

**HISTORIC FIRE RETURN INTERVALS FOR ARIZONA and NEW MEXICO:
A REGIONAL PERSPECTIVE FOR SOUTHWESTERN LAND MANAGERS**

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Executive Summary

Numerous ecosystems in the southwestern U.S. have historically experienced frequent wildfires that have shaped and maintained their species composition and vegetation structure (McPherson 1995; Swetnam and Baisan 1996). A number of land management practices, including fire suppression and livestock grazing, have essentially removed fire from these systems (Wright and Bailey 1982; Swetnam and Baisan 1996, McPherson 1997, Miller and Rose 1999). In many forested systems, for example, fire suppression has led to significant structural changes, including unnaturally dense canopies with many small diameter trees and little herbaceous cover, and contributed to altered fire regimes (Covington and Moore 1994). Altered fire regimes (defined by Schmidt and others (2002) as a departure in the frequency and severity of fire from pre-Euro-American settlement or pre-1900) are now the norm in fire-adapted ecosystems in the Southwest and have resulted in increasingly larger wildfires and hence increasing attention to the way land is managed in the Southwest (Swetnam and Betancourt 1998).

We present a map of historic fire return intervals (FRI), pre-widespread-European settlement (1890), for the states of Arizona and New Mexico. Our goal in developing this map is not to re-create a fire regime study for the Southwest, but to add a literature-rich look at historic fire frequency for the southwestern United States. Through this analysis we identified historic fire return intervals (FRI) for 21 Potential Natural Vegetation Types (PNVTs) throughout Arizona and New Mexico. The FRI were then grouped into 6 FRI classes (1 = *High Frequency*, 2 = *Moderate Frequency*, 3 = *Variable Frequency*, 4 = *Low Frequency*, 5 = *None* or no frequency of fire, and 6 = *Not Applicable areas (NA)*, such as urban areas.

Results of this analysis revealed that, 64% of the land within the state boundaries of Arizona and New Mexico fall into the high or moderate frequency FRI classes, while 19% of both states are comprised of vegetation communities that experience fires infrequently. A majority of the “high frequency” class PNVTs consist of federal lands (23,569,851 acres). Of these, the USDA Forest Service (USFS) manages the largest proportion (48%). One exception is the Great Plains Grassland PNVT, of which 76% is found on private lands. Nonetheless, 63% of the Ponderosa Pine PNVT (a PNVT with the highest fire frequency) is found on USFS managed lands. Additionally, a moderate amount of the bi-state area is characterized by a highly variable fire frequency (13%).

A closer examination of USFS lands in Region 3 reveals that eight national forests (the Apache Sitgreaves, Carson, Coconino, Coronado, Gila, Lincoln, Prescott and Santa Fe) individually manage lands where 30% or more of the vegetation falls within the “high frequency” FRI class. Alternatively, 30% of the lands managed by the Tonto National Forest contain essentially non-fire adapted PNVTs (low or no fire frequencies; Riparian forests, Alpine and tundra, and Warm desert communities). Not surprisingly, an overall view of national forests in the southwest shows that 73% of these lands possess a high or moderate fire frequency while just 7% possess historically low fire frequency.

Based on these analyses it is clear that fire was historically of frequent occurrence in the Southwest, in non-desert locations. Given the overall high frequency of fire, historically, and the recent federal mandate to restore fire to fire adapted ecosystems, it will be necessary for land managers and the public to recalibrate their sense of fire frequency within the Southwest landscape.

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Introduction

Numerous ecosystems in the southwestern U.S. have historically experienced frequent wildfires that have shaped and maintained their species composition and vegetation structure (McPherson 1995; Swetnam and Baisan 1996). A number of land management practices, including fire suppression and livestock grazing, have essentially removed fire from these systems (Wright and Bailey 1982; Swetnam and Baisan 1996, McPherson 1997, Miller and Rose 1999). In many forested systems, for example, fire suppression has led to significant structural changes, including unnaturally dense canopies with many small diameter trees and little herbaceous cover, and contributed to altered fire regimes (Covington and Moore 1994). Altered fire regimes (defined by Schmidt and others (2002) as a departure in the frequency and severity of fire from pre-Euro-American settlement or pre-1900) are now the norm in fire-adapted ecosystems in the Southwest and have resulted in increasingly larger wildfires and hence increasing attention to the way land is managed in the Southwest (Swetnam and Betancourt 1998). Recently, this attention has led to nation wide coarse-scale mapping projects that investigate changes within fire regimes (Schmidt and others 2002) and/or work to map wildland fire, fuels, and behavior being conducted by LANDFIRE.

As an addition to this on-going body of work, we present a map of historic fire return intervals (FRI), pre-widespread-European settlement (1890), for the states of Arizona and New Mexico. Fire return intervals differ from fire regimes in that a FRI is a description of the number of times fire has occurred within an area, where as a fire regime is a description of not only the number of times a fire has occurred within an area but also describes the intensity of those fires. Our goal in developing this map is not to re-create a fire regime study for the Southwest, but to add a literature rich look at historic fire frequency for the southwestern United States. By elucidating the historic frequency of fire events in the Southwest, these maps should be generally useful to land managers and their partners as they provide a historical context for regional ecosystem and fire management planning. Additionally, we focus our discussion of fire frequency on those lands in the Southwest managed by the USDA Forest Service because of the predominance of fire-adapted ecosystems within the agency's jurisdictional boundaries.

Methods

We first acquired digital land cover data from the recently completed Southwest Regional Gap Analysis Project (SWReGAP), a collaborative project coordinated by the USGS's GAP Analysis Program covering five states (<http://earth.gis.usu.edu/swgap/>). This geo-referenced spatial data set is based on multi-season data acquired from Landsat 7 Enhanced Thematic Mapper 30 m satellite imagery and coincident digital elevation models (DEMs). Land cover types were interpreted and described by USGS and NatureServe ecologists using the National Vegetation Classification System (NVCS) on the level of ecological systems and alliances (*cf.* <http://earth.gis.usu.edu/swgap/index.html>). For the states of Arizona and New Mexico, 98 land cover types or ecosystem types, were identified. We then aggregated these ecosystem types into 21 Potential Natural Vegetation Types (PNVT) based on similar land cover type descriptions, locations within mapped boundaries of current and historic vegetation, and on-the-ground knowledge of TNC ecologists regarding the location of vegetation within the Southwest. Hence PNVTs are coarse-scale groupings of ecosystem

types that share a similar geography, vegetation, and historic ecosystem disturbances such as fire and flooding.

Our aggregation of current vegetation into potential vegetation classes is limited by the extent to which we could identify historic vegetation from the current description. For some ecosystem types this information was readily available in the NVCS descriptions. For example, the Apacherian-Chihuahuan Mesquite Upland Scrub ecosystem type description states that “during the last century, the area occupied by this system has increased through conversion of desert grasslands as a result of drought, overgrazing by livestock, and/or decreases in fire frequency.” For other ecosystem types, such as Aspen, historic vegetation information was not identifiable and so current vegetation serves as a proxy for historic vegetation. We realize that this is a limitation to the maps and information we present, however, we feel that even with this limitation that the maps offer a valuable synthesis of fire frequency information. Our crosswalk between SWReGAP ecosystem types and TNC-designated PNVTs can be found in Appendix 1. A GIS-based PNV map for the states of Arizona and New Mexico and corresponding area calculations were also generated (Appendix 1, Figure 1.1).

Historic fire return intervals (FRI) were assigned for each PNV based on currently available information found in the scientific literature. The FRIs identified represent a range of means across all fire sizes and types and were obtained from detailed fire scar data or knowledge of the fire ecology of a PNV and its dominant species and/or known fire histories of nearby vegetation. When fire scar data were available, FRIs were based on the range of mean FRIs given for all fire sizes and types for all studies within that PNV. It is important to note that these FRI ranges were not scale corrected and hence some of the variation captured in these FRI ranges may be the result of sampling intensity and distribution. When information was obtained from fire ecology information and/or nearby fire histories, the full FRI range cited from all sources within a PNV were used. A GIS map was then generated to reflect historic FRIs across the states of Arizona and New Mexico. We conducted two sets of analyses using the resultant historic FRI map: (1) area calculations of FRI by land tenure using SWReGAP stewardship data (<http://earth.gis.usu.edu/swgap/>), and (2) area calculations of FRI by USDA Forest Service (USFS) Region 3 forest boundaries.

Given the large regional scale at which we were attempting to identify FRI information, multiple ecosystem types were grouped together. Grouping vegetation at this scale necessitated the creation of PNVs that combined ecosystem types for which detailed FRI data exist with ecosystem types for which little is known. This was especially true of the Pinyon Juniper Woodland PNV which is composed of ecosystem types that exist across large elevation and geographic gradients. The Pinyon Juniper Woodland PNV includes pinyon juniper isolated mesa tops as well as juniper savannas intermixed with grasslands. Because of the varied location and community structure of this PNV, and limited and variable fire information available for the Southwest, we attributed this PNV with a large FRI range of between 6 and 400 years. Large-scale aggregation also created PNVs that incorporated geographically isolated ecosystem types that may be dissimilar in structure and FRI but were nevertheless grouped with the PNV that surrounded it. This was especially notable for the Great Basin/Colorado Plateau Grassland and Steppe PNV. We incorporated ecosystem types such as Inter-Mountain Basins Greasewood Flat and Mat Saltbush Shrubland into the Great Basin/Colorado Plateau Grassland and Steppe PNV instead of a shrubland type due to their limited

extent and their location within a known grassland area. Finally, we identified one PNVNT, Aspen Forest and Woodland, as a separate PNVNT although it exists as a component of other PNVNTs, such as Ponderosa Pine and Mixed Conifer Forest, with varying FRIs. This resulted in us attributing this PNVNT with a large FRI range of 2 to 300 years. While we made generalizations, in order to group ecosystem types within PNVNTs and attribute PNVNTs with mean FRI ranges, the overall results represent a spatially comprehensive synthesis of FRI information for the Southwest at a regional scale.

Additionally, it is important to note that the SWReGAP map has not been accuracy checked, however, we know from discussions with USFS staff that there are errors within this vegetation map. We realize that errors associated with the original map may be compounded by our grouping process and may result in erroneous information at a site specific scale. However, this crosswalk allows for a comprehensive look at FRIs across the entire southwest region, hence we feel that despite accuracy issues, this map provides a valuable tool for comparing fire frequencies, by PNVNTs, for Region 3 Forests and other landowners within Arizona and New Mexico.

Results and Discussion

We identified 21 historic fire return intervals (FRI), some of which overlap in number of years (Table 1). Figures 1 depicts this classification for the states of Arizona and New Mexico. To facilitate interpretation and to provide more context for the role fire played in pre-European settlement times in shaping the Southwest's ecosystems, FRI classes were broken into six groupings reflecting fire frequencies across PNVNTs. FRI class 1 represents those PNVNTs with "*High Frequency*," FRI class 2 represents those PNVNTs with "*Moderate Frequency*," FRI class 3 represents PNVNTs with "*Variable Frequency*", FRI class 4 represents PNVNTs with "*Low Frequency*", FRI class 5 represents PNVNTs without a fire frequency "*None*", and FRI class 6 represents areas where fire frequency is not applicable "*N/A*", such as urban areas. Figure 2 provides a graphical interpretation of these groupings.

Table 1. Identification of scientific literature sources used in the creation of the historic fire return intervals (FRIs) for Arizona and New Mexico TNC-designated PNVNTs. FRIs and corresponding classes are listed in order of highest fire frequencies.

Potential Natural Vegetation Type (TNC-designated)	Historic Mean Fire Return Interval (years)	FRI Class	Source(s)
Ponderosa Pine	2.07 – 17.1	1	Sneed and others 2002; Swetnam and Baisan 1996
Montane Grassland	2.07 – 22	1	Based on ponderosa pine and mixed conifer mean FRIs (Dick-Peddie 1993; White 2002)
Madrean Encinal Woodland	2.5 – 10	1	Based on semi-desert grassland and Madrean pine oak woodland mean FRIs
Semi-desert Grassland	2.5 – 10	1	Bahre 1985; Kaib and others 1996; McPherson 1995
Madrean Pine Oak Woodland	3 – 8	1	Danzer and others 1996; Fulé and Covington 1997; Fulé and Covington 1998; Fulé and Covington 1999; Fulé and others 1995; Fulé and others 1997; Fulé and others 2005; Kaib and others 1996; Swetnam and Baisan 1995; Swetnam and Baisan 1996; Swetnam and others 1992

Great Plains Grassland	5 – 10	1	Brockway and others 2002 ; Wright and Bailey 1982
Mixed Conifer Forest	9.9 – 22	2	Baisan and Swetnam 1990; Dietrich 1983; Grissino-Mayer and others 1995; Heinlein and others 2005
Great Basin/Colorado Plateau Grassland & Steppe	10 – 30	2	Wright and Bailey 1982
Sagebrush Shrubland	12 – 70	2	Gottfried and others 1995; Miller and Tausch 2001; Wright and Bailey 1982
Interior Chaparral	20 – 100	2	Cable 1975; Pase and Brown 1982; Sneeade and others 2002; Wright and Bailey 1982
Aspen Forest and Woodland (all types)	2.5 – 400	3	Based on ponderosa pine, mixed conifer, and spruce fir mean FRIs
Pinyon Juniper Woodland	6 – 400	3	Baker and Shinneman 2004; Gottfried and others 1995; Paysen and others 2000; Wright and Bailey 1982
Subalpine Grassland	9.9 – 400	3	Based on mixed conifer and spruce fir mean FRIs (Dick-Peddie 1993)
Spruce Fir Forest	150 – 400	4	Grissino-Mayer and others 1995; Fulé and others 2003; Swetnam and others 2005
(Warm) Desert Communities	> 250	4	Thomas 1991
Gallery Coniferous Riparian Forest	350 – 400	4	Crane 1982; Pavek 1993 b
Cottonwood Willow Riparian Forest	Infrequent – similar to adjacent fire regimes	4	Reed 1993; Stromberg and Ortiz-Zuazaga 1998; Taylor 2000; Tirmenstein 1990; Uchytel 1990 a; Wright and Bailey 1982
Mixed Broadleaf Deciduous Riparian Forest	Infrequent – similar to adjacent fire frequencies	4	Pavek 1993 a; Uchytel 1990 b; Wright and Bailey 1982
Montane Willow Riparian Forest	Infrequent – similar to adjacent fire frequencies	4	Crane 1989; Tesky 1992; Uchytel 1989
Wetland/Cienega	Infrequent – similar to adjacent fire frequencies	4	Davis and others 2002
Alpine & Tundra	None	5	Moir 1993
Urban/Agricultural/Barren/Other	NA	6	NA

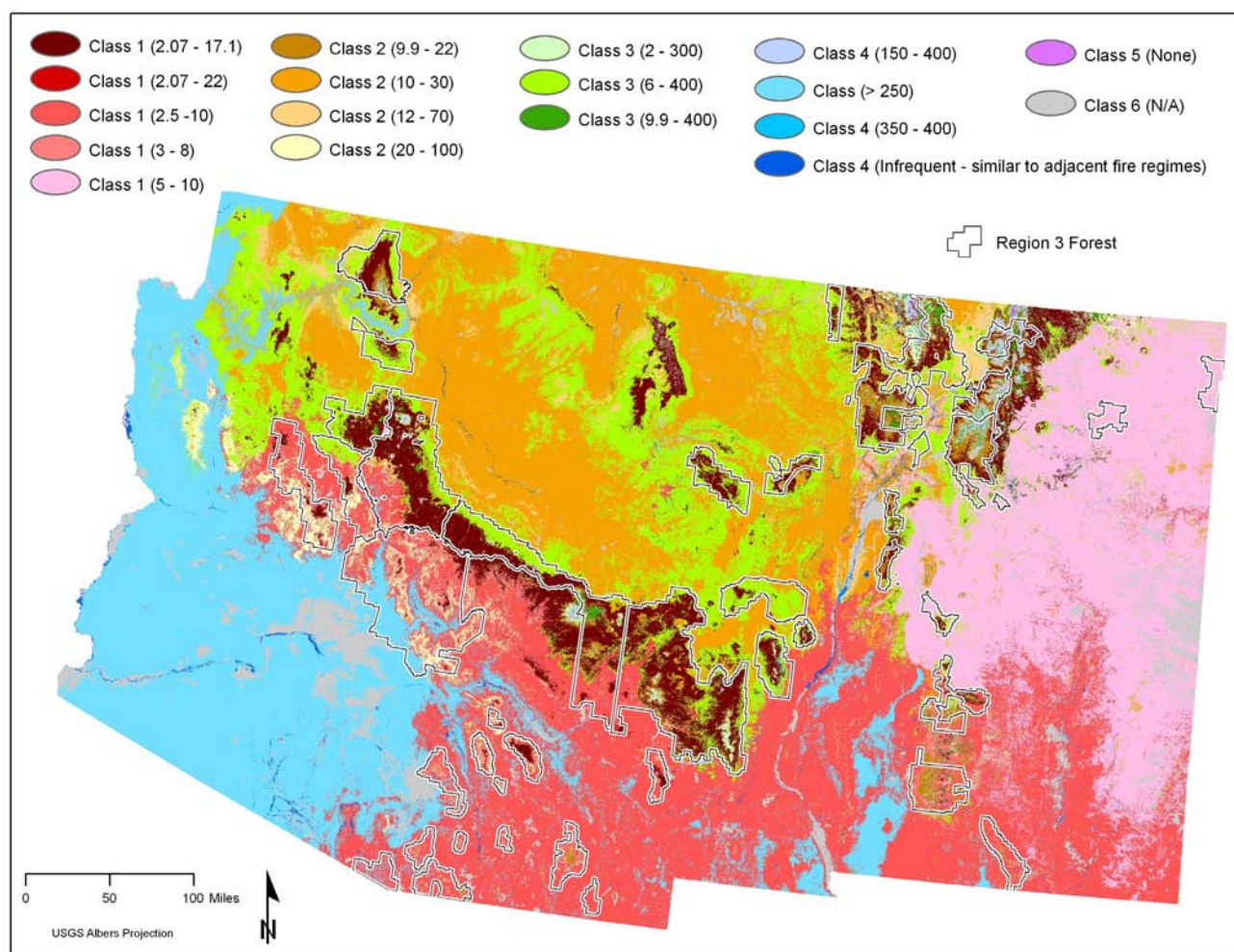


Figure 1. Historic fire return interval (FRI) map for Arizona and New Mexico circa 1890. Classes based on TNC-designated PNVs aggregated from SWReGAP ecosystem types. FRI classes and related PNVs are as follows: (1) Ponderosa Pine, Montane Grassland, Madrean Encinal, Semi-desert Grassland, Madrean Pine Oak Woodland, and Great Plains Grassland; (2) Mixed Conifer Forest, Great Basin/Colorado Plateau Grassland & Shrubland, Sagebrush Shrubland, Interior Chaparral; (3) Aspen Forest and Woodland, Pinyon Juniper Woodland, and Subalpine Grassland; (4) Spruce Fir Forest, Desert Communities, Gallery Coniferous Riparian Forest, Cottonwood Willow Riparian Forest, Mixed Broadleaf Deciduous Riparian Forest, Montane Willow Riparian Forest, and Wetland/Cienega; (5) Alpine & Tundra; (6) Urban/Agriculture/Barren/Other.

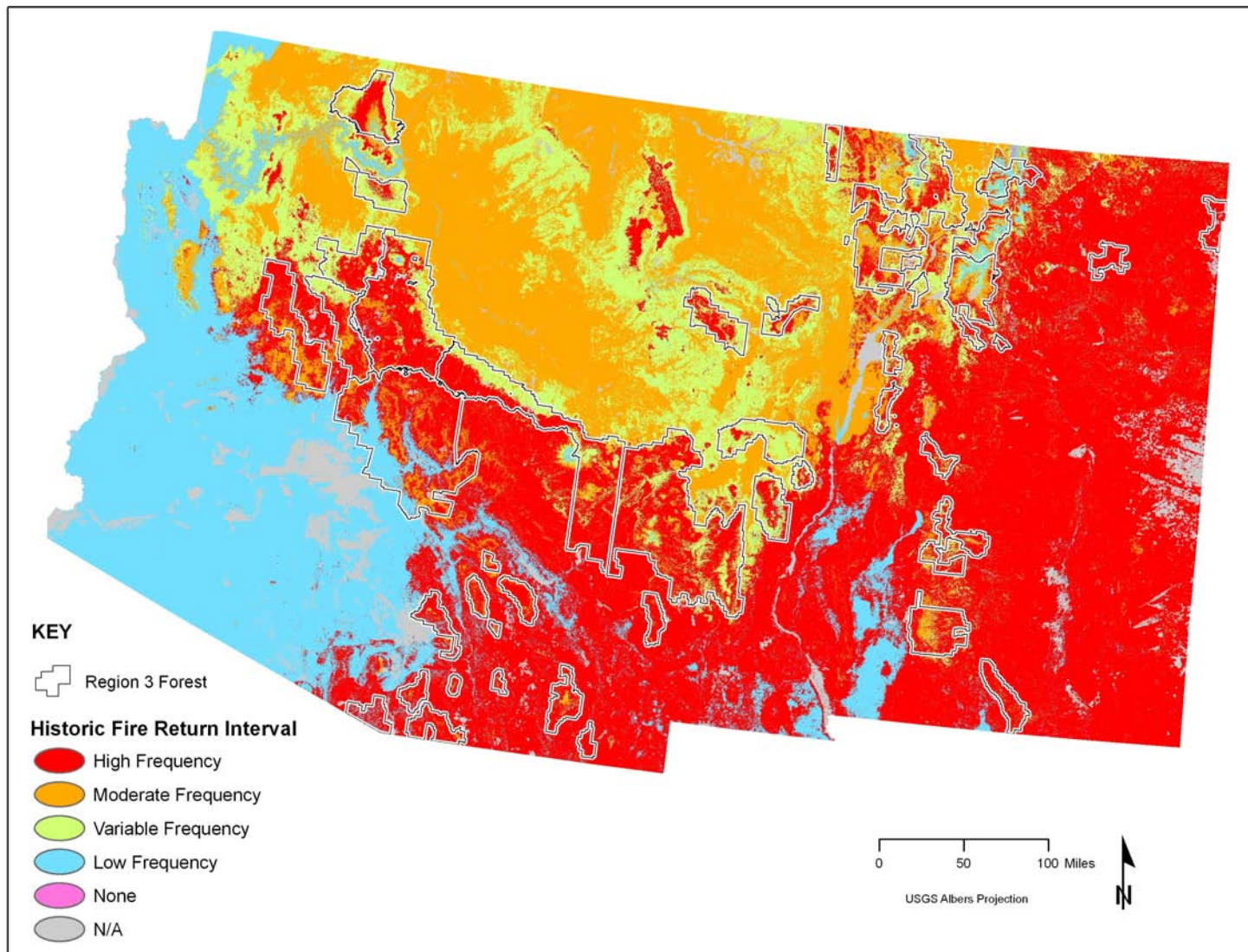


Figure 2. Fire frequency groupings map for Arizona and New Mexico. See Table 2 for description of FRI classes and corresponding PNVTs.

Land tenure

Sixty four percent of the land within the state boundaries of Arizona and New Mexico fall into the high or moderate frequency FRI classes, while 19% of this area is comprised of vegetation communities that experience fires infrequently (Figure 3). A majority of the “high frequency” FRI classes consist of federal lands (23,569,851 acres). Of these, the USDA Forest Service (USFS) manages the largest proportion (48%). One exception is Great Plains Grassland, of which 76% is found on private lands. Nonetheless, 63% of the Ponderosa Pine PNVT (a PNVT with one of the highest fire frequencies) is found on USFS managed lands (Table 2). Additionally, a moderate amount of the landscape is characterized by a highly variable fire frequency (13%).

Table 2. Percent fire return interval (FRI) class across land tenure for Arizona and New Mexico (rows total to 100%). Acreage calculations can be found in Appendix 1, Table 1.2. All calculations are based upon USGS Albers projection NAD83 (USGS 2005).

FRI CLASS and ASSOCIATED TNC- designated PNVT		All Other Feds	Other	Private	State	Tribal	USFS
HIGH FREQUENCY (Class 1 = 2.07 – 22 years)	Ponderosa Pine	2	0	15	2	17	63
	Montane Grassland	0	0	46	0	6	47
	Madrean Encinal	11	0	19	9	18	42
	Woodland						
	Semi-desert Grasslands	37	1	30	22	4	6
	Madrean Pine Oak Woodland	2	0	6	2	31	59
	Great Plains Grassland	6	0	76	15	1	2
MODERATE FREQUENCY (Class 2 = 9.9-100 years)	Mixed Conifer Forest	5	3	13	1	11	68
	Great Basin/Colorado Plateau	14	0	23	11	49	3
	Grassland and Steppe						
	Sagebrush Shrubland	28	0	24	7	36	5
	Interior Chaparral	16	0	19	11	11	43
VARIABLE FREQUENCY (Class 3 = 150 -400 years)	Aspen Forest and Woodland	1	2	18	0	15	64
	Pinyon Juniper Woodland	19	0	24	8	31	18
	Sub-alpine Grassland	3	4	30	2	9	52
	Spruce Fir Forest	2	2	22	0	12	61

FRI CLASS and ASSOCIATED TNC- designated PNT		All Other Feds	Other	Private	State	Tribal	USFS
LOW FREQUENCY (Class 4 = 150 -400	Desert Communities Gallery	57	1	13	13	13	4
	Coniferous Riparian Forest Cottonwood	1	0	87	1	6	6
	Willow Riparian Forest Mixed Broad	16	2	35	8	36	4
	Leaf Deciduous Riparian Forest Montane	18	1	39	6	22	14
	Willow Riparian Forest Wetland/Cieneg a	14	4	36	10	10	27
		18	2	49	10	9	12
	NONE (Class 5)	0	0	80	0	0	20
	NA (Class 6)	5	1	76	5	11	2

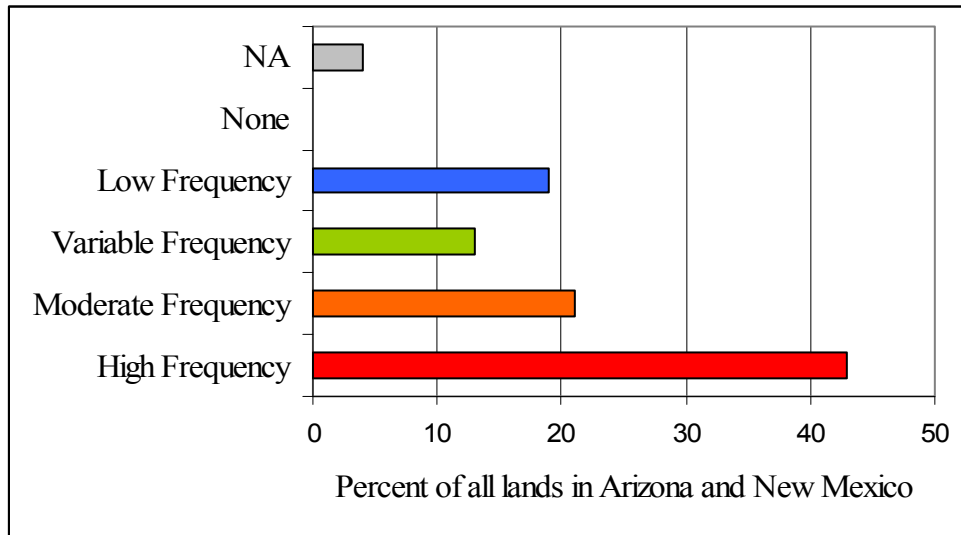


Figure 3. Percent of FRI class groupings across Arizona and New Mexico.

Forest Service Lands

A closer examination of USFS lands in Region 3 reveals that eight national forests (the Apache Sitgreaves, Carson, Coconino, Coronado, Gila, Lincoln, Prescott and Santa Fe) individually manage lands where 30% or more of the vegetation falls within the “high frequency” FRI class (Table 3). Alternatively, 30% of the lands managed by the Tonto National Forest contains essentially non-fire adapted FRI classes (Riparian forests, Alpine and tundra, and Warm desert communities). Not surprisingly, an overall view of national forests in the southwest shows that 73% of these lands possess a high or moderate fire frequency while just 7% possess historically low fire frequency (Figure 4).

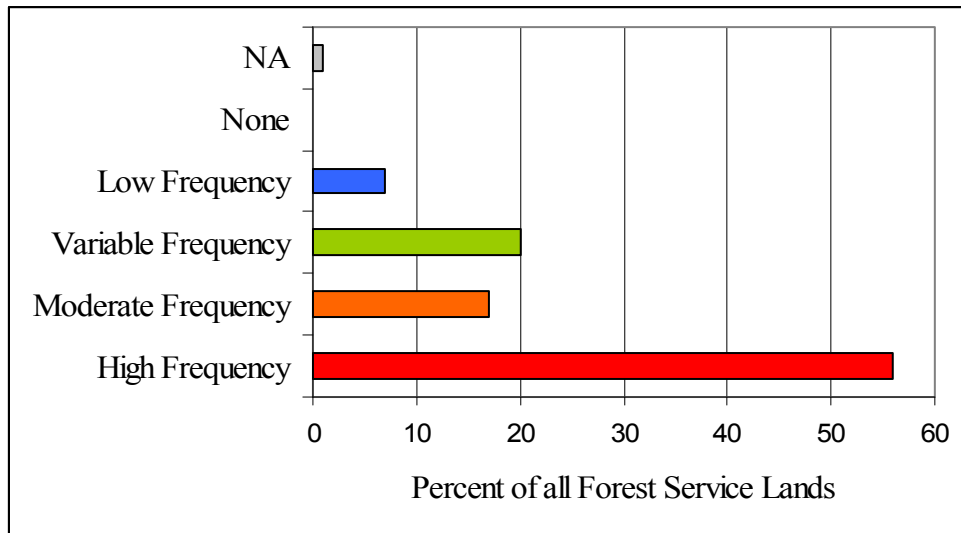


Figure 4. Percent of FRI class groupings across all USFS Region 3 national forests.

Conclusions

Based on these analyses it is clear that fire was historically of frequent occurrence in the Southwest, in non-desert locations. Given the overall high frequency of fire, historically, and the recent federal mandate to restore fire to fire adapted ecosystems, it will be necessary for land managers and the public to recalibrate their sense of fire frequency within the Southwest landscape. It is important to mention that while fire was historically of frequent occurrence, the intensity of these frequent fires, in many of the PNVTs, was lower than the intensity of fires that burn within these systems today. Due to the changes in fire frequency and intensity over the last 120 years, we cannot expect to simply re-introduce fire at the same frequency that it occurred historically. However, we should manage vegetation with an understanding of the frequency of historic processes.

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Table 3. Percent fire return interval (FRI) class across USDA Forest Service Region 3 national forests (rows total to 100%). Acreage calculations can be found in Appendix 1, Table 1.3. All calculations are based upon USGS Albers projection NAD83 (USGS 2005).

FRI CLASS and ASSOCIATED TNC- designated PNT		Apache- Sitgreaves	Carson	Cibola	Coconino	Coronado	Gila	Kaibab	Lincoln	Prescott	Santa Fe	Tonto
HIGH FREQUENCY (Class 1 = 2.07 – 22 years)	Ponderosa Pine	16	7	9	14	1	30	10	1	2	9	2
	Montane Grassland	0	97	0	0	0	0	0	0	0	3	0
	Madrean Encinal Woodland	10	0	1	8	26	14	0	12	14	0	15
	Semi-desert Grasslands	5	0	2	7	25	3	0	12	9	0	37
	Madrean Pine Oak Woodland	2	0	0	4	17	4	0	19	12	0	41
	Great Plains Grassland	0	8	61	0	0	0	0	6	0	25	0
	Mixed Conifer Forest Great	12	16	6	3	2	13	6	10	0	32	0
MODERATE FREQUENCY (Class 2 = 9.9-100 years)	Basin/Colorado Plateau	9	7	17	23	2	17	15	0	2	6	1
	Grassland and Steppe Sagebrush Shrubland	0	43	1	0	0	0	50	0	0	6	0
	Interior Chaparral	1	2	1	6	11	4	1	4	27	2	40
	Aspen Forest and Woodland	9	35	4	5	2	27	2	2	0	14	0
VARIABLE FREQUENCY (Class 3 = 150 –400 years)	Pinyon Juniper Woodland	11	8	21	9	0	17	19	2	4	8	0

FRI CLASS and ASSOCIATED TNC- designated PNVT		Apache- Sitgreaves	Carson	Cibola	Coconino	Coronado	Gila	Kaibab	Lincoln	Prescott	Santa Fe	Tonto
	Sub-alpine Grassland	18	37	1	10	0	3	9	5	0	18	0
LOW FREQUENCY (Class 4 = 150 -400 years)	Spruce Fir Forest	5	49	3	2	0	5	6	5	0	25	0
	Desert Communities	0	0	2	2	17	0	1	0	1	0	76
	Gallery Coniferous	0	100	0	0	0	0	0	0	0	0	0
	Riparian Forest Cottonwood	0	2	5	1	27	0	0	5	1	19	40
	Willow Riparian Forest	0	5	34	1	2	0	0	21	1	13	23
	Mixed Broad Leaf Deciduous	0	5	34	1	2	0	0	21	1	13	23
	Riparian Forest Montane	8	6	9	10	11	5	0	18	10	2	20
	Willow Riparian Forest	5	5	1	15	0	8	9	3	2	30	22
	Wetland/Cieneg a	5	5	1	15	0	8	9	3	2	30	22
NONE (Class 5)	Alpine and Tundra	0	19	0	81	0	0	0	0	0	0	0
NA (Class 6)	Urban and Other	5	5	1	15	0	8	9	3	2	30	22

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Appendix 1

Table 1.1. TNC-designated Potential Natural Vegetation Types (PNVT) crosswalk to SWReGAP ecosystem types.

TNC-PNVT	SWReGAP Ecosystem Type	Total
Alpine and Tundra	Rocky Mountain Alpine Bedrock and Scree	1
	Rocky Mountain Alpine Fell-Field	1
	Rocky Mountain Dry Tundra	1
Alpine and Tundra Total		3
Aspen Forest and Woodland	Inter-Mountain West Aspen-Mixed Conifer Forest and Woodland	1
	Rocky Mountain Aspen Forest and Woodland	1
Aspen Forest and Woodland Total		2
Cottonwood Willow Riparian Forest	Western Great Plains Riparian Woodland and Shrubland	1
	Invasive Southwest Riparian Woodland and Shrubland	1
	North American Warm Desert Riparian Mesquite Bosque	1
Cottonwood Willow Riparian Forest Total		3
Desert Communities	Chihuahuan Mixed Salt Desert Scrub	1
	Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub	1
	Chihuahuan Succulent Desert Scrub	1
	Mojave Mid-Elevation Mixed Desert Scrub	1
	North American Warm Desert Active and Stabilized Dune	1
	North American Warm Desert Badland	1
	North American Warm Desert Bedrock Cliff and Outcrop	1
	North American Warm Desert Pavement	1
	North American Warm Desert Playa	1
	North American Warm Desert Volcanic Rockland	1
	North American Warm Desert Wash	1
	Sonora-Mojave Creosotebush-White Bursage Desert Scrub	1
	Sonora-Mojave Mixed Salt Desert Scrub	1
	Sonoran Mid-Elevation Desert Scrub	1
	Sonoran Paloverde-Mixed Cacti Desert Scrub	1
Desert Communities Total		15
Gallery Coniferous Riparian Forest	Rocky Mountain Subalpine-Montane Riparian Woodland	1
Gallery Coniferous Riparian Forest Total		1
Great Basin/Colorado Plateau Grassland and Steppe	Colorado Plateau Blackbrush-Mormon-tea Shrubland	1
	Colorado Plateau Mixed Bedrock Canyon and Tableland (not with Mixed Conifer)	1
	Inter-Mountain Basins Greasewood Flat	1
	Inter-Mountain Basins Juniper Savanna	1
	Inter-Mountain Basins Mat Saltbush Shrubland	1
	Inter-Mountain Basins Mixed Salt Desert Scrub	1
	Inter-Mountain Basins Montane Sagebrush Steppe	1
	Inter-Mountain Basins Playa	1
	Inter-Mountain Basins Semi-Desert Grassland	1
	Inter-Mountain Basins Semi-Desert Shrub Steppe	1
	Inter-Mountain Basins Shale Badland	1
	Inter-Mountain Basins Volcanic Rock and Cinder Land	1
	Inter-Mountain Basins Wash	1
	Invasive Annual and Biennial Forbland	1
	Invasive Annual Grassland	1
	Southern Colorado Plateau Sand Shrubland	1
Great Basin/Colorado Plateau		16

TNC-PNVT	SWReGAP Ecosystem Type	Total
Grassland and Steppe Total		
Great Plains Grassland	Southern Rocky Mountain Juniper Woodland and Savanna	1
	Western Great Plains Cliff and Outcrop	1
	Western Great Plains Foothill and Piedmont Grassland	1
	Western Great Plains Mesquite Woodland and Shrubland	1
	Western Great Plains Sandhill Shrubland	1
	Western Great Plains Shortgrass Prairie	1
Great Plains Grassland Total		6
Interior Chaparral	Coahuilan Chaparral	1
	Great Basin Semi-Desert Chaparral	1
	Mogollon Chaparral	1
	Rocky Mountain Gambel Oak-Mixed Montane Shrubland (Not with Mixed Conifer)	1
Interior Chaparral Total		4
Madrean Encinal Woodland	Madrean Encinal	1
	Madrean Pinyon-Juniper Woodland	1
Madrean Encinal Woodland Total		2
Madrean Pine Oak Woodland	Madrean Pine-Oak Forest and Woodland	1
		1
Madrean Pine Oak Woodland Total		2
Mixed Broad Leaf Deciduous Riparian Forest	Rocky Mountain Bigtooth Maple Ravine Woodland	1
	Rocky Mountain Lower Montane Riparian Woodland and Shrubland	1
	North American Warm Desert Riparian Woodland and Shrubland	1
Mixed Broad Leaf Deciduous Riparian Forest Total		3
Mixed Conifer Forest	Madrean Upper Montane Conifer-Oak Forest and Woodland	1
	Recently Logged Areas	1
	Rocky Mountain Cliff and Canyon	1
	Rocky Mountain Montane Dry-Mesic Mixed Conifer Fores	1
	Rocky Mountain Montane Mesic Mixed Conifer Forest an	1
Mixed Conifer Forest Total		5
Montane Grassland	Rocky Mountain Subalpine Mesic Meadow	1
Montane Grassland Total		1
Montane Willow Riparian Forest	North American Warm Desert Lower Montane Riparian Woodland	1
	Rocky Mountain Subalpine-Montane Riparian Shrubland	1
Montane Willow Riparian Forest Total		2
Pinyon Juniper Woodland	Colorado Plateau Pinyon-Juniper Shrubland	1
	Colorado Plateau Pinyon-Juniper Woodland	1
	Great Basin Pinyon-Juniper Woodland	1
	Recently Chained Pinyon-Juniper Areas	1
	Rocky Mountain Lower Montane-Foothill Shrubland (Not with Montane Conifer)	1
	Southern Rocky Mountain Pinyon-Juniper Woodland	1
Pinyon Juniper Woodland Total		6
Ponderosa Pine	Rocky Mountain Ponderosa Pine Woodland	1
Ponderosa Pine Total		1
Sagebrush Shrubland	Colorado Plateau Mixed Low Sagebrush Shrubland	1
	Inter-Mountain Basins Active and Stabilized Dune	1
	Inter-Mountain Basins Big Sagebrush Shrubland	1
Sagebrush Shrubland Total		3
Semi-desert Grasslands	Apacherian-Chihuahuan Mesquite Upland Scrub	1
	Apacherian-Chihuahuan Piedmont Semi-Desert Grassland	1
	Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub	1
	Chihuahuan Gypsophilous Grassland and Steppe	1

TNC-PNVT	SWReGAP Ecosystem Type	Total
	Chihuahuan Sandy Plains Semi-Desert Grassland	1
	Chihuahuan-Sonoran Desert Bottomland and Swale Grass	1
	Invasive Perennial Grassland	1
	Madrean Juniper Savanna	1
Semi-desert Grasslands Total		8
Spruce Fir Forest	Rocky Mountain Lodgepole Pine Forest	1
	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest	1
	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and	1
	Rocky Mountain Subalpine-Montane Limber-Bristlecone	1
Spruce Fir Forest Total		4
Sub-alpine Grassland	Southern Rocky Mountain Montane-Subalpine Grassland	1
Sub-alpine Grassland Total		1
Wetland/Cienaga	North American Arid West Emergent Marsh	1
	Rocky Mountain Alpine-Montane Wet Meadow (Not with Montane grasslands)	1
	Western Great Plains Saline Depression Wetland	1
Wetland/Cienaga Total		3

Table 1.2. Acreages by fire return interval (FRI) class for the states of Arizona and New Mexico by land tenure (data based on SWReGAP stewardship data). All calculations are based upon USGS Albers projection NAD83 (USGS 2005).

Historic Fire Return Interval (FRI), years	FRI Class & PNV	All Other Fed	Other	Private	State	Tribal	USFS
2.07 – 17.1	1 Ponderosa Pine	224,011	44,123	1,408,402	147,013	1,588,888	5,835,394
2.07 – 22	1 Montane Grassland	10	6	16,916	0	2,323	17,206
2.5 – 10	1 Madrean Encinal Woodland	719,447	2,157	1,259,842	609,288	1,165,201	2,736,198
2.5 – 10	1 Semi-desert Grasslands	9,896,323	184,995	7,996,824	5,914,714	951,875	1,642,361
3 – 8	1 Madrean Pine Oak Woodland	26,957	193	89,215	30,105	438,390	831,905
5 – 10	1 Great Plains Grassland	1,323,225	11,387	16,055,178	3,158,254	181,062	316,814
9.9 – 22	2 Mixed Conifer Forest	81,167	52,048	225,926	13,765	191,057	1,216,376
10 – 30	2 Great Basin/Colorado Plateau Grassland and Steppe	3,491,846	18,545	5,695,532	2,599,302	12,175,871	684,383
12 – 70	2 Sagebrush Shrubland	774,280	11,691	642,128	184,716	977,178	134,539
20 – 100	2 Interior Chaparral	486,205	10,988	590,557	350,791	333,123	1,345,884
2.5 – 400	3 Aspen Forest and Woodland	3,873	11,564	93,203	2,239	75,933	335,915

Historic Fire Return Interval (FRI), years	FRI Class & PNT	All Other Fed	Other	Private	State	Tribal	USFS
6 – 400	3 Pinyon Juniper Woodland	3,470,842	51,643	4,442,461	1,505,366	5,647,841	3,375,212
9.9 – 400	3 Sub-alpine Grassland	16,553	27,026	183,444	10,676	55,740	311,699
150 – 400	4 Spruce Fir Forest	11,822	10,425	128,233	2,256	71,987	355,165
> 250	4 Desert Communities	15,035,621	252,764	3,418,209	3,340,618	3,429,576	1,018,346
350 – 400	4 Gallery Coniferous Riparian Forest	10	1	1,145	12	76	73
Infrequent – similar to adjacent fire regimes	4 Cottonwood Willow Riparian Forest	83,272	10,812	183,646	40,733	192,641	19,405
Infrequent – similar to adjacent fire frequencies	4 Mixed Broad Leaf Deciduous Riparian Forest	53,184	4,261	115,811	17,332	65,485	42,591
Infrequent – similar to adjacent fire frequencies	4 Montane Willow Riparian Forest	15,898	4,145	42,799	11,503	12,139	31,195
Infrequent – similar to adjacent fire frequencies	4 Wetland/Cienega	12,880	1,107	35,077	7,085	6,773	8,906
None	5 Alpine and Tundra	0	0	6,082	0	6	1,529

Historic Fire Return Interval (FRI), years	FRI Class & PNT	All Other Fed	Other	Private	State	Tribal	USFS
NA	6 Urban and Other	280,885	79,978	4,496,824	280,662	619,839	129,503

Table 1.3. Acreages by fire return interval (FRI) class for National Forests contained in the USDA Forest Service Region 3. All calculations are based upon USGS Albers projection NAD83 (USGS 2005).

Historic Fire Return Interval (FRI), years	FRI Class & PNVT	Apache- Sitgreaves	Carson	Cibola	Coconino	Coronado	Gila	Kaibab	Lincoln	Prescott	Santa Fe	Tonto	Total
2.07 – 17.1	1 Ponderosa Pine	926,398	408,070	509,062	814,731	65,352	1,754,596	555,246	68,515	98,390	505,652	130,237	5,836,249
2.07 – 22	1 Montane Grassland	0	16,612	0	0	0	0	0	68	0	508	0	17,188
2.5 – 10	1 Madrean Encinal Woodland	275,325	0	18,888	219,642	723,945	396,357	464	331,714	370,189	109	399,792	2,736,424
2.5 – 10	1 Semi-desert Grasslands	74,035	177	41,052	106,745	406,439	47,891	6,743	203,817	146,529	111	608,621	1,642,160
3 – 8	1 Madrean Pine Oak Woodland	16,600	8	558	29,719	139,207	32,136	2,872	162,185	103,542	332	344,860	832,019
5 – 10	1 Great Plains Grassland	0	24,972	191,860	0	0	0	0	19,786	0	80,208	0	316,827
9.9 – 22	2 Mixed Conifer Forest	146,291	189,579	74,146	30,960	26,776	157,164	70,571	123,115	0	392,848	5,140	1,216,591
10 – 30	2 Great Basin/Colorado Plateau Grassland and Steppe	62,520	51,185	113,327	159,549	13,941	115,892	100,616	1,185	13,911	43,041	9,369	684,537
12 – 70	2 Sagebrush Shrubland	654	57,884	745	84	0	189	67,210	3	0	7,790	0	134,560

Historic Fire Return Interval (FRI), years	FRI Class & PNVT	Apache- Sitgreaves	Carson	Cibola	Coconino	Coronado	Gila	Kaibab	Lincoln	Prescott	Santa Fe	Tonto	Total
20 – 100	2 Interior Chaparral	18,019	32,816	9,474	76,771	151,392	48,811	19,489	53,266	368,286	23,409	544,002	1,345,734
2.5 – 400	3 Aspen Forest and Woodland	28,985	118,438	13,455	18,261	6,625	90,282	7,669	6,068	0	45,942	147	335,873
6 – 400	3 Pinyon Juniper Woodland	381,926	278,117	724,637	290,201	101	578,597	640,028	70,754	138,414	269,444	3,291	3,375,508
9.9 – 400	3 Sub-alpine Grassland	56,800	113,874	1,623	31,815	0	10,218	26,806	14,493	0	55,759	22	311,409
150 – 400	4 Spruce Fir Forest	18,525	174,958	10,752	7,210	0	17,931	20,826	17,609	0	87,359	3	355,173
> 250	4 Desert Communities	782	0	19,946	22,953	173,705	4,694	10,961	3,207	10,116	0	771,587	1,017,951
350 – 400	4 Gallery Coniferous Riparian Forest	0	73	0	0	0	0	0	0	0	0	0	73
Infrequent –similar to adjacent fire regimes	4 Cottonwood Willow Riparian Forest	0	297	960	181	5,291	16	27	980	207	3,582	7,820	19,361

Historic Fire Return Interval (FRI), years	FRI Class & PNV	Apache-Sitgreaves	Carson	Cibola	Coconino	Coronado	Gila	Kaibab	Lincoln	Prescott	Santa Fe	Tonto	Total
Infrequent – similar to adjacent fire frequencies	4 Mixed Broad Leaf Deciduous Riparian Forest	79	2,304	14,331	323	777	152	27	8,904	436	5,398	9,801	42,533
Infrequent – similar to adjacent fire frequencies	4 Montane Willow Riparian Forest	2,454	2,017	2,744	3,044	3,573	1,544	8	5,676	3,260	594	6,229	31,144
Infrequent – similar to adjacent fire frequencies	4 Wetland/Cienega	0	7,329	1,140	2	14	44	0	22	0	326	0	8,877
None	5 Alpine and Tundra	0	294	0	1,234	0	0	0	0	0	0	0	1,529
NA	6 Urban and Other	6,203	6,832	1,601	19,622	637	9,744	12,248	3,405	2,139	38,679	27,903	129,013

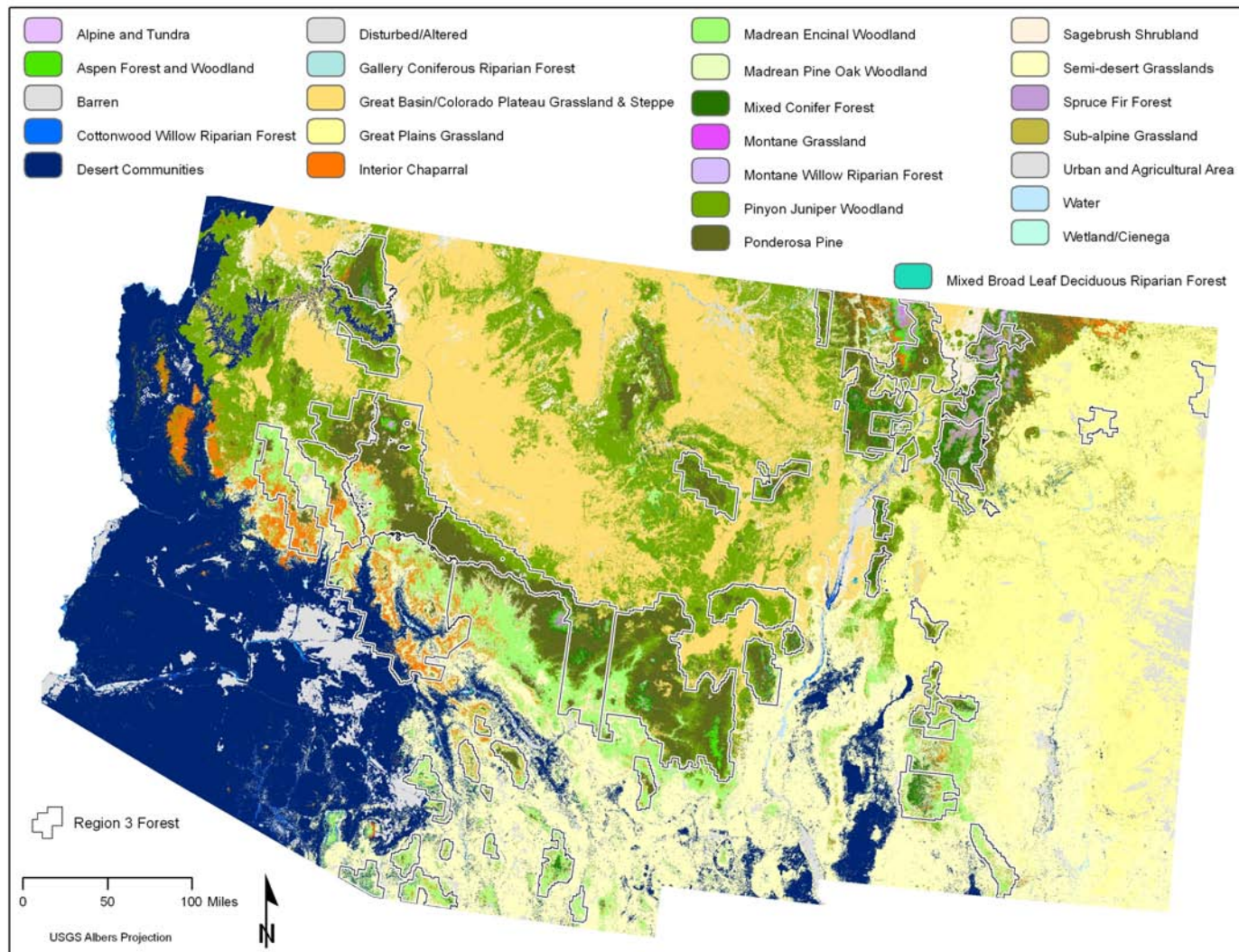


Figure 1.1. GIS-generated map of TNC-designated PNVTs for the states of Arizona and New Mexico. Re-classified data based on SWReGAP land cover data. Black lines represent USDA Forest Service Region 3 national forest boundaries.