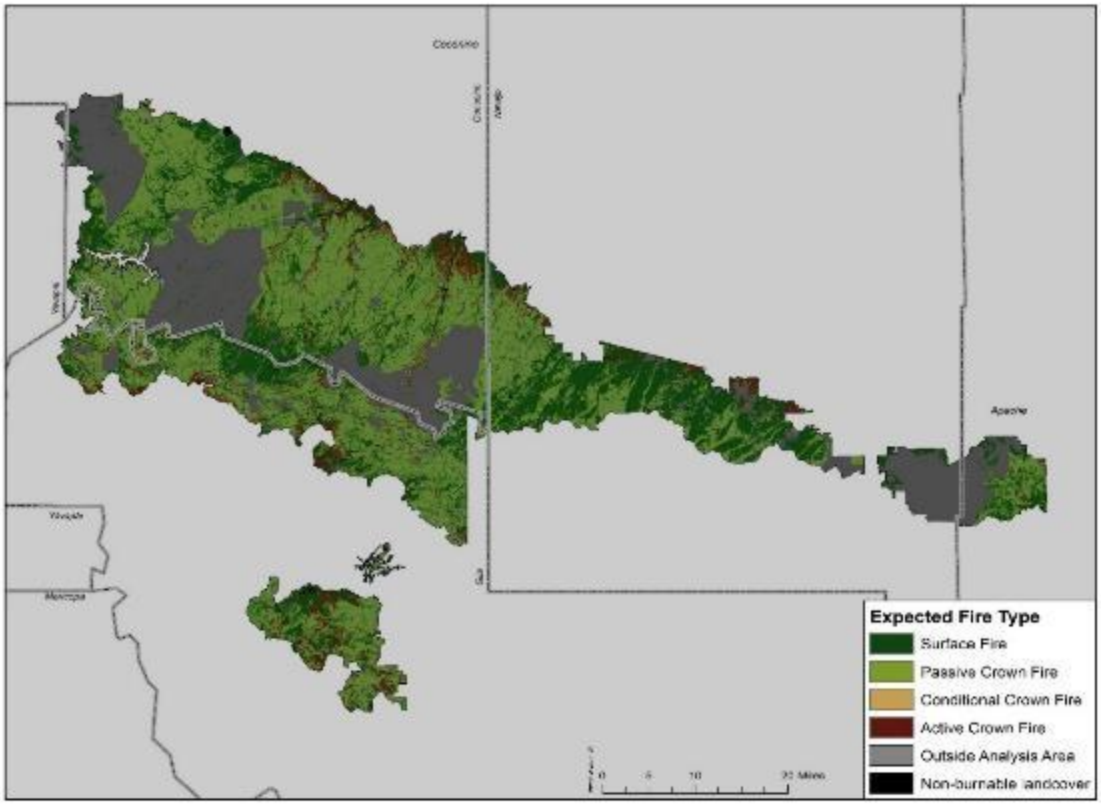

Figure 13. Expected Fire Type for Alternative 2, under modeled weather conditions

Post wildfire watershed effects increase with the percent of the watershed burns with moderate to high severity fire (Cannon 2010; Neary 2011). Under Alternative 2, 9 watersheds are expected to burn with active crown fire under extreme weather conditions for over 30 percent of the watershed, which would result in moderate to high severity effects (Figure 32). Three watersheds are have over 50 percent of the watershed expected to burn with active crown fire. Watersheds 67 (Bear Canyon) and 40 (Miller Canyon) have the highest proportion of potential for active crown fire (55 percent for both). If a wildfire were to burn within these watersheds, detrimental post wildfire effects, such as debris flows, would be expected.

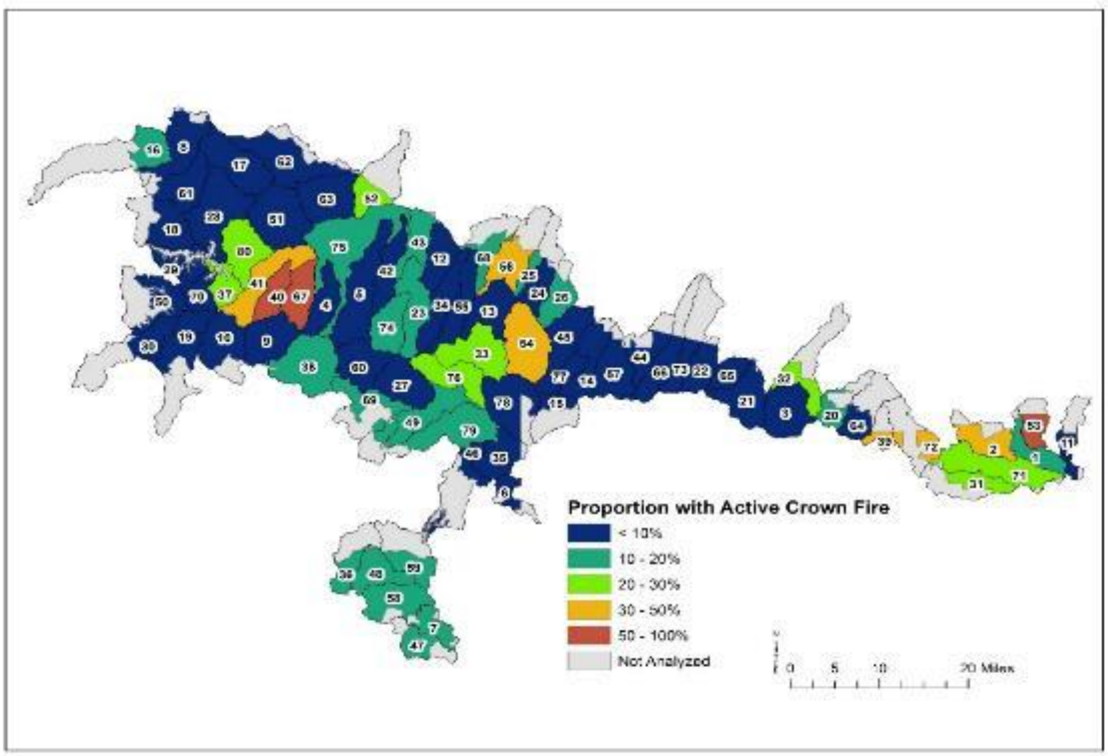

Figure 14: Proportion of each HUC6 watershed with Active Crown Fire for Alternative 2, under modeled weather conditions

- Fire Hazard Index

Alternative 2 would decrease the risk of undesirable wildfire behavior and effects that could threaten lives, resources, and infrastructure. After implementation, the Fire Hazard Index decreases resulting in 15% of the project area is within the moderate to extreme FHI, down from 37% in the existing conditions (Figure 33). The areas of moderate to extreme presents difficult and dangerous suppression conditions during a wildfire and potential for adverse post fire effects on soils and surface water quality.

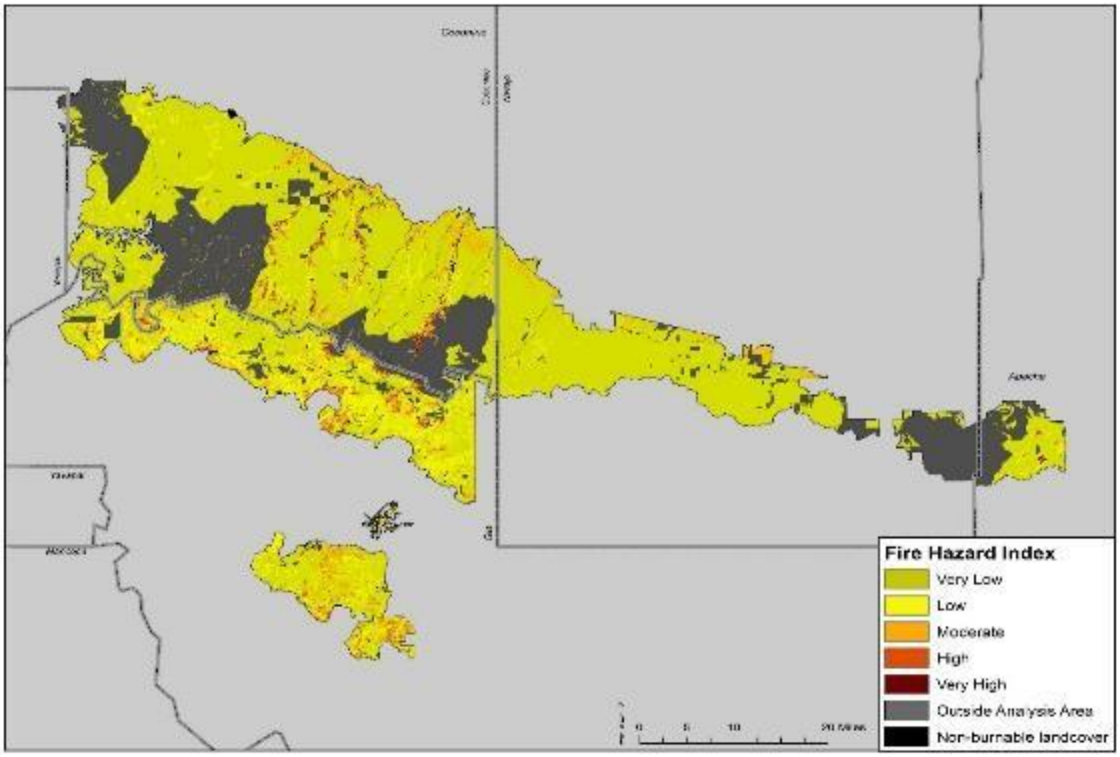

Figure 15: Fire Hazard Index for Alternative 2, under modeled weather conditions.

There are 3 watersheds with over 50% of the watershed in the moderate to extreme FHI categories (Figure 34). Watershed 40 (Miller Canyon, 61%) and 67 (Bear Canyon, 65%) have the highest proportion of FHI in the moderate to very high class. Large wildfires in these watersheds would still have a high potential to be difficult and dangerous to suppress, and have a high potential for adverse post fire effects.

- Surface Fuels loadings

Under the Alternative 2, surface fuel loading would initially increase with mechanical treatment. As first and second entry prescribed burns are implemented, these fuel loadings would decrease in most areas except those proposed for MSO treatments, which are designed to maintain a higher level of fuel loading, especially Coarse Woody Debris (dead/down woody fuels greater than 3" in diameter).

Desired conditions for total surface fuel loadings are less than 27 tons/ac in Ponderosa Pine vegetation types and less than 30 tons/ac in Dry Mixed Conifer. Figure 74 highlights those areas where surface fuel loading is expected to exceed desired conditions under Alternative 2. .

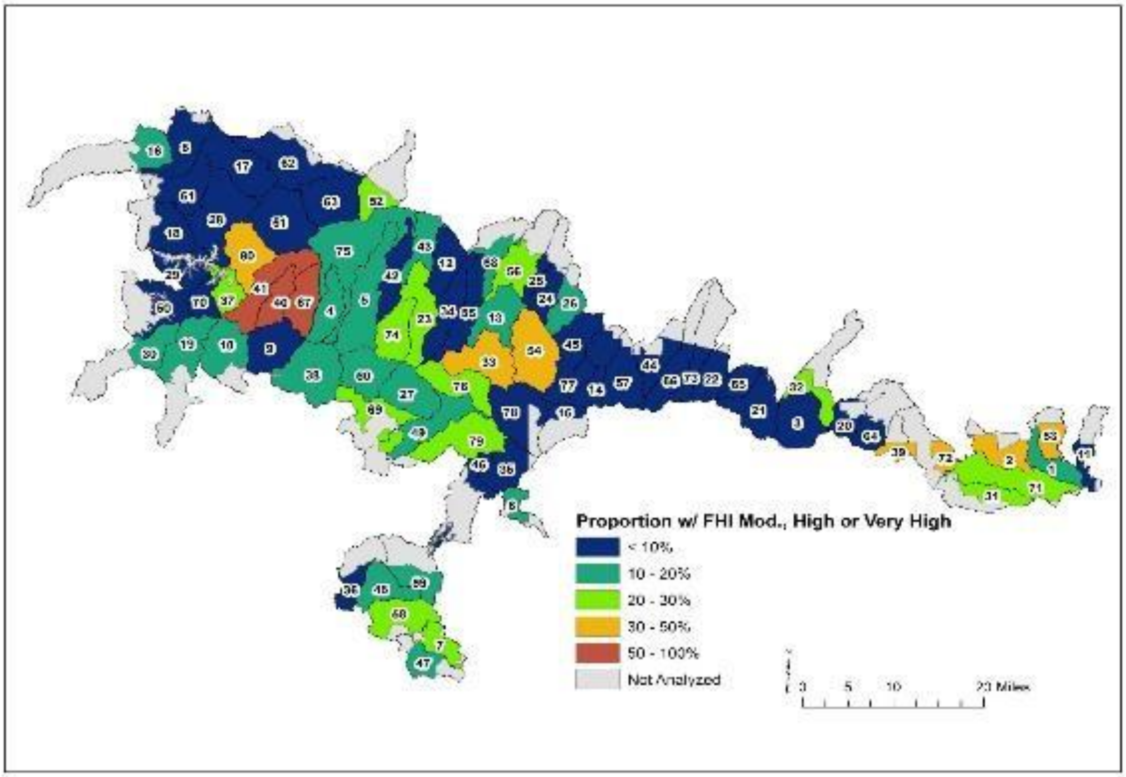

Figure 16. Proportion of each HUC6 watershed with moderate, high, or very high fire hazard Index for Alternative 2, under modeled weather conditions.

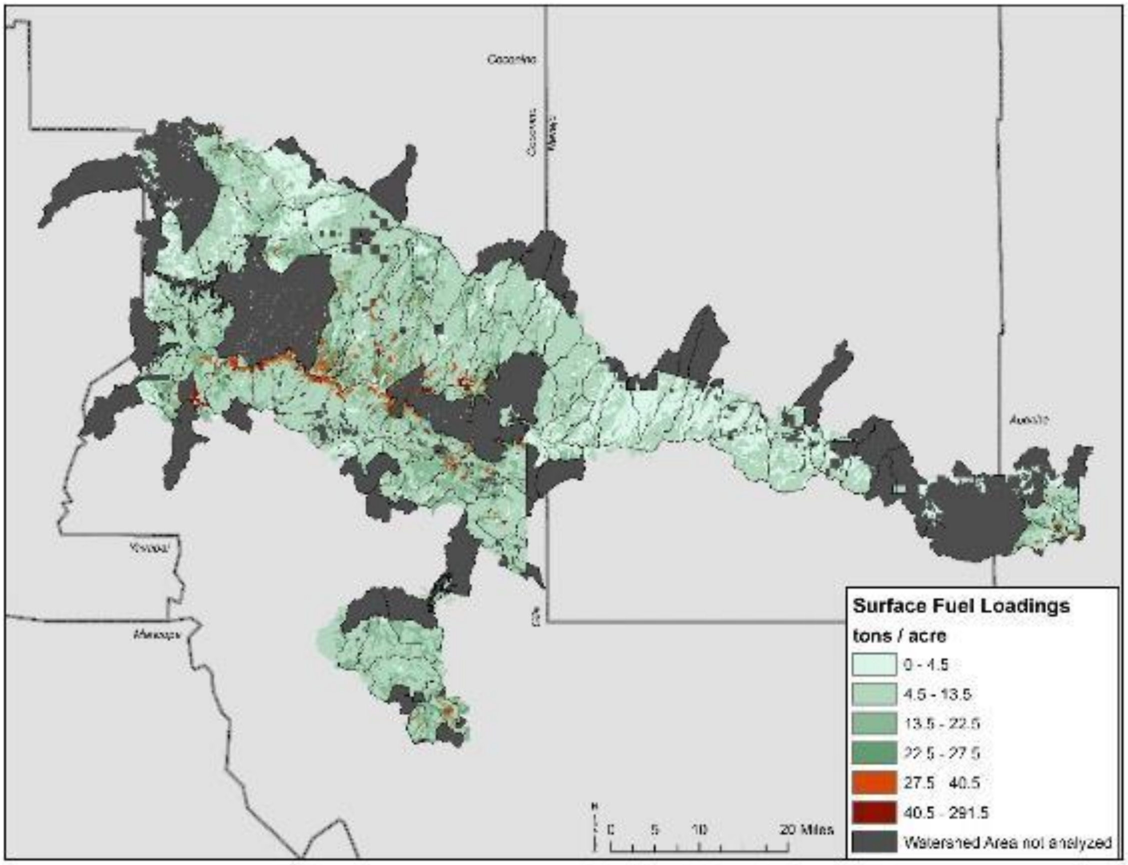

Figure 17: Surface Fuel Loads for Alternative 2, under modeled fire weather

- Effects on Values, Resources and Assets
  - *Wildfire Management*

Wildfire management environment would become safer and more effected as both CFA and FHI decrease. Even under extreme fire weather, suppression tactics would be more effective than current conditions. Decision space for managing unplanned ignitions would expand as Rim Country is implemented.

- *WUI*

Under the Alternative 2, WUI areas on Forest Service lands across the treatment area would be more fire adapted, however increasing smoke from prescribed fires would be present next to homes. CFA and FHI both decrease on Forest Service lands (Table 16). The potential for home and asset loss from crown fires, high intensity surface fires and ember lofting from fires on Forest Service land would decrease. The need for private and non-forest service land owners to manage fuels on their lands in order to compliment Rim Country initiatives will be imperative to fully mitigate risk and impacts from wildfires.

Table 21. Alternative 2 metrics for the Wildland Urban Interface

WUI CLASS	Total Acres	Fire Hazard Index				Fire Type	
		Very Low - Low	moderate	high	very high	Passive & Active Crown Fire	Active Crown Fire
High Value Rec Sites	375	36%	6%	6%	5%	64%	10%
Comm Sites	2074	35%	6%	2%	0%	65%	6%
NonFS Lands	22638	43%	6%	1%	0%	57%	6%
Transmission Lines	4083	39%	6%	1%	0%	61%	6%
FS Buildings	1683	33%	6%	4%	1%	67%	5%

Vegetation Cover Type

At the project scale, active crown fire and Fire Hazard Index are reduced for all target vegetation cover types (Table 17). At the project area scale, ponderosa pine would meet desired conditions for active crown fire (less than 10), under Alternative 2 even under the extreme conditions modeled.

Table 22. Alterative 2 metrics for vegetation cover type

ERU	Total Acres	Fire Hazard Index				Fire Type	
		Very Low - Low	moderate	high	very high	All Crown Fire	Active Crown Fire
Ponderosa Pine	556284	97%	2%	1%	0%	81%	**1%**
PIPO Evergreen Oak	147989	95%	4%	1%	0%	85%	**0%**
Dry Mixed Conifer	49281	74%	10%	9%	7%	77%	11%
Wet Mixed Conifer	3130	83%	4%	7%	6%	74%	13%
Aspen	1438	98%	1%	1%	0%	6%	2%
Pinyon Juniper	135085	74%	22%	4%	0%	71%	25%
Madrian Pinyon Oak	23318	55%	25%	19%	1%	86%	41%
Grasslands	18851	100%	0%	0%	0%	16%	**0%**
Riparian Areas	14567	92%	5%	2%	1%	48%	2%

- Large and old trees

Under Alternative 2, the potential for fire-related mortality of large and/or old trees would be reduced across the landscape. Ignition techniques or other mitigations would be employed to minimize residence time in duff adjacent to old trees whenever possible. Under this alternative, low severity fire would be used in the vicinity of old trees and, to the degree it is practicable, ladder fuels and excessive surface fuel buildups adjacent to old trees would be removed before burning. Scorch is one of the primary factors in large and old tree mortality (Jerman et al. 2004), and is influenced by the vertical arrangement of fuels. Prescribed fire and mechanical treatments in the vicinity of old and/or large trees would decrease fuel loading in the immediate vicinity of these trees, decreasing the potential for crown scorch.

- Emissions and Air Quality

This alternative would meet the purpose and need, and desired conditions for Air Quality. During windows of opportunity, whenever fire weather and expected fire effects are favorable, fire managers on the Apache-Sitgreaves, Coconino and Tonto National Forests strive to treat as many acres with wildland fire as possible every year, while remaining within legal, climatological, social, and logistical limits. This means that the only change that is likely to occur under this Alternative would be from the greater flexibility in blocking out burn units, because so much more area would have been treated and/or planned and analyzed for prescribed fire. There may also be room some potential for increased coordination of resources between forests in the area. Impacts on air quality are indirect effects of implementing prescribed fire. Although the impact of this is not quantifiable at this time, it would likely be an increase in annual acres burned with no increase in air quality impacts, because it could increase the number of acres that could be burned in a single burn period.

The number of days (duration) of smoke impacts, as well as the intensity (concentration) of the impacts are of concern to the public. While the variability from year to year would be large, under this alternative, prescribed fire would need to be implemented on up to 58,333 acres annually to produce an average fire return interval of 10 years across 583,330 acres proposed for prescribed fire. Potential air quality impacts during implementation of Alternative 2, and the necessary maintenance burning after the initial implementation has been completed may be noticeable, although National Ambient Air Quality Standards would not be exceeded. First entry burns produce much more emissions per acre than subsequent burns (see discussion on page XX and Figure 30). However, even if the slash was removed from the forest and although the prescribed burning would be spread over many years, the area to be burned would increase significantly and periodic burning would be required across the treatment area to maintain a low fuel load and a healthy forest. Any wildfire that burned subsequent to implementing Alternative 2 would result in lower emissions than if the area burned in a wildfire given current conditions because there would be less biomass to burn (*Figure 76*).

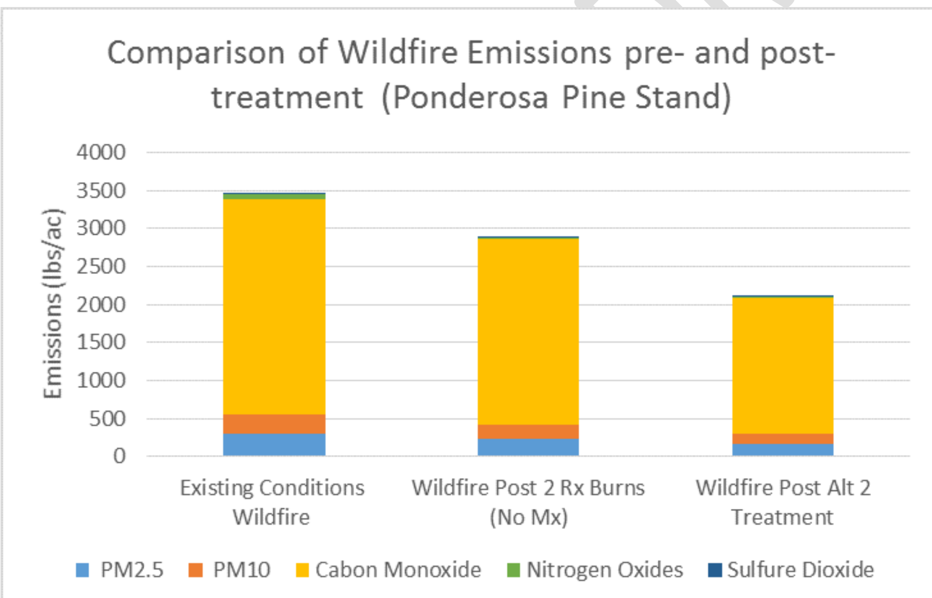

Figure 18. Alternative 2 comparison of wildfire emissions pre- and post- treatments

The amount of smoke allowed by the DEQ would not increase, and any burning done in the proposed treatment areas would comply with the National Ambient Air Quality Standards (NAAQS). The number of days of smoke impacts, as well as nuisance smoke (emissions that comply with NAAQS but are considered by the public to be a nuisance) may increase under this alternative, for the following reasons. The Apache-Sitgraves, Coconino and Tonto National Forests already burn on the high end of what would be their maximum acres and allowed emissions.

Under Alternatives 2, the number of acres available for prescribed fire would increase by 953,132 acres, which could average an additional 58,333 acres a year with prescribed fire and wildfire. This, in turn, would increase the flexibility for the forests in laying out burn units and managing prescribed fires. With potential for larger burn units, it would be possible to burn 'hotter', so that, although more acres may be burned at one time, the heat created by increased fire behavior is could provide more 'lift' for the smoke, increasing dispersal and minimizing smoke impacts.

Overall, surface fuel loading would decrease with a corresponding decrease in the volume of potential emissions from wildfires and future prescribed fires. However, there is no projected change in CWD fuel loading for Very Low (PAC Burn Only) treatments, andin these areas, smoldering fuels would produce high levels of smoke, as well as a high likelihood of high severity fire effects.

The likelihood and degree of potential impacts from wildfire smoke would decrease as fuel loading decrease after prescribed burns. After implementation, Watersheds 75 (East Clear Creek-Clear Creek) and 33 (Long Tom canyon-Chevelon Canyon) have the greatest potential to produce emissions because of surface fuel loading. Under Alternative 2 all but 22 watersheds decrease in total surface fuel loadings. One remains effectively the same (56, Durfee Draw – Chevelon Canyon), and 20 increase in fuel loadings (see Table 25 below). Watershed 2 (Upper Rocky Arroyo) and 41 (East Clear Creek) increase the most (29 and 23% respectively).

- *Alternative 3 – Focused*

From a fire ecology perspective, direct and indirect effects of Alternative 3 relate primarily to treatments that include mechanical thinning, prescribed fire, or both to meet the purpose and need of the Rim Country. This alternative proposes to conduct about 528,060 acres of restoration activities over about 10 years or until objectives are met. On average, 48,316 acres of vegetation would be mechanically treated annually. On average, 52,806 acres of prescribed fire would be implemented annually across the Forests (within the treatment area). Up to two prescribed fires24 would be conducted on all acres proposed for burning over the 10-year period.

  - *Direct and Indirect Effects*

From a fire ecology perspective, direct and indirect effects of Alternative 3 relate primarily to treatments that include mechanical thinning, prescribed fire as described in the section Effects Common to All Action Alternatives, page 311. Areas without treatments will have the indirect effects associated with Alternative 1 (see section Alternative 1 – No Action, page304).

    - Rim Country Project Area Metrics and Measures
    - Fire Type

Alternative 3 is expected to reduce the potential for active and conditional crown fire closer to desired conditions for all vegetation cover types (see Table 19 below), however desired conditions will not be fully attained. Over the rim country project area, 18% of the area burned under extreme weather conditions would be expected to be active or conditional crown fire, down from 31% given existing conditions (Figure 38). Passive crown fire increases slightly

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4 A single prescribed fire may include burning piles and a follow-up broadcast burn. Prescribed fire would be implemented as indicated by monitoring data to augment wildfire acres, with the expectation that desired conditions would require a fire return interval of about 10 years.

(56% up from 47% EC) under extreme conditions, due to the desired clumpy canopy characteristics of the mechanical treatments. Under less extreme wind conditions (5 MPH instead of 20 MPH), the majority of the landscape would be expected to burn as a surface fire, and only limited acres would be expected to burn with active crown fire.

Post wildfire watershed effects increase with the amount of a watershed that burns at high severity fire (Cannon 2010; Neary 2011). Under Alternative 3, 16 watersheds have expected active crown fire under extreme weather conditions for over 30% of the watershed, which would result in high severity effects (Figure 39). Six watersheds are have over 50% of the watershed expected to burn with active crown fire. Watersheds 67 (Bear Canyon) and 56 (Durfee Draw-Chevelon Canyon) have the highest proportion of potential for active crown fire (55% and 67% respective). If a wildfire were to burn within these watersheds, detrimental post wildfire effects would be expected.

- Fire Hazard Index

Alternative 3 would decrease the risk of undesirable wildfire behavior and effects that could threaten lives, resources, and infrastructure. After implementation, the Fire Hazard Index decreases resulting in 22% of the project area is within the moderate to very high FHI (Figure 40), down from 37% in the existing conditions. The areas of moderate to extreme presents difficult and dangerous suppression conditions during a wildfire and potential for adverse post fire effects on soils and surface water quality, up from 37% in the existing conditions.

There are 6 watersheds with over 50% of the watershed in the moderate to very high FHI categories (Figure 41). Watershed 67 (Bear Canyon, 65%) and 59 (Upper Spring Creek, 77%) have the highest proportion of FHI in the moderate to very high class. Large wildfires in these watersheds have a high potential to be difficult and dangerous to suppress, and have a high potential for adverse post fire effects.

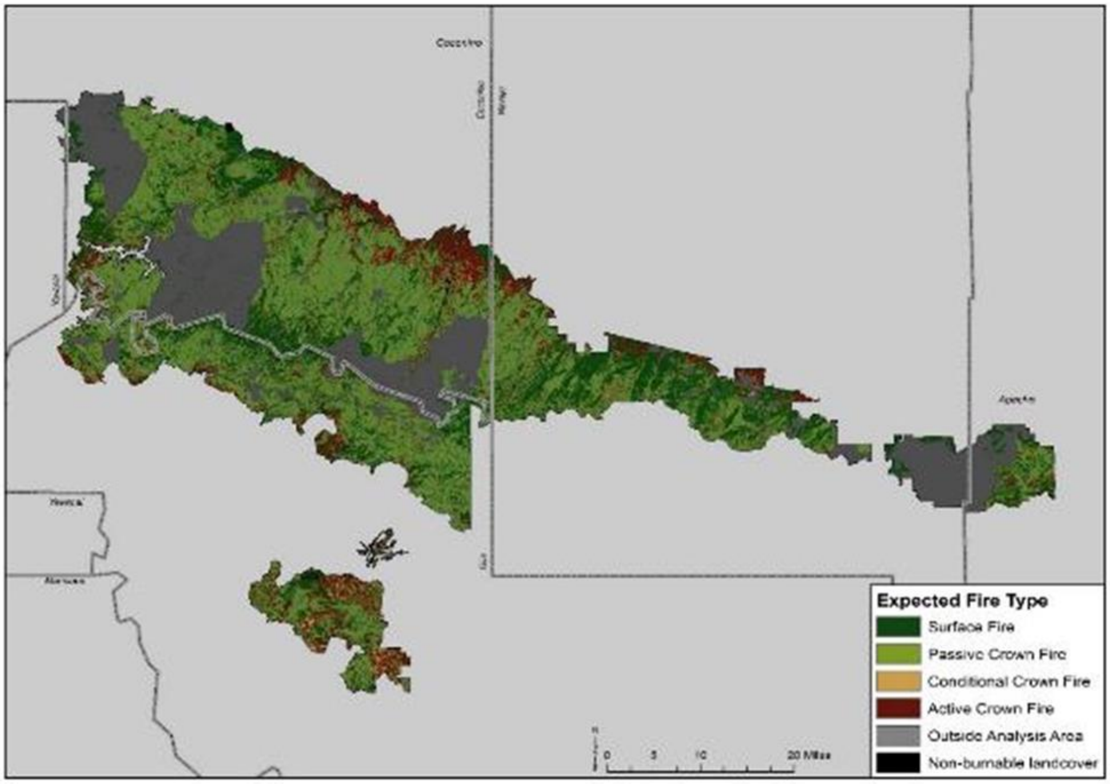


Figure 19. Expected Fire Type for Alternative 3, under modeled weather conditions

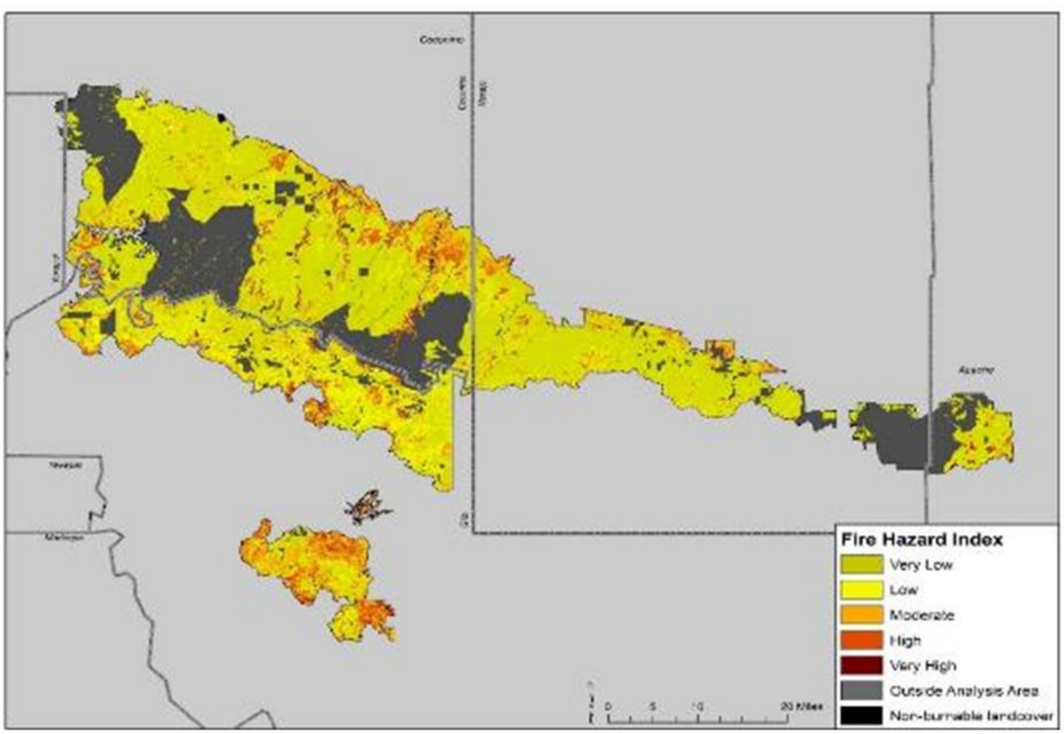


Figure 20. Fire Hazard Indix for Alternative 3, under modeled weather conditions

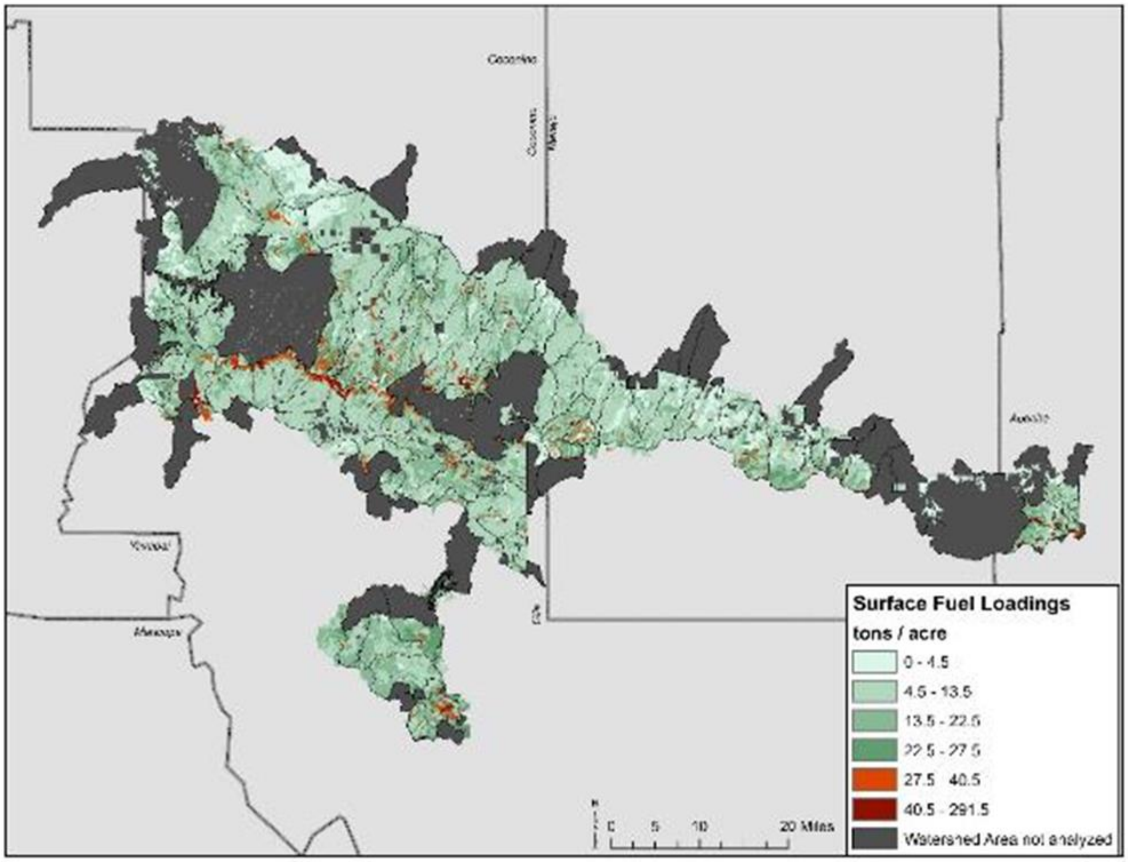


Figure 21. Total Surface Fuel Loadings for Alternative 3, under modeled weather conditions

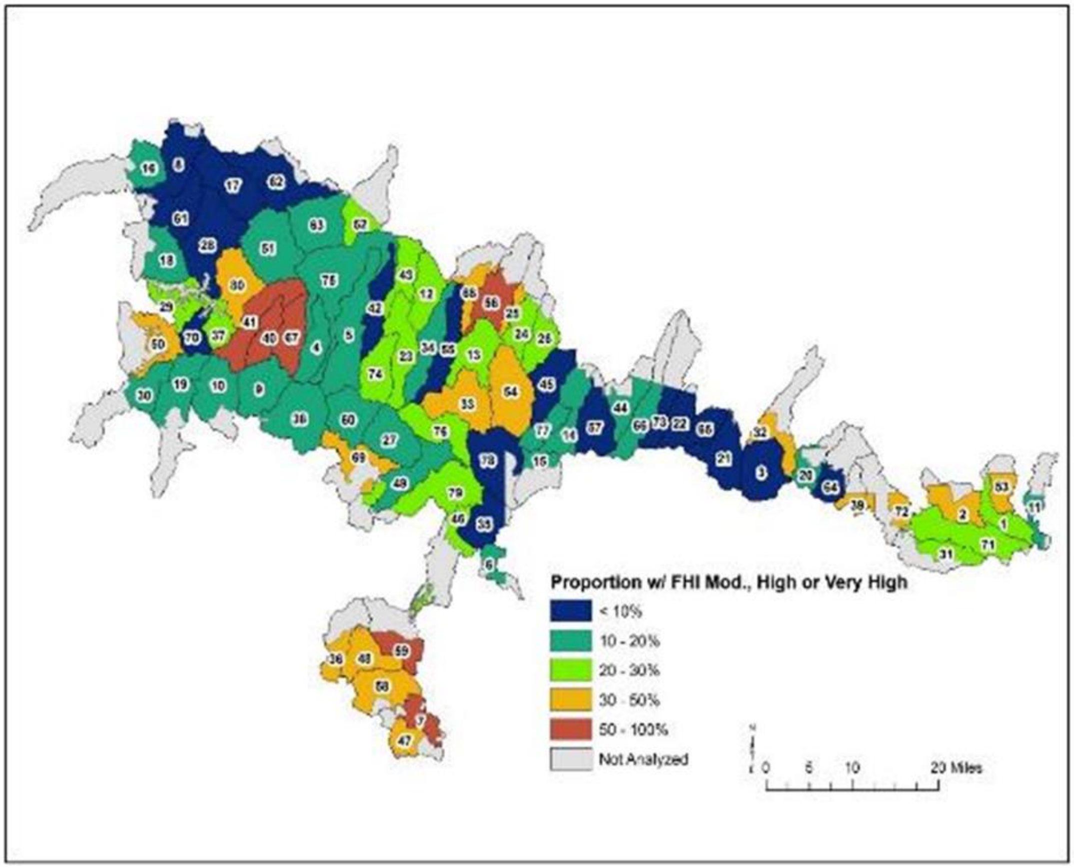


Figure 22. Proportion of each HUC6 watershed with Moderate, High, or Very High Fire Hazard Indes for Alternative 2, under modeled weather conditions

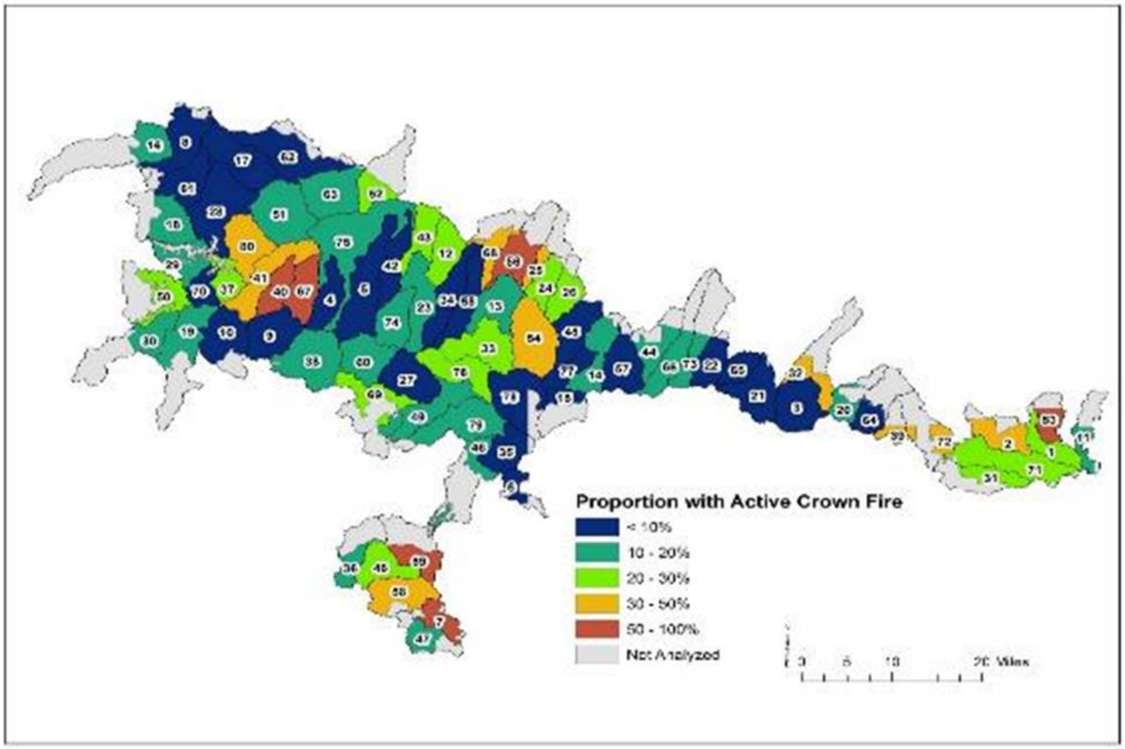


Figure 23. Proportion of each HUC6 watershed with Active Crown Fire for Alternative 3, under modeled weather conditions

- Surface Fuel Loadings

Under the Alternative 3, surface fuel loading would initially increase with mechanical treatment, and would also increase where no treatments occur. As first and second entry prescribed burns are implemented, these fuel loadings would decrease in most areas except those proposed for MSO treatments, which are designed to maintain a higher level of fuel loading, especially Coarse Woody Debris (dead/down woody fuels greater than 3” in diameter).

Desired conditions for total surface fuel loadings are less than 27 tons/ac in Ponderosa Pine vegetation types and less than 30 tons/ac in Dry Mixed Conifer. Figure 79 highlights those areas where surface fuel loading is expected to exceed desired conditions under Alternative 3

- Effects on Values, Resources and Assets

  - *Wildfire Management*

Wildfire management environment would become safer and more effected as both CFA and FHI decrease. However in areas where no treatments are planned, CFA and FHI both increase. Even under extreme fire weather, suppression tactics would be more effective than current conditions. Decision space for managing unplanned ignitions would expand as Rim Country (and other projects) are implemented.

  - *WUI*

Under the Alternative 3, WUI areas on Forest Service lands across the treatment area would be more fire adapted, however increasing smoke from prescribed fires would be present next to homes. CFA and FHI both decrease on Forest Service lands (Table 19). The potential for home and asset loss from crown fires, high intensity surface fires and ember lofting from fires on

Forest Service land would decrease. The need for private and non-forest service land owners to manage fuels on their lands in order to compliment Rim Country initiatives will be imperative to fully mitigate risk and impacts from wildfires.

Table 23: Alternative 3 metrics for the Wildland Urban Interface

WUI CLASS	Total Acres	Fire Hazard Index				Fire Type	
		Very Low - Low	moderate	high	very high	Passive & Active Crown Fire	Active Crown Fire
High Value Rec Sites	375	81%	8%	6%	5%	65%	11%
Comm Sites	2074	86%	8%	6%	1%	68%	11%
NonFS Lands	22638	87%	8%	4%	0%	63%	10%
Transmission Lines	4083	84%	10%	6%	1%	65%	15%
FS Buildings	1683	80%	8%	10%	3%	71%	14%

- Vegetation Cover Type

At the project scale, active crown fire and Fire Hazard Index are reduced for all target vegetation cover types (Table 20). At the project area scale, ponderosa pine would not meet desired conditions for active crown fire (<10%), under Alternative 3 under the extreme conditions modeled, however it would move the cover type closer to desired conditions.

Table 24: Alternative 3 metrics by Vegetation Cover class

Vegetation Cover Type	Total Acres	Fire Hazard Index				Fire Type	
		Very Low - Low	moderate	high	very high	All Crown Fire	Active Crown Fire
Ponderosa Pine	556284	75%	7%	16%	3%	75%	22%
PIPO Evergreen Oak	147989	36%	33%	26%	5%	62%	30%
Dry Mixed Conifer	49281	26%	17%	28%	29%	29%	54%
Wet Mixed Conifer	3130	29%	4%	26%	41%	30%	70%
Aspen	1438	95%	1%	3%	2%	4%	5%
Pinyon Juniper	135085	36%	33%	28%	3%	53%	67%
Madrian Pinyon Oak	23318	19%	33%	41%	7%	55%	80%
Grasslands	18851	98%	2%	0%	0%	3%	3%
Riparian Areas	14567	70%	11%	13%	6%	35%	19%

- Large and old trees

Under Alternative 3, the potential for fire-related mortality of large and/or old trees would be reduced across the landscape where treatments are implemented in the same manner as Alternative 2 (see page XX). In areas where no treatments are applied, old trees would respond as in Alternative 1 (see page XX).

- Emissions and Air Quality

This alternative would meet the purpose and need, and desired conditions for Air Quality. Effects to Air Quality from smoke emissions will be a mix of Alternative 1 and Alternative 2. 528,060acres would be treated resulting in lower emissions from a post-treatment wildfire. XX acres would increase in potential wildfire emissions due to increases in surface fuel loadings and crown fire potential.

The number of days (duration) of smoke impacts, as well as the intensity (concentration) of the impacts are of concern to the public. While the variability from year to year would be large, under Alternative 3, prescribed fire would need to be implemented on up to 52,806 acres annually to produce an average fire return interval of 10 years across 528,060 acres proposed for prescribed fire. Implementing prescribed fire as proposed in Alternative 3 would result in lower emissions than if the area burned in a wildfire because there would be less biomass to burn (Figure 36).

Under Alternatives 3, the number of acres available for prescribed fire would increase by 52,806 acres, This, in turn, would increase the flexibility for the forests in laying out burn units and managing prescribed fires. With potential for larger burn units, it would be possible to burn 'hotter', so that, although more acres may be burned at one time, the heat created by increased fire behavior is could provide more 'lift' for the smoke, increasing dispersal and minimizing smoke impacts.

Surface fuel loading would decrease where treatments are implemented, decreasing the volume of potential emissions from wildfires and future prescribed fires. However, there is no change in CWD fuel loading for Very Low (PAC Burn Only) treatments (XX acres). In these areas, smoldering fuels would produce high levels of smoke, as well as a high likelihood of high severity fire effects.

The likelihood and degree of potential impacts from wildfire smoke would decrease as fuel loading decrease after prescribed burns. After implementation, Watersheds 75 (East Clear Creek-Clear Creek) and 79 (Haigler Creek) have the greatest potential to produce emissions because of surface fuel loading (Figure 43 of Fire Ecologist Specialist Report 2019). Under Alternative 3 all but 46 watersheds decrease in total surface fuel loadings. Five remain effectively the same (< 3% change), and 41 increase in fuel loadings (see Table?? below). Watershed 1 (Upper Rocky Arroyo) and 133 (Decker Wash) increase the most (29% and 28% respectively).

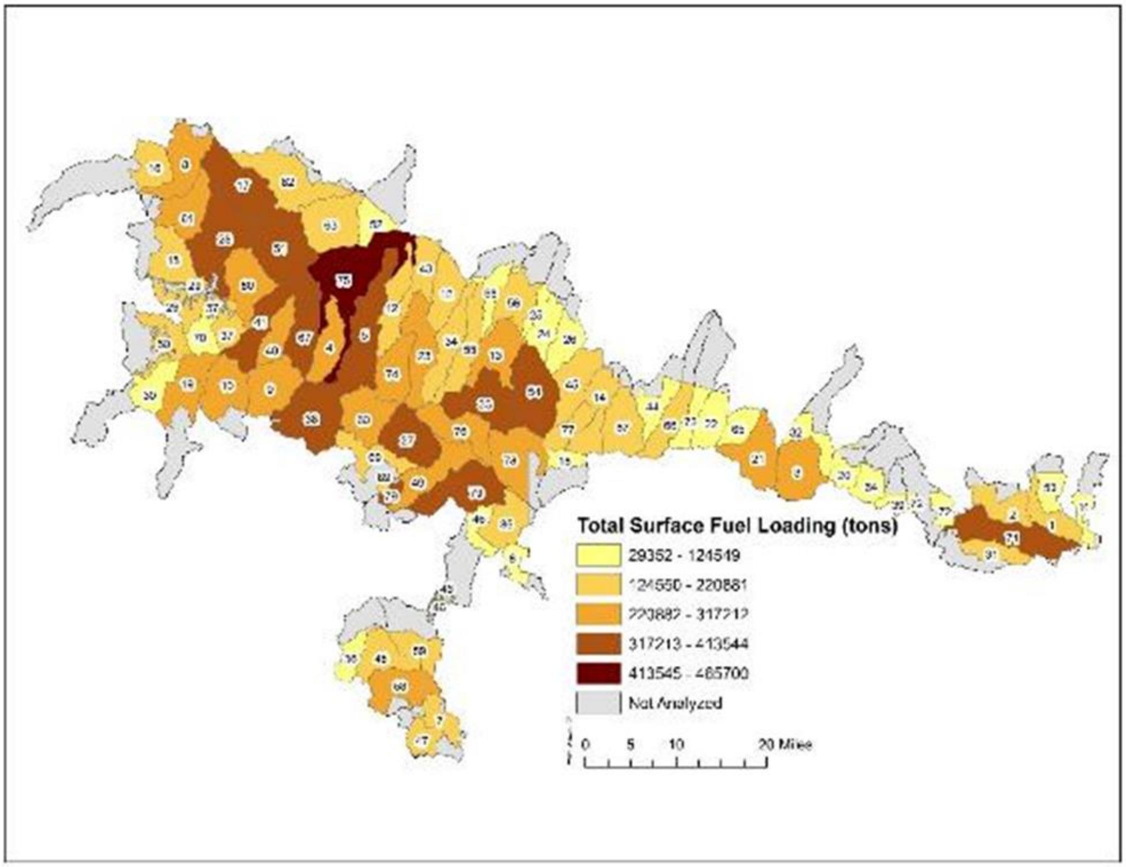


Figure 24. Total Surface Fuel loadings of each HUC-6 watershed for Alternative 3, as modeled using FVS

- *Comparison of Alternatives*

This report analyzed the effectiveness of 3 alternatives for modifying composition, pattern, and structure as a means of restoring healthy ecological function to ponderosa pine, specifically in regards to fire ecology and air quality. All action alternatives are expected to reset the current trajectory of areas proposed for treatment towards greater sustainability and resilience. Aspen, grasslands, oak communities, and some pinyon/juniper communities associated with ponderosa pine are included. Restoring historic fire regimes plays both direct and indirect roles in achieving or maintaining desired conditions for these vegetation communities. All action alternatives move the Rim Country proposed treatment area toward desired conditions. Differences between them are discussed below, and summarized at the end of this section.

  - *Fire Type*

The change from existing conditions to post-treatment conditions in the action alternatives results primarily from: 1) mechanical treatments breaking up the vertical and horizontal continuity of canopy fuels; 2) mechanical treatments and prescribed fire raising canopy base heights; and 3).

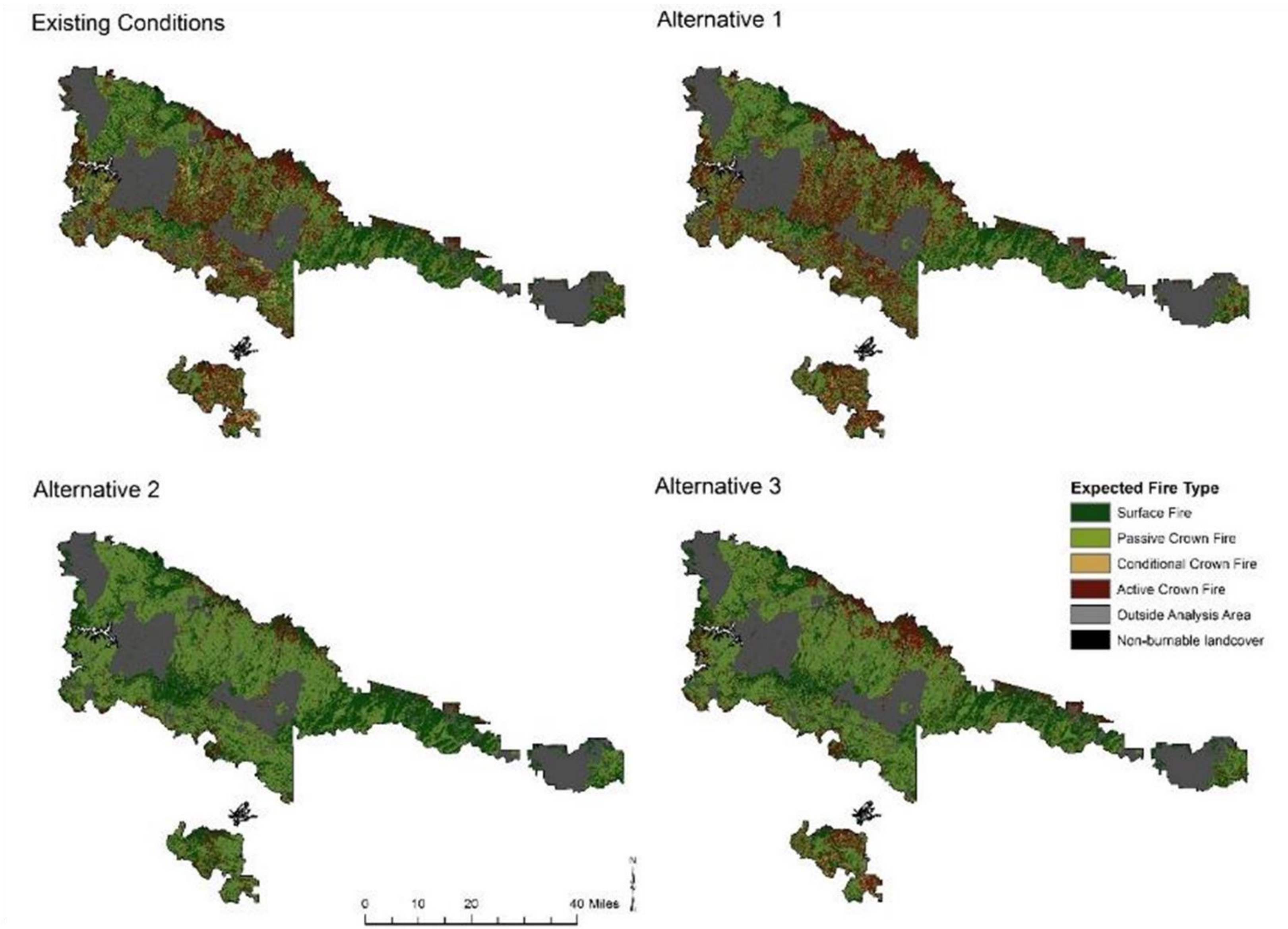


Figure 25. Comparison of fire type for each alternative

Table 25: Comparison of Alternatives Fire Type within the Wildland Urban Interface. The ↑ symbol indicates increases compared to existing conditions (EC), while the ↓symbolindicate decreases.

WUI CLASS	Total Acres	Fire Type							
		Passive & Active Crown Fire				Active Crown Fire			
		EC	ALT1	ALT2	ALT3	EC	ALT1	ALT2	ALT3
High Value Rec Sites	375	79%	↑83%	↓64%	↓65%	38%	↑40%	↓10%	↓11%
Communication Sites	2074	75%	↑79%	↓65%	↓68%	27%	↑28%	↓6%	↓11%
NonFS Lands w/ Struc	22638	68%	↑73%	↓57%	↓63%	28%	↑29%	↓6%	↓10%
Transmission Lines	4083	66%	↑74%	↓61%	↓65%	32%	↑33%	↓6%	↓15%
FS Buildings	1683	83%	↑85%	↓67%	↓71%	41%	↑43%	↓5%	↓14%

Desired condition for ponderosa pine is to have potential for less than 20% crown fire.

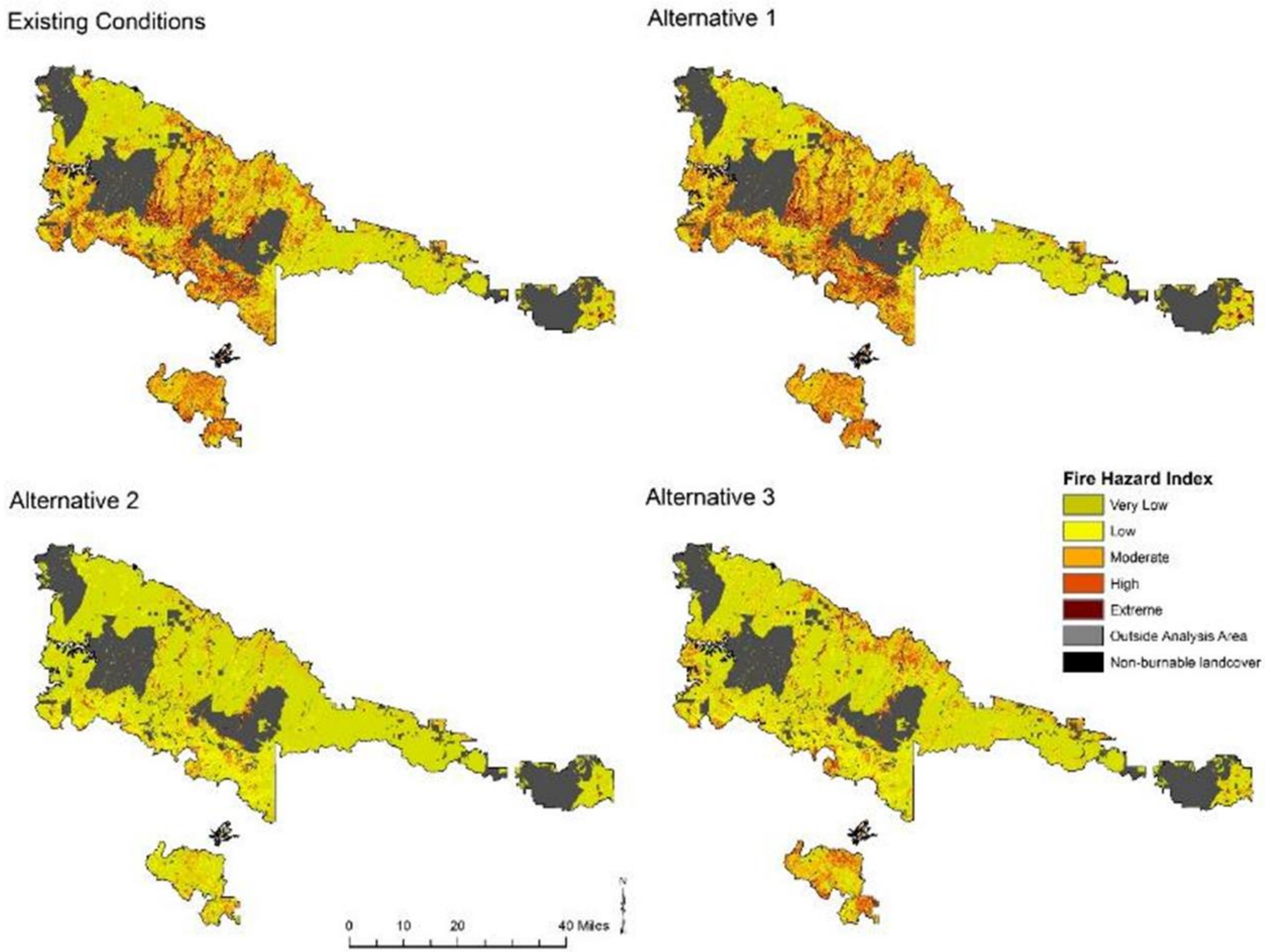
Table 26: Comparison of Alternatives for Fire Type by vegetation cover class for extreme fire weather

Vegetation Cover Type	Total Acres	Fire Type							
		All Crown Fire				Active Crown Fire			
		EC	ALT1	ALT2	ALT3	EC	ALT1	ALT2	ALT3
Ponderosa Pine	556284	72%	81%	75%	79%	21%	22%	1%	5%
Ponderosa Pine Evergreen Oak	147989	82%	85%	62%	72%	29%	30%	0%	9%
Dry Mixed Conifer	49281	75%	77%	29%	33%	50%	54%	11%	14%
Wet Mixed Conifer	3130	71%	74%	30%	30%	66%	70%	13%	14%
Aspen	1438	6%	6%	4%	4%	4%	5%	2%	2%
Pinyon Juniper	135085	71%	71%	53%	62%	65%	67%	25%	49%
Madrian Pinyon Oak	23318	85%	86%	55%	71%	79%	80%	41%	59%
Grasslands	18851	15%	16%	3%	5%	3%	3%	0%	5%
Riparian Areas	14567	44%	48%	35%	35%	18%	19%	2%	2%

Fire Hazard Index

- *Surface Fuel Loading*

There are no desired conditions for total surface fuel loading, but 20 tons/acres is a reasonable recommendation for average maximum surface fuel loading for the area of this analysis (see discussion on page 30 of the Fire Ecologist Specialist Report 2019). Historic levels were estimated to be 5 - 20 tons/acre for CWD alone.



2439
2440 Figure 26. Fire hazard index

Table 27: Comparison of Alternatives by Fire Hazard Index for the Wildland Urban Interface Classes

WUI CLASS	Total Acres	Fire Hazard Index															
		Very Low - Low				moderate				high				very high			
		EC	ALT1	ALT2	ALT3	EC	ALT1	ALT2	ALT3	EC	ALT1	ALT2	ALT3	EC	ALT1	ALT2	ALT3
High Value Rec Sites	375	49%	45%	83%	81%	16%	19%	6%	8%	18%	18%	6%	6%	16%	19%	5%	5%
Comm Sites	2074	66%	63%	92%	86%	15%	16%	6%	8%	17%	18%	2%	6%	2%	3%	0%	1%
NonFS Lands	22638	66%	63%	93%	87%	16%	17%	6%	8%	15%	18%	1%	4%	3%	3%	0%	0%
Transmission Lines	4083	64%	61%	93%	84%	18%	17%	6%	10%	15%	18%	1%	6%	3%	4%	0%	1%
FS Buildings	1683	51%	49%	89%	80%	14%	14%	6%	8%	27%	29%	4%	10%	8%	9%	1%	3%

Table 28: Comparison of Alternatives by Fire Hazard Index for each Vegetation Cover Type

Vegetation Cover Type	Total Acres	Fire Hazard Index															
		Very Low - Low				moderate				high				very high			
		EC	ALT1	ALT2	ALT3	EC	ALT1	ALT2	ALT3	EC	ALT1	ALT2	ALT3	EC	ALT1	ALT2	ALT3
Ponderosa Pine	556284	77%	75%	97%	93%	9%	7%	2%	3%	12%	16%	1%	3%	2%	3%	0%	0%
Ponderosa Pine Evergreen Oak	147989	41%	36%	95%	75%	31%	33%	4%	16%	24%	26%	1%	8%	4%	5%	0%	1%
Dry Mixed Conifer	49281	29%	26%	74%	70%	18%	17%	10%	12%	27%	28%	9%	11%	26%	29%	7%	8%
Wet Mixed Conifer	3130	32%	29%	83%	82%	5%	4%	4%	4%	25%	26%	7%	7%	38%	41%	6%	6%
Aspen	1438	95%	95%	98%	97%	1%	1%	1%	1%	3%	3%	1%	1%	2%	2%	0%	0%
Pinyon Juniper	135085	37%	36%	74%	53%	34%	33%	22%	27%	26%	28%	4%	19%	2%	3%	0%	1%
Madrian Pinyon Oak	23318	20%	19%	55%	37%	31%	33%	25%	30%	43%	41%	19%	29%	6%	7%	1%	4%
Grasslands	18851	98%	98%	100%	100%	2%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Riparian Areas	14567	74%	70%	92%	92%	11%	11%	5%	5%	11%	13%	2%	2%	5%	6%	1%	1%

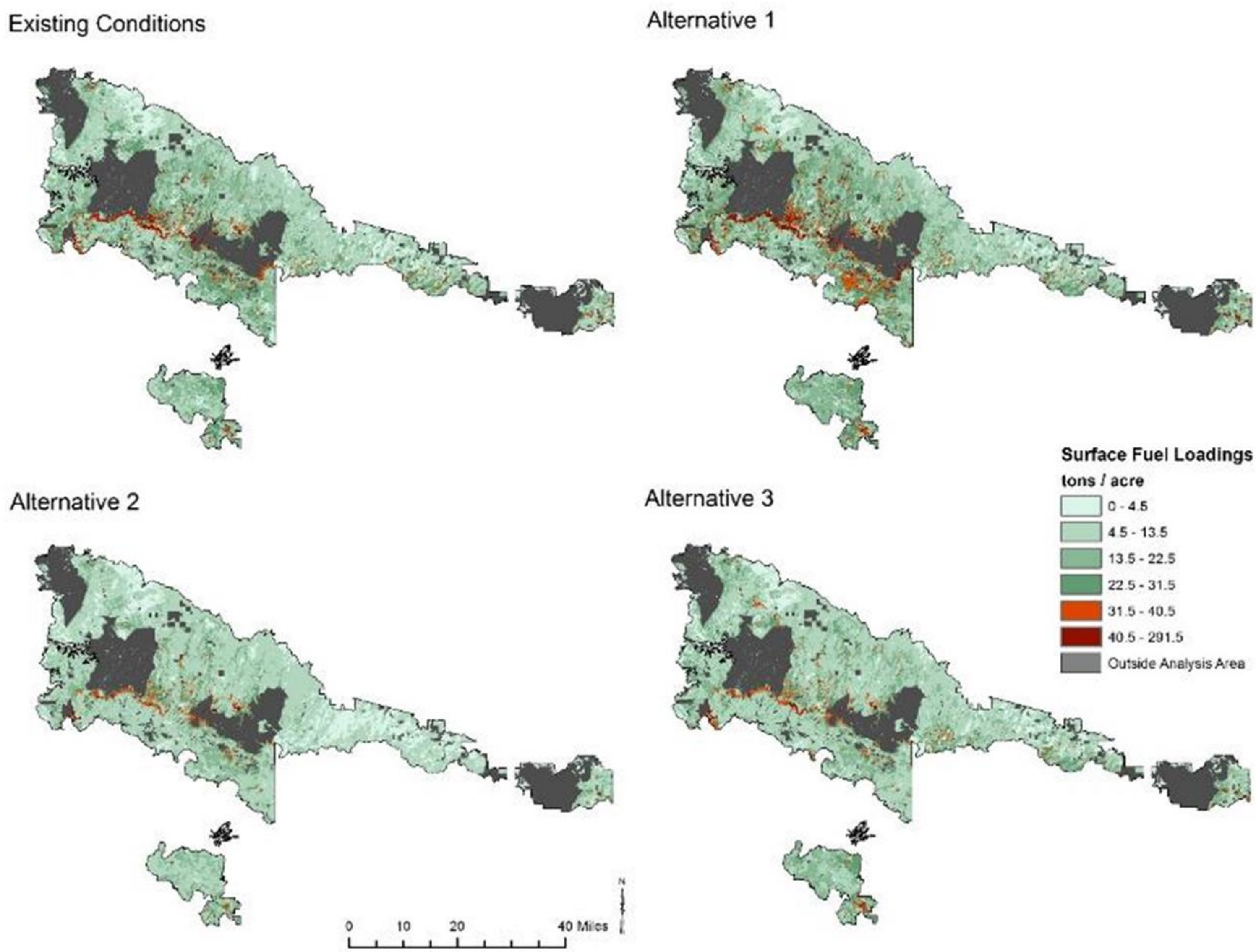


Figure 27. Surface fuel loading

▪ Emissions and Air Quality

Table 29: Comparison of Percent Changes in Total Surface Fuel Loadings from existing conditions***

Map Label	Watershed Name	Existing Total SFL	ALT 1 % Change	ALT 2 % Change	ALT 3 % Change
1	Upper Brown Creek	143,874	26%	-10%	10%
2	Upper Rocky Arroyo	117,828	30%	29%	29%
3	Mortensen Wash	238,345	9%	-55%	-7%
4	Barbershop Canyon	316,351	19%	-22%	-22%
5	Leonard Canyon	490,214	19%	-22%	-22%
6	Gentry Canyon	77,488	16%	-25%	-25%
7	Reynolds Creek	176,637	20%	-19%	7%
8	Double Cabin Park-Jacks Canyon	264,058	17%	7%	10%
9	East Verde River Headwaters	389,775	12%	-27%	-26%
10	Webber Creek	327,236	16%	-16%	-16%
11	Sepulveda Creek	72,897	23%	-23%	-1%
12	Cabin Draw	159,183	24%	-21%	0%
13	Upper Chevelon Canyon-Chevelon Canyon Lake	234,868	25%	-10%	2%
14	Bear Canyon-Black Canyon	185,764	16%	-46%	8%
15	Bull Flat Canyon	79,640	6%	-47%	5%
16	Red Tank Draw	194,843	14%	5%	5%
17	Upper Willow Valley	290,666	23%	-20%	10%
18	Home Tank Draw	140,654	15%	-22%	7%
19	Pine Creek	349,252	12%	-31%	-27%
20	Linden Draw	75,116	7%	-45%	-8%
21	West Fork Cottonwood Wash-Cottonwood Wash	229,322	9%	-53%	2%
22	Upper Day Wash	64,663	28%	-22%	19%
23	Upper Willow Creek	355,012	19%	-14%	-14%
24	Middle Wildcat Canyon	93,047	15%	-21%	9%
25	Lower Wildcat Canyon	28,219	18%	4%	18%
26	Upper Potato Wash	106,747	19%	-22%	-3%
27	Christopher Creek	444,690	11%	-26%	-26%
28	Lower Willow Valley	337,796	19%	-22%	2%
29	Upper West Clear Creek	148,312	19%	-22%	-12%
30	Hardscrabble Creek	148,864	13%	-30%	-25%
31	Billy Creek	118,406	22%	19%	22%
32	Dodson Wash	71,678	15%	-11%	11%
33	Long Tom Canyon-Chevelon Canyon	394,280	21%	2%	2%
34	Upper West Chevelon Canyon	271,066	20%	-24%	-24%
35	Parallel Canyon-Cherry Creek	237,399	16%	-33%	-33%
36	Rock Creek	105,061	21%	-21%	8%
37	Clover Creek	140,657	33%	15%	15%
38	Ellison Creek	397,878	17%	-15%	-4%
39	Fools Hollow	49,749	19%	15%	16%
40	Miller Canyon	195,395	21%	19%	19%
41	East Clear Creek-Blue Ridge Reservoir	289,492	25%	23%	23%
42	Wilkins Canyon	210,859	24%	-27%	-23%
43	Lower Willow Creek	158,542	20%	-6%	-5%
44	Upper Pierce Wash	78,338	5%	-47%	5%
45	Upper Brookbank Canyon	182,964	23%	-26%	-12%
46	Gruwell Canyon-Cherry Creek	121,988	19%	-30%	-13%
47	Workman Creek	138,566	27%	-22%	-7%
48	Buzzard Roost Canyon	187,727	28%	-10%	10%
49	Gordon Canyon	381,345	14%	-26%	-25%
50	Upper Fossil Creek	173,917	20%	-23%	16%

51	Windmill Draw-Jacks Canyon	353,747	17%	-18%	5%
52	Hart Tank	45,265	23%	18%	18%
53	Ortega Draw	63,924	25%	18%	21%
54	Upper Wildcat Canyon	370,140	25%	5%	6%
55	Alder Canyon	214,676	23%	-23%	-19%
56	Durfee Draw-Chevelon Canyon	134,595	18%	0%	16%
57	Buckskin Wash	191,122	6%	-60%	-7%
58	Upper Salome Creek	214,917	33%	-17%	6%
59	Upper Spring Creek	179,642	22%	-27%	21%
60	Horton Creek-Tonto Creek	341,225	14%	-25%	-15%
61	Brady Canyon	222,194	17%	13%	15%
62	Tremaine Lake	129,905	28%	4%	26%
63	Dogie Tank-Jacks Canyon	142,974	20%	-6%	17%
64	Bagnal Draw-Show Low Creek	93,232	10%	-46%	-3%
65	Stinson Wash	64,844	14%	-32%	-8%
66	Upper Phoenix Park Wash	110,842	15%	-40%	15%
67	Bear Canyon	285,961	18%	17%	17%
68	Lower West Chevelon Canyon	65,172	20%	5%	19%
69	Bull Tank Canyon-Tonto Creek	164,608	22%	-24%	-12%
70	Toms Creek	125,511	29%	-17%	-17%
71	Porter Creek	319,069	27%	11%	24%
72	Show Low Lake-Show Low Creek	56,145	19%	12%	12%
73	Decker Wash	52,388	28%	-24%	28%
74	Gentry Canyon	327,002	19%	-10%	-10%
75	East Clear Creek-Clear Creek	499,780	20%	-12%	-7%
76	Woods Canyon and Willow Springs Canyon	241,500	22%	21%	21%
77	West Fork Black Canyon	122,169	16%	-49%	15%
78	Canyon Creek Headwaters	315,160	18%	-19%	-15%
79	Haigler Creek	509,875	17%	-22%	-20%
80	Long Valley Draw	252,547	18%	10%	17%

****Includes ?? acres of in watersheds that have treatments planned in other projects, these numbers may in reality be lower due to the effects of those treatments which were not analyzed in this report.

The amount of biomass consumed during a prescribed fire (and therefore the emissions produced) is more easily controlled than for wildfires burning on dry, hot, windy days. When comparing alternatives, all of the action alternatives propose prescribed fire at some level which could impact air quality in the surrounding communities but in a controllable manner. The post-treatment conditions from implementing these alternatives would reduce the amount of biomass available to burn during wildfire which would moderate fire behavior, fire effects, and reduce the emissions potential of wildfire occurring in those areas. Alternative A does not propose any prescribed burning, and would produce increasing amounts of biomass available to burn in the event of a wildfire. This would have direct and most likely uncontrollable impacts on recreation and surrounding communities from emissions, as well as longer lasting fire effects.

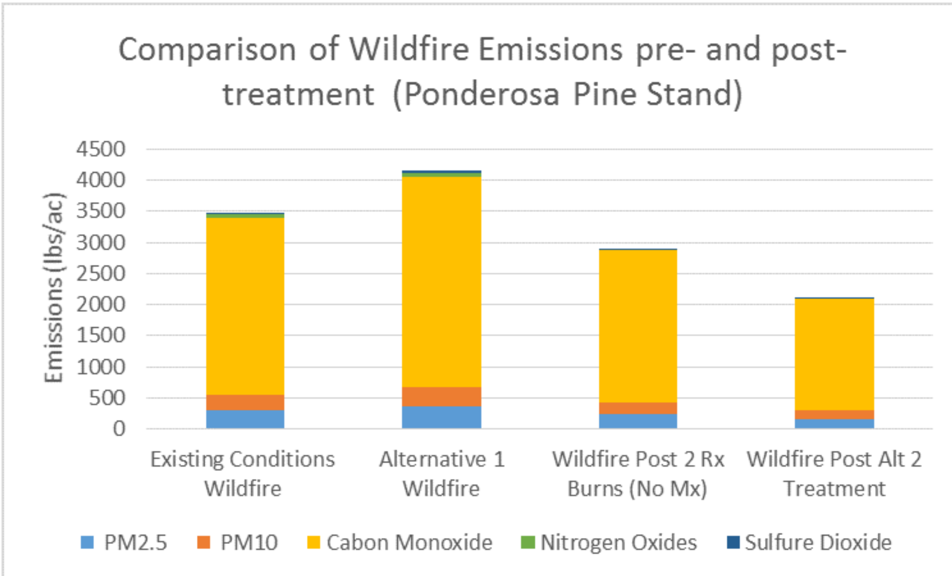


Figure 28. Comparison of Wildfire Emissions pre- and post-treatment in a Ponderosa Pine stand

Examining the cumulative effects from smoke on air quality differs from the evaluation of cumulative effects for many other resources because of the transient nature of air quality impacts. It is a relatively simple exercise to estimate the total tons per acres of emissions, but there is no calculation that correlates total annual emissions to total concentrations of emissions. As discussed earlier, air quality impacts are measured as concentrations of emissions, whether it's in µg/m3 for National Ambient Air Quality Standards (NAAQS), or in deciviews measuring visibility in Class I Areas. Cumulative effects are not the total emissions produced in a day or a year, but rather the concentration of all fire emissions in a given airshed at a given time. For NAAQS these concentrations have a varying time weighted period depending on the pollutant. For PM10 and PM2.5, they are measured as a 24 hour average, and as an annual arithmetic mean (Kleindienst 2012). The area of analysis discussed for air quality includes all three forests, the Verde River Airshed, the Lower Salt River Airshed, and the Little Colorado River Airshed (FIGURE XX). The season for broadcast burning is about April through October, pile burning is most often done in the winter months, and wildfires generally occur from April through October. More acres are proposed to be burned in the implementation than are currently being burned annually on all forests, so there would be prescribed burning on more days each year. However, after the first entry burn, fuel loads would be significantly decreased, so potential tons/acre of emissions would be significantly lower. Additionally, because of the decrease in fuels, fire behavior potential would also be significantly lower, so there would be more potential to burn on days with better smoke dispersal (higher winds and more lift).

The action alternatives propose prescribed burning at different levels. There are too many variables affecting the concentration of smoke at specific locations for a given prescribed fire for a spatially explicit evaluation on the scale of this project a year (or more) in advance of implementing a burn. Burn Plans are tiered to the NEPA document for which they direct prescribed fire implementation, and include spatial modeling that identifies what effects are expected where, and helps determine conditions that would produce the desired results to minimize impacts from emissions. It is reasonable to assume there is a correlation between the amount of smoke produced in a fire, and the potential for that smoke to produce undesirable impacts.

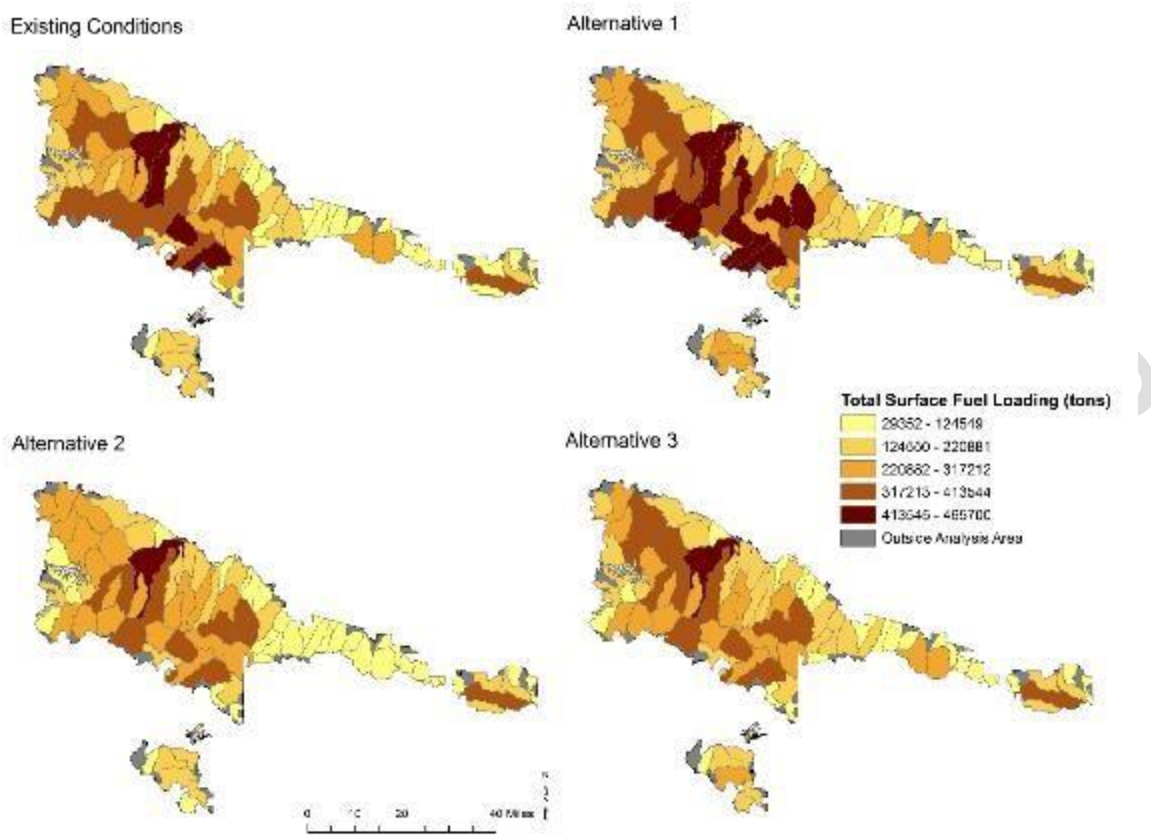


Figure 29. Surface fuel loading comparison

- *Cumulative Effects*

Cumulative effects include the effects of wildfire and vegetation management activities (mechanical treatments, prescribed fire and road decommissioning) on fire behavior and fire effects, including air quality. The time frame considered for past activities is about 10 years(2009-2018) based on recovery times and fuel accumulation rates and 10 years for future and foreseeable at which time the majority of the actions proposed will have been completed. Assumptions include that about 33% of acres burned in wildfires are high severity unless more specific data are available.

For the Rim portion of the DEIS, the effects of wildfires and other projects are considered for the approximately 1.239 million acres project area. Prevailing winds during fire season generally have a western, southwestern or southerly component to them, so fires burning adjacent to the western or southern border of the project area have a greater potential to burn into the project area than fires further away or in other directions. The USFS and the National Interagency Fire Center define ‘large fires’ as at least 300 acres in grass or shrub fuels, or at least 100 acres in timber (USDA 2014a). All fires included occurred from 2009 through 2018 and are at least 100 acres.

For the Environmental Consequences and Affected Environment analyses fire type, fire hazard index and surface fuel loading were evaluated for assessing movement towards desired conditions because they are indicators of potential fire behavior and effects, including air quality. Specific data are not available for many other projects. Fore projects included in the cumulative effects analysis, the treatments and the project objectives were considered as they relate to fire behavior and effects and air quality.

- *Cumulative Effects – Wildfires and Past Vegetation Management Activities and Wildfires s*

Table 30: Past Vegetation Management Activities

Project Name	Year	Mechanical	Prescribed Fire	Other Activities*	Forest
Bruno Thining and Slash	2009	0	70	0	Apache-Sitgreaves
whitcom wui	2009	925	0	0	Apache-Sitgreaves
hilltop II Fuels reduction	2011	0	799	616	Apache-Sitgreaves
Rodeo-Chediski Site Prep for Reforestation (#48660)	2016	0	0	0	Apache-Sitgreaves
Show Low South (#29987)	2011	3372	0	0	Apache-Sitgreaves
Rodeo-Chediski Fire RX Burn	2012	0	9506	14832	Apache-Sitgreaves
Timber Mesa/Vernon WUI	2012	18781	39760	20441	Apache-Sitgreaves
Rim Lakes Forest Restoration	2016	12483	1335	6447	Apache-Sitgreaves
Section 31 Fuels Restoration	2017	44	0	0	Apache-Sitgreaves
Larson Forest Restoration	2015	1867	0	2516	Apache-Sitgreaves
Upper Rocky Arroyo Restoration	2016	696	5411	3960	Apache-Sitgreaves
Post Tornado Resource Protection and Recovery	2011	765	0	0	Coconino
Lake Mary Road ROW Clearing (ADOT)	2016	788	0	0	Coconino
Upper Beaver Creek Watershed Fuel Reduction	2010	20608	64000	0	Coconino
Blue Ridge Community Fire Risk Reduction	2012	0	45000	0	Coconino
Clints Well Forest Resotration	2013	11	6639	0	Coconino
Hutch Mountain communication site	2017	1	0	0	Coconino
Parallel Prescribed Burn	2014	0	4759	0	Tonto
Cherry Prescribed Burn	2012	0	6582	0	Tonto
Myrtle WUI	2012	103891	75800	1835	Tonto
Pierce Reforestation	2009	0	0	406	Apache-Sitgreaves
Rodeo-Chediski Riparian Planting	2010	0	0	1	Apache-Sitgreaves

Bill Dick, Foster and Jones Spring Enhancement	2013	0	0	0	Coconino
long Valley work center meadow resotration	2018	0	0	18	Coconino
ASNF No NEPA docs found - various activities reported in FACTS but not tied to named project	unkno wn	42763	74202	16656	Apache-Sitgreaves
CONF No NEPA docs found - various activities reported in FACTS but not tied to named project	unkno wn	16049	15174	4695	Coconino
TNF No NEPA docs found - various activities reported in FACTS but not tied to named project	unkno wn	15565	26386	43711	Tonto

*Other activities include but not limited to fuels chipping, range forage improvement or manipulation, range vegetation control, wildlife habitat improvement, tree encroachment control, tree release, fuels compaction, special products removal, insect control and prevention planting, fuel break creation, cultural site protection, scarification and seeding, pruning,

Vegetation treatments and wildfires near, adjacent to, and within the project area have contributed to shaping the existing vegetation conditions for the treatment area with prescribed fire and/or mechanical treatments. Within the project area, near, adjacent to, or within the treatment area, there are about 131,945 acres on which projects were completed within the last 10 years that included mechanical thinning and/or prescribed burning acres (Table 30) and have, or may, affect potential fire behavior and effects within the treatment area. This was demonstrated by the Upper Beaver Creek prescribed fires completed in 2013. These treatments allowed for the 2017 Snake Ridge wildfire to be managed for resource objectives, and influenced the final fire perimeter. Objectives of these projects include fuels reduction, maintenance burning, recreating historic stand conditions in PJ (mixed severity), and reducing the risk of stand replacement fire and the rate of spread, intensity, and severity of wildfires that do occur.

From 2009 – 2018, 81 wildfires greater than 100 acres burned within the project acre, for a total of 217,780 acres burned (Figure 49). Many of the wildfires that burned within the project area in the last 10 years were managed primarily for resource objectives (as opposed to being managed primarily for suppression), 38 wildfires totaling 126,310 acres burned within the project area. Other fires may have had some resource benefit management objectives as well, however the information needed to assess this is not available. The fire severity of these fires was primarily

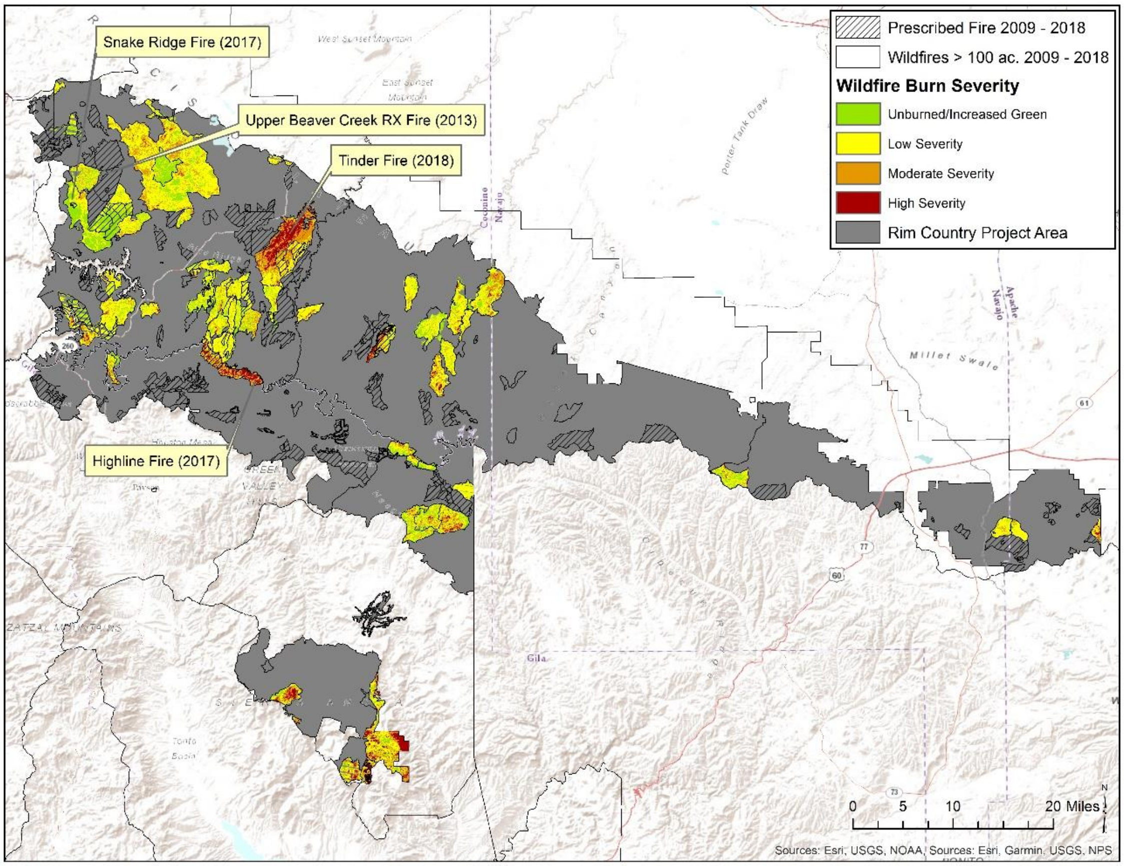


Figure 30: Recent Wildfire and Prescribed Fire (2009 – 2018) and the associated wildfire burn severity

low to moderate severity.

Approximately 12,193 acres have burned at high severity within the project area in the last 10 years. The Tinder fire (managed for suppression) burned with 27% (4,328 acres) high severity, and 33 homes were destroyed. The Highline fire (also managed for suppression) burned with 18% high severity. Post fire debris flows initiated in part from the Highline Fire claimed the lives of 10 people and caused significant damage to the watershed. These fires show the potential for loss given the current climate and vegetation conditions that produce high severity fires.

Management actions completed under all of the projects listed in Table 30 have decreased the potential for active crown fire and crown fire initiation on acres thinned, and the potential for crown fire initiation, and high severity effects from surface fire on about 100,840 acres of prescribed fire, and about 217,780 acres of wildfire. Across the project area other projects have affected vegetation in similar ways to those described under the alternatives, though there are some variations in treatments, particularly older fuels treatments. Past mechanical and prescribed fire treatments decreased the potential for crown fire by breaking up the vertical and horizontal continuity of canopy fuels. Prescribed fire and low severity wildfires further decreased the potential for crown fire, by removing additional ladder fuels, decreasing canopy bulk density, and raising canopy base height. Maintenance burning and wildfires decreased surface fuel loading in most areas burned, decreasing the potential intensity of subsequent fires.

Where wildfires and treatments as described above are close to, or adjacent to treatments proposed in the action alternatives, they would augment the moderating effect the change in fuel structure would have on wildfires moving though the area by increasing the acres where high severity fire effects would not be supported. These areas may also augment the potential size and locations of burn units for the action alternatives because the moderated fire behavior in burned and/or thinned areas would allow prescribed fire to be implemented with broader burn windows and higher intensity fire (if desired) while still meeting control and resource objectives.

The combined effects of these projects and the wildfires that have burned in and near the project area have created a mosaic of stand conditions across much of project area and the adjacent areas. These projects and wildfires have moved all of the treatment area in the project area and adjacent areas closer to the Historic Range of Variation, in addition to decreasing the potential size and severity of wildfires in areas within and adjacent to the proposed treatment areas.

- *Air Quality*

Past treatments and wildfires have decreased the potential emissions by removing canopy fuels, mostly from thinning, but also some from wildfire and prescribed fire. Low to Moderate severity fire would have consumed surface fuels, further decreasing potential for emissions on about 205,587 acres. Where wildfires burned with high severity (~12,193 acres in and adjacent to the project area), fine canopy fuels (needles and small twigs) were consumed leaving tree stems and branches, some of which have fallen and are now Coarse Woody Debris which have the potential to smolder for days, or weeks.

Cumulative Effects – Current and Foreseeable Vegetation Management Activities

Current, ongoing, and foreseeable projects within the Rim Country project area are shown in Table 62. Some of these projects are in the early stages of proposal development or are on hold, so their implementation is reasonably foreseeable but not assured. The acreages shown under mechanical vegetation management and fuels treatments are not all mutually exclusive. There are many acres on which proposed fuels treatments (mechanical and prescribed fire) overlap with proposed mechanical vegetation management treatments.

Table 62. Approximate Acres of Current, Ongoing, and Reasonably Foreseeable Vegetation Management Activities within the Project Area.

Treatment	Treatment Type	**Current Projects** Approximate Acres	**Reasonably Foreseeable Projects** Approximate Acres
	Thinning -Habitat Improvement	89,579	10,975
Mechanical Vegetation Management	Thinning – Fuels Reduction Emphasis	114,570	41,046
	Thinning – Restoration Emphasis	53,578	285
	Savanna/Grassland Restoration	0	39,000
	Salvage	5,678	0

Treatment	Treatment Type	**Current Projects** Approximate Acres	**Reasonably Foreseeable Projects** Approximate Acres
	Range Cover Manipulation	34,701	54,147
	Powerline Hazard Tree Removal and Right of Way	4,580	22,963
Total Mechanical:		**302,686**	**168,416**
Fuels Treatments (With Mechanical)	Mechanical Fuels Treatment	155,244	49,165
	Pile and Burn	133,168	5,070
	Broadcast Burn	250,373	59,640
Total Fuels Treatments		**538,175**	**113,875**

- *Alternative 1*

Fuel treatments have been, and continue to be implemented in WUI closest to major population centers, but much of the landscape is still vulnerable to undesirable fire behavior and effects, including changes in site productivity, loss of critical habitat, flooding, erosion, weed infestations, damaged infrastructure, and the longer term effects of having thousands of acres of dead trees nearby for decades.

Alternative 1 would continue to maintain 977,656 acres with increasing potential for high severity fire effects and behavior, though the effects would be mitigated to some degree by current and reasonably foreseeable projects, and any beneficial wildfires that may occur in the future. Alternative 1 would not contribute to improving the structure, composition, and patterns within the area proposed for treatment. Within the area considered for cumulative effects for Fire Ecology and Air Quality, there would be some improvement from the projects listed above, which includes nearly a half million acres of mechanical treatments as well as close to half a million acres of prescribed fire in current and foreseeable projects. However, the effects would be much less with no Rim Country treatment because of less spatial continuity between treatments than would be created with any of the action alternatives. It would not put the ponderosa pine forests, or the vegetative communities that are cohorts of ponderosa pine on trajectories towards being resilient or sustainable. The treatment area would continue to become less adapted to fire, increasing the potential for undesirable fire behavior and effects when wildfires do occur. When fires did occur, many would have potential for extreme fire behavior and could produce large areas of high severity, which could extend well outside of the treatment area. Many fires starting within the untreated project area would have potential to spread outside of the treatment area. Extreme fire behavior would put lives, property, infrastructure, and natural resources at risk. Effects would also extend well beyond the perimeters of the fire, and would include such effects as flooding, sedimentation, decreased water quality and quantity, decreased soil productivity, and other effects of fires burning out of their natural range of variation. In effect, Alternative A would produce the effects described for an area much larger than the area proposed for treatment in the action alternatives.

- *Air Quality*

Air quality would be unaffected by prescribed fire from the treatment area, but would be affected by prescribed fires from projects listed in. Emissions from close to 450,000 acres of prescribed fire from current, ongoing, and reasonably foreseeable projects would be managed in compliance with regulations and requirements of the Arizona Department of Environmental Quality (ADEQ). Wildfires occurring in the untreated areas would produce more emissions in areas that were not treated than in areas that were treated, and could augment the effects of prescribed fires (from current and foreseeable projects) on air quality. Areas with potential for impact would be the Colorado River Airshed, the Little Colorado River Watershed, and the Verde River Watershed. Class 1 airsheds that could be affected include Grand Canyon National Park, Sycamore Canyon Wilderness Area.

- *Cumulative Effects – Alternatives 2 and 3*

As described in the direct and indirect effects section, treatments proposed in Alternative 2 would move considerable acres toward desired conditions for fire behavior and effects across the project area. When considered with past wildfires, and past, current, ongoing, and reasonably foreseeable management activities, this alternative would augment the effects of proposed treatments at multiple scales, creating mosaics of potential fire behavior and effects, dominated by low severity fire. The proposed treatments would fill in most of the acres between past, current, ongoing, and foreseeable management activities, creating a more cohesive, contiguous, restored landscape across the project area.

- *Air Quality*

All prescribed fires would be implemented in compliance with ADEQ regulations and requirements as well as forest plan direction to meet legal standards and provide for public safety. Emissions from prescribed fires proposed in Alternatives 2 and 3 would utilize many of the same burn windows that the nearly 450,000 acres of current, ongoing, and reasonably foreseeable prescribed fire projects would use. However, the increased acres of prescribed fire would allow more flexibility for implementation, and may make it possible to burn more acres at once with the same impacts.

Areas with potential for impact include the Colorado River Airshed, the Little Colorado River Watershed, and the Verde River Watershed. Class 1 airsheds that could be affected include Petrified Forest National Park, Sierra Anches Wilderness Area and Mazatzal Wilderness Area. As more acres are treated, there would be broader burn windows, potentially resulting in more days of prescribed fire and days of air quality impacts.

Climate Change

All Alternatives

Climate change is expected to result in extreme weather conditions, with more extreme droughts and higher temperatures, making conditions for undesirable fire and insect outbreaks even more prevalent in the western United States. As a part of current, ongoing, and reasonably foreseeable management actions, there would be prescribed fire and mechanical thinning adjacent to, or within, the 4FRI Rim Country project area. Thinning, prescribed burning, or allowing wildfires that produce only low to moderate-severity effects reduces on-site carbon stocks and releases carbon into the atmosphere at a lower rate than high-severity fire.

Carbon sequestration is an important dynamic of climate change that has been and continues to be affected by current and past forest management. Fire suppression practices have changed the dynamics of fire in ponderosa pine forests across the southwest, resulting in greater fuel-loads and increased risk of uncharacteristic fire. Although current conditions, with dense forest stands can sequester more carbon than open forests, shrublands, or grasslands, it is not a stable state. These forests are prone to increasingly large, high severity wildfires, which release a pulse of carbon emissions, shifting carbon storage from live trees to standing dead trees and woody debris (North et al. 2009). Kolb et al. (2007) have shown that biomass and carbon may fail to recover; the Horseshoe Fire was still a net carbon source fifteen years after the fire. Savage and Mast (2005) showed that these conditions can persist for decades.

High severity fire in ponderosa pine forests releases large quantities of CO2 to the atmosphere. The emissions below are associated with ponderosa within an existing, healthy fire regime. Far more carbon is stored in the healthy ponderosa pine forest than the area recovering from a high severity fire. Figure 3-** displays modeled emissions from a VSS4 stand with no mechanical treatment prior to burning.

Both thinning and prescribed burning would help to mitigate the negative effects of stand replacing fire in dry, dense forests, by consuming less biomass and releasing less carbon into the atmosphere (Finkral and Evans 2008, Wiedinmyer and Hurteau 2010). They found that while the treatment initially produced a 30 percent reduction in the carbon held in trees, it significantly reduced the threat of an active crown fire, which they predicted would kill all the trees and release 3.7 tons of carbon per acre in any untreated areas. Such findings are especially important when one considers that climate change is expected to cause conditions that support uncharacteristic fire and insect outbreaks to become even more prevalent in the western United States. Thinning, prescribed burning, or allowing wildfires that produce only low to moderate severity effects reduces on-site carbon stocks and releases carbon into the atmosphere at a lower rate than high severity fire.