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U.S. DEPARTMENT OF AGRICULTURE

Southwestern Region|PR-R3-16-22|August 2023

Forest Health Conditions in Arizona & New Mexico

2023

Cover photos clockwise from top left: 1. Urediniospores of *Cronartium ribicola* (causal agent of white pine blister rust) emerging from the leaves of the alternate host, *Ribes* spp.; 2. Aerial photo of pinyon pine impacted by pinyon needle scale and drought, Apache-Sitgreaves National Forests, Arizona; 3. tamarisk leaf beetle (USDA Forest Service photo by Camden Bruner); 4. Branch flagging in ponderosa pine caused by Prescott scale, Arizona.

Forest Health Conditions in Arizona and New Mexico – 2023
Southwestern Region
Forest Health Protection

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Weather Conditions in Brief

Drought

Over the last 23 years, the southwestern US has experienced multiple extended drought periods with recovery periods that are relatively short (Figure 1). Drought conditions were slightly alleviated in 2023 by record winter precipitation across much of the Southwest. Conditions worsened as the summer progressed due to a lackluster monsoon season, particularly in portions of New Mexico (Figure 2).

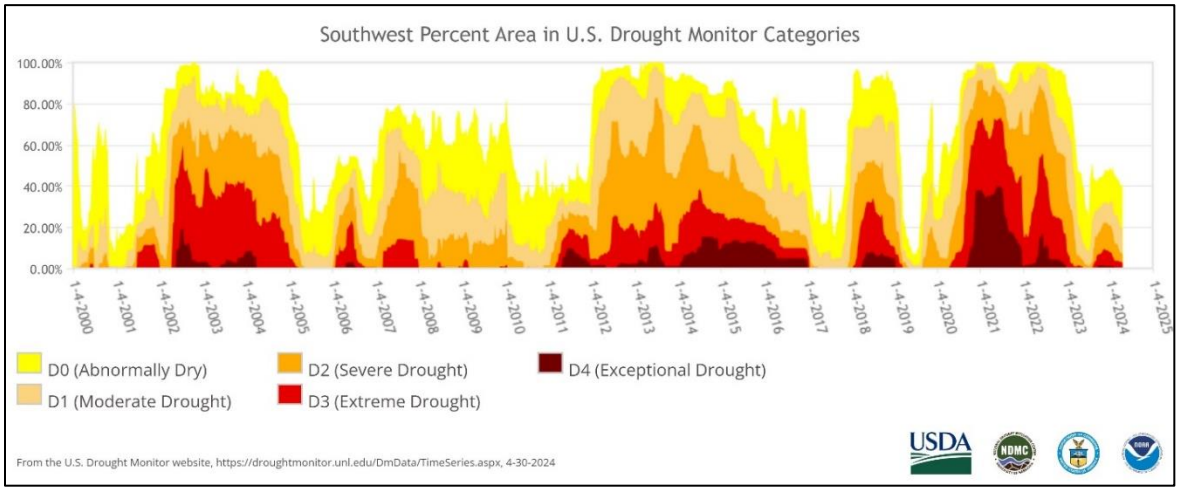

Figure 1: Percent of the southwestern U.S. in various drought monitor categories from 2000-2023. Source: https://droughtmonitor.unl.edu/DmData/TimeSeries.aspx

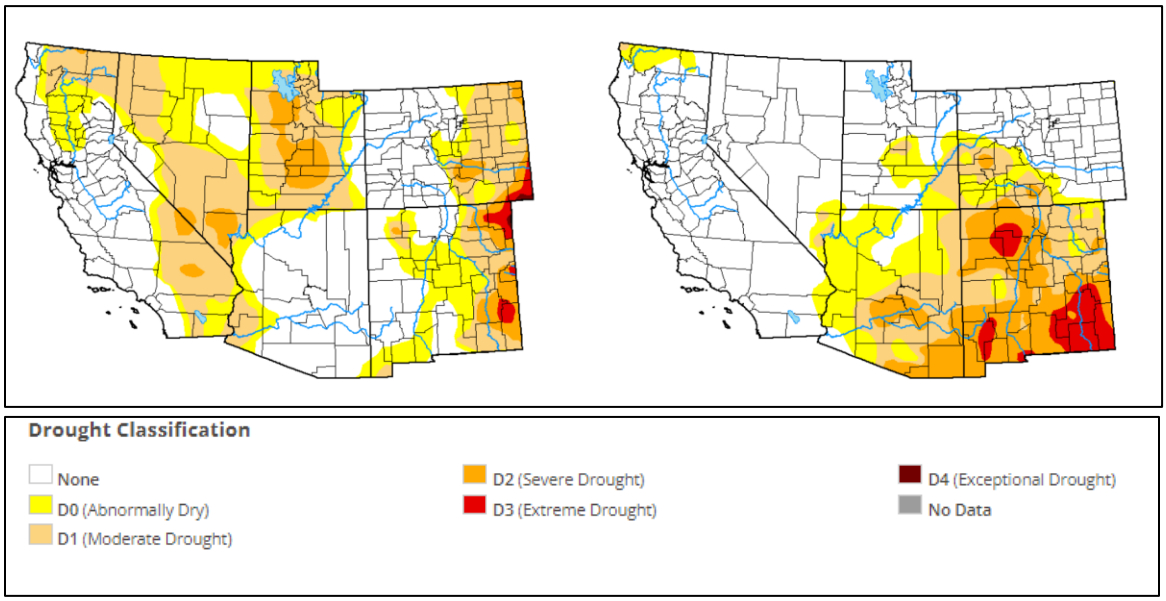

Figure 2: US Drought Monitor comparison map of the southwestern US between March 28, 2023 (left) and September 12, 2023 (right). Source: https://droughtmonitor.unl.edu/Maps/CompareTwoWeeks.aspx

Temperatures

Temperatures for the Southwest in 2023 were generally above average, with much of New Mexico well above average (Figure 3). In addition, Phoenix, AZ had the warmest summer on record in 2023.

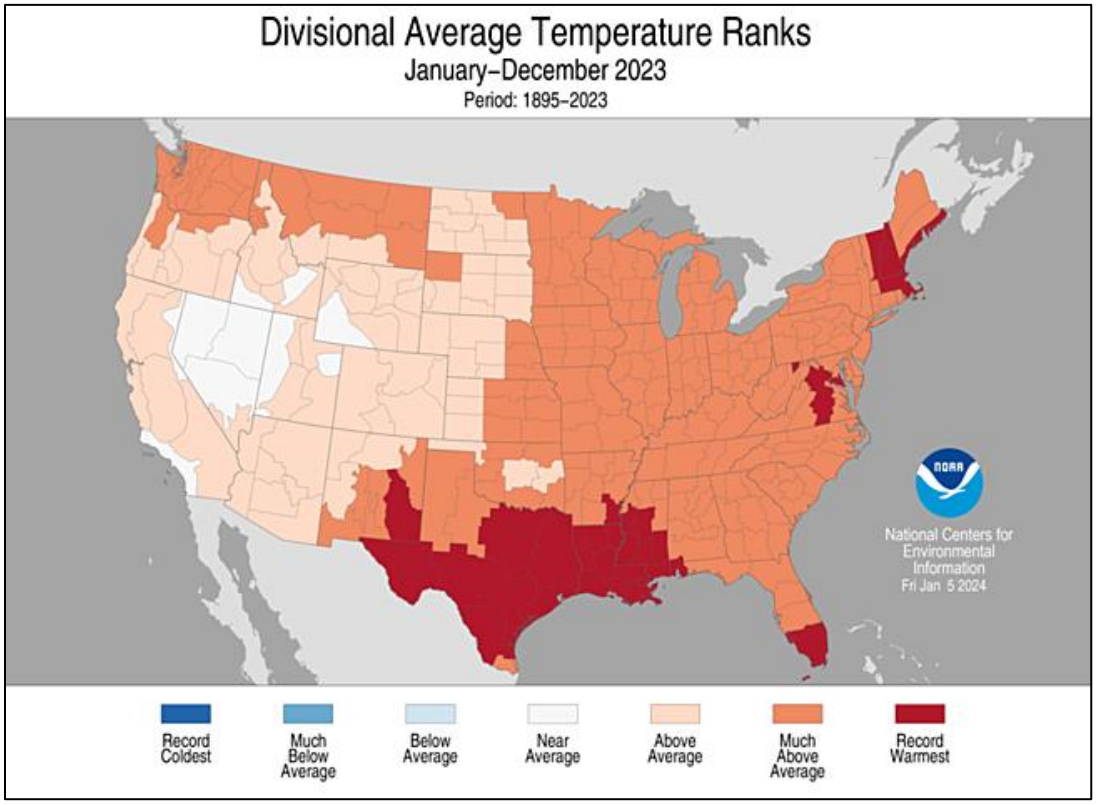

Figure 3: Average temperature ranks for the contiguous US for January – December 2023. Source: https://www.ncei.noaa.gov/access/monitoring/us-maps/divisional-tavg-rank/12/202312.png

Regional Forest Insect and Disease Summary

Aerial Survey Summary

In 2023, aerial detection surveys (ADS) covered approximately 21.5 million acres of the Southwestern Region (Table 1, Figure 4). Aerial surveys primarily covered national forest land (55% of area surveyed), followed by tribal (23%), state and private (17%), and other federal lands (4%). Additional riparian area was flown in southern Arizona to evaluate the presence tamarisk leaf beetle defoliation on state and private lands since 2022. Ground based monitoring data also contributed to the insect and disease data in 2023. Specifically, acres with pinyon pine mortality attributed to pinyon needle scale and drought were added on the Clifton Ranger District (RD), Apache-Sitgreaves National Forests (NFs) and adjacent San Carlos Apache Tribal Lands.

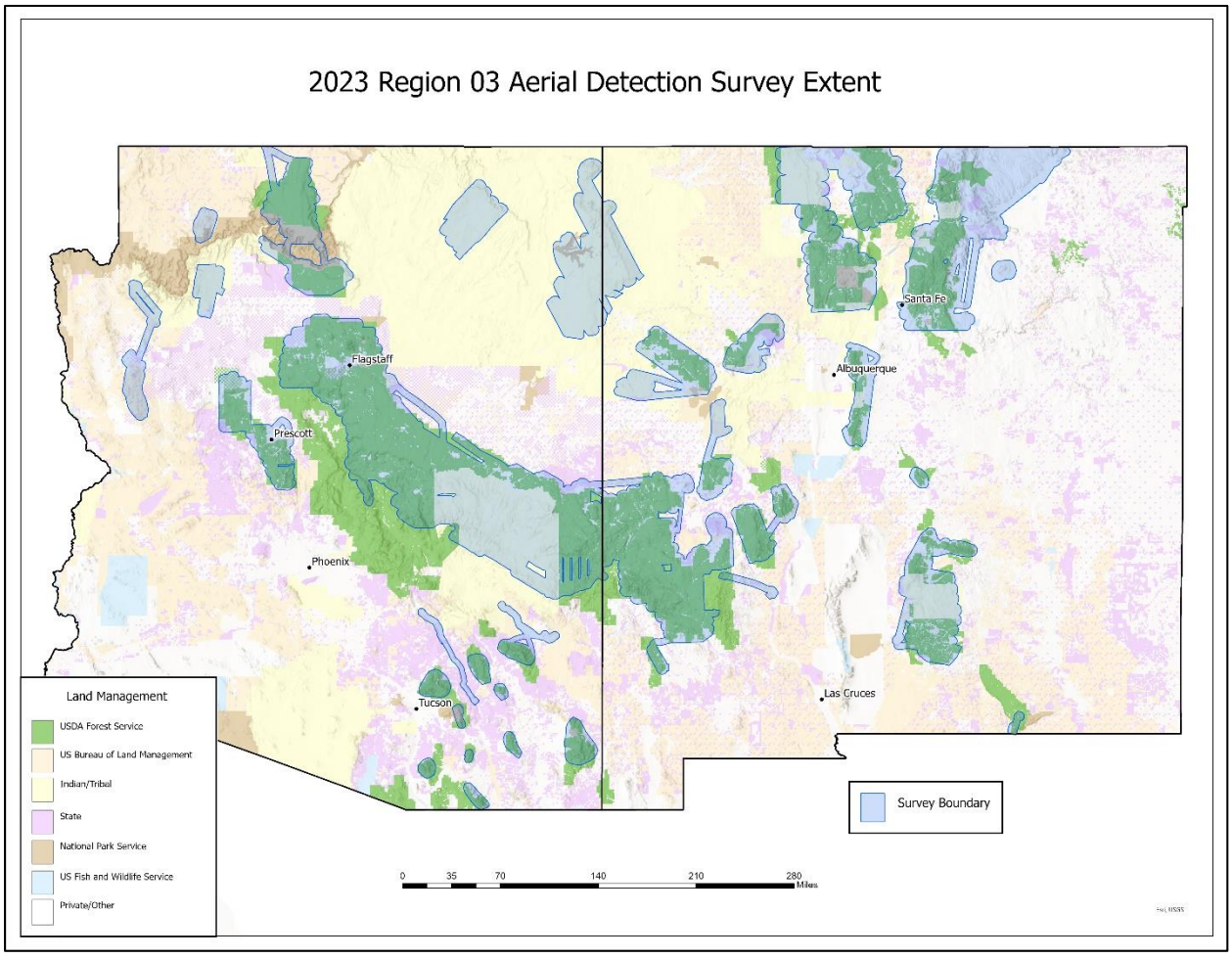

Figure 4. Areas of the Southwestern Region surveyed during 2023 aerial detection survey flights.

Table 1. Aerial detection survey acres flown in 2023 in the Southwestern Region.[1]

Land Ownership	State	Forested[1,2]	Woodland[1,2]	Total[1,2]
National Forest Lands	AZ	3,072,300	2,689,500	5,761,800
Bureau of Land Management	AZ	22,200	109,700	132,000
Department of Defense	AZ			
National Park Service	AZ	137,800	190,700	328,500
Department of Defense	AZ	28,700	20,100	48,800
Tribal	AZ	1,368,100	2,171,400	3,539,500
State and Private	AZ	198,400	369,700	568,100
Arizona Total		**4,827,600**	**5,551,200**	**10,378,800**
National Forest Lands	NM	4,092,600	1,981,200	6,073,800
Bureau of Land Management	NM	43,300	195,600	238,900
Bureau of Reclamation	NM	1,600	*	1,600
Department of Defense	NM		100	100
Department of Energy	NM	9,000	10,900	19,900
National Park Service	NM	87,000	18,300	105,400
Tribal	NM	885,500	567,700	1,453,100
U.S. Fish & Wildlife Service	NM	*	100	100
State and Private	NM	1,869,800	1,201,100	3,071,000
New Mexico Total		**6,988,900**	**3,975,000**	**10,963,900**
Grand Total		**11,816,500**	**9,526,200**	**21,342,700**

* Indicates less than 50 acres of land ownership and vegetation type surveyed.

[1] Values rounded to the nearest hundred, sum of individual numbers may differ from totals due to rounding.

[2] Vegetation type is based on USFS R3 Ecological Response Unit data, non-forested/woodland acres are not summarized here, nor in totals.

Total acreage of flown area is 28,333,692.

Bark Beetle Summary

Tree mortality attributed to bark beetles was mapped on 50,140 acres in 2023, a substantial decrease from the 752,360 acres mapped in 2022 and 772,940 acres detected in 2021 (Table 2). All bark beetle species recorded by aerial survey showed a decrease in acres impacted from 2022 levels. Regionwide, the complex of bark beetle species causing mortality of ponderosa pine contributed to the most acres with mortality for any forest type. Acres with ponderosa pine mortality decreased across the region from 310,160 acres in 2022 to 15,369 acres in 2023. Spruce beetle-caused mortality was the second highest acreage in the region with approximately half the amount mapped in 2022, decreasing to 12,658 acres from 24,980 acres. Pinyon pine beetles showed the largest decrease in activity across the region from 355,900 acres mapped with mortality in 2022 to 2,348 acres mapped in 2023.

In Arizona, ponderosa pine bark beetles were the most prevalent mortality agent mapped for the third year in a row, with 9,157 acres mapped, substantially down from the 179,450 acres mapped in 2022. Fir engraver activity in Arizona accounted for the second highest acreage mapped with bark beetle mortality across the state with 4,439 acres, a decrease from 42,930 acres mapped in 2022. Douglas-fir beetle activity was roughly the same as 2022 with 2,441 acres with activity mapped in 2023 and 2,430 acres mapped in 2022. Western balsam bark beetle-caused mortality declined from 7,280 acres mapped in 2022 to 476 acres in 2023. In 2023, Arizona had 411 acres with bark beetle-related pinyon pine mortality, substantially down from the 167,680 acres mapped in 2022. Spruce beetle levels in Arizona remained low with 330 acres mapped in 2022 and 181 acres mapped in 2023.

In New Mexico, spruce beetle was the predominant bark beetle causing mortality with 12,477 acres with mortality mapped in 2023. This is about half of the acreage mapped in New Mexico in 2022 (24,660 acres). Douglas-fir beetle and beetles impacting ponderosa pine were the second and third highest acres recorded with bark beetle activity with 7,414 and 6,213 acres, respectively. This was a decline in acreage for both beetles with 25,260 acres mapped with Douglas-fir beetle activity in 2022 and 130,710 acres mapped with ponderosa pine beetle activity in 2022. Fir engraver activity in New Mexico also declined to 4,480 acres in 2023 from 6,850 acres mapped in 2022. Like Arizona, pinyon ips activity declined dramatically in New Mexico from 188,220 acres mapped in 2022 to 1,937 acres in 2023. Western balsam bark beetle damage in New Mexico remained low, dropping from 560 acres mapped in 2022 to only 41 acres in 2023.

Table 2. Bark beetle[1] incidence by ownership (acres) from aerial detection surveys in 2023 in Arizona and New Mexico[2].

Owner[3]	Ponderosa pine bark beetles[4]	Pinyon ips	Douglas-fir beetle	Fir engraver	Spruce beetle	Western balsam bark beetle
Apache-Sitgreaves National Forest	2,885	22	7	148	16	3
Coconino National Forest	442	1	80	373	1	1
Coronado National Forest	437	3	91	230		23
Kaibab National Forest	1,834	21	1,517	1,250		285
Prescott National Forest	28	2		18		
Tonto National Forest	220	1	2	250		
Bureau of Land Management	299	1				
Department of Defense	11	1		0		
Bureau of Reclamation	0					
Canyon De Chelly National Monument	1					
Grand Canyon National Park	191	1	432	750		67
Saguaro National Park	27			44		
Walnut Canyon National Monument	0					
Hopi Tribal	0	2				
Hualapai Tribal	26	2				
Kaibab Tribal	0					
Navajo Tribal	109	317	231	1		67
San Carlos Tribal	1,053	3				
White Mtn Apache Tribal	1,520	33	83	1,368	164	31
Other Tribal	2					
State & Private	72	3		8		
Arizona Total	**9,157**	**411**	**2,441**	**4,439**	**181**	**476**
Carson National Forest	592	1	2,421	318	9,739	37
Cibola National Forest	288	412	111	471		1
Gila National Forest	2,152	156	238	245		
Lincoln National Forest	719	1	162	72	1	
Santa Fe National Forest	114	1	2,948	2,112	2,482	
Bureau of Land Management	2	20	28	75		
Department of Energy	5		4			
Bandelier National Monument	1					
El Malpais National Monument	1					
Valles Caldera National Preserve	1		160		1	
Acoma Pueblo	0					
Isleta Pueblo	2	1				
Jemez Pueblo	1		1	14		
Jicarilla Apache Tribal	5	2	339	9		
Laguna Pueblo	0		0			
Mescalero Apache Tribal	73	1	34	87		1
Navajo Nation	26	182	68	294		1
Picuris Pueblo	0		1			
Ramah Tribal	0	1				
Santa Clara Pueblo	0		0			
Taos Pueblo	1	0	375	1	7	
Zuni Pueblo	2	266	2			
State & Private	2,230	894	523	782	247	1
New Mexico Total	**6,213**	**1,937**	**7,414**	**4,480**	**12,477**	**41**
Grand Total	**15,369**	**2,348**	**9,855**	**8,919**	**12,658**	**517**

[1] Only major bark beetle and mortality agents shown. Agents detected with lesser activity may not be represented in the table.

[2] Values rounded to the nearest acre, sum of individual values may differ from totals due to rounding and multiple agents occurring in the same location; a blank cell indicates no damage was observed, a value of 0 indicates that damage was observed but occurred on less than a half-acre.

[3] Values based on landownership, thus any inholdings are summarized with their ownership category.

[4] Ponderosa pine bark beetle attributed mortality may include acreage from similar hosts such as Apache, Arizona, and Chihuahua pines.

Defoliation and Sap Sucker Damage Summary

Defoliation from insects and diseases (including agents not included in Table 3) decreased slightly across the region from 303,700 acres in 2022 to 277,295 acres in 2023 (Table 3). Most of the acres with defoliation were detected in New Mexico (84%) and attributed to the western spruce budworm (72%). Western spruce budworm damage increased from 174,900 acres detected in 2022 to 199,002 acres in 2023. In 2023, western spruce budworm damage was only mapped in New Mexico. Pinyon needle scale, a native sap sucking insect, affected the second highest number of acres in 2023 with a total of 32,330 acres mapped regionwide, a decrease from the 52,820 acres mapped in 2022. Most of this damage was mapped in southeastern Arizona (74%). Aspen damage had the third highest number of acres mapped in the region with 15,737 acres in 2023, down from 26,830 acres mapped in 2022. Aspen damage recorded during aerial surveys includes defoliation, dieback, and mortality. In 2023, slightly less aspen damage was mapped in Arizona (48%) than in New Mexico (52%).

In Arizona, four major agents contributed to foliar damage mapped in 2023. Pinyon needle scale damage was the most prevalent and was mapped on 23,813 acres in 2023, similar to the 24,320 acres reported in 2022. Most pinyon needle scale damage in 2023 was mapped in southeastern Arizona and ground surveys contributed to this acreage total. Acres mapped with tamarisk leaf beetle-caused defoliation doubled, with 12,023 acres observed in 2023 compared to 6,760 acres reported in 2022. This increase is due in part to additional riparian acres surveyed in southern Arizona as well as more damage being mapped in central Arizona around the Salt River. Aspen damage mapped from the air was 7,603 acres in 2023, up from 4,470 acres detected in 2022. Approximately 45% of the acres with aspen damage were recorded as mortality. Additional aspen damage attributed to oystershell scale (an invasive sap sucker), pathogens, and ungulate herbivory was recorded on 200 acres during ground surveys. Branch and tip dieback (flagging) was mapped on 3,909 acres of ponderosa pine most of which was later attributed to Prescott scale (a native sap sucker). Most of the damage was mapped on White Mountain Apache Tribal Lands in eastern Arizona. In addition to biotic agents, aerial observers mapped 1,974 acres with aspen and ponderosa pine defoliation in 2023 that was caused by a severe hailstorm north of the Grand Canyon on the Kaibab NF in 2022 (this damage is not included in Tables 3 or 4).

In New Mexico, the most prevalent defoliator was western spruce budworm, which caused damage on 199,002 acres in 2023, up from the 173,320 acres mapped in 2022. Ponderosa pine defoliation attributed to pine needleminer was mapped on 11,381 acres, the second highest damage amount for defoliators in New Mexico but a decrease from 30,180 acres mapped in 2022. Pinyon needle scale, the third highest damaging defoliating agent in New Mexico, declined in 2023 with 8,518 acres mapped, down from 28,500 acres mapped in 2022. Aspen damage also declined substantially in New Mexico with 8,134 acres mapped in 2023 and 22,360 acres mapped in 2022. Douglas-fir tussock moth acreage declined slightly in New Mexico with 2,642 acres mapped in 2023 and 3,110 acres mapped in 2022. Mapped acres with oak defoliation in New Mexico in 2023 was about half the acres mapped in 2022, 2,555 acres mapped in 2023 and 5,180 acres mapped in 2022. Defoliation in ponderosa pine was also mapped from sawflies (858 acres) and other defoliation (2,533 acres). The other defoliation was mapped on both the Carson NF (48%) and on Zuni Pueblo Tribal Lands (52%) and attributed to winter injury (Table 4). Only 2 acres with tamarisk leaf beetle defoliation were mapped in New Mexico in 2023, down from 60 acres mapped in 2022.

Table 3. Defoliation[1] and aspen damage incidence by ownership (acres) from aerial detection surveys in 2023 in Arizona and New Mexico[2].

Owner[3]	Western Spruce Budworm	Aspen damage[4]	Needleminer ponderosa	Prescott scale ponderosa	Sawfly ponderosa	Pinyon needle scale	Tamarisk Leaf Beetle	Douglas-fir tussock moth	Oak defoliation
Apache-Sitgreaves National Forests		644		124		11,658			
Coconino National Forest		21				59	13		
Coronado National Forest									
Kaibab National Forest		2,022							
Prescott National Forest						205			
Tonto National Forest						609	28		
Bureau of Land Management		10					599		
Department of Defense									
Bureau of Reclamation							33		
Canyon De Chelly National Monument									
Grand Canyon National Park		2,085							
Saguaro National Park									
Walnut Canyon National Monument									
Hopi Tribal									
Hualapai Tribal									
Kaibab Tribal							23		
Navajo Tribal		662					254		
San Carlos Tribal						8,574	916		
White Mtn Apache Tribal		2,128		3,785		1,950	126		
Other Tribal							93		33
State & Private		31				757	9,937		
Arizona Total		**7,603**		**3,909**		**23,813**	**12,023**		**33**
Carson National Forest	72,884	1,366	5,102			0		58	50
Cibola National Forest	1,764	345			18	19		2,201	13
Gila National Forest		17			78	1,592			
Lincoln National Forest	5,672	329				984			394
Santa Fe National Forest	31,786	4,715	1,114						23
Bureau of Land Management	16				137	82			
Department of Energy									
Bandelier National Monument									
El Malpais National Monument									
Valles Caldera National Preserve	1,206	1							
Acoma Pueblo					56				
Isleta Pueblo									
Jemez Pueblo									
Jicarilla Apache Tribal	2,042								243
Laguna Pueblo		4							
Mescalero Apache Tribal	966	15				3,913			
Navajo Nation		121							
Picuris Pueblo									
Ramah Tribal									
Santa Clara Pueblo	69	11	41						
Taos Pueblo	8,635	53							
Zuni Pueblo						1,928	2		
State & Private	73,962	1,157	5,124		569			384	1,832
New Mexico Total	**199,002**	**8,134**	**11,381**		**858**	**8,518**	**2**	**2,642**	**2,555**
Grand Total	**199,002**	**15,737**	**11,381**	**3,909**	**858**	**32,330**	**12,025**	**2,642**	**2,587**

[1] Only major defoliator agents shown. Less commonly detected agents or those with lesser activity may not be represented in the table.

[2] Values rounded to the nearest acre, sum of individual values may differ from totals due to rounding and multiple agents occurring in the same location; a blank cell indicates no damage was observed, a value of 0 indicates that damage was observed, but occurred on less than a half-acre.

[3] Values based on landownership, thus any inholdings are summarized with their ownership category.

[4] Aspen damage includes a combination of insect defoliation and other biotic and abiotic factors causing aspen decline, dieback, and in some cases mortality.

Disease Summary

Dwarf mistletoe is the most common and widespread pathogen in the Southwest. Because aerial detection surveys do not allow for identification of dwarf mistletoe infestations and yearly ground estimates are limited, the overall estimated acreage affected does not change from year to year. Current estimates (Arizona 1,873,000 acres and New Mexico 2,073,000 acres across all ownerships) are based on historical records, which indicate that over one-third of the ponderosa pine acreage and about one-half of the mixed conifer acreage have some level of infection. Recent roadside surveys showed similar affected area in ponderosa pine compared with these historical records.

Root diseases are also widely distributed across the region (219,000 acres and 860,000 acres across all ownerships for Arizona and New Mexico, respectively), but poorly documented. The most prominent root diseases in the region are caused by *Armillaria* spp. and *Heterobasidion occidentale*, and these diseases often interact with bark beetles, drought, and other tree stressors to cause tree mortality. Foliar diseases generally occur sporadically based on environmental conditions. Disease can be a chronic issue in areas conducive to infection.

White pine blister rust, a disease caused by the introduced fungus *Cronartium ribicola*, continues to injure and kill southwestern white and limber pine in the Southwest. Tree mortality from this disease is most prevalent on the Sacramento Mountains of southern New Mexico, but the disease can be found in many parts of the Southwest, including eastern Arizona and parts of northern New Mexico.

Abiotic Summary

Severe to exceptional drought conditions across much of the Southwest were alleviated following a heavy monsoon season in 2022 and significant precipitation during the following winter. Abiotic damage subsequently declined across the Southwestern Region in 2023 (Table 4). Limited impacts were still documented from woodlands to high elevation forests, primarily in New Mexico. Drought-induced discoloration of all conifer species (though primarily ponderosa pine) was mapped on 25,046 acres regionwide, down from 172,790 acres in 2022. Widespread drought-induced dieback in juniper has largely declined in the region with only 158 acres mapped in Arizona in 2023 after being observed on over 98,850 acres in 2022. Mortality associated with a large 2021 red belt winter injury event in southern New Mexico subsided, but a new red belt event occurred in northern New Mexico where 1,185 acres were impacted on the Carson NF. As noted above, hail damage was also mapped on 1,974 acres on primarily aspen and ponderosa pine in 2023 that was caused by a severe hailstorm north of the Grand Canyon on the Kaibab NF in 2022. Salt damage of ponderosa pine along roadways was also mapped on about 406 acres across the Southwestern Region in 2023, down from 620 acres reported in 2022.

Table 4. Abiotic damage[1] incidence by ownership (acres) from aerial detection surveys in 2023 in Arizona and New Mexico[2].

Owner[3]	Juniper drought dieback	Oak crown dieback	Ponderosa branch flagging[4]	Ponderosa drought discoloration	Winter injury ponderosa	Oak drought discoloration	Drought discoloration other spp.	Windthrow all spp.
Apache-Sitgreaves National Forests	86		1	686				161
Coconino National Forest	0		39	63				
Coronado National Forest						39	27	
Kaibab National Forest	1		0	1,974			1	129
Prescott National Forest		71						
Tonto National Forest								
Bureau of Land Management	29	572						
Department of Defense								
Bureau of Reclamation								
Canyon De Chelly National Monument								
Grand Canyon National Park		23		10				
Saguaro National Park								
Walnut Canyon National Monument								
Hopi Tribal	1							
Hualapai Tribal	0	25	0					
Kaibab Tribal								
Navajo Tribal	1	63					28	
San Carlos Tribal	0		99	74			685	
White Mtn Apache Tribal	39		165	1,099			481	
Other Tribal								
State & Private	1							
Arizona Total	**158**	**753**	**304**	**3,906**		**39**	**1,222**	**291**
Carson National Forest				6,589	1,185			
Cibola National Forest				565		7	776	
Gila National Forest	0		1	2,053			1,530	
Lincoln National Forest			1	2,150		25	52	
Santa Fe National Forest								
Bureau of Land Management				42				
Department of Energy								
Bandelier National Monument								
El Malpais National Monument								
Valles Caldera National Preserve								
Acoma Pueblo								
Isleta Pueblo								
Jemez Pueblo								
Jicarilla Apache Tribal				95				
Laguna Pueblo								
Mescalero Apache Tribal			1	123				
Navajo Nation	1		0	547			915	
Picuris Pueblo								
Ramah Tribal								
Santa Clara Pueblo								
Taos Pueblo								
Zuni Pueblo								
State & Private	1		0	4,368	1,283		43	200
New Mexico Total	**2**		**3**	**16,531**	**2,468**	**32**	**3,316**	**200**
Grand Total	**160**	**753**	**307**	**20,437**	**2,468**	**71**	**4,538**	**491**

[1] Only major abiotic damage shown. Less commonly detected damage may not be represented in the table.

[2] Values rounded to the nearest acre, sum of individual values may differ from totals due to rounding and multiple agents occurring in the same location; a blank cell indicates no damage was observed, a value of 0 indicates that damage was observed, but occurred on less than a half-acre.

[3] Values based on landownership, thus any inholdings are summarized with their ownership category.

[4] Ponderosa branch flagging includes acres with damage caused by twig beetles and general branch flagging with no insect damage.

Status of Major Insects

Bark Beetles

The overall total acreage with tree mortality attributed to bark beetles decreased across the region in 2023 for all beetle species tracked by aerial survey (Table 2). Most of the bark beetle damage for the region was mapped on Forest Service lands (72%).

Pinyon-Juniper Woodlands

Acres with bark beetle-attributed mortality in pinyon-juniper woodlands declined substantially in 2023 (Figure 5). Some of this decrease was due to surveys of additional areas in New Mexico that were only conducted in 2022. The total area with bark beetle mortality observed in the pinyon-juniper woodlands decreased from 355,900 acres in 2022 to 2,348 acres in 2023. The mortality was only recorded for pinyon, no juniper mortality was mapped.

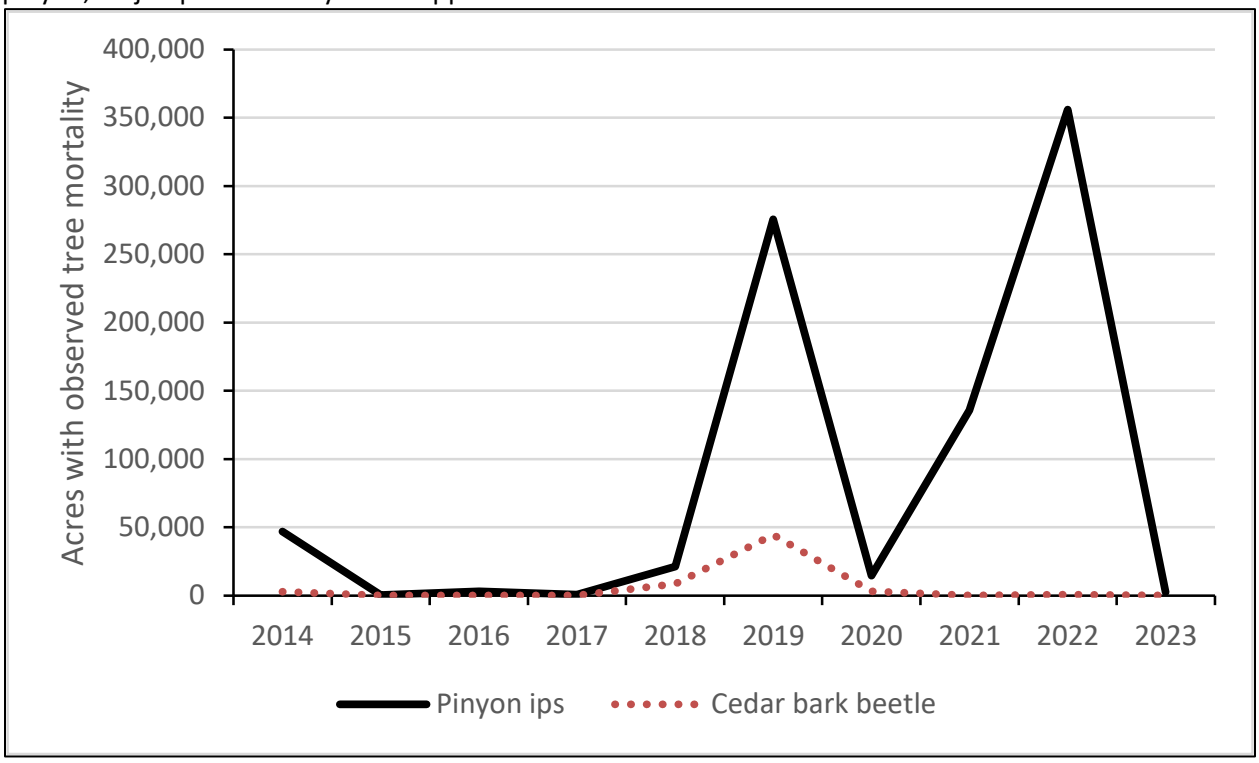

Figure 5: Pinyon-juniper mortality associated with pinyon ips and cedar bark beetles in the Southwestern Region over the last ten years.

Pinyon Ips

Ips confusus

Host: Pinyon pine

Acres with pinyon mortality decreased substantially from 355,900 acres in 2022 to only 2,350 acres in 2023 (Table 2, Figure 5). It should be noted that in 2022, special early season survey flights were conducted due to observed mortality resulting in a larger area of pinyon-juniper woodland coverage than in typical years which contributed to the increased acreage in that year. Most of the mortality was observed in New Mexico (1,937 acres; 82%) on the Cibola NF (412 acres) and Navajo Nation Tribal Lands

(182 acres) (Figure 6) and Gila NF (156 acres). In Arizona, Navajo Nation Tribal Lands accounted for the greatest proportion of pinyon mortality (317 acres; 77%).

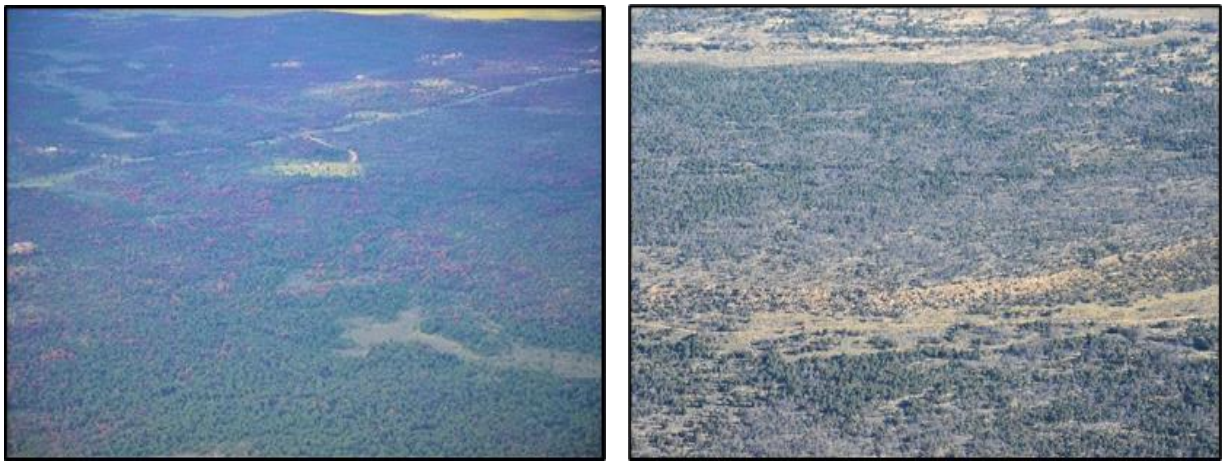

Figure 6: Severe pinyon mortality was widespread on the Navajo Nation in 2022 (left) while dead pinyon persists (gray appearance) in 2023 (right).

Cedar Bark Beetles

Phloeosinus spp.

Host: Junipers and Arizona cypress

Juniper mortality has historically been linked to cedar bark beetle activity in the Southwest and ground surveys in 2022 found many dead alligator junipers with evidence of attack. However, in recent years, many junipers had dieback, with the lower branches of the trees often remaining green, and, other than in alligator juniper, evidence of bark beetles was scarce. During 2021-2023 most of the fading juniper were thus mapped as dieback, rather than mortality as described in the Abiotic section of this document under “drought”. In 2022, cedar bark beetle activity was only associated with 30 acres in Arizona and 520 acres in New Mexico. In 2023, no acres of mortality attributed to cedar bark beetles were mapped (Figure 5).

Juniper Twig Pruner

Styloxus bicolor

Host: Junipers

The juniper twig pruner is a native longhorn beetle that causes tip dieback. In 2021, drought conditions contributed to large stands of juniper branch flagging and associated juniper twig pruner activity on the Chino Valley RD of the Prescott NF in Arizona. In 2022, the damage on the Prescott NF seems to have declined; however, damage was noted in Coconino and Apache Counties of Arizona. Within New Mexico, juniper twig pruner was observed in 2022 during a site visit near El Rito RD, Carson NF, and on Santa Ana Pueblo Tribal Lands. Damage from juniper twig pruners usually results in minor damage. Damage caused by this agent was detected in 2023 on 1,245 acres of Apache Tribal Lands, primarily on White Mountain Apache Tribal Lands in Arizona. No damage was mapped in New Mexico in 2023.

Ponderosa Pine Forest Type

In the Southwestern Region, ponderosa pines are attacked by a diverse complex of bark beetles, most commonly in the *Ips* and *Dendroctonus* genera. These beetles overlap geographically, and it is quite common to find several species co-occurring within the same tree.

Ponderosa pine mortality decreased throughout most of the region, with 15,369 acres mapped in 2023 compared to 310,160 acres mapped in 2022 (Figure 7). The majority of the damage (59%) occurred in Arizona with 9,157 acres. In Arizona, most of the damage (32%; 2,885 acres) was recorded on the Apache-Sitgreaves NFs, but the Kaibab NF, San Carlos Apache Tribal Lands (Figure 8) and White Mountain Apache Tribal Lands all had over 1000 acres as well (Table 2). Most of the mortality in New Mexico was located on state and private lands (2,230 acres, 36%) and the Gila NF (2,152 acres, 35%).

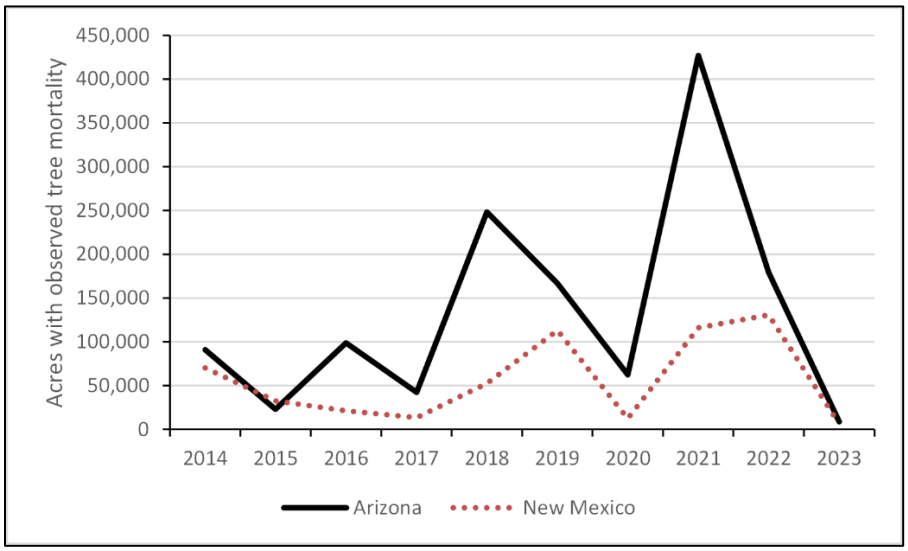

Figure 7: Ponderosa pine mortality attributed to bark beetles in the Southwestern Region over the last ten years.

Figure 8: Ponderosa pine mortality observed on San Carlos Apache Tribal Lands, Arizona in 2023.

Mixed Conifer Forest Type

Mortality in mixed conifer forests from bark beetles (primarily consisting of Douglas-fir beetle on Douglas-fir and fir engraver on white fir) has declined throughout the Southwestern Region, likely due to the abundant winter moisture the region received in 2023. Douglas-fir and white fir mortality in 2022 was mapped for approximately 76,000 total acres. In 2023, only 18,774 acres were mapped. White fir had the largest decrease in acres with mortality, in this forest type (Figure 9).

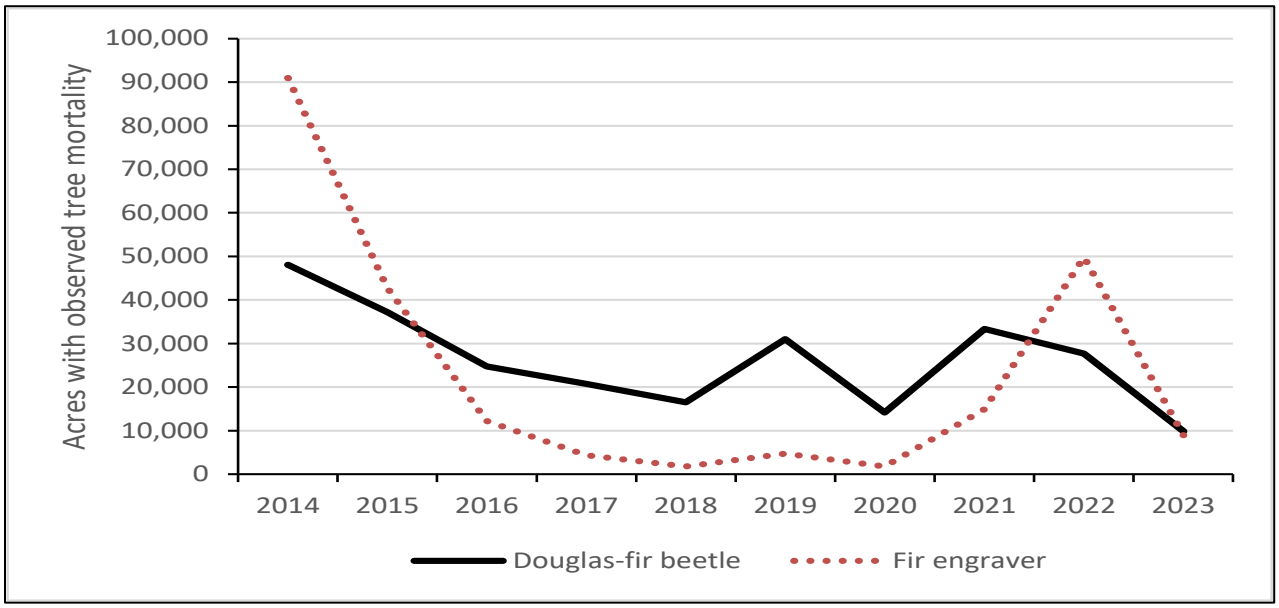

Figure 9: Mixed conifer mortality associated with Douglas-fir and fir engraver in the Southwestern Region over the last ten years.

Douglas-fir Beetle

Dendroctonus pseudotsugae

Host: Douglas-fir

Douglas-fir beetle activity is most common in dense stands of mature Douglas-fir. At endemic levels, this beetle species will target stressed trees such as those injured by fire, infected by dwarf mistletoe or root disease, or trees experiencing severe defoliation or drought stress. Generally, Douglas-fir beetle will only affect small pockets or individual trees, but infestations may grow to larger outbreaks during periods of suitable climate and widespread susceptible host trees. In 2023, Douglas-fir mortality from Douglas-fir beetle decreased across the region from 27,680 acres in 2022 to 9,855 acres in 2023 (Figure 9). New Mexico accounted for 75% of the total Douglas-fir beetle activity. Concentrations of mortality were highest on the Carson (2,421 acres) and Santa Fe (2,948 acres) NFs in New Mexico (Figure 10, Table 2). Acres with Douglas-fir mortality attributed to Douglas-fir beetle in Arizona in 2023 was similar to levels mapped in 2022, with 2,430 acres with mortality mapped in 2022 and 2,441 acres mapped with mortality in 2023. Similar to 2022, the majority of acres (1,517 acres; 62%) for Arizona occurred on the Kaibab NF.

Figure 10: New (red trees) and older (gray trees) Douglas-fir mortality in the Jemez Mountains on the Santa Fe National Forest, New Mexico.

Fir Engraver

Scolytus ventralis

Hosts: White fir, corkbark fir

Fir engraver-caused mortality is often linked to root disease and drought-stressed trees growing in dense stands on warm, dry sites in the Southwest. Fir mortality may be more prevalent on drier south- and west-facing slopes.

White fir mortality attributed to fir engraver decreased considerably regionwide, with total acres mapped declining from 49,780 acres in 2022 to 8,919 acres in 2023 (Figure 9). The acreage was split relatively evenly between Arizona (4,439 acres) and New Mexico (4,480 acres). In Arizona, this acreage was a substantial decrease from 42,930 acres mapped in 2022. The majority of fir engraver activity in Arizona was mapped on White Mountain Apache Tribal Lands (31%) and the Kaibab NF (28%), although the acreage mapped for both areas was still a decline from acres mapped the previous year, decreasing to 1,368 acres from 6,200 acres for the White Mountain Apache Tribal Lands and 1,250 acres from 17,290 acres for the Kaibab NF. In New Mexico, white fir mortality attributed to fir engraver also decreased with 6,850 acres mapped in 2022. Mortality was observed primarily on the Santa Fe NF, particularly on the Pecos-Las Vegas RD (63%) (Figure 11). The activity is likely a result of ongoing root disease that has continually weakened trees in these areas.

Figure 11: White fir mortality (yellow trees) in the Pecos Wilderness on the Santa Fe National Forest, New Mexico, the scattered distribution of killed trees is characteristic of attack by fir engraver beetles.

Spruce-fir Forest Type

At around 9,000' elevation, mixed conifer forests start to transition to spruce-fir forests. Engelmann spruce and corkbark fir are the primary tree species, but blue spruce, southwestern white and limber pines, Rocky Mountain bristlecone pine, and aspen may also be present.

Spruce Beetle

Dendroctonus rufipennis

Host: Spruce

Spruce mortality attributed to spruce beetle decreased across the Southwestern Region from 24,980 acres mapped with mortality in 2022 to 12,658 acres in 2023 (Figure 12). Spruce beetle activity in Arizona was once again minimal in 2023 with 181 acres mapped, down from 2022 when 330 acres of mortality were documented during aerial surveys. The majority of the mortality (91%) in Arizona was mapped on White Mountain Apache Tribal Lands. New Mexico accounted for almost 99% of bark beetle-caused spruce mortality regionwide. Within New Mexico, most of the spruce mortality was mapped on the Carson NF (78%).

Western Balsam Bark Beetle

Dryocoetes confusus

Hosts: Corkbark fir

Corkbark fir mortality attributed to western balsam bark beetle decreased regionwide from 7,830 acres in 2022 to 517 acres in 2023 (Figure 12). Most of the mortality attributed to western balsam bark beetle was observed in Arizona, which accounted for 92% of the damage, and the majority of corkbark fir mortality within the state occurred on the Kaibab NF (60%) north of the Grand Canyon. Fir engraver can also cause corkbark fir mortality and is indistinguishable from mortality caused by western balsam bark beetle during aerial surveys.

New Mexico acreage affected by western balsam bark beetle decreased, falling from 560 acres in 2022 to 41 acres in 2023. Most of the area affected was located on the Carson NF (90%). This bark beetle

commonly interacts with root diseases caused by *Armillaria* spp. or *Heterobasidion occidentale* to kill trees. The interaction of bark beetles and root disease is common in many forests throughout the West. Signs of infection by *Armillaria* spp. can be consistently found on dead corkbark fir trees in many spruce-fir forests across the Southwestern Region.

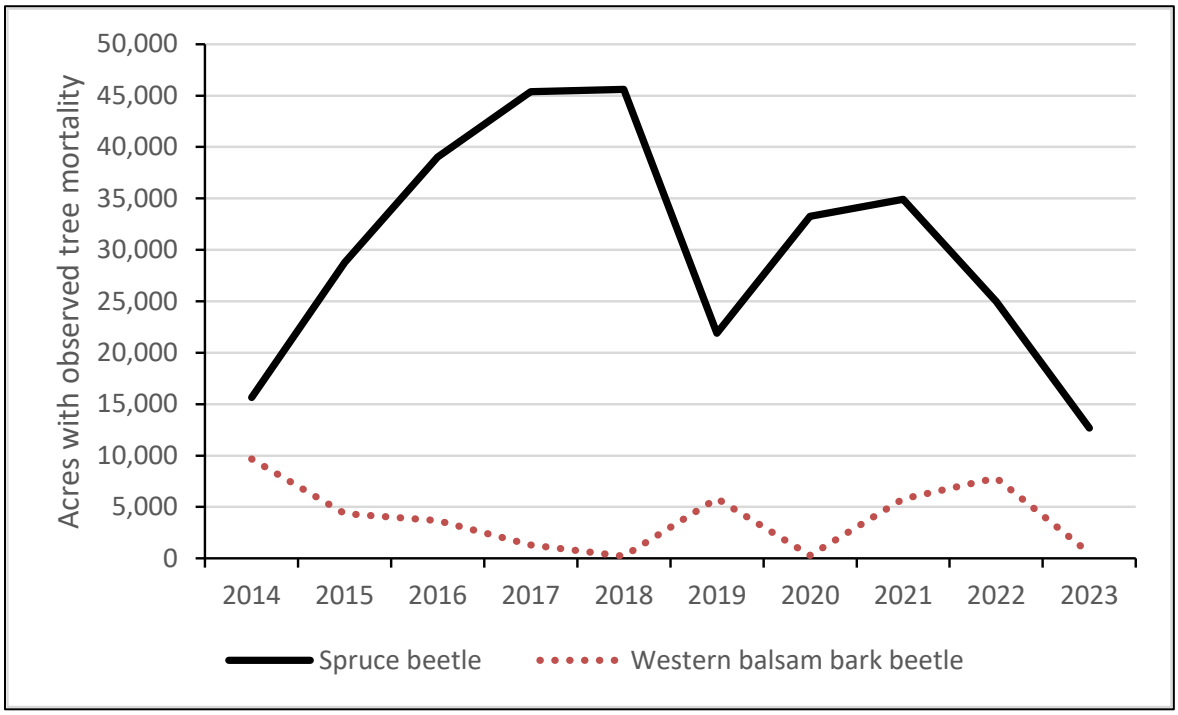

Figure 12: Tree mortality in spruce-fir forests attributed to spruce beetle and western balsam bark beetle in the Southwestern Region over the last ten years.

Defoliators

Defoliation damage in 2023 ranged from removal of foliage to crown discoloration, dieback, branch flagging and premature needle drop due to desiccation or tissue necrosis. Acres observed with damage from defoliators (including less prominent agents not included in Table 3) decreased slightly regionwide from 303,700 acres in 2022 to 277,295 in 2023 (Table 3). Western spruce budworm continues to cause the most acreage of defoliation compared to other agents in the region. All the budworm-caused damage was observed in New Mexico. Pinyon needle scale was the most predominant agent causing defoliation in Arizona.

Pinyon-Juniper Woodlands

Pinyon Needle Scale

Matsucoccus acalyptus

Host: Pinyon pine

Pinyon needle scale infestations are persistent in many pinyon-juniper woodlands throughout the region and repeated defoliation caused by this insect can cause reduced growth and stunted needles. In severe outbreaks, small trees may be killed. While chronic in many places, the amount of visible defoliation varies from year-to-year. Depending upon the severity of the defoliation and timing of ground visits and survey flights, this damage can be quite difficult to detect from the air and thus numbers may vary from year-to-year.

Acres with damage attributed to pinyon needle scale decreased in 2023 from 52,820 acres in 2022 to 32,330 acres regionwide (Table 3). Most of this damage (23,813 acres, 74%) was detected in Arizona, similar to the 24,320 acres mapped in the state in 2022. Pinyon needle scale damage accounted for almost 55% of Arizona's total acres with defoliation. Approximately 20,230 acres were noted during ground surveys on the Clifton RD on the Apache-Sitgreaves NFs. Chronic needle scale and drought have contributed to mortality of pinyon pine in this area (Figure 13).

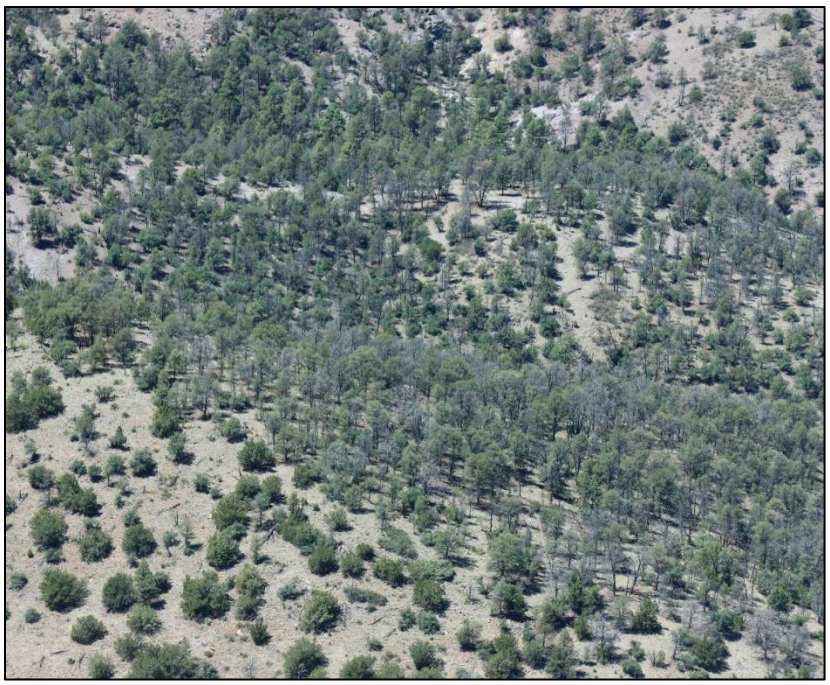

Figure 13: Chronic pinyon needle scale and drought caused thin crowns resulting in widespread pinyon stress and mortality on the Clifton Ranger District, Apache-Sitgreaves National Forests, Arizona.

New Mexico saw a substantial decrease in acres impacted by pinyon needle scale with 8,518 acres mapped in 2023, down from 28,500 acres in 2022. The majority (46%) of the damage in New Mexico was mapped on Mescalero Apache Tribal Lands (Figure 14).

Figure 14: "Thinyon" symptoms characteristic of pinyon stands across Mescalero Apache Tribal Lands and Lincoln National Forest in New Mexico due largely to pinyon needle scale.

Ponderosa Pine Forest Type

Pine Sawflies

Neodiprion spp. and *Zadiprion* spp.

Host: Ponderosa pine

Pine sawfly defoliation in ponderosa pine was less than twice the acreage in 2023 compared to 2022, with all acres occurring for the second year in a row in New Mexico. In 2022, 2,250 acres were mapped with defoliation attributed to sawflies, while in 2023, 858 acres were mapped. In 2022, the majority (70%) of this damage occurred on the Cibola, Gila, and Lincoln NFs, while in 2023 the damage was mapped predominantly on state and private lands (66%; 569 acres) (Figure 15). Acres with defoliation on the Cibola NF decreased from 1,000 in 2022 to 18 acres in 2023, activity on the Gila NF decreased from 530 acres in 2022 to 78 in 2023, and no damage was mapped on the Lincoln NF in 2023 compared to 30 acres mapped in 2022.

Figure 15: Defoliation of ponderosa pine from suspected sawfly activity (gray/green trees) on Elk Mountain, Reserve Ranger District, Gila National Forest, New Mexico.

Unknown Defoliator

Host: Ponderosa pine

In Arizona, severe and widespread defoliation of ponderosa pine was observed on approximately 3,700 acres during the 2022 aerial detection survey over the North Kaibab RD, Kaibab NF. A follow-up site visit was conducted in August of 2023 and hail was identified as the causal agent of the defoliation. In 2023, aerial observers mapped 1,974 acres with aspen and ponderosa pine defoliation still affected by this severe weather event. For more information on this incident see “Hail damage” in the Abiotic section of this document.

Pandora Moth

Coloradia pandora

Host: Ponderosa pine

Pandora moth has a 2-year life cycle, with feeding and moth flight occurring in alternate years, so that most of the defoliation occurs every other year. Outbreaks occur on a 20–30-year cycle. No observations of pandora moth were reported in New Mexico or Arizona in 2023.

Pine Needleminer

Coleotechnites ponderosae

Host: Ponderosa pine

Figure 16: Needleminer damage in a ponderosa pine stand on the Jemez Mountains, New Mexico.

Ponderosa pine needleminer activity dropped from 30,180 acres in 2022 to 11,381 acres in 2023. As in 2022, all of the damage was reported in New Mexico and was documented mostly on state and private lands (45%), the Carson NF (45%), and the Sante Fe NF (10%) (Figure 16). The ponderosa pine needleminer outbreak that caused a large area of discolored ponderosa pine over the past five years on state and private lands in the northeastern part of New Mexico continued in 2023. However, acres observed with damage continued to decrease from the 100,000 acres detected in 2021 and overall impacts appear to be subsiding.

Prescott Scale

Matsucoccus vexillorum

Host: Ponderosa pine

Figure 17: Branch flagging (trees with branches with red foliage) in ponderosa pine caused by the Prescott needle scale on White Mountain Apache Tribal Lands in Arizona.

Branch flagging in ponderosa pine increased from 633 acres in 2022 to 3,950 acres in 2023. In 2022, branch-flagging was mapped in various locations across Arizona and ground surveys attributed damage to twig beetles. In 2023, however, over 95% of branch-flagging was ground surveys attributed the damage to Prescott scale (3,909 acres). The damage in 2023 occurred primarily in the White Mountains on White Mountain Apache Tribal Lands (Figure 17). Prescott scale is a native sap sucking scale insect that causes branch flagging in early summer but rarely causes tree mortality.

Mixed Conifer Forest Type

Aspen Defoliation, Dieback, and Mortality

Western tent caterpillar, *Malacosoma californicum*

Large aspen tortrix, *Choristoneura conflictana*

Oystershell scale, *Lepidosaphes ulmi*

Black leaf spot, *Drepanopeziza populi-albae*

Complex of drought and other insects and diseases

Figure 18: Mixed conifer mortality and aspen damage observed on the North Rim of the Grand Canyon National Park, Arizona in 2023.

In the Southwestern Region, aspen mortality, dieback, and defoliation are monitored through a combination of aerial and ground surveys. Aspen damage decreased regionwide to 15,737 acres in 2023 from 26,830 acres in 2022. New Mexico had slightly more damage (52%) than Arizona. In New Mexico, the majority of the damage was mapped on the Santa Fe NF (58%). In Arizona, the damage was more widespread with most of the acreage split between the Kaibab NF (27%), Grand Canyon National Park (27%) and White Mountain Apache Tribal Lands (28%) (Figure 18). Approximately 45% of the acres with aspen damage were recorded as mortality in Arizona.

The number of acres with aspen damage decreased in New Mexico during 2023 from 22,360 in 2022 to 8,134 acres mapped in 2023. Western tent caterpillar is often the primary defoliating agent, however, large aspen tortrix has also historically contributed to the defoliation. In 2022, this defoliator was found in several sites on the Carson NF.

In Arizona, ongoing ground surveys and a network of permanent monitoring plots are used to evaluate impacts from agents that are not easily detected by aerial surveys including invasive oystershell scale, other native insects and diseases, and ungulate browse on aspen regeneration, recruitment, and tree health. For more on oystershell scale see the Other Entomology and Pathology Activities section.

Douglas-fir Tussock Moth

Orgyia pseudotsugata

Hosts: True firs, Douglas-fir, and spruce

Douglas-fir tussock moth activity decreased in the region from 3,320 acres mapped in 2022 to 2,642 acres mapped in 2023. Douglas-fir tussock moth was only mapped in New Mexico in 2023. Most of the damage was once again mapped on the Cibola NF (83%), although the acreage mapped declined to 2,201 acres from the 2,920 acres mapped in 2022. In Arizona, no damage was mapped and the outbreak on the Safford RD, Coronado NF, which accounted for the majority of the damage mapped in 2022, appears to have subsided.

In New Mexico, a Douglas-fir tussock moth outbreak on the Manzano Mountains, Mountainair RD, Cibola NF was observed in 2022-2023. The defoliation associated with this outbreak covered roughly 5,200 acres over two years around the southeastern tip of the Manzano Mountains. All life stages of the insect were detected and signs of nuclear polyhedrosis virus were observed on mid-late instar

caterpillars in 2023. Egg mass surveys conducted over winter indicate that the current outbreak will likely decline in 2024. Severe defoliation that occurred near Red Canyon Campground is visible from the ground and air. White fir, Douglas-fir, and even some ponderosa pines were severely defoliated.

In 2023, Douglas-fir tussock moth defoliation activity was observed on mostly private lands (382 acres) near Taos and Questa, New Mexico and adjacent Carson NF (58 acres) (Figure 19). Egg mass surveys conducted on accessed private lands this winter indicate that the defoliation activity will likely continue in 2024. Increase in surveillance will be undertaken in 2024 to monitor these populations.

Defoliation by Douglas-fir tussock moth declined in southeastern Arizona in 2023, with the small, isolated outbreak occurring along the Scenic Swift Trail Highway at the southeastern edge of Mount Graham apparently collapsing with some moderate mortality of white fir as a result.

Figure 19: Douglas-fir tussock moth affected 58 acres of mixed conifer (reddish grey) in Rito Premero, Rito del Medio, Latir Creek as well as Arroyo Seco of the Questa Ranger District on the Carson National Forest, New Mexico.

Western Spruce Budworm

Choristoneura freemani

Hosts: True firs, Douglas-fir, and spruce

Western spruce budworm activity increased slightly across the Southwestern Region from 174,900 acres in 2022 to 199,002 acres (Table 3, Figure 20). The damage was mapped exclusively in New Mexico.

In Arizona, few acres are impacted by western spruce budworm given the lack of contiguous host type in the state. The number of acres with western spruce budworm had been increasing in Arizona but, in 2022, acres with damage declined to approximately one third of the acres reported in 2021 and declined further in 2023 with no acres detected.

Most western spruce budworm-caused defoliation occurred in the northern part of New Mexico, particularly on the Carson (37%) and Santa Fe (16%) (Figure 21) NFs and adjacent state and private lands (37%). Elevated levels of defoliation have been observed in mixed conifer and spruce-fir stands in this area for the past four decades. Douglas-fir has been the preferred host although white fir and Engelmann spruce are also commonly defoliated. Twig dieback, top-kill, and tree mortality have resulted from the chronic defoliation and understory regeneration has been significantly affected in some stands.

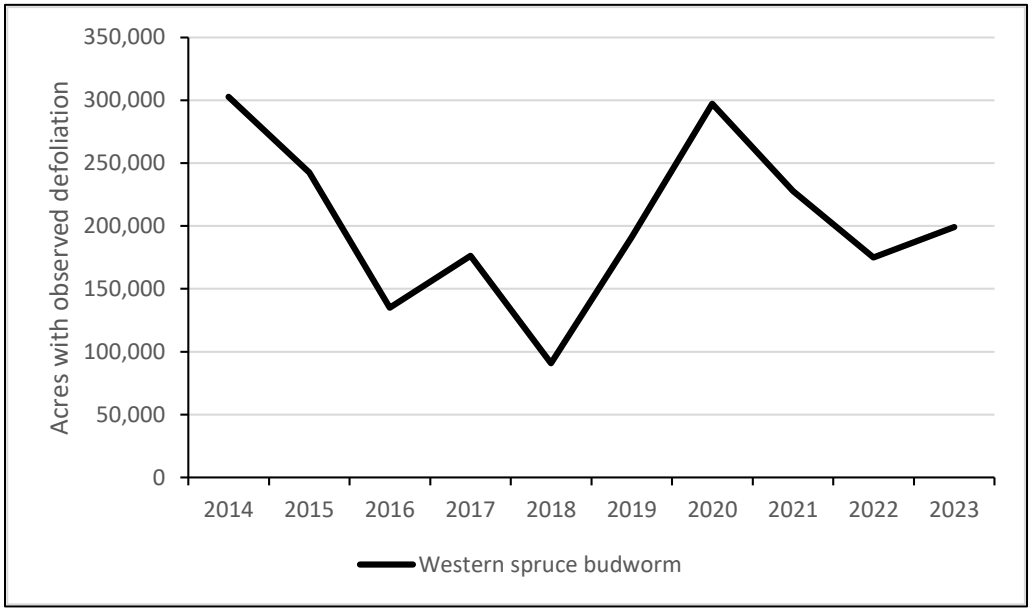

Figure 20: Defoliation attributed to western spruce budworm in the Southwestern Region for the last ten years.

Figure 21: Defoliation of mixed conifers by western spruce budworm on the Santa Fe National Forest, New Mexico.

Spruce-fir Forest Type

Spruce Aphid

Elatobium abietinum

Hosts: primarily Engelmann and occasionally blue spruce

Spruce aphid is an exotic, invasive insect with periodic outbreaks that can cause significant damage and mortality of Engelmann spruce. Spruce aphid damage has been minimal in the last three years (Figure 22) and mapped exclusively in Arizona. In 2023, 60 acres of damage was mapped on White Mountain Apache Tribal Lands (81%) and neighboring Apache-Sitgreaves NFs.

The most recent spruce aphid activity observed in New Mexico was reported at Ski Apache on the Lincoln NF during the winter of 2018-2019. At that time, ground visits identified feeding damage and some live aphids.

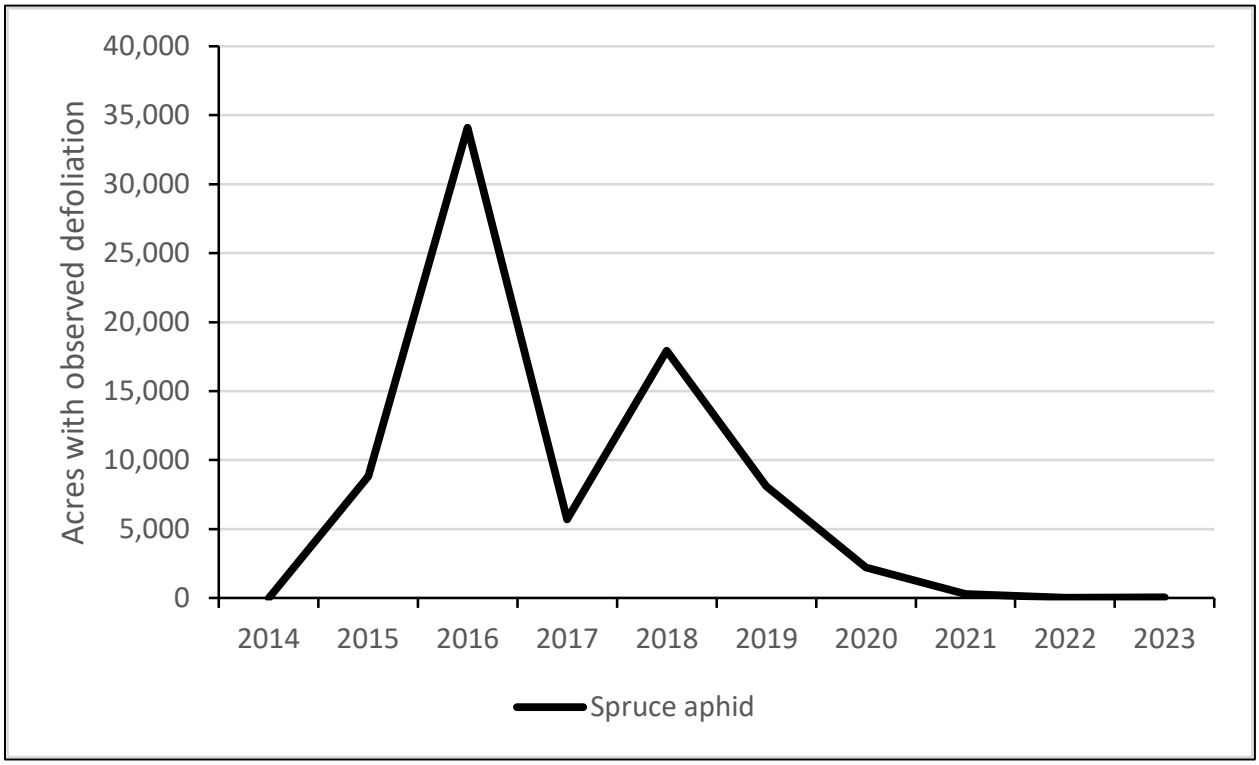

Figure 22: Defoliation attributed to spruce aphid in the Southwestern Region over the last 10 years.

Miscellaneous Insects

Aspen Bark Beetle

Trypophloeus populi

Host: Aspen

Aspen bark beetle activity was noted in Arizona during 2023. Aspen bark beetles, mainly *Trypophloeus populi*, mass attacked individual mid- to large-diameter aspen trees in several areas in Arizona including in high elevation forest types on the San Francisco Peaks, Coconino NF and near Greens Peak, Apache-Sitgreaves NFs, and north of the Grand Canyon on the Kaibab NF. The species is known to cause damage

in stressed aspen. Short larval galleries are packed with frass and stained brownish black with symbiotic fungi as larvae mature.

Goldspotted Oak Borer

Agrilus auroguttatus

Hosts: Emory oak, silverleaf oak

Acres of drought-stressed Emory and silverleaf oaks with goldspotted oak borer damage decreased in 2023 to only 33 acres from 320 acres mapped in 2022. The damage was mapped exclusively in Arizona with 99% damage mapped on the Safford RD, Coronado NF. Typically, goldspotted oak borer is a secondary pest in drought-affected oaks stands. Dieback, discoloration, and mortality of oaks has been mapped at low levels across much of the host type for the last few years. Ground surveys indicate the pathogens *Biscogniauxia mediterranea* and another undescribed *Biscogniauxia* sp. play an important role in the decline of many Emory and silverleaf oak stands. This agent is not discernable during ADS flights, although it appears to be widespread in drought-impacted oak woodlands. It is unclear how large of a role these pathogens play in the damage mapped via aerial surveys. For more on this agent see "canker diseases" in the Status of Major Diseases section of this document.

Western Rose Chafer

A large area of oak defoliation was observed on 3,480 acres in the vicinity of Nogal Peak on the Lincoln NF in New Mexico in 2022. Ground checks revealed skeletonized leaves that indicated western rose chafer as a likely damage causal agent but was not confirmed. In 2023, oak defoliation was still occurring but decreased to 394 acres (Figure 23). Symptoms of infection by a fungal pathogen named *Articulara quercina* were found in these oaks and may also be causing some of the defoliation. The presence of the pathogen was morphologically confirmed on samples collected in the area.

Figure 23: Oak defoliation (yellow gray tops) in Nogal Canyon, Lincoln National Forest, New Mexico.

Twig Beetles

Pityophthorus spp.

Hosts: Common or two-needle pinyon and ponderosa pine

In 2023, a total of 4,216 acres of ponderosa pine was mapped with branch flagging across the region. The majority (99%) of this was mapped in Arizona, primarily on White Mountain Apache Tribal Lands (94%) and, as noted previously, most of this damage was attributed to Prescott scale, not twig beetle. Ground and aerial observations in 2022 noted twig beetles and drought contributing to branch and twig flagging in ponderosa and pinyon pines, and in some cases, tree mortality in pinyon pine on the Coconino and Kaibab NFs. In New Mexico in 2023, ponderosa branch flagging was only mapped on 3 acres total across the Gila NF, Lincoln NF, and Mescalero Apache Tribal Lands.

Status of Major Diseases

Mistletoes

Dwarf Mistletoes

Arceuthobium spp.

Hosts: Conifers

Dwarf mistletoes are among the most widespread and damaging forest pathogens (disease-causing organisms) in the Southwestern Region with over one-third of the ponderosa pine type (Figure 24) and up to one-half of the mixed conifer type having some level of infection. Damage to host trees from dwarf mistletoe infection includes growth reduction, deformity (especially the characteristic witches' brooms), and decreased longevity (Figure 25). Severely infested areas have higher tree mortality rates than uninfected areas. Weakened trees can be killed by other damaging agents such as bark beetles. Dwarf mistletoes have an ecological role, as they provide bird roosting habitat and an occasional food source for some mammals and birds. There are eight species of dwarf mistletoe in the region, each with a primary tree host. The species that primarily affect ponderosa pine, pinyon pine, and Douglas-fir are the most common and are found throughout most of their respective host ranges, while the other species have more limited distributions. In 2023, remeasurements were completed on a permanent plot network established in 1991. These data will provide information on dwarf mistletoe incidence, impacts, and rate of spread. More information can be found in the "Other Entomology and Pathology Activities in 2023".

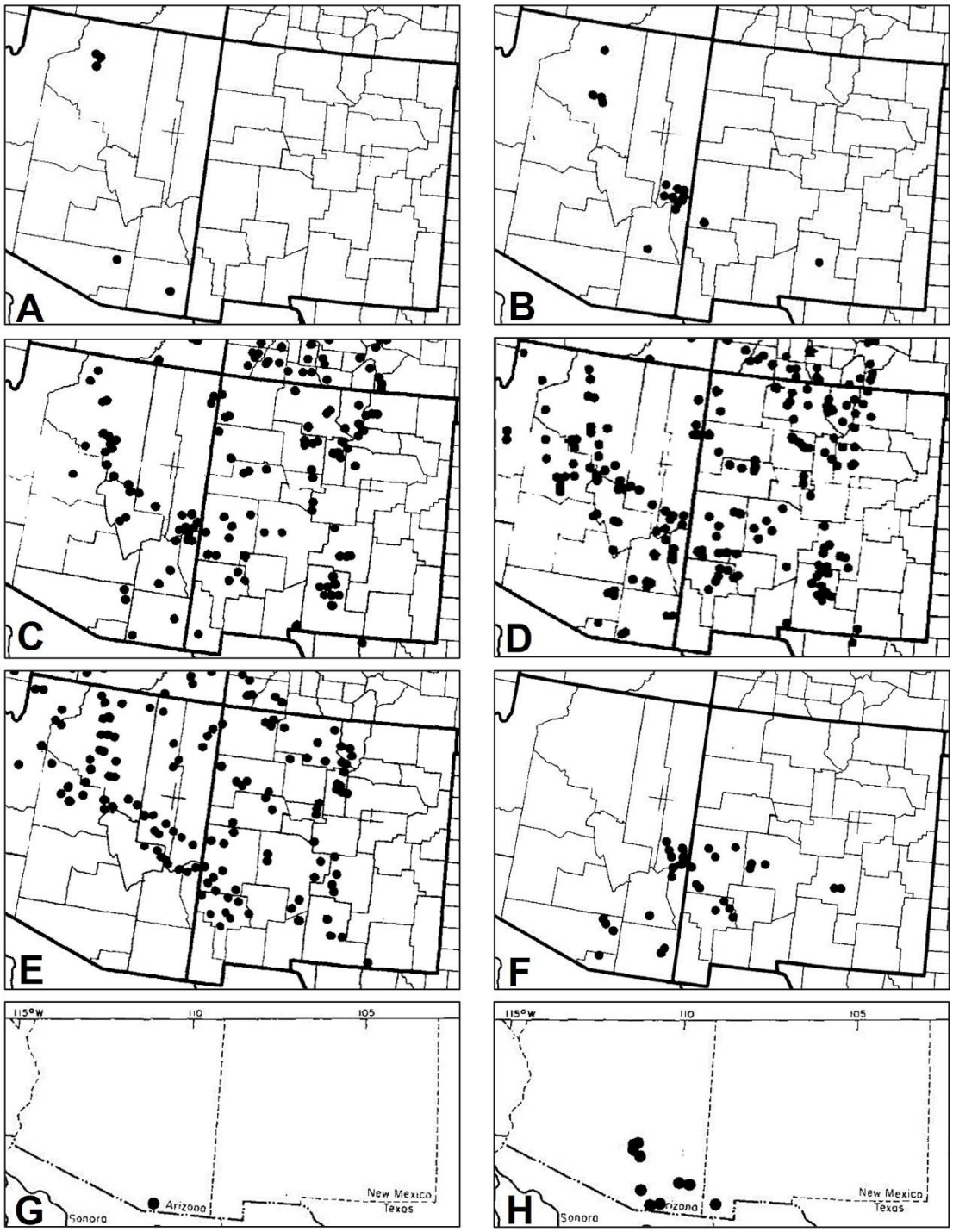

Figure 24: Distributions of dwarf mistletoe species in the Southwestern Region principally infecting white fir (A, *Arceuthobium abietinum* f. sp. *concoloris*), spruce (B, *A. macrocarpum*), Douglas-fir (C, *A. douglasii*), ponderosa pine (D, *A. vaginatum* subsp. *cryptopodum*), pinyon pine (E, *A. divaricatum*), southwestern white pine (F, *A. apachecum* and G, *A. blumeri*), and Chihuahua pine (H, *A. gillii*). Maps are adapted from Hawksworth and Wiens (1996).

Figure 25: A ponderosa pine witches' broom heavily infested with southwestern dwarf mistletoe (left) and a female shoot loaded with explosively dispersed seeds and a witches' broom in the background (right).

True Mistletoes

Phoradendron spp.

Hosts: Junipers, Arizona cypress, white fir, and various hardwoods

Eight species of true mistletoe occur in the Southwestern Region. These mistletoes are less damaging to their hosts than dwarf mistletoes, but heavy infestations can reduce host longevity during periods of drought. The leafless *Phoradendron juniperinum* on junipers is probably the most widespread and abundant species. Big leaf mistletoe (*P. macrophyllum*) is ubiquitous throughout many riparian areas in the region where it infects most riparian hardwood species (excluding oaks). Southwestern oak mistletoe (*P. coryae*) is common on oaks in lower elevations and in southern portions of the region. Desert mistletoe (*P. californicum*), another leafless species, can be abundant on mesquite and palo verde in desert woodlands. There is one true mistletoe known to infect white fir (*P. pauciflorum*), which is limited to southern Arizona. *Phoradendron densum* is also common in Arizona cypress around Sedona.

Root Diseases

Root diseases are common in forests of the Southwestern Region. They can predispose trees to root failure, a concern in campgrounds and other developed recreation areas. In the Southwest, root diseases affect a wide range of hosts but are more common in mixed conifer and spruce-fir forests than in ponderosa pine. Root disease can also be found in hardwood species. Root diseases spread slowly, so overall extent changes little from year to year. Root disease is often described as a "disease of the site" as it can persist in the soil as a saprophyte on stumps and large roots for decades after host trees are removed or killed by fire.

Armillaria Root Disease

Armillaria spp.

Hosts: Spruce, true firs, Douglas-fir, white fir, ponderosa and pinyon pines, oaks, and occasionally aspen

Armillaria root rot is the most common root disease in the Southwest, where it is estimated to account for up to 80% of all root disease-associated mortality (Figure 26). Although all conifer species and size

classes can be infected, root disease is more common in old growth mixed conifer and spruce-fir forests. *Armillaria solidipes* (=*A. ostoyae*) is the major *Armillaria* species in southwestern coniferous forests. *Armillaria gallica* has also been identified in mixed conifer forests in Arizona but is typically considered a saprophyte of dead trees. In addition, *A. mellea* has been found in live oaks in southern Arizona. Previous surveys in mixed conifer forests on the North Kaibab RD, Kaibab NF found *Armillaria* spp. on about 30% of standing live trees.

Figure 26: Recent Southwestern white pine mortality with severe Armillaria root disease as indicated by the white mycelial fan (left). Ponderosa pine with Armillaria root disease displaying diagnostic white mycelial fan (right).

Heterobasidion Root Disease (Formerly Annosus Root Disease)

Heterobasidion irregulare and *H. occidentale*

Hosts: Ponderosa pine (*H. irregulare*), true firs and Engelmann spruce (*H. occidentale*)

Heterobasidion root disease is the second most common root disease in the Southwest, where it is found in higher elevation ponderosa pine and mixed conifer forests throughout Arizona and New Mexico. Fruiting bodies are commonly found inside hollow stumps and sometimes on downed logs and upturned roots. *Heterobasidion occidentale* is common in white fir in the Southwest but also occurs on

subalpine fir and Engelmann spruce. *Heterobasidion irregulare* affects ponderosa pine and is found throughout the region. It does not commonly cause disease in the Southwest. Like *Armillaria* spp., *Heterobasidion* spp. are known as saprophytes or nutrient recyclers of dead woody material as well as pathogens and may persist on a site even in the absence of live hosts.

Other Common Root Diseases

Other common root diseases in the Southwest include Schweinitzii root and butt rot, caused by the fungus *Phaeolus schweinitzii*, which is often found on older Douglas-fir and occasionally on ponderosa pine, southwestern white pine, white fir, and spruce (Figure 27). Tomentosus root disease, caused by *Onnia tomentosa*, is found on spruce and Douglas-fir and can be a major hazard tree consideration where it occurs in developed recreation sites. Numerous removals occurred in New Mexico in 2023 due to this disease after widespread infection was found in Hopewell Lake Campground on the Carson NF in late 2022. Black stain root disease, caused by *Leptographium* spp., appears to be rare in the Southwest but has been reported in pinyon pine in northern New Mexico and Douglas-fir on Mescalero Apache Tribal Lands. Infections by another less aggressive species of *Leptographium* have also been observed recently in pinyon pine in New Mexico. Ganoderma root rot is caused by two species of *Ganoderma*, *G. applanatum* and *G. lucidum. Ganoderma applanatum* is the primary root disease affecting aspen in the Southwest. The disease causes crown dieback, windthrow, and mortality, especially in older aspen stands (though aspen of all ages are affected). Aspen stands on mesic sites seem to have higher incidence of disease compared to drier sites. *Ganoderma lucidum* affects many hardwood species, including Fremont cottonwood, Emory and silverleaf oak, Arizona sycamore, and netleaf hackberry. Infection may lead to gradual decline, and the presence of a fruiting body indicates high potential for failure.

Figure 27: *Phaeolus schweinitzii* fruiting body next to an infected cut stump (left) and the characteristic brown rot caused by this root disease pathogen (right).

Stem Decays

Stem decays are common in older trees throughout the Southwestern Region. Decay represents an economic loss in terms of timber production and can increase hazards on developed sites, but decayed trees also provide important cavity habitat for many wildlife species, especially birds. One of the most common stem decays causing brown rot in the Southwest is red belt fungus, *Fomitopsis schrenkii*, which affects conifers and sometimes aspen. Prominent stem decays causing white rots in the region include red rot, *Dichomitus squalens*, of ponderosa and pinyon pines; red ring rot, *Porodaedalea pini*, affecting most conifers; paint fungus, *Echinodontium tinctorium*, on true fir and occasionally Douglas-fir or spruce; false tinder conk, *Phellinus tremulae*, on aspen; pouch fungus, *Cryptoporus volvatus*, a sap rot found on bark beetle-killed conifers; *Phellinus everhartii* and *Inonotus dryophilus* on oak species; *Inonotus munzii* on cottonwoods; and *Phellinus weirianus* on Arizona walnut. Widespread and severe stem decay caused by *Phellinus tremulae* resulted in a failure of a large live tree that fell across the roadway was identified in Jacks Creek Campground on Santa Fe NF in 2023, and subsequent removal of numerous hazard tree. Decay in the butts of fire-injured ponderosa pine, most likely red rot, also led to hazard tree removals in the Banco Bonito Staging Area on Valles Caldera National Preserve in 2023.

Stem Rusts

White Pine Blister Rust

Cronartium ribicola

Hosts: Southwestern white, limber, and Rocky Mountain bristlecone pines (aecial stage); *Ribes*, *Castilleja*, and *Pedicularis* spp. (telial stage)

White pine blister rust, caused by *Cronartium ribicola*, is the only known exotic invasive forest disease in the Southwestern Region, where thousands of acres of mesic mixed conifer forest have severe infection (more xeric sites generally have low to moderate infection). Top kill is very common in severely affected areas (Figure 28). Although Rocky Mountain bristlecone pine is susceptible, white pine blister rust has not yet affected this species within the Southwestern Region.

Figure 28: White pine blister rust-caused topkill on a southwestern white pine in the Sacramento Mountains, New Mexico (left), aecial spore sacs on an infected branch in the Zuni Mountains, New Mexico (center), and heavy production of uredospores on *Ribes*, an alternate host of this invasive disease (right).

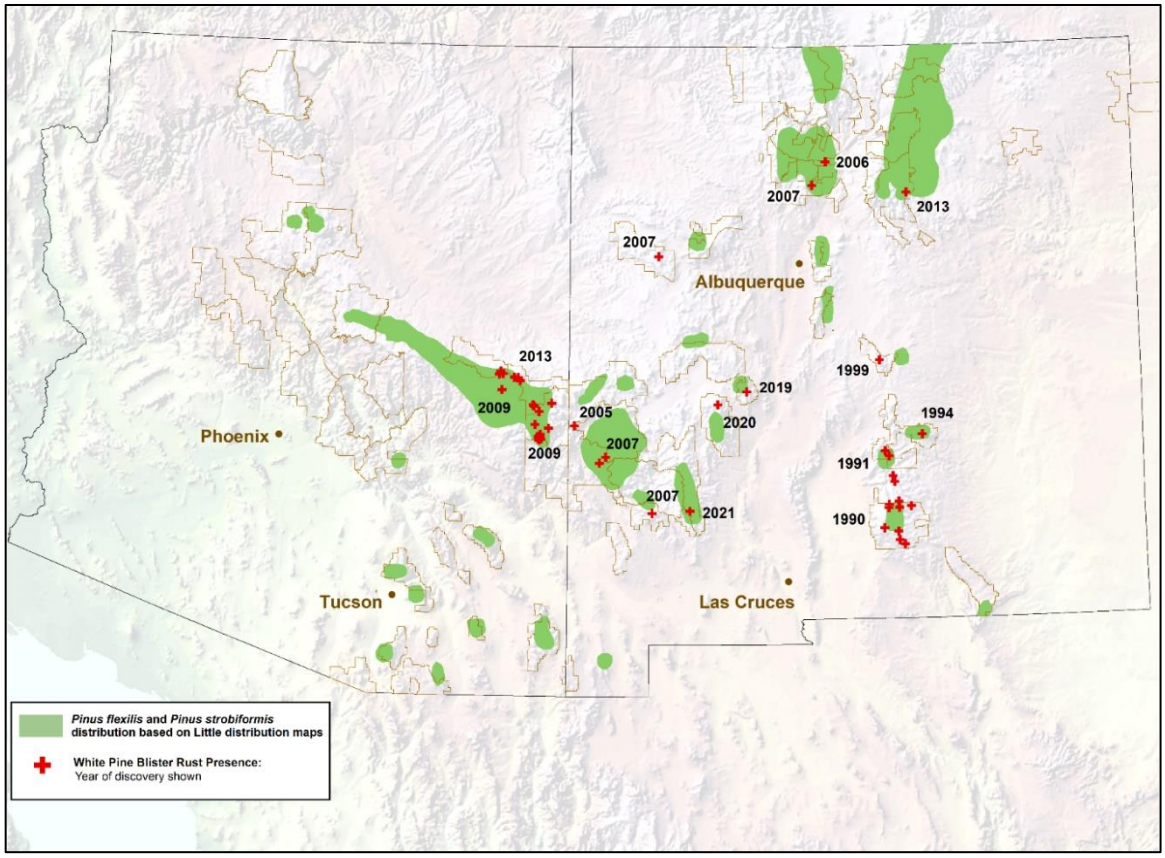

Figure 29. Distribution of known white pine blister rust infection centers within the Southwestern Region and the year in which they were discovered. USDA Forest Service image.

In New Mexico, this disease continues to cause heavy damage to southwestern white pines on the Sacramento Mountains, where the disease has likely been established for over 40 years (Figure 29). Based on a set of representative monitoring plots, roughly 45% of the white pines in this area, which includes Mescalero Apache Tribal Lands and most of the Lincoln NF, are infected. White pine blister rust also occurs on the Gila, Cibola, and Santa Fe NFs of New Mexico. In 2022, white pine blister rust infection on the Black Range of the Gila NF was confirmed, and the disease is now found on most mountain ranges in central and southern New Mexico.

In Arizona, white pine blister rust was first detected in 2009 on White Mountain Apache Tribal Lands and neighboring Apache-Sitgreaves NFs, which are still the only land management units known to be affected in this state (Figure 29). Age estimation of older cankers suggest the white pine blister rust pathogen may have been present for 20 years but at undetectable levels. Since 2009, favorable weather conditions for the pathogen have allowed for continued disease expansion into new areas, including into more moderate hazard sites throughout most of the White Mountains. However, white pine blister rust is still absent throughout much of the host type in Arizona.

In collaboration with Northern Arizona University, permanent monitoring plots have been established throughout the host type in the region, and a remeasurement of this network was completed in 2023. Spore trapping for *C. ribicola* also occurred in 2023 in collaboration with Colorado State University. Several strategies to conserve genetic resistance against white pine blister rust are being implemented. More information on white pine blister rust projects can be found in the “Other Entomology and Pathology Activities in 2023” section.

Broom Rusts

Melampsorella caryophyllacearum

Hosts: True firs (aecial stage) and chickweed (telial stage)

Chrysomyxa arctostaphyli

Hosts: Spruce (aecial stage) and bearberry or kinnikinnick (telial stage)

There are two species of broom rust that occur at relatively low frequency on their respective hosts in the Southwestern Region. However, higher infestations of fir broom rust occur on the Sandia and Manzano Mountains of central New Mexico and a few other locations (Figure 30). Damage from this easily recognized disease has not been well quantified, but infection can result in top-kill, especially in spruce. Falling brooms or stem breakage may present a hazard in developed recreation sites.

Figure 30: Fir broom rust symptoms on a white fir in the Sandia Mountains, New Mexico (left) and the aecial spore sacs on needles within the broom (right).

Limb Rust and Western Gall Rust

Cronartium arizonicum and *Endocronartium harknessii*, respectively

Hosts: Ponderosa pine (aecial stage) and *Castilleja* spp. (telial stage, *C. arizonicum* only)

There are two rust diseases on ponderosa pine in the Southwestern Region. The most frequently observed is *Cronartium arizonicum*, the cause of limb rust. Limb rust is common in portions of Arizona and can be quite damaging to individual trees. Limb rust incidence in New Mexico is infrequent but has been found on Jicarilla Apache Tribal Lands. The fungus causes orange-colored pustules on dying branches with progressive upward and downward branch mortality, generally initiating from the center

of the crown. Waves of new infection are initiated by climate conditions conducive to this disease and may occur at intervals of several years.

Western gall rust, caused by *Endocronartium harknessii*, deforms but seldom kills older trees. Infection typically causes the growth of large galls on infected branches. Occasionally, during wave infection years, this pathogen has caused mortality in seedlings and saplings. The pathogen that causes this rust disease does not have an alternate host, and infection proceeds from pine to pine. This disease is uncommon in the Southwestern Region.

Canker Fungi

Canker diseases are commonly associated with damaged or stressed trees. Disturbances which may inflict mechanical damage to trees or stressors such as drought can increase the incidence of canker diseases. These pathogens are often involved in aspen mortality and dieback due to the soft living tissue of the bark, which makes aspen extremely susceptible to wounding and subsequent infection. Sooty bark canker, caused by *Encoelia pruinosa*, is the most lethal canker of aspen, while Cytospora canker, caused by *Cytospora* spp., is the most common (Figure 31).

Valsa melanodiscus (anamorph *Cytospora umbrina*) causes alder heat canker, which continued to be observed in association with dieback and mortality of Arizona alder (*Alnus oblongifolia*) in 2023. Damage and mortality related to this pathogen was observed in Oak Creek Canyon, Red Rock RD, Coconino NF as well as along Tonto Creek and the East Verde River, Payson RD, Tonto NF (Figure 31). Alder heat canker has been associated with large scale dieback and mortality of alder in Alaska, Colorado, and New Mexico.

Pathogens in the genus *Biscogniauxia* were first observed causing dieback and mortality of Emory and silverleaf oaks in 2018 and have since been observed on the Nogales, Douglas, and Safford RDs, Coronado NF, Bradshaw RD, Prescott NF, and the Pleasant Valley RD, Tonto NF (Figure 31 and Figure 32). In 2024, *Biscogniauxia* spp. were observed for the first time on the Red Rock RD, Coconino NF. These pathogens were also observed on dead oaks on the Silver City and Reserve RDs, Gila NF, in 2022, representing the first observations in New Mexico. The most severe dieback and mortality associated with these pathogens thus far has been observed in Madera Canyon in the Santa Rita Mountains and along Turkey Creek in the Chiricahua Mountains of southeastern Arizona. Mortality is distributed across size classes. Two species have been identified, *Biscogniauxia mediterranea* and an undescribed *Biscogniauxia* species. Pathogens of this genus are generally associated with dieback and mortality of drought-stressed trees. As conditions in the Southwest continue to become hotter and drier, it is likely these pathogens will continue to become more prevalent on the landscape.

Figure 31: Orange discoloration, oozing, and diffuse pattern associated with cytospora on aspen (left). Sunken tissue and diffuse pattern associated with alder heat canker; note the beetle and woodpecker activity which is commonly associated with this canker and alder dieback in Arizona (middle). Flat, dark fruiting body of *Biscogniauxia* spp. And associated canker on Emory oak.

Figure 32: Damaged and discolored oaks on the Coronado National Forest likely due to *Biscogniauxia* spp.

Foliar Diseases

Foliar diseases in the Southwest may occur in conifers (needle casts) or hardwoods. Fungal species causing these diseases may overwinter in old leaf litter from the previous year or in previously infected foliage that has not been cast. Outbreaks are sporadic and highly dependent on favorable weather conditions, generally coinciding with above average moisture in the spring and/or early summer. In conifers, symptoms may be similar to winter injury or salt damage, but the presence of fruiting bodies on needles can allow for confirmation of needle cast disease. Fruiting bodies are typically black in color but can be tan or brown. Foliar diseases in hardwoods are most often observed in aspen, cottonwood, willow, and sycamore. Heavy infections may cause defoliation, particularly in the lower crowns where humidity tends to be higher. Although occasional outbreaks can appear quite dramatic, foliar diseases rarely cause long-term damage in the region.

In New Mexico, no major damage by foliar pathogens was observed via aerial survey in 2023 other than the previously mentioned 394 acres of oak defoliation partially attributed to *Articularia quercina* infection (see Western Rose Chafer). Some *Bifusella* needle cast was observed in understory southwestern white pine in a stand on Mescalero Apache Tribal Land during ground surveys (Figure 33). In Arizona, chronic white pine needle cast caused by *L. arcuata* has been observed impacting southwestern white pine on the San Francisco Peaks and is particularly severe at higher elevations where conditions are more conducive to this pathogen (Figure 33). In addition, sycamore anthracnose (A*piognomonia veneta*) continues to affect riparian areas throughout Arizona. This foliar disease is particularly noticeable in Oak Creek Canyon and Wet Beaver Creek near Sedona where the infection appears to be a chronic issue.

Figure 33: *Bifusella* needle cast symptoms and elongated black fruiting bodies on older needles killed by the disease in an understory southwestern white pine on Mescalero Apache Tribal Lands in New Mexico (left), and southwestern white pine exhibiting red crown discoloration due to *Lophodermella arcuate* infection on the Coconino National Forest in Arizona (right); note the dark green ponderosa pine which is not susceptible to this disease.

Abiotic Damage

Salt

De-icing salt use has contributed to chronic ponderosa pine damage along highways in the Southwestern Region (Table 4). Approximately 406 acres with salt damage were observed from aerial surveys in 2023, decreasing from 620 acres in 2022. About 250 acres with damage were mapped in Arizona, and 155 acres were mapped in New Mexico. Damage has typically been observed along major corridors, including county and city roadways, as states, counties, and municipalities continue use of de-icing salts. Application of dust abatement salt is also associated with damage to ponderosa pine along dirt roads in rural housing areas. Damage may be more widespread than observed during aerial surveys, as it is typically more obvious when viewed from the ground.

Red Belt Winter Injury

Late season winter injury can inflict significant damage to affected trees. In New Mexico, a 6,480-acre red belt event was recorded in 2021 with discoloration found on a variety of conifer species of different age and size, including ponderosa pine, Douglas-fir, and white fir. About 85% of this damage occurred on the Lincoln NF with the remainder found on Mescalero Apache Tribal Lands and state and private lands. The red belt event was apparent from south of Sierra Blanca north throughout the Smokey Bear RD and included a large area of the Capitan Mountains. Red belt is a landscape-scale winter injury event that occurs with the sudden appearance of warm dry winds (e.g., Chinook winds) producing a temperature inversion. A relatively thin layer of warm air arrives that cannot mix downward and continues to contact side slopes. Trees exposed to unseasonably warm air by day receive seasonably cold air at night. This alteration of warm and cold air exposure, along with the frozen condition of the soil, results in desiccation injury because daytime transpiration removes moisture from the needles more rapidly than roots in frozen soil can replace it. Although most affected trees were expected to recover, high mortality occurred across about 14% of the impacted area (910 acres) in 2022.

All 2021 red belt areas on the Lincoln NF and Mescalero Apache Tribal Lands had recovered by 2023, but a new red belt winter injury event occurred across 1,185 acres of the Valle Vidal Unit of the Questa RD, Carson NF between The Rock Wall and Beatty Lakes during the winter of 2022-2023. Ponderosa pine was the primary host damaged, but other conifer species in the area were also affected. As severely impacted areas may experience higher mortality in future years, continued monitoring will occur. Red belt and other winter injury events may become more common with a changing climate leading to milder winters.

Drought

The Southwestern Region experienced exceptional drought conditions entering 2022, but significant monsoon precipitation that summer as well as heavy snowpack in higher elevations across much of the region in the winter of 2022-2023 somewhat alleviated the dry conditions. Some drought-induced damage was still apparent in 2023. Evidence of this acute drought stress was observed to some extent in all tree species but was particularly notable in ponderosa pine (Table 4). Juniper crown dieback across Arizona had largely subsided in 2023 with 158 acres mapped across multiple ownerships in the state, down from 98,850 acres in 2022 (Table 4). Only two acres of juniper dieback were mapped in New Mexico in 2023 after not being observed in 2022.

Drought-stressed ponderosa pine exhibited slight yellowing of needles and some premature needle loss (Figure 34). Symptoms were most evident on dry ridges and upper slopes. New Mexico accounted for most of the drought stress mapped in ponderosa pine with 16,531 acres in 2023, down from 74,470

acres in 2022 (Table 4). Most of this damage was mapped on the Carson NF (6,589 acres), state and private lands (4,368 acres), Lincoln NF (2,150 acres), and Gila NF (2,053 acres). In Arizona, acres of ponderosa pine drought impacts increased from 610 acres in 2022 to 3,906 acres in 2023. Most of the damage was mapped on Kaibab NF (1,974 acres) and White Mountain Apache Tribal Lands (1,099 acres). In contrast, drought stress affecting other species declined from 96,440 acres in 2022 to 1,259 acres in 2023. Most of this damage was mapped on San Carlos Apache (685 acres) and White Mountain Apache Tribal Lands (481 acres). Delayed, late season damage associated with drought stress can be high, and normal ADS flights may underestimate damage in years of acute drought. Drought stress may increase susceptibility to insects and diseases which do not affect vigorous trees. Drought may also act as a principal mortality agent.

Figure 34: Drought-stressed, discolored ponderosa on White Mountain Apache Tribal Lands in eastern Arizona, August 2023.

Hail

Hail damage was observed on 1,970 acres of ponderosa pine and aspen in 2023. All the damage was located on the North Kaibab RD, Kaibab NF in Arizona. Forest Health Protection staff visited the large polygon of damage which had been mapped in 2022 and 2023 to determine the causal agents. Symptoms observed were consistent with hail damage, including thin crowns, cracked, broken, or discolored older needle cohorts and mechanical damage to boles and the upper surface of branches. Damage was most prevalent on the south side of affected trees with little to no damage to the northside (Figure 35). Damage was more severe in the tops of the crowns across age/size classes. In addition, elevated recent mortality was observed across size/age classes. Many ponderosa pine showed signs and symptoms of Armillaria root disease and bark beetles, while aspen showed signs and symptoms of secondary canker pathogens, mainly Cytospora canker. Widespread aspen overstory mortality was observed. However, most clones exhibited a strong sprouting response indicating the root systems remained healthy. The large hail event likely acted as an inciting factor in the decline observed in this

area, placing additional stress on affected trees which led to increased susceptibility to root disease, canker pathogens, and beetle activity**.**

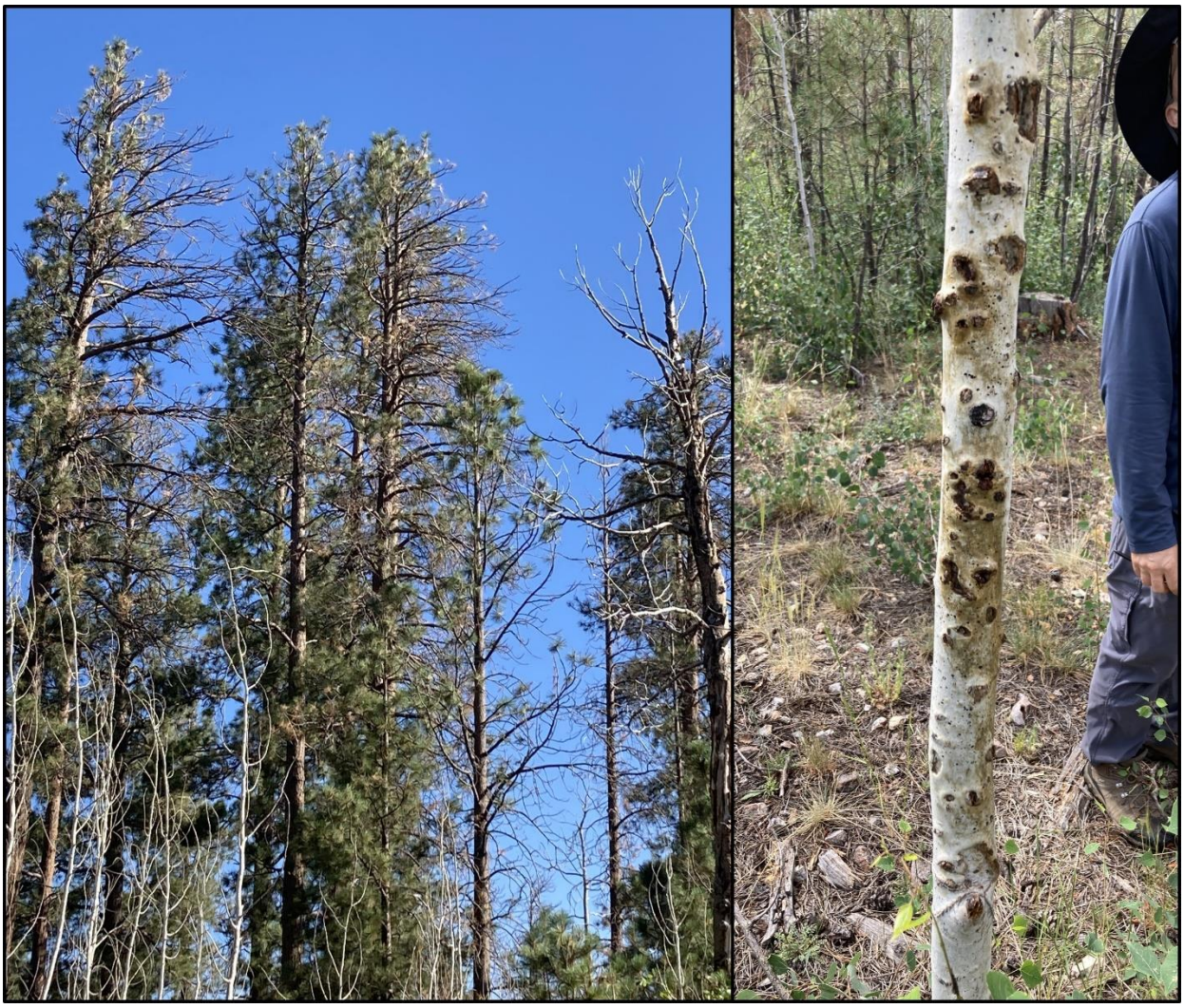

Figure 35: Ponderosa pine exhibiting thin, hail damaged crowns with damage most severe on the south side (left). Aspen displaying mechanical damage from hail and subsequent cankers. Damage was most severe on the south side of the stem (right).

Invasive Species

Invasive species and diseases have increasingly become a greater threat throughout the Southwestern Region. Invasive species means, with regard to a particular ecosystem, a non-native organism whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health (from Executive Order 13112, as amended – Safeguarding the Nation from the Impacts of Invasive Species, 2016). The Executive Order requires Federal agencies to prevent and control these species and to minimize their economic, ecological, and human health impacts. Invasive insects and diseases are covered in the entomology, pathology, and in the special projects section while mainly invasive plants are covered here.

Table 5 shows some of the major invasive species and diseases that pose the greatest threats to terrestrial and aquatic ecosystems on national forests and grasslands in the Southwestern Region. Many other invasive or exotic species (e.g., introduced fish species) also can seriously impact native species. Further information on invasive species associated with national forests and grasslands in the Southwestern Region may be found at http://www.fs.usda.gov/main/r3/forest-grasslandhealth/invasivespecies.

Table 5. Major invasive species and diseases threatening national forests and grasslands in Arizona and in New Mexico.

Type	Common name, Species	Impacts
Pathogens	Chronic wasting disease, prion-based Chytrid fungus, *Batrachochytrium dendrobatidis* Whirling disease, *Myxobolus cerebralis* White pine blister rust, *Cronartium ribicola*	Deer and elk Amphibians Salmonid fish species Five needle pines
Terrestrial Plants	Buffelgrass, *Cenchrus ciliaris* Cheatgrass, *Bromus tectorum* Giant cane, *Arundo donax* Musk thistle, *Carduus nutans* Yellow bluestem, *Bothriochloa ischaemum*	Desert plant communities Grasslands and shrublands Waterways Grasslands and shrublands Grasslands and shrublands
Invertebrates	Northern crayfish, *Orconectes virilis* Spruce aphid, *Elatobium abietum* Oystershell scale, *Lepidosaphes ulmi* Quagga mussel, *Dreissena rostriformis bugensis*	Aquatic plants and animals Engelmann and blue spruce Aspen and other hardwoods Streams, rivers, and lakes
Vertebrates	American bullfrog, *Lithobates catesbeiana* Feral hog, *Sus scrofa*	Aquatic animals Plant communities and small animals

Common Invasive Plant Species in Region 3*

Annual Grasses

Cheat grass	*Bromus tectorum*
Red brome	*Bromus*

Perennial Grasses

Buffelgrass	*Pennisetum ciliare*
Fountain grass	*Cenchrus setaceus*
Yellow bluestem grass	*Bothriochloa ischaemum*

Annual and Perennial Forbs

Sahara mustard	*Brassica tournefortii*
London rocket	*Sisymbrium irio*
Stinknet	*Oncosiphon pilulifer*
Russian thistle	*Salsola tragus*
Dalmation toadflax	*Linaria dalmatica*
Diffuse knapweed	*Centaurea diffusa*
Bull thistle	*Cirsium vulgare*
Scotch thistle	*Onopordum acanthium*

Woody Perennials

Giant reed	*Arundo donax*
African sumac	*Searsia lancea*
Salt cedar	*Tamarix ramosissima*
Siberian elm	*Ulmus pumila*
Russian olive	*Elaeagnus angustifolia*

*This is not an exhaustive list. Just the most common.

Highlight of Three Species

Buffelgrass

Buffelgrass (*Cenchrus ciliaris*) is the single greatest invasive threat to the Sonoran Desert in the Southwestern Region. This bunchgrass was originally introduced from Africa into the southwestern U.S. as a forage grass and has since spread into the Sonoran Desert. Buffelgrass out-competes native desert vegetation for water, nutrients, and sunlight. The grass also forms a dense, continuous fine fuel that

promulgates wildfire, leading to more widespread and intense fires. Plant species native to the Sonoran Desert, such as saguaro cactus (*Carnegiea gigantea*) and palo verde (*Parkinsonia microphylla*), are not adapted to fire and are generally extirpated after several fire cycles.

The Coronado NF and other land management agencies in Arizona are currently engaged in intensive management projects to detect and control buffelgrass on a landscape scale. The Sonoran Desert Museum coordinates efforts by local federal agencies, state agencies, and private organizations in the fight against buffelgrass.

Yellow Bluestem

Yellow bluestem (*Bothriochloa ischaemum*) is a warm-season perennial bunchgrass that is commonly found along many road systems in the Southwestern Region. The panicle of yellow bluestem has a fan or finger-like appearance, and the stem has a pale-yellow stem color below the nodes that transitions into green (Figure 36). This bunchgrass species was originally imported from Eurasia and northern Africa in the early 1900s for erosion control and as a forage crop for haying and grazing. Yellow bluestem is very adaptable and highly aggressive, especially in disturbed areas. It can form a monoculture that lowers biodiversity of native plant communities by reducing abundance, diversity, and richness of native plant species. Infestations of yellow bluestem also alter soil carbon: nitrogen ratios and the composition of soil microbial communities, including arbuscular mycorrhizae. This transformation in soil properties can inhibit growth of native plant species. In addition, yellow bluestem-infested areas can be relatively unsuitable for nesting, brood rearing, or year-round habitat for grassland bird species. The lower bird numbers may reflect decline in arthropod abundance and/or biomass. Yellow bluestem has become invasive in native grasslands and pastures in the Midwest, southcentral Arizona, and the southern Great Plains (Oklahoma, Texas, and eastern New Mexico).

Figure 36. Yellow bluestem near Algin, Arizona. Borderlands Restoration Network photo.

Saltcedar

One of the most widely distributed invasive species in the Southwestern Region is saltcedar (*Tamarix* spp.), which occurs as a shrub or tree along many waterways and riparian areas. In 2001, several species of the tamarisk leaf beetle (*Diorhabda* spp.) from central Eurasia were released in western states as a host-specific biocontrol agent. Adult tamarisk leaf beetle and larvae both consume saltcedar foliage, which can damage or kill the plant over several years. Feeding by the beetle causes saltcedar leaves to dry out and turn brown while remaining on the stem (Figure 37); thus, crown discoloration is commonly seen in affected saltcedar stands.

Figure 37. Tamarisk leaf beetle. USDA Forest Service photo by Camden Bruner.

Since their release, different species of tamarisk leaf beetle have migrated throughout much of Arizona and New Mexico. Further information on the tamarisk leaf beetle may be found at the website of RiversEdge West (formerly, the Tamarisk Coalition) at https://www.riversedgewest.org.

Areas with defoliated saltcedar may become infested by other invasive weeds that need to be controlled. In addition, the advancing migration of tamarisk leaf beetle species threatens nesting habitat used by the federally listed southwestern willow flycatcher (*Empidonax traillii extimus*), which nests in saltcedar-dominated plant communities that have replaced native willow species (*Salix* spp.).

Invasive Plants Program Activities in 2023

Activity on Forest Service Lands

During 2023 there were several important developments in the Southwestern Region. The Regional Invasive Species Program Manager and Pesticide Use Coordinator position was filled by Janet Nickerman in June 2023. Prior to June, the position was filled as collateral duties by Andrew Graves and Joel McMillin. This position covers all State, Private and Tribal and Forest Service lands.

In displaying invasive species information, it's difficult to weigh the importance of each species in treatment acres. For example, smaller treated acres might be critical to stopping an initial introduction of a new invasive species spread. A larger treatment of invasives might be part of a larger treatment to keep it from spreading further.

Table 6 may not be the complete treatment on Forest Service lands in 2023. There was a change in the reporting system and there were technical challenges.

Table 6: Invasive Treatments on Forest Service Lands.

Latin Name	Common Name	Acres	Forest
Acroptilon repens	hardheads	0.1	Coronado NF
Aegilops cylindrica	Jointed goatgrass	1.4	Coronado NF
Bothriochloa bladhii	Caucasian bluestem	0.2	Coronado NF
Bothriochloa ischaemum	Yellow bluestem	11.1	Coronado NF
Bromus japonicus	Japanese brome	44	Gila NF
Bromus rubens	Field brome	89.1	Coronado NF
Bromus tectorum	Cheatgrass	145.4	Coconino NF and Gilia NF
Lepidium (Carderia) draba	whitetop	0.5	Coconino NF
Carduus nutans	Musk thistle	2.3	Coconino NF
Centaurea diffusa	Diffuse knapweed	279.7	Coconino NF
Centaurea stoebe L. micranthos	Spotted knapweed	1.1	Coconino NF
Cirsium vulgare	Bull thistle	586.9	Coconino NF and Gila NF
Conium maculatum	Poison hemlock	5.1	Coconino NF
Euphorbia esula	Leafy spurge	897	Coconino NF
Linaria dalmatica	Dalmatian toadflax	444.8	Coconino NF
Marrubiam vulgare	Horehound	18.1	Coconino NF and Gila NF
Onopordum acanthium	Scotch cottonthistle	382.8	Cibola NF, Coconino NF and Kaibab NF
Pennisetum ciliare	Buffelgrass	11778.5	Coronado NF
Peteria scoparia	Rush peteria	5928.2	Coronado NF
Salvia aethiopis	Mediterranean sage	25.3	Coconino NF
Salsola tragus	Prickly Russian thistle	37.5	Coconino NF
Tamarix ramosissima	Saltcedar	951.7	Cibola NF and Gila NF
Tribulus terrestris	Puncturevine	0.4	Coconino NF
Ulmus pumila	Siberian elm	35.9	Cibola NF and Gila NF

State Programs

Arizona

In 2023, three invasive species agreements were issued to Arizona Department of Forestry and Fire Management (DFFM) for a total of $230,000. The three agreements are Observatory Mesa Invasive Species Treatment Area, Cocopah North Riverfront projects and capacity building.

The Observatory Mesa Invasive Plant Prevention and Control project targets musk thistle, bull thistle, scotch thistle, Dalmatian toadflax and field bindweed. The Bipartisan Infrastructure Law (BIL)-Invasive funding is $100,000 is part of the funding used for treatment. Additional funding is from Arizona Nonnative Vegetative Species Eradication Fund is $97,000 and Flagstaff matching funds are $22,750, for a total of $219,750 to treat 458 acres with 31.5 acres for reseeding with native species.

The Cocopah North Riverfront Project targets saltcedar, phragmites and other invasives along 30 acres on the Colorado River on Cocopah Tribal Lands. This invasive vegetation treatment is the first phase of a larger project that seeks to utilize treated wastewater to restore riparian land and create wetland habitat. A restoration design and engineering plan was completed for this project in January 2023. As part of overall compliance with Federal grant requirements, this invasive plant project will be field audited at least once, during the operational period of the project. This BIL-funded invasive project is for $100,000.

In 2023, an additional agreement is the DFFM Capacity Building grant of $30,000. The intent of this grant is for DFFM is have additional funding to build its invasive species program. For further information on grant programs for invasive plants in Arizona, contact the Willie Sommers with DFFM (wsommers@dffm.az.gov).

New Mexico

In 2023, one grant agreement was issued to New Mexico's Energy, Mineral, Natural Resource Department (EMNRD). This funding is for treatment of the Tiffany Fire invasive, early detection rapid response (EDRR) and invasive treatment areas.

The grant funds will be used for noxious weed eradication and riparian habitat restoration activities on private lands within the Tiffany Fire boundary. It was the largest bosque fire in recent history, encompassing 9,200 acres of federal and private lands and destroying thousands of acres of mature gallery forests in the Middle Rio Grande. EMNRD will enter into an agreement with Sierra Soil and Water Conservation District to administer restoration activities on private lands, specifically the eradication of tamarisk monoculture systems have perpetuated along a six-mile stretch of private lands in the Middle Rio Grande, between Bureau of Reclamation lands and Bosque del Apache National Wildlife refuge. The agreement is $100,000.

For further information on grant programs for invasive plants in New Mexico, contact the Ashley Taylor with EMNRD (Ashley.Taylor@emnrd.nm.gov).

Other Entomology and Pathology Activities in 2023

Forest Health Regional Training

The FHP staff provides annual training opportunities to resource managers on insect and disease identification, effects, and management as well as hazard tree identification and mitigation. In 2023, the classroom portion of these regional trainings were held virtually. Presentations were given live via Microsoft Teams, well attended, and included multiple agencies and diverse participants. Presentations were recorded and made available to internal and external partners. Follow-up field training days occurred in Arizona on the Kaibab and Apache-Sitgreaves NFs for Forest Service personnel from both Arizona and New Mexico. Additional field trainings were provided in Arizona to Forest Inventory and Analysis staff. Typically, regional trainings occur annually with the location alternating between Arizona and New Mexico. Another virtual regional training is being planned for 2024, followed by field days in each respective FHP zone.

Dwarf Mistletoe Plot Re-Measure

The Pest Trend Impact Plot System (PTIPS), focused largely on southwestern dwarf mistletoe, was established in 1991 and has been re-measured on roughly 10-year intervals. The fourth re-measure of the plot network was initiated in 2017 in Arizona and 2020 in New Mexico. The PTIPS plots in Arizona were completed in 2020, and the plots in New Mexico were completed in 2023. This long-term plot system was established to assess rate of southwestern dwarf mistletoe spread, as well as impacts on growth and survival of ponderosa pine infected by the pathogen. Data have been collected on tree status (live or dead), severity of infection, height, diameter, presence of regeneration, and presence of other pathogens or insects which may impact the health of the tree. These data, along with data from a plot network monitoring effects of fire on southwestern dwarf mistletoe, are being used to develop new parameters for the dwarf mistletoe model in Forest Vegetation Simulator and serve as the basis for updated management guidelines for the region. *For more information, contact Gregory Reynolds or Nicholas Wilhelmi.*

White Pine Blister Rust Genetic Resistance

In 2023, FHP continued work to sustain southwestern white pine and limber pine in the face of the introduced pathogen *Cronartium ribicola*, the causal agent of white pine blister rust. This work is being conducted in collaboration with Dr. Kristen Waring of Northern Arizona University, Dr. Owen Burney of New Mexico State University, Dr. Richard Sniezko of the Dorena Genetic Resource Center (DGRC), and others. Seeds were collected from parent trees across the range of southwestern white pine to grow and test for resistance to white pine blister rust and assess adaptive traits. Progeny of these parent trees were inoculated with *Cronartium ribicola* at DGRC in Cottage Grove, OR to evaluate resistance. A small percentage (around 5%) of trees have shown resistance in these trials with locations of parent trees distributed across much of the Region. Progeny from these inoculations that showed resistance are being grafted into an orchard at Tyrell Seed Orchard to conserve this resistant genetic material. Two regional field trials have been established in cooperation with the Mescalero Apache Tribe (2017) in New Mexico and the Apache-Sitgreaves National Forests (2018) in Arizona. These are long-term, fenced test sites that will be used to evaluate the durability of various disease resistance mechanisms observed at DRGC.

In addition, FHP has collected scion from parent trees throughout the region over the last several years which have shown some level of resistance to white pine blister rust, either via major gene resistance or quantitative resistance. No scion was collected in 2023. Overall, resistant trees have been collected from

the Lincoln NF and Mescalero Apache Tribal Lands in southern New Mexico, the Zuni Mountains (Cibola NF) of northern New Mexico, and the White Mountains of Arizona (Apache-Sitgreaves NFs). Scion material is being grafted into a seed orchard in Mora, NM and will be used to provide disease resistant seed for future reforestation efforts. In 2023, FHP and partners at Northern Arizona University also completed a ten-year remeasure of an extensive permanent plot network which spans much of the region. This plot network consists of 80 permanent plots that were randomly established between 2010-2012 to monitor the spread and intensification of white pine blister rust.

Spore trapping to monitor airborne *C. ribicola* spore stages and distribution of the pathogen also occurred in 2023 across three sites each in Arizona and New Mexico in a collaborative project with Colorado State University. Motorized, rotating traps with Vaseline-coated microscope slides were deployed with slides collected and switched out weekly (Figure 38). Initial analysis of the 2023 trapping season is underway. In addition, infected Ribes samples were collected from the Apache-Sitgreaves NF and sent to DGRC as part of a study to assess genetic variation of *Cronartium ribicola*. *For more information, contact Gregory Reynolds or Nicholas Wilhelmi.*

Figure 38: A motorized, rotating spore trap used to monitor airborne spores of *Cronartium ribicola*, the cause of white pine blister rust; spores are intercepted on microscope slides coated with petroleum jelly and quantified weekly using qPCR.

Roadside Hazard Tree Issues Following Fires

Plots have been established on two severe 2016 wildfires in New Mexico to assess the failure rate of fire-killed snags. The Doghead Fire in the Manzano Mountains, Cibola NF and North Fire in the San Mateo Mountains, Cibola NF have been assessed annually since the respective fires. Results from the two sites have been dramatically different, with nearly all the killed trees on the Doghead Fire falling within the first two years post-fire while only about a third of the trees have failed on the North Fire seven years post-fire. Higher rates of woodborers and extremely high wind speeds affected the Doghead Fire plots and may account for the difference in failure rates observed. Regardless of the disparity in results, this work demonstrates the importance of rapid post-fire roadside hazard tree mitigation work. An additional site is being established on the 2022 Cerro Pelado Fire, Santa Fe NF to supplement the existing plot network. *For more information, contact Gregory Reynolds.*

Assessing Potential for Spruce Beetle Outbreak Following Spruce Aphid Defoliation

In 2020, Arizona Zone FHP entomologists, in collaboration with scientists from Rocky Mountain Research Station in Flagstaff, AZ, Logan, UT, and Bozeman, MT and faculty at Northern Arizona University, received funding from Evaluation Monitoring (EM) to assess the impact of spruce aphid defoliation on the performance of spruce beetles. The study consisted of an individual tree study to monitor how well beetles perform in spruce with different levels of aphid-caused defoliation and a network of plots stratified by defoliation levels as determined by aerial surveys. For the individual tree study, thirty trees with a range of defoliation severities were baited with a pheromone lure to incite spruce beetle attacks. These trees were monitored over the summer. Spruce beetle success was evaluated by examining each tree for the presence of successful galleries and presence of larvae or pupae. Defense characteristics, in the form of terpene concentration, resin volume and resin ducts, were also analyzed for each tree. Tree mortality 18 months after baiting was higher for trees with high defoliation than trees with medium defoliation or low defoliation but was attributed to defoliation and root rot more than bark beetles. Mean resin duct density over 2021-22 was about two-fold greater for trees with medium or high defoliation compared with low defoliation. Phloem concentration of total terpenes and each of 34 constituent terpenes was similar among defoliation classes. Five months after baiting, an average of 67% of pitch tubes had beetle galleries, but this percentage did not differ over defoliation classes. The percentage of pitch tubes with larvae was lower than for galleries and differed among defoliation classes. Larvae were completely absent in trees with low defoliation, scarce in trees with moderate defoliation (6%), and most common in trees with high defoliation (20%). Results of this study suggest that spruce bark beetle under endemic conditions do not gain a reproductive advantage from trees defoliated by spruce aphid and beetle outbreaks likely do not initiate from aphid defoliation events. For the plot level data, we completed data collection in the summer of 2022, and analysis of these data are in progress. *For more information, contact Monica Gaylord*.

Anti-aggregant Pheromones to Reduce Ips Beetle Attacks on Ponderosa Pine

Arizona Zone entomologists, Joel McMillin and Monica Gaylord, teamed up with researchers Chris Fettig and Jackson Audley, from the Pacific Southwest Research Station, to test the efficacy of an anti-aggregant pheromone in preventing bark beetle attacks on ponderosa pine outside of Flagstaff, Arizona. In May of 2023, the team identified 75 small diameter (8-12 inch at breast height) ponderosa pine in an old plantation approximately 10 miles north of Flagstaff. These 75 trees were baited with the attractant lure for pine engraver (*Ips pini*). Two different doses of anti-aggregant (verbenone in the form of SPLAT verb) were than applied to 50 of the trees; 25 receiving a low dose (70 grams) and 25 receiving the double dose (140 grams) (Figure 39). The trees were monitored over the summer and a final check was done in October of 2023 to assess the number of successful attacks. Due to generally low beetle populations, only 8 trees total were attacked. The study will be repeated in 2024 in hopes of a higher percentage of trees being challenged. *For more information, contact Monica Gaylord.*

Figure 39: Ponderosa pine with bait for pine engraver (plastic bubble capsules, lower left) and SPLAT dollop (upper center).

Pinyon Ips Phenology

Pinyon pine is a major component of woodland ecosystems and many wildland-urban interfaces in the southwestern United States. These woodlands are important for wildlife habitat, ranching, firewood, and cultural practices to many Native American tribes. Presently, woodlands in many areas are more densely populated than they were prior to Euro-American settlement. High density woodlands can increase tree stress, particularly in times of drought. Following a period of drought in 2002-2004 mortality of pinyons was extensive and many of the trees were attacked by pinyon ips. For most of 2020, and into summer of 2021, the Southwest experienced severe drought conditions and an increase in pinyon pine mortality has since been observed. The interacting roles of drought, temperature and insects are not well-understood in pinyon mortality. Pinyon ips life history, including number of generations per year, is only loosely known. Beginning in 2022, with the collaboration of Barbara Bentz, Matt Hansen, and Jim Vandygriff (Rocky Mountain Research Station, Logan, Utah) studies were undertaken to study pinyon ips phenology and describe key events in its life cycle. Ips phenology is being studied by deploying passive and emergence traps while recording bark beetle attacks on selected trees that were baited with lures and instrumented with temperature probes. Air and phloem temperatures were measured and will be correlated with important beetle life cycle events. Lab studies conducted over winter in Logan, UT were carried out by rearing field collected pinyon ips in phloem sandwiches at a range of constant temperatures from egg to adult. A basic phenology model will be parameterized using field and laboratory data. *For more information contact Monica Gaylord or Steven Souder*.

Developing Integrated Pest Management Strategies for Aspen Infested with Invasive Oystershell Scale

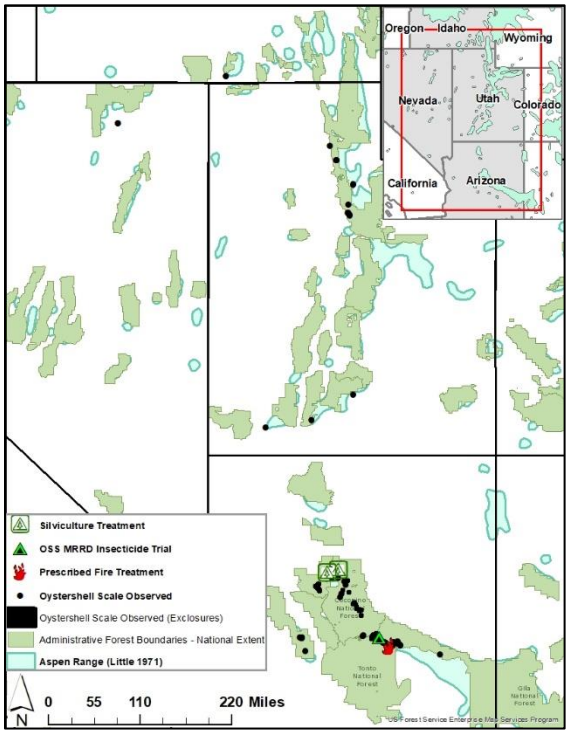

Figure 40: Map of OSS occurrence in forested ecosystems across the western US, and location of silviculture, fire, and proposed pesticide treatments in Arizona.

In 2023, major strides were made towards building an integrated pest management (IPM) program to manage aspen infested with invasive oystershell scale (OSS) in the western US. A team of agency and academic partners received a total of $308,000 (2023-2026) from USDA National Institute of Food & Agriculture Crop Protection and Pest Management Program to fund a proposal titled “IPM for oystershell scale, an invasive pest of aspen forests and urban trees”. Main objectives include research and monitoring of OSS phenology in Arizona and Utah, monitoring efficacy of treatments (silviculture and pesticide) to mitigate OSS infested aspen, expand extent monitoring beyond Arizona, and create outreach materials and recommendations for land/resource managers. These main objectives are major gaps in research and monitoring required to develop an IPM program for OSS. An extensive aspen plot network of nearly 300 plots across Arizona in native stands and plots within treated exclosures were leveraged. Partners on the Coconino, Kaibab, and Apache-Sitgreaves NFs have implemented silviculture and prescribed fire treatments that are being monitored before and after treatments (Figure 40).

In 2023, significant work was done to move a pesticide trial with Dinotefuran forward on the Mogollon Rim

RD, Coconino NF. In 2023, baseline data for non-target and target monitoring related to Dinotefuran treatments and baseline phenology and weather data was collected. In 2023, 28 plots were re-measured on the Flagstaff RD, Coconino NF, and 25 new plots installed on the Kaibab NF, and 32 plots installed or re-measured in the Apache-Sitgreaves NFs, all for treatment efficacy monitoring.

The impact and footprint of invasive OSS in aspen goes beyond Arizona, and additional monitoring beyond the known infested area is a critical next step. Other major accomplishments include the professional development and successful defense of a PhD dissertation by Conor Crouch at Northern Arizona University, who focused on monitoring aspen health, regeneration, recruitment, and the biotic and abiotic factors that limit aspen resiliency in the Southwest. New literature on 1. OSS phenology, intensification and spread on aspen, 2. Extent impact and drivers of OSS invasions in aspen ecosystems in Arizona, and a systematic review of aspen ecology and management in the Southwest are major chapters and major contributions to our working knowledge on aspen and OSS. *For more information contact Amanda Grady*.

Using Survey123 to Monitor Extent and Severity of Oystershell Scale on All Lands

The USDA Forest Service and partners have documented rapid and widespread OSS impacts, predominantly on National Forest System (NFS) lands in Arizona from 2017 to the present. However, it has been realized that OSS is not only an emergent issue in the Southwestern Region, nor does it only affect aspen on NFS lands. In support of broad survey and detection monitoring for invasive oystershell scale, FHP has worked with the Southwestern Region's Geospatial program to create a new Survey123 application (app) called the "Oystershell Scale Survey Form". This app was developed to be used broadly by natural resource managers including state and other federal partners, interested aspen stakeholders such as in academia and other organizations, and by the public. To use the survey, one must download the Survey123 application and then search the downloaded surveys for "Oystershell Scale Survey Form". Once the form is downloaded, users can contribute data to the nationwide and all lands database. Users are prompted to answer questions about who is collecting the data, land ownership, the state and location of observations, the stand type affected, presence or absence of OSS, OSS severity on individual trees and or stands of trees, size class and species impacted, and at the end users are asked to take a close-up picture to validate OSS on an individual tree or shrub and a faraway picture to document stand conditions. Questions are supported by pictures and examples of answers to increase accuracy of data. Please download the app and contribute to our database as you encounter OSS on the landscape or in your backyard. Scan the QR code below to open our Oystershell Scale Survey Form if you already have Survey123 downloaded on your device. *For more information contact Amanda Grady.*

Oystershell Scale Survey Form

Biological Evaluations and Technical Assistance

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Grady, A.M. 2023 Evaluation of proposed Eagle Creek pinyon pine disturbance response project, Clifton Ranger District, Apache-Sitgreaves National Forests. AZ-FHP-23-04.
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Crouch, C.D., **Grady, A.M., Wilhelmi, N.P**., Hofstetter, R.W., Waring, K.M. 2023. Oystershell scale: an invasive insect threatening sustainability of aspen ecosystems in the Southwest. In 71st Western Forest Insect Work Conference. April 24-27, 2023, Seattle, WA. https://www.wfiwc.org/portfolio-2/project-six-ydf8z

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Forest Health Staff

Arizona Zone

Joel McMillin *(928) 556-2073*

Joel has been the Zone Leader and Supervisory Entomologist for the Arizona Zone since May 2019. His primary duties include supervisory and managerial responsibilities for the Arizona Zone staff and providing oversight of Arizona Cooperative Forest Health program of the State Forester's office. Interests include quantifying impacts of forest insects, bark beetle semiochemicals, stand hazard rating systems for bark beetles and fire-insect interactions. Joel previously served as Group Leader/Supervisory Entomologist with Boise Field Office in the Intermountain Region and Entomologist with the Arizona Zone.

Isaac Dell *(928) 556-2071*

Isaac was the forest health specialist with the Arizona Zone from August 2022-August 2023. Duties included conducting the annual aerial detection survey of Arizona, QA/QC of geospatial data on the health of treed areas affected by insects and disease maintained in the National Insect and Disease Survey database, technical and field support, serving as the Alternate Unit Aviation Officer and remote pilot. Previously Isaac researched the effects temperature on spruce beetle flight phenology. He was formerly with the Alaska Region (10) since August 2020, and the Rocky Mountain Region (2) from 2015 to 2018.

Monica Gaylord *(928) 556-2074*

Monica has been a forest entomologist with the Arizona Zone since July 2014. Her primary responsibility is providing technical assistance on bark beetle management to land managers. Previously she was assistant research professor at Northern Arizona University. Forest Health interests include how drought and restoration treatments impact tree susceptibility to southwestern pine bark beetles, fire-bark beetle interactions, and single tree protection against bark beetle attacks.

Amanda Grady *(928) 556-2072*

Amanda has been a forest entomologist with the Arizona Zone since October 2011, previously with the Pacific Southwest Region. Primary responsibilities include providing technical assistance on forest insect management to federal land managers, forest health monitoring related to defoliating and sap sucking insects and conducting aerial detection surveys. Special interests include integrated pest management development for emergent invasive insects in Arizona.

Nicholas Wilhelmi *(928) 556-2075*

Nicholas has been a plant pathologist with the Arizona Zone since January 2017. Primary responsibilities include providing forest disease technical assistance to federal and tribal land managers and hazard tree identification/mitigation training for the Arizona Zone. Current interests include conservation of genetic resistance to white pine blister rust in five needle pines, emerging drought driven pathogens, and aspen monitoring.

New Mexico Zone

Andrew Graves *(505) 842-3287*

Andrew has been the Zone Leader for the New Mexico Zone since October 2020. His primary duties include supervisory and managerial responsibilities for the New Mexico Zone staff. Interests include bark beetle/fungal interactions, the response of insects to drought stressed hosts, pheromones, and DNA

analysis of bark beetle species and their hosts. Andrew previously served as a forest entomologist with the New Mexico Zone since October 2010.

John Formby *(505) 842-3285*

John was a forest health specialist for the New Mexico Zone from August 2022-August 2023. Primary responsibilities included aerial detection surveys, GIS processing and management, and field and technical assistance. Previously John served as the Forest Health Program Manager for the New Mexico Forestry Division where he provided technical assistance and management recommendations for forest pest insects and disease on state and private lands. Previous research interest and experience with southern pine beetle, insect-plant interactions, and ambrosia beetle management and physiology.

Gregory J. Reynolds *(505) 842-3288*

Greg has been a plant pathologist with the New Mexico Zone since January 2017. His primary responsibility is providing technical assistance on forest disease management to national forests and tribal lands as well as managing the hazard tree program for the zone. His current focus is on nursery pathogens (e.g. *Fusarium* spp.), preservation of genetic resistance to white pine blister rust in five-needle pines, and dwarf mistletoe epidemiology. Greg previously served as a plant pathologist (identifier) with the Animal and Plant Health Inspection Service in New Jersey.

Steven Souder *(505) 842-3286*

Steve has been an entomologist with the New Mexico Zone since October 2020. His primary responsibility is providing technical assistance on forest insect management to national forests, tribal lands, and other federal land managers in New Mexico. Steve previously worked on fruit fly research with the Agricultural Research Service in Hawaii for over a decade.

Regional Staff

Crystal Tischler *(505) 842-3284*

Crystal has been the regional aerial survey program manager since September 2022. Crystal previously served as forest health coordinator with the NM office since September 2008. Responsibilities include managing the aerial detection survey program for the region. Her previous work experience is in forest management, fuels reduction, timber sale administration, and community wildfire protection planning.

Zach Hall *(505) 842-3284*

Zach has been a regional survey technician since November 2022. His primary responsibilities include supporting the regional aerial survey, geospatial, and remote sensing programs. He has previously worked as an aircraft sensor operator and as a biologist with the National Park Service.

Janet Nickerman *(626) 353-8439*

Invasive Plant Program Manager and Pesticide Use Coordinator since June 2023 and previously served as Acting Regional Invasive Species Program Manager and Pesticide Use Coordinator from August 2022 through February 2023. Primary responsibilities include providing oversight of pesticide use in the region and guiding the invasive species program for National Forests and in collaboration with State, Private, Tribal and other federal partners in the Southwest.

Appendix: Species Index

Table 7. Common and scientific names for forest insects and diseases* frequently encountered in the Southwestern Region.

Insects		**Diseases**	
Cedar bark beetles	*Phloeosinus* spp.	Armillaria or shoestring root rot	*Armillaria* spp.
Cone beetles	*Conophthorus* spp.	Black canker	*Ceratocystis fimbriata*
Douglas-fir beetle	*Dendroctonus pseudostugae*	Black leaf spot	*Drepanopeziza populi*
Douglas-fir tussock moth	*Orgyia pseudotsugae*	Comandra blister rust	*Cronartium comandrae*
Fall webworm	*Hyphantria cunea*	Cytospora canker	*Cytospora chrysosperma*
Fir engraver	*Scolytus ventralis*	Dwarf mistletoe	*Arceuthobium* spp.
Flatheaded wood borers	*Buprestidae*	Elytroderma needle cast	*Elytroderma deformans*
Janet's looper	*Nepytia janetae*	False tinder conk	*Phellinus tremulae*
Juniper twig pruner	*Styloxus bicolor*	Fir broom rust	*Melampsorella caryophyllacearum*
Large aspen tortrix	*Choristoneura conflictana*	Ganoderma root rot	*Ganoderma applanatum*
Mountain pine beetle	*Dendroctonus ponderosa*	Gymnosporgangium rust	*Gymnosporangium* spp.
New Mexico fir looper	*Galenara consimilus*	Heterobasidion root rot	*Heterobasidion irregulare, H. occidentale*
Oystershell scale	*Lepidosaphes ulmi*	Hypoxylon canker	*Entoleuca mammata*
Pandora moth	*Coloradia pandora*	Indian paint fungus	*Echinodontium tinctorium*
Pine coneworm	*Dioryctria auranticella*	Ink spot leaf blight	*Ciborinia whetzelii*
Pine engravers	*Ips* spp.	Limb rust	*Cronartium arizonicum*
Pine needle scale	*Chionaspis pinifoliae*	Lophodermella needle cast	*Lophodermella* spp.
Pine sawflies	*Neodiprion* spp.*, Zadiprion* spp.	Melampsora rust	*Melampsora* spp.
Pine-feeding needleminers	*Coleotechnites* spp.	Pinyon needle rust	*Coleopsorium jonesii*
Pinyon ips	*Ips confusus*	Biscogniauxia canker of oak	*Biscogniauxia* spp., including *B. mediterranea*
Pinyon needle scale	*Matsucoccus acalyptus*	Red band needle blight	*Dothistroma septosporum*
Ponderosa pine seedworm	*Cydia piperana*	Red belt fungus	*Fomitopsis schrenkii*
Red turpentine beetle	*Dendroctonus valens*	Red ring rot	*Porodaedalea pini*
Roundheaded pine beetle	*Dendroctonus adjunctus*	Red rot	*Dichomitus squalens*
Roundheaded wood borers	*Cerambycide*	Rhabdocline needle cast	*Rhabdocline* spp.
Spruce aphid	*Elatobium abietum*	Schweinitzii root and butt rot	*Phaeolus schweinitzii*
Spruce beetle	*Dendroctonus rufipennis*	Sooty bark canker	*Encoelia pruinosa*
Tiger moth	*Lophocampa ingens*	Spruce broom rust	*Chrysomyxa arctostaphyli*
Twig beetles	*Pityopthorus* spp.*, Pityogenes* spp.*, Pityoborus secundus*	Sycamore anthracnose	*Apiognomonia veneta*
Western balsam bark beetle	*Dryocoetes confusus*	Tomentosus root rot	*Onnia tomentosa*
Southwestern pine beetle	*Dendroctonus barberi*	True fir needle cast	*Lirula abietis-concoloris*
Western shoot borer	*Eucosma sonomana*	True mistletoe	*Phoradendron* spp.
Western spruce budworm	*Choristoneura fremmanni*	Western gall rust	*Endocronartium harknessii*
Western tent caterpillar	*Malacosoma californicum*	White pine blister rust	*Cronartium ribicola*

*Pathogen scientific names are updated routinely and may not match the regional field guide