United States Department of Agriculture

Forest Insect and Disease Conditions in the Southwestern Region, 2019

Forest Service | Southwestern Region | Forest Health PR-R3-16-19 | March 2020

Cover photos: Clockwise from left: white pine blister rust canker with aecia on a southwestern white pine; aspen defoliation caused by the fungal disease black leaf spot; bark beetle-killed ponderosa pine on insect and disease training field trip.

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Conditions in Brief

2019 Weather Summary for the Southwestern U.S.

In 2019, the Southwestern Region (Arizona and New Mexico) experienced above average temperatures, although much of western and northeastern Arizona and parts of northern New Mexico were cooler than normal (Figure 1). Similarly, much of Arizona experienced above average precipitation while most of New Mexico was drier than normal (Figure 2). Deviations from normal temperature and precipitation were not as extreme as in the previous year, and significant snowpack during the 2018-2019 winter alleviated drought stress across much of the region, though drought conditions did persist in northeastern Arizona and northwestern New Mexico, potentially contributing to mortality observed in that area.

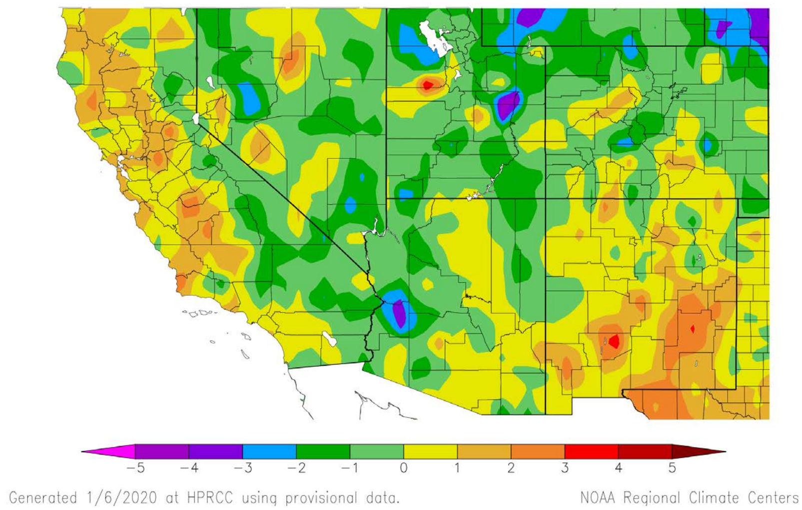

Figure 1. Departure in degrees (F) from normal temperature in the Southwestern U.S. for 2019 (Source: High Plains Regional Climate Center, https://hprcc.unl.edu/).

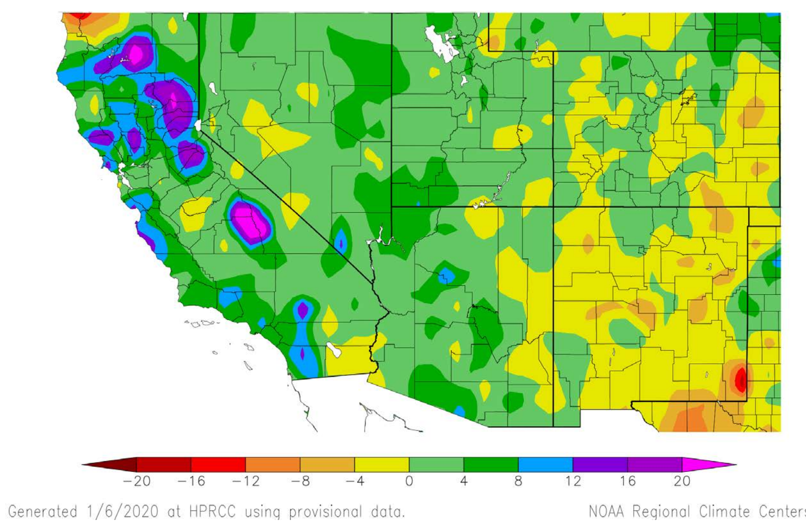

Figure 2. Departure from normal precipitation (inches) in the Southwestern U.S. for 2019 (Source: High Plains Regional Climate Center, https://hprcc.unl.edu).

Regional Forest Insect and Disease Summary

Aerial Survey Summary

In 2019, aerial detection surveys (ADS) covered approximately 23.2 million acres of the Southwestern Region. Aerial surveys primarily covered national forest land (54% of area surveyed) followed by tribal (24%), state and private (17%), and other federal lands (5%) (Table 1, Figure 3). An ArcGIS Online story map summarizing the 2019 aerial detection survey results can be accessed at https://arcg.is/1jTCnL.

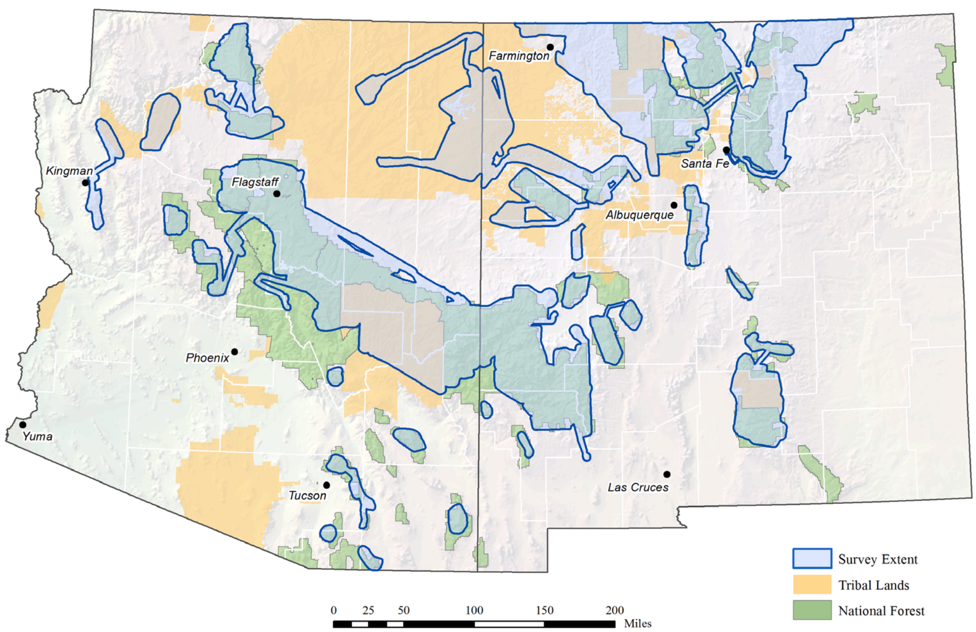

Figure 3. Areas surveyed during 2019 aerial detection survey flights.

Table 1. Aerial detection survey acres flown in 2019 in the Southwestern Region.*

Land ownership	State	Forested	Woodlands	Total
National Forest Lands	AZ	3,403,300	2,480,300	5,883,600
Bureau of Land Management	AZ	6,500	90,700	97,200
Department of Defense	AZ	39,200	9,400	48,600
National Park Service	AZ	117,700	158,200	275,900
Tribal	AZ	1,180,000	2,541,600	3,721,700
Other federal lands	AZ	1,400	3,200	4,600
State and Private	AZ	189,600	470,800	660,400
Arizona Total		**4,937,800**	**5,754,200**	**10,692,000**
National Forest Lands	NM	4,366,700	2,207,500	6,574,100
Bureau of Land Management	NM	62,000	664,900	726,900
Department of Defense	NM	100	800	1,000
National Park Service	NM	85,600	4,300	89,900
Tribal	NM	949,000	959,000	1,908,000
Other federal lands	NM	4,600	11,700	16,300
State and Private	NM	1,928,200	1,250,900	3,179,100
New Mexico Total		**7,396,300**	**5,099,100**	**12,495,400**

*Values rounded to the nearest 100; sum of individual values may differ from totals due to rounding.

Special Survey Arizona Zone

The Arizona Zone staff conducted a special early season survey in May 2019 to document damage caused by pandora moth (*Coloradia pandora*) on the Kaibab National Forest (NF). Aerial surveyors mapped 1,920 acres with very light to light defoliation of ponderosa pines on the North Kaibab Ranger District (RD), a large decrease from the 19,690 acres impacted in 2017 (Figure 4). This drop in defoliation likely signifies the end of the outbreak, which started in 2013. This outbreak was similar to the 1978-84 outbreak, which occurred in relatively the same location and also ended after four generations. Based on historical trends, another outbreak may occur in approximately 30 years.

Figure 4. Pandora moth larvae (red circle, left image) caused widespread ponderosa pine defoliation across the North Kaibab Ranger District from 2013-2019. Damage severity and extent was light and scattered in 2019 (right image).

Special Surveys New Mexico Zone

The New Mexico Zone staff conducted a special early season survey in May 2019 to document damage caused by Janet's looper (*Nepytia janetae*) on the Santa Fe NF (Figure 5). A similar early season survey was conducted in 2018. During the 2019 early season survey, the amount of new defoliation observed was substantially reduced compared to 2018 due to previous defoliation activity which had heavily defoliated many of the areas as well as recent precipitation knocking off other partially fed upon needles. Activity had not expanded much beyond the 2018 affected area, and within that general area 5,600 acres with defoliation were observed between this special survey and the regular aerial detection flights.

Figure 5. Defoliation damage caused by Janet's looper. The defoliation continued during the winter of 2018-2019 on the Santa Fe National Forest, but new defoliation was not as severe as observed following the winter of 2017-2018.

A special survey of pinyon pine mortality in northwestern New Mexico was conducted in September 2019 after aerial and ground observations in the greater Four Corners area reported elevated levels of tree mortality. Overall, pinyon mortality was higher than endemic levels but not as widespread as initially expected. Scattered tree mortality in the small groups typical of pinyon ips activity was observed throughout the surveyed area (Figure 6).

Figure 6. Pinyon pine mortality observed during the New Mexico special survey in Largo Canyon on Bureau of Land Management lands.

Bark Beetle Summary

Region-wide, there was an increase in the area with bark beetle-caused tree mortality from 2018 levels for pinyon-juniper and mixed conifer and decreases for ponderosa pine and spruce-fir (Figure 7, Figure 9, Figure 11, and Figure 13), with tree mortality attributed to bark beetles mapped on over 663,500 acres in 2019 (Table 2). This is an increase by about 50% from the area affected (394,500 acres) in 2018. Much of this increased activity occurred in pinyon-juniper woodlands in northeastern Arizona (41% of all bark beetle mortality recorded region-wide) and was likely driven by drought conditions that returned in August of 2019 due to lack of summer monsoon rains (https://droughtmonitor.unl.edu/Maps.aspx). Previous drought events in the region have also been correlated with increases in bark beetle attributed pinyon pine mortality. Although there was a significant increase in the overall acreage affected by bark beetles, much of the mortality was observed in small, scattered pockets across the landscape, and 84% of the affected area had less than 10% mortality.

Ponderosa pine mortality was observed across all land ownerships in Arizona. The mortality was uniformly distributed and declined from 248,380 acres with mortality in 2018 to 166,890 acres with mortality in 2019. Significant increases in pinyon mortality were also observed across northern Arizona, especially on Hopi and Navajo Tribal Lands in 2019. Approximately 50% of all beetle activity in Arizona was attributed to pinyon ips activity.

In New Mexico during 2019, ponderosa pine bark beetles accounted for the most area affected with tree mortality (55% of the total acres mapped with mortality in the state). Over 87% of ponderosa pine beetle-caused tree mortality occurred in small pockets on the Navajo Nation. Spruce beetle was also a significant damage agent in New Mexico (11% of all acres mapped with mortality in the state), occurring primarily on the Carson and Santa Fe NFs and adjacent state and private land. The area with spruce beetle attributed tree mortality, however, did decline in 2019 (21,790 acres) from 2018 levels (45,570 acres).

Table 2. Bark beetle[1] incidence by ownership (acres) from aerial detection surveys in 2019 in Arizona and New Mexico[2].

Owner[3]	Ponderosa pine bark beetles	Pinyon ips	Douglas-fir beetle	Spruce beetle	Western balsam bark beetle	Fir engraver	Cedar bark beetles
Apache-Sitgreaves NFs	34,280	< 5	3,120	< 5	< 5	880	7,110
Coconino NF	15,120	< 5	10	< 5	< 5	470	2,390
Coronado NF	5,760	< 5	1,710			300	< 5
Kaibab NF	3,970	230	50	< 5		< 5	< 5
Prescott NF	200	20	< 5			40	< 5
Tonto NF	2,350	< 5	120			20	50
Bureau of Land Management	10	< 5					
Fort Huachuca	80	< 5	< 5				< 5
Navajo Army Depot	< 5						
Grand Canyon Nat. Park	20	150	< 5			< 5	< 5
Canyon De Chelly Nat. Mon.	2,450	11,780	< 5				4,200
Saguaro Nat. Park	< 5						
Sunset Crater Nat. Mon.	< 5						
Walnut Canyon Nat. Mon.							
Wupatki Nat. Mon.							
Hopi Tribal		48,340					2,810
Hualapai Tribal	20	< 5					3,380
Navajo Nation	80,890	167,190	7,910		790	1,180	14,740
Navajo-Hopi JUA		1,500					830
San Carlos Apache	3,980	< 5					< 5
White Mtn. Apache	14,630	740	430	120	10	340	< 5
State & Private	3,140	130				< 5	6,320
Arizona Total	**166,890**	**230,100**	**13,360**	**120**	**800**	**3,240**	**41,830**
Carson NF	780	790	700	5,610	50	90	< 5
Cibola NF	1,900	350	3,410		10	160	< 5
Gila NF	5,330	100	120		< 5	10	< 5
Lincoln NF	240	10	30	40	90	< 5	
Santa Fe NF	4,170	420	10,130	13,970	< 5	290	
Bureau of Land Management	100	13,780	< 5				30
Bureau of Reclamation		170					
Bandelier Nat. Mon.			< 5				
El Malpais Nat. Mon.	< 5						
Valles Caldera Nat. Preserve	150		490				
Acoma Pueblo	< 5	< 5					
Isleta Pueblo	< 5		< 5				
Jemez Pueblo	610	< 5					
Jicarilla Apache Tribal	20	570	170	130			20
Laguna Pueblo	20	< 5	10				
Mescalero Apache Tribal	30	< 5	30	90	< 5	< 5	< 5
Navajo Nation	99,180	24,110	1,120		4,510	900	2,470
Picuris Pueblo	< 5	< 5	< 5				
Ramah Tribal	< 5	< 5					
San Ildefonso Pueblo	< 5						
Santa Clara Pueblo	< 5		< 5				
Taos Pueblo	< 5		500		< 5	< 5	
Ute Mountain		170					
Zia Pueblo		10					
Zuni Pueblo	< 5	10	< 5				
State & Private	570	5,110	890	1,950	350	70	40
New Mexico Total	**113,130**	**45,590**	**17,620**	**21,790**	**5,030**	**1,520**	**2,550**
SW Region Total	**280,020**	**275,690**	**30,980**	**21,910**	**5,830**	**4,760**	**44,380**

[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 10, 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.
[3]Values based on landownership, thus any inholdings are summarized with their ownership category.

Defoliation Summary

Defoliation from insects and diseases increased across the region from 210,950 acres affected in 2018 to 382,480 acres in 2019 (Table 3). The majority of the defoliation (332,880 acres) occurred in New Mexico and was attributed to western spruce budworm (56%), pine needleminer (14%), pinyon needle scale (14%), and various insects and pathogens on aspen (13%). Aspen damage contributed 69% of recorded total area with defoliation in Arizona. Defoliation from spruce aphid decreased substantially in Arizona from 17,940 acres recorded in 2018 to 8,100 acres in 2019 (Table 3). Most of the damage was observed on White Mountain Apache Tribal Lands. Western spruce budworm defoliation increased from 90,710 acres in 2018 to 191,290 in 2019 (Table 3). The majority of the western spruce budworm defoliation was observed on the Carson and Santa Fe NFs and surrounding state and private lands. The Janet's looper outbreak continued for a second season in northern New Mexico, with approximately 5,600 acres with defoliation in 2019. The last outbreak of this insect was recorded in 2007 on the Sacramento Mountains in southern New Mexico. Pine needleminer damage was mapped on 47,000 acres in 2019, primarily on state and private land neighboring Carson NF in the Sangre de Cristo Mountains of northern New Mexico. This was down from the 65,800 acres mapped in 2018. The Douglas-fir tussock moth outbreak on the Cibola NF is in decline, affecting over 1,500 acres in 2019, down slightly from 1,800 acres in 2018 (Table 3). Douglas-fir tussock moth activity also decreased in Arizona on the Coconino NF with 570 acres with defoliation in 2019, down from 1,020 acres reported in 2018. The pandora moth outbreak in Arizona is also subsiding. The number of acres with defoliation decreased from 19,960 acres in 2017 to only 1,920 acres in 2019.

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. Our 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. In 2017, about 30 years since the last survey, a project was initiated to survey for southwestern dwarf mistletoe infections in ponderosa pine along roadways on several of the national forests in New Mexico; these surveys have thus far supported the incidence estimates in ponderosa pine from historical records (33.6% with some level of infection). 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 occur sporadically based on environmental conditions. Several minor foliar diseases were identified in the Southwest Region in 2019 during aerial detection and ground surveys. All of the aforementioned aspen defoliation in Arizona was attributed to black leaf spot disease, although other agents like western tent caterpillar and large aspen tortrix likely contributed to the recorded damage.

White pine blister rust, a disease caused by an introduced fungus, 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.

Table 3. Defoliation[1] and all aspen damage incidence by ownership (acres) from aerial detection surveys in 2019 in Arizona and New Mexico[2].

Owner[3]	Western spruce budworm	Aspen damage[4]	Douglas-fir tussock moth	Sawfly - Ponderosa	Pinyon needle scale	Spruce aphid	Pandora moth
Apache-Sitgreaves NFs		7,030	740			960	
Coconino NF	160	1,390	570			< 5	
Coronado NF			30				
Kaibab NF	2,960	250					1,920
Prescott NF					230		
Tonto NF		< 5	160				
Bureau of Land Management							
Fort Huachuca							
Navajo Army Depot							
Grand Canyon Nat. Park	130	20					
Canyon De Chelly Nat. Mon.							
Saguaro Nat. Park							
Sunset Crater Nat. Mon.							
Walnut Canyon Nat. Mon.							
Wupatki Nat. Mon.							
Hopi Tribal							
Hualapai Tribal					40		
Navajo Nation		15,360					
Navajo-Hopi JUA							
San Carlos Apache							
White Mtn. Apache	330	9,930				7,130	
State & Private		170			70		
Arizona Total	**3,580**	**34,160**	**1,500**		**340**	**8,100**	**1,920**
Carson NF	89,190	5,000					
Cibola NF	2,370	2,060	1,540	950	1,610		
Gila NF		1,110			5,760		
Lincoln NF		330			3,090		
Santa Fe NF	29,450	5,900			8,360		
Bureau of Land Management	90	10			240		
Bureau of Reclamation							
Bandelier Nat. Mon.		70					
El Malpais Nat. Mon.							
Valles Caldera Nat. Preserve	1,880	20					
Acoma Pueblo				10			
Isleta Pueblo		< 5			50		
Jemez Pueblo							
Jicarilla Apache Tribal	580	100					
Laguna Pueblo							
Mescalero Apache Tribal		< 5			1,750		
Navajo Nation		25,280			110		
Picuris Pueblo							
Ramah Tribal							
San Ildefonso Pueblo							
Santa Clara Pueblo							
Taos Pueblo	4,870	50					
Ute Mountain							
Zia Pueblo							
Zuni Pueblo							
State & Private	59,290	4,080	30	520	24,530		
New Mexico Total	**187,710**	**44,010**	**1,560**	**1,470**	**45,510**		
SW Region Total	**191,290**	**78,170**	**3,060**	**1,470**	**45,850**	**8,100**	**1,920**

[1]Only major defoliator agents show. Less commonly detected agents or those with lesser activity may not be represented in the table.
[2]Values rounded to the nearest 10, 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.
[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 and in some cases mortality.

Status of Major Insects

Bark beetles

As previously mentioned, overall totals of tree mortality for pinyon pine, juniper, Douglas-fir, white fir, and corkbark fir were elevated across the region in 2019. In New Mexico, the statewide total area affected with ponderosa mortality increased for the second consecutive year following a six-year trend of decreasing mortality; however, decreases were actually seen in most portions of the state. Ponderosa mortality in Arizona declined significantly for an overall state-wide decrease in activity but increased significantly in the northeastern portion of the state, particularly on Navajo Nation Tribal Lands. In Arizona, elevated levels of juniper and pinyon pine mortality were evident during the summer of 2019. Because ground checks are not feasible at all locations in all years, most dying conifer trees are attributed to bark beetles. In some systems, especially the mixed conifer forests, root diseases and other agents contribute to mortality.

Pinyon-Juniper Forest Type

The pinyon-juniper forest type had a region-wide increase in bark beetle-attributed mortality (Figure 7). Total area with mortality in the pinyon-juniper forest type increased from 29,660 acres in 2018 to 320,070 acres in 2019, more than a ten-fold increase. The majority of the damage was recorded in Arizona (Table 2), although a significant amount of activity occurred in New Mexico as well. This large increase in acres affected dwarfs the outbreaks that were mapped in 2013 and 2014. However, the intensity, i.e. the number of trees affected per acre, was generally low with tree mortality lightly scattered across the landscape. Over 85% of the area with pinyon mortality was classified as having very light (1-3%) or light (4-10%) mortality.

Pinyon Ips

Ips confusus
Host: Pinyon Pine

In 2018, Arizona and New Mexico combined had 21,060 acres with pinyon ips attributed mortality. In 2019, acres with pinyon mortality increased dramatically to 275,690 (Table 2; Figure 7). This is the most significant pinyon mortality event recorded during the past decade. The majority of the mortality occurred in Arizona (83%), primarily on the Navajo Nation (Figure 8) and Hopi Tribal Lands (Table 2). While New Mexico did not have as much acreage impacted by pinyon ips as Arizona, there was still a substantial increase from the 2,760 acres mapped in 2018 to 45,590 acres in 2019. This is also affected by the special survey in New Mexico which increased the amount of pinyon-juniper woodlands surveyed. The majority of this mortality occurred on Navajo Nation and Bureau of Land Management lands in northwestern New Mexico (Table 2).

Cedar Bark Beetles

Phloeosinus spp.
Host: Arizona cypress and junipers

In 2018, Arizona and New Mexico combined had 8,600 acres with juniper mortality attributed to bark beetles. In 2019, area with juniper mortality increased to 44,380 acres (Figure 7). Arizona reported over 94% of the juniper mortality for the region, with the majority occurring at the lower elevations of the host range on Navajo Nation Tribal Lands, the Apache-Sitgreaves NFs, state and private lands, and Canyon de Chelly National Monument. Significant damage also occurred on Hualapai and Hopi Tribal Lands and on the Coconino NF. Aerial surveys designated juniper in these areas as beetle killed. Extensive ground surveys were not conducted in 2019. In 2018, ground surveys found evidence of bark beetles in some trees; however, many trees were dead with no apparent damage from insects or disease. It is suspected that the resurgent drought conditions in northeast Arizona in the summer of 2019 or some other abiotic event or causal agent may have played a significant role in this mortality event. New Mexico had less activity than Arizona, but it did increase from 220 acres with juniper mortality mapped in 2018 to 2,550 acres in 2019 (Table 2).

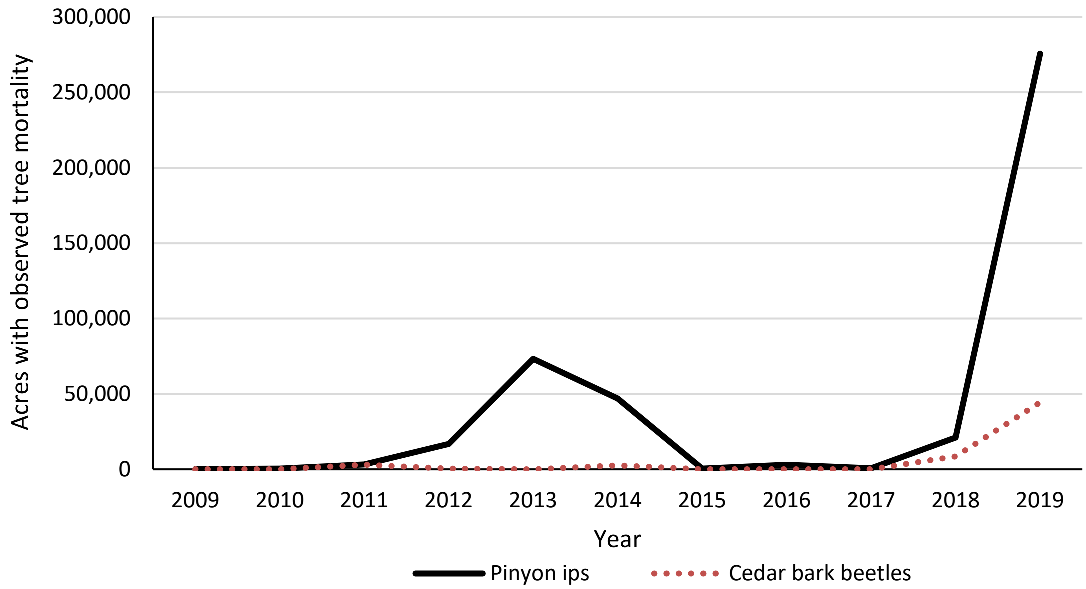

Figure 7. Pinyon-juniper mortality associated with pinyon ips and cedar bark beetles in the Southwestern Region for the last ten years.

Figure 8. Pinyon mortality observed on Defiance Plateau of the Navajo Nation; grey trees are older mortality and tan colored trees are current year mortality.

Ponderosa Pine Forest Type

In the Southwestern Region, ponderosa pine supports 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 multiple species co-occurring within the same trees. Therefore, as of 2015, specific bark beetle species causing ponderosa pine mortality are no longer identified during aerial surveys.

In 2019, 280,020 acres with ponderosa pine mortality across the region were detected, a decrease in activity from the 300,970 acres affected in 2018 (Figure 9). Most of this damage occurred in small pockets of 1-5 trees scattered across the landscape, and the majority (60%) again occurred in Arizona (Table 2). About half of the total acres with ponderosa pine mortality in Arizona occurred on the Navajo Nation in the Chuska Mountains, but most areas had a trace level of intensity affecting only 1-3% of the treed area. The northern edge of the Mogollon Rim also had larger pockets of mortality, especially in the vicinity of Flagstaff (Kaibab/Coconino NFs), Gash and Hutch Mountain area (Coconino NF), and from the Chevelon Canyon vicinity east to the Escudilla Peak Area (Apache-Sitgreaves NFs, Figure 10). Ground surveys found numerous beetle species, including several species of engraver beetles, western pine beetle, roundheaded pine beetle, and red turpentine beetle.

In New Mexico, ponderosa pine mortality decreased substantially throughout most parts of the state (Table 2). During surveys it was quite noticeable that many areas had reduced levels of ponderosa pine mortality compared to 2018 surveys. Outside of the activity on the Navajo Nation, the area with ponderosa pine mortality in New Mexico decreased from over 50,000 acres in 2018 to just under 14,000 acres in 2019 (Table 2). Slight increases in ponderosa pine bark beetle activity were observed on the Carson and Santa Fe NFs. The overall statewide area with ponderosa pine mortality, however, did increase to over 113,000 acres in 2019. The vast majority of this activity occurred in the Chuska Mountains on Navajo Nation lands at trace levels (1-3%) of intensity across the landscape. Some larger pockets of scattered mortality were also observed across the Jemez Mountains (Santa Fe NF), and areas of ponderosa pine mortality were identified on the Gila NF, although activity there declined from 30,800 acres mapped in 2018 to 5,330 acres in 2019. This activity was scattered throughout the forest, with most on the Quemado, Reserve, and Silver City RDs. The bark beetle outbreak on the Pinos Altos Range of the Gila NF is subsiding with only relatively minor amounts of new ponderosa pine mortality occurring in this area.

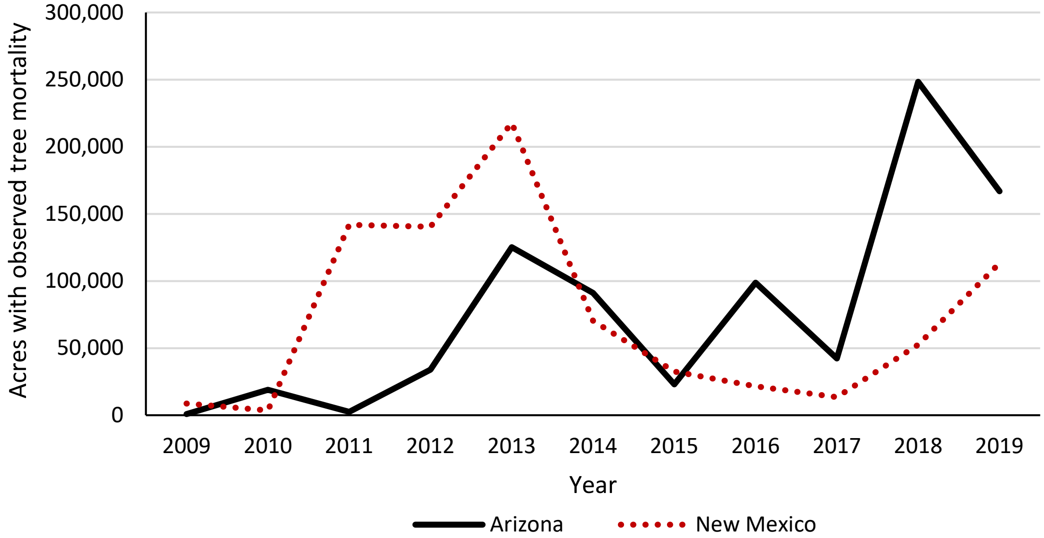

Figure 9. Ponderosa pine mortality attributed to bark beetles in the Southwestern Region for the last ten years.

Figure 10. Ponderosa pine mortality observed northwest of Show Low, Arizona on the Apache-Sitgreaves National Forests.

Mixed Conifer Forest Type

Moderate increases of bark beetle activity in mixed conifer forests occurred in 2019 compared to 2018. In 2018, 18,260 acres with mortality from Douglas-fir and fir engraver beetles were observed (Figure 11). In 2019, this area increased to around 35,740 acres. Most recently, beetle activity in the mixed conifer in the Southwestern Region has been associated with wildfires.

Douglas-fir Beetle

Dendroctonus pseudotsugae
Host: Douglas-fir

In 2019, Douglas-fir mortality from Douglas-fir bark beetles increased from 16,490 acres to 30,980 acres across the region, the first increase in activity since a peak in 2013-2014 (Figure 11). The 2013 peak was primarily due to an outbreak of Douglas-fir beetle within the half a million-acre Wallow Fire that occurred in eastern Arizona primarily on the Apache-Sitgreaves NFs in 2011. In 2019, aerial surveys mapped 3,120 acres with Douglas-fir beetle activity across the Apache-Sitgreaves NFs, most of which was outside the Wallow Fire perimeter, and activity from this beetle across Arizona was at elevated levels compared to 2018 (Table 2). Acres in Canyon de Chelly National Monument with Douglas-fir mortality continued to decline from 20 acres of new tree mortality mapped in 2018 to less than five acres in 2019.

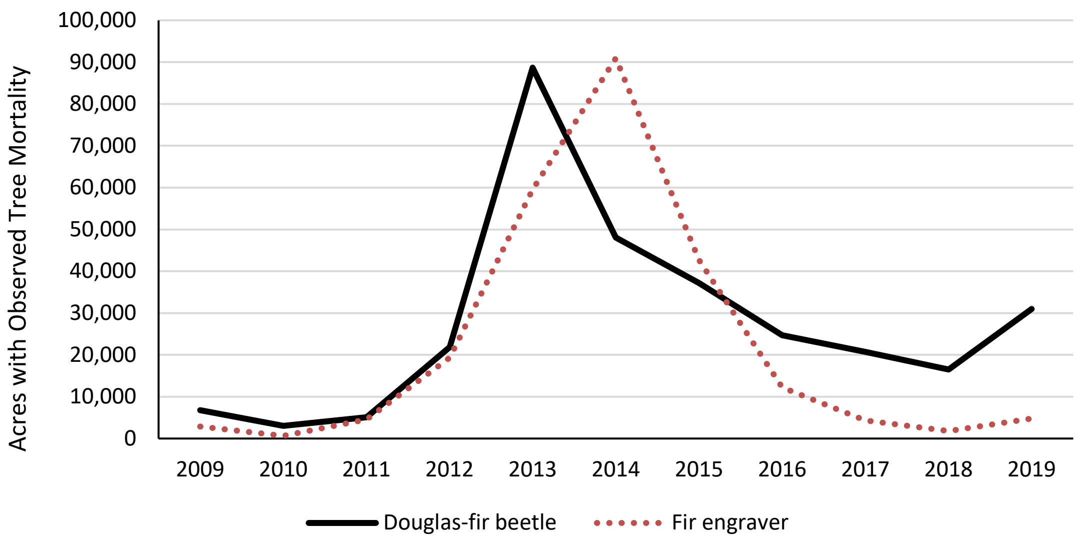

Figure 11. Mixed conifer mortality associated with two species of bark beetles in the Southwestern Region in the last ten years.

In New Mexico, Douglas-fir mortality from Douglas-fir bark beetles increased slightly from 16,160 acres in 2018 to 17,620 acres in 2019 (Table 2). Douglas-fir beetle-caused tree mortality in 2019 occurred primarily on the Santa Fe and Cibola NFs. Activity was effectively the same on the Cibola NF in 2018 and 2019, affecting 3,410 acres, particularly on the San Mateo Mountains of the Magdalena RD, much of which was associated with the recent North Fire (Figure 12). Activity on the Santa Fe NF has been ongoing for a number of years, particularly as bark beetle populations have continued to affect stands adjacent to or within the boundaries of recent wildfires. Activity on the Santa Fe NF increased from 7,370 acres in 2018 to 10,130 acres in 2019. Large areas of scattered Douglas-fir mortality were observed around Rio Medio, Pecos Wilderness, Santa Fe watershed, and Bull Creek in the Sangre de Cristo Mountains; and Rito Peñas Negras to Calaveras Canyons in the Jemez Mountains.

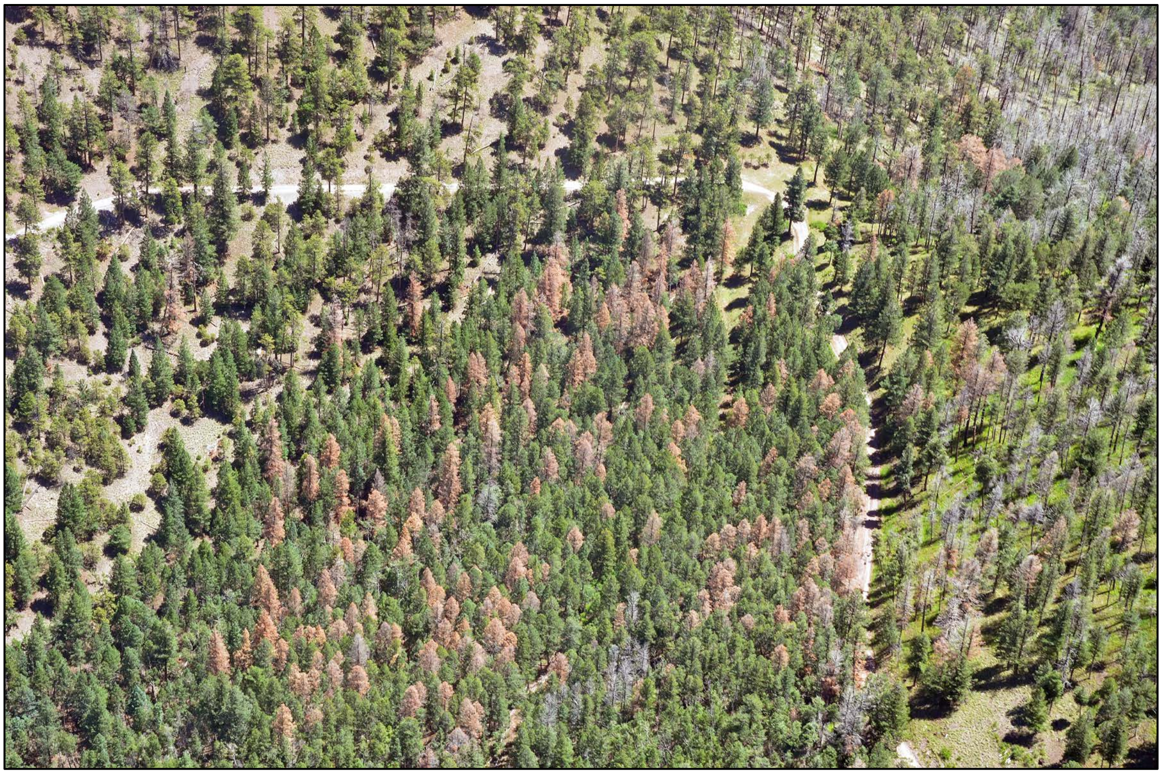

Figure 12. Douglas-fir tree mortality from Douglas-fir beetle along the edge of the North Fire scar in the San Mateo Mountains of Cibola National Forest.

Fir Engraver

Scolytus ventralis
Host: White fir

White fir mortality from fir engraver beetles often occurs when trees are exposed to a previous stressor such as drought, increased competition due to high stand densities, defoliation, or root rots. The resulting tree mortality may be most predominant on drier south- and west-facing slopes and the lower elevations of north-facing slopes. Mortality can occur in all size and age classes.

Across the region, mortality in white fir increased from 1,780 acres affected in 2018 to 4,760 acres in 2019 (Figure 11). In Arizona, fir engraver increased significantly from only 50 acres mapped in 2018, the majority of which was on the Apache-Sitgreaves NFs, to 3,240 acres mapped in 2019 on multiple national forests and tribal lands. New Mexico had less fir engraver activity than Arizona (Table 2). The majority of the white fir mortality in 2019 in New Mexico was on the Navajo Nation, along with 10 to 290 acres mapped for each of the state's national forests other than the Lincoln NF. Fir engraver activity on the Sandia Mountains of the Cibola NF, where activity was very high from 2013 to 2016, has remained low in recent years. Defoliation by Douglas-fir tussock moth in this area, however, may trigger increased fir engraver activity in the future.

Ips

Ips bonanseai
Host: Southwestern white pine

Ground surveys in 2018 and 2019 identified *Ips bonanseai* attacking and killing southwestern white pines within the perimeter of the Frye Fire in the Pinaleño Mountains on the Safford RD, Coronado NF. Mountain pine beetle was also occasionally present in some of these dead trees. Mortality occurred across all tree size classes. *Ips bonanseai* are not generally considered aggressive tree killers. It is suspected that beetles were exploiting trees stressed by the drought and the 2017 fire. This area will continue to be monitored with ground surveys in 2020 as part of the beetle suppression project occurring in the Frye Fire area. More information can be found in the "Other Entomology and Pathology Activities in 2019" section of this document under "Frye Fire, Coronado National Forest".

Spruce-fir Forest Type

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

Spruce Beetle

Dendroctonus rufipennis
Host: Spruce

Region-wide, acres with spruce beetle-caused tree mortality declined from 45,620 in 2018 to 21,910 in 2019 (Figure 13). In Arizona, the area with spruce beetle mortality has been consistently low, with 50 acres in 2018 and 120 acres in 2019. Most of the activity was observed in a few small areas on White Mountain Apache Tribal Lands in the White Mountains of east central Arizona. This spruce beetle activity was mapped in areas previously defoliated by spruce aphid. In New Mexico, spruce beetle activity continued to kill Engelmann spruce in the northern part of the state, primarily on the Carson and Santa Fe NFs and adjacent state and private lands. However, aerial surveyors mapped 21,790 acres in 2019, less than half the overall acreage affected in 2018 (45,570 acres). Stands experiencing several years of bark beetle activity have recorded > 50% spruce mortality, and little new activity was observed in these areas. Spruce beetle continues to expand in stands near Elk Mountain, the Pecos Wilderness area, and on the Tres Piedras RD, Carson NF. Spruce beetle activity on Sierra Blanca Peak in the southern part of the state continues to affect the Ski Apache ski area and nearby Mescalero Apache Tribal Lands. A small amount of spruce mortality was also detected on Jicarilla Apache Tribal Lands in 2019.

Western Balsam Bark Beetle

Dryocoetes confusus
Hosts: Subalpine and corkbark fir

Fir mortality attributed to western balsam bark beetle increased from 200 acres affected in 2018 to 5,830 acres in 2019 (Figure 13). As in the past several years, the majority of the activity was reported in New Mexico (5,030 acres), with the damage in 2019 occurring primarily on Navajo Nation Tribal Lands (4,510 acres). About 99% of the 800 acres recorded in Arizona were also on Navajo Nation Tribal Lands. Small areas with mortality attributed to western balsam bark beetle were observed in each of the national forests in New Mexico and on some surrounding state and private lands, as well as on the Apache-Sitgreaves and Coconino NFs in Arizona. This bark beetle may be interacting with root diseases caused by *Armillaria* spp. or *Heterobasidion occidentale* to kill trees in these areas. The interaction of bark beetles and root disease is common in dead subalpine fir to the north in Colorado, and signs of infection by *Armillaria* spp. can be consistently found on dead corkbark fir trees in the Sandia Mountains of Cibola NF and Sangre de Cristo Mountains of Santa Fe NF.

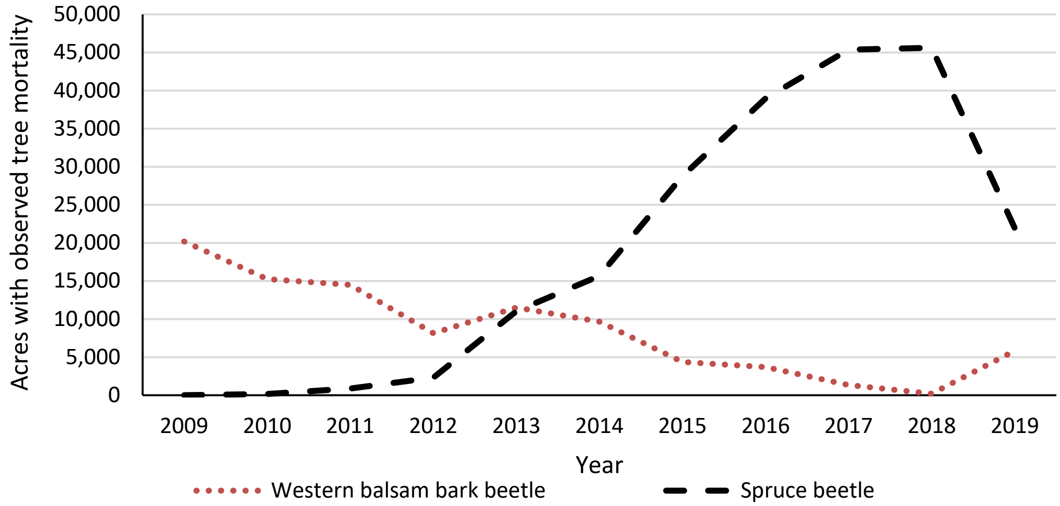

Figure 13. Tree mortality in spruce-fir forests attributed to two species of bark beetles in the Southwestern Region in the last ten years.

Defoliators

Acres observed with damage from prominent defoliators increased from 210,950 in 2018 to 382,480 in 2019. Regionally, acres with defoliation from all major agents individually increased with the exceptions of spruce aphid, pandora moth, pine needleminer, and Janet's looper.

Pinyon-Juniper Forest Type

Pinyon Needle Scale

Matsucoccus acalyptus
Host: Pinyon pine

The amount of damage detected from pinyon needle scale increased dramatically across the region in 2019, from 1,220 acres in 2018 to 45,850 acres (Table 3). Most of the defoliation in 2019 was recorded in New Mexico (45,510 acres), and over half of this acreage was on state and private lands. Significant damage also occurred on all national forests in New Mexico except the Carson NF, on Mescalero Apache and Navajo Nation Tribal Lands, and on Bureau of Land Management lands. Activity was particularly noticeable in the spring as last year's infected needles began to yellow and fall prematurely (Figure 14). Areas in the city of Santa Fe, along the I-25 corridor from Santa Fe to Las Vegas, and throughout the East Mountains outside of Albuquerque were especially affected. In Arizona, most of the pinyon needle scale-affected acreage occurred on the Prescott NF and smaller areas on Hualapai Tribal Lands and state and private land (Table 3). Repeated attacks from this insect can cause reduced growth and stunted needles. In severe outbreaks, small trees may be killed directly while larger trees are often predisposed to pinyon ips. Depending upon the severity of the defoliation and timing of flights, this damage can be quite difficult to detect from the air and, thus our numbers may vary from year-to-year more than actual incidence on the landscape.

Figure 14. Typical fading of older foliage caused by pinyon needle scale.

Ponderosa Pine Forest Type

Pandora Moth

Coloradia pandora
Host: Ponderosa pine

The pandora moth outbreak on the Kaibab Plateau continued to subside in extent and severity during this fourth cycle of defoliation. Damage associated with the outbreak was initially identified during aerial surveys in 2013 around Jacob Lake, though the population had been increasing for several years at that point. The visible damage from this insect is caused by feeding during the caterpillar stage, which occurs every other year during outbreaks due to the two year life cycle. In 2019, we recorded 10% of the damage that was observed during the 2017 flight (Table 3). All damage has been detected during special early aerial surveys over the affected areas. Permanent plots were monitored in 2018; at that time less than 2% pine mortality was found across the surveyed area, which included the 2013, 2015, and 2017 impact areas. The outbreak is expected to end after four cycles of damage, similar to the previous outbreak reported at this location from 1978-1984.

Pine Sawflies

Neodiprion and *Zadiprion* spp.
Host: ponderosa pine

In 2019, pine sawfly damage on ponderosa pine was mapped on 1,470 acres, with all of the damage occurring in New Mexico (Table 3). This was an increase from the 300 acres affected in 2018. The majority of this damage occurred on Gallinas Mountains on the Mountainair RD of the Cibola NF where a large area of defoliation was observed. Ground evaluations of this outbreak have not yet confirmed sawflies as the cause of the defoliation. The other significant area of activity was on state lands of the Luera Mountains where an ongoing outbreak has continued.

Pine Needleminer

Coleotechnites ponderosae
Host: ponderosa pine

For the past two years, ponderosa pine defoliation associated with ponderosa pine needleminers was found primarily on state and private lands along the eastern slopes of the Sangre de Cristo Mountains neighboring the Carson NF (Figure 15). This defoliation affected over 47,000 acres of private and state lands in 2019, a decline from the 65,800 acres observed in 2018. Ground surveys identified the ponderosa pine needleminer as responsible for the discoloration, although the aerial signature had dissipated by the time these ground surveys occurred. Red band needle blight was also found in spring ground surveys and may have played some role in this discoloration (see Foliar Pathogens). No pine needleminer activity was observed in Arizona in 2019.

Figure 15. Ponderosa pine with yellow discoloration in Vermejo Park Ranch east of Carson National Forest.

Mixed Conifer Forest Type

Aspen Defoliation and Mortality

Western tent caterpillar, *Malacosoma californicum*
Large aspen tortrix, *Choristoneura conflictana*
Oystershell scale, *Lepidosaphes ulmi*
Black leaf spot, *Drepanopeziza populi*
Complex of drought and other insects and diseases

Aspen damage, a combination of defoliation and other biotic and abiotic damage, increased substantially across the region from 19,720 acres in 2018 to 78,170 acres in 2019. The majority of the damage (56%) was observed in New Mexico (Table 3). In Arizona, 34,160 acres of aspen damage were detected, a drastic increase from 860 acres in 2018. Most of the affected area in Arizona was attributed to black leaf spot, a fungal foliar disease (see front cover). Nearly half of the Arizona acreage (15,360 acres) was detected in the Chuska Mountains on Navajo Nation Tribal Lands, where no aspen damage was mapped in 2018. Substantial areas with damage were also observed on White Mountain Apache Tribal Lands (9,930 acres) and the Apache-Sitgreaves NFs (7,030 acres), with less significant areas of activity occurring on the Coconino and Kaibab NFs. Ground surveys on these forests indicate there have been declines in aspen recruitment, establishment, and overstory condition. This decline, which is associated with oystershell scale and other factors, is reducing resilience and longevity of infected trees. Oystershell scale has been observed for decades in urban areas, but widespread, severe impacts on aspen in forest settings have only recently been documented. More information on oystershell scale in Arizona may be found in the “Other Entomology and Pathology Activities in 2019” section of this document under “Aspen Monitoring in Northern Arizona”.

In New Mexico, aspen damage more than doubled from 18,860 acres in 2018 to 44,010 acres in 2019. More than half was in the Chuska Mountains on Navajo Nation Tribal Lands, where no aspen damage was mapped in 2018. On the Carson NF, aspen damage declined to 5,000 acres, mostly on the west side of the forest, from 10,180 acres mapped in 2018. The damage in this area has been defoliation by western tent caterpillar. On the Santa Fe NF, aspen damage, also primarily from western tent caterpillar, increased from 3,160 acres in 2018 to 5,900 acres in 2019. The largest pockets of damage were in the northwestern portion of the Jemez Mountains, Big Tesuque area of the Española RD, and around Cow Creek on the Pecos-Las Vegas RD. In the Cow Creek area, aspen leaf beetle (*Chrysomela* sp.) activity was observed causing widespread damage in addition to western tent caterpillar during a ground check.

Douglas-fir Tussock Moth

Orgyia pseudotsugata
Hosts: True firs, Douglas-fir, and spruce

Acres with defoliation attributed to Douglas-fir tussock moth (DFTM) increased slightly in Arizona and New Mexico from 2,910 acres observed in 2018 to 3,060 acres in 2019. Each state accounted for about half of this acreage. A new DFTM outbreak was observed in Arizona in the Pinal Mountain Recreation Area on the Globe RD of Tonto NF. Early warning traps and sequential egg mass sampling indicated the population is increasing in the Pinal Mountains. The DFTM outbreak on the Mogollon Rim has mostly subsided due to high egg mass and pupal parasitism, although damage is spreading into a few new patches at that location. Large patches of mixed conifer defoliation were mapped on the Apache-Sitgreaves NF near the Bear Wallow Wilderness; however, the agent responsible for the defoliation at these sites was not confirmed.

In New Mexico, severe defoliation of white fir from DFTM continued on the Sandia Mountains of the Cibola NF in 2019, accounting for the majority of the acreage mapped in the state. The outbreak affected less acreage compared to 2018 (1,540 acres, down from 1,800 acres), but still occurred within the same footprint. This was the fourth year of the outbreak and the third year of clearly visible defoliation during aerial detection surveys. Severe defoliation (>75%) has occurred in several recreation sites along the Crest Highway. Trap catches on the Lincoln and Santa Fe NFs were low.

Western Spruce Budworm

Choristoneura freemani
Hosts: True firs, Douglas-fir, and spruce

Western spruce budworm activity increased in the region from 90,710 acres in 2018 to 191,290 acres in 2019 (Figure 16). Historically, most of the damage in the Southwestern Region occurs in New Mexico, which has a greater proportion of susceptible host type. In 2019, 3,580 acres of budworm activity were mapped in Arizona, primarily on the Kaibab NF where acres increased from 270 in 2018 to 2,960 in 2019 (Table 3).

In New Mexico, defoliation by western spruce budworm had been in decline since a peak in 2009, but increased in 2019 to 187,710 acres from 89,580 acres in 2018. Western spruce budworm outbreaks are associated with increased precipitation, and the heavy snowpack during winter 2018-2019 contributed to the increased level of defoliation observed in 2019. The majority of western spruce budworm-caused defoliation occurred in the forests in the northern part of the state, particularly on the Carson and Santa Fe NFs and adjacent state and private lands (Figure 17). Surveyors noted that individual tree defoliation within the affected areas was much heavier than normal. Elevated levels of defoliation have been observed in this area for three decades in both dry and wet mixed conifer forest stands, as well as some spruce-fir stands. Douglas-fir, white fir, and Engelmann spruce have all been surveyed with defoliation, but Douglas-fir has been the preferred host species. Twig dieback, top-kill, and tree mortality have resulted from continuous defoliation, and understory regeneration has been significantly affected in some stands. The severe activity that normally occurs on Mount Taylor of the Cibola NF increased to 2,370 acres in 2019 after being nearly absent there in 2018, when 130 acres were affected.

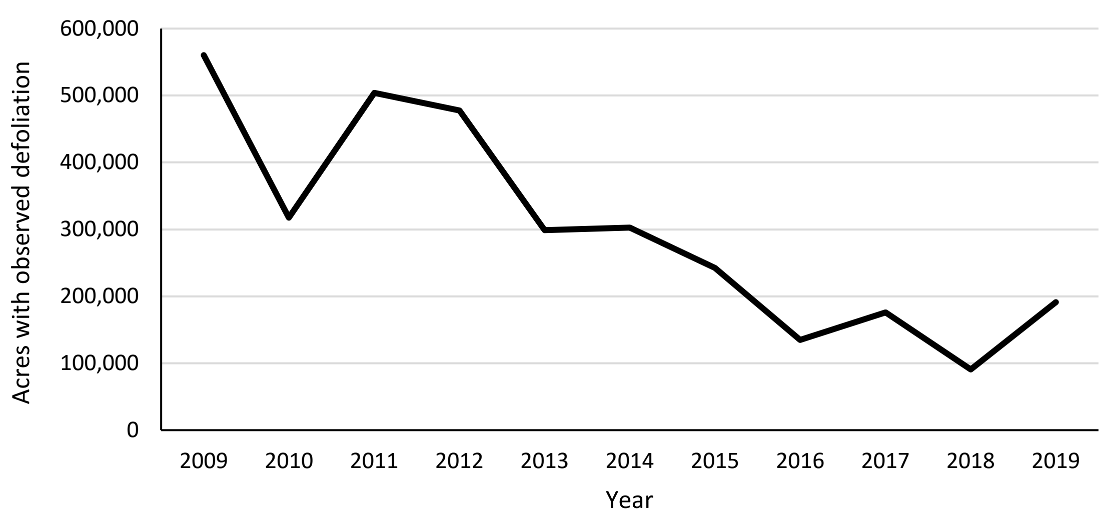

Figure 16. Defoliation attributed to western spruce budworm in the Southwestern Region for the last ten years.

Figure 17. Heavy defoliation by western spruce budworm in a mixed conifer forest on the Valle Vidal of Carson National Forest.

Janet's Looper

Nepytia janetae
Hosts: Douglas-fir, white fir, occasionally spruce, corkbark fir, and five-needle pines

In New Mexico, on the Santa Fe NF, mixed conifer defoliation was observed near Tesuque Creek from Hyde Park Road during January of 2018. Ground visits revealed the presence of Janet's looper, an inchworm that defoliates several conifer species. Because it is a winter feeder, special flights were conducted in May of 2018 and 2019 to map the area affected and avoid confusion with defoliation caused by western spruce budworm, which is visible during the summer when the normal aerial surveys are conducted. During the 2019 special survey and regular aerial detection survey flights, areas with new defoliation were observed on 5,600 acres along the east side of Hyde Park Rd, in the Santa Fe Watershed, and extending in to the Pecos Wilderness up to the Stewart Lake area, northeast of Elk Mountain, and from Black Mountain north along the ridge to Spring Mountain. This was a decline from 10,670 acres mapped in 2018, and the overall footprint of activity didn't expand significantly.

Spruce-fir Forest Type

Spruce Aphid

Elatobium abietinum
Hosts: Engelmann and blue spruce

Spruce aphid is an exotic invasive that can cause significant damage to and mortality of Engelmann spruce. Acres with current defoliation from this insect decreased substantially across the region in 2019 (Figure 18). Most of the damage was recorded in eastern Arizona, primarily on the Apache-Sitgreaves NFs on top of Greens Peak and around Mount Baldy on White Mountain Apache Tribal Lands (Table 3, Figure 19). In 2018, 17,940 acres with defoliation were mapped, and 8,100 acres were mapped in 2019. More information on spruce aphid in Arizona may be found in the "Other Entomology and Pathology Activities in 2019" section of this document under "Evaluating a Bio-Pesticide for Spruce Aphid Control in Arizona". During two ground visits in the winter of 2018-2019 to Ski Apache ski area on the Lincoln NF in New Mexico, evidence of spruce aphids (mostly feeding but also a few live aphids) was observed, but damage was minimal and not observable during aerial detection flights.

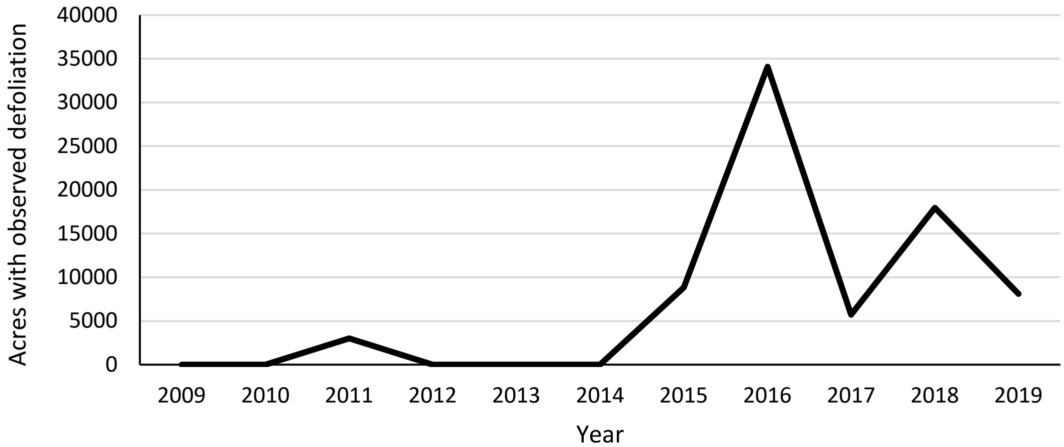

Figure 18. Defoliation attributed to spruce aphid in the Southwestern Region over the last ten years.

Figure 19. Single tree spruce mortality on the Apache-Sitgreaves NFs (left) and group defoliation and subsequent mortality on White Mountain Apache Tribal Lands (right).

Status of Major Diseases

Mistletoes

Dwarf Mistletoes

Arceuthobium spp.
Hosts: All conifers

Figure 20. Female shoots of southwestern dwarf mistletoe with seeds on a ponderosa pine branch.

Dwarf mistletoes are among the most widespread and damaging forest pathogens (disease-causing organisms) in the Southwest; over one-third of the ponderosa pine type (Figure 20) and up to one-half of the mixed conifer type has some level of infection. Damage from dwarf mistletoe infection includes growth reduction, deformity (especially the characteristic witches' brooms), and decreased longevity. Severely infested areas have much higher tree mortality rates than uninfected areas. Weakened trees can be killed by other damaging agents, like bark beetles or root disease. 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 Southwest, each with a primary tree host. The three species affecting ponderosa pine, pinyon pine, and Douglas-fir are found throughout most of their respective host ranges, while the other species have more limited distributions. In 2019, a plot network was remeasured 20+ years after implementation of prescribed fire treatments to determine the long-term influence of burning on dwarf mistletoe incidence and severity. More information can be found in the "Other Entomology and Pathology Activities in 2019" section of this document under "Prescribed Fire Effects on Southwestern Dwarf Mistletoe".

True Mistletoes

Phoradendron spp.
Hosts: Junipers and various hardwoods

Eight species of true mistletoe occur in the Southwest. These mistletoes are less damaging to their hosts than dwarf mistletoes, but heavy infestations reduce host longevity during periods of drought. *Phoradendron juniperinum* on junipers is probably the most widespread and abundant species. Big leaf mistletoe (*P. macrophyllum*) is ubiquitous throughout most riparian areas in the Southwest 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, and desert mistletoe (*P. californicum*) 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 fairly common in forests of the Southwest. They can predispose trees to root failure, a concern in campgrounds and other recreation areas. In the Southwest, root diseases are usually more common in mixed conifer and spruce-fir forests than in ponderosa pine forests and can also be common in hardwood trees. 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 continues to persist in the soil on stumps and large roots after host trees are removed or killed by fire.

Armillaria Root Disease

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

Figure 21. Mycelial fan associated with Armillaria root rot on a killed Douglas-fir seedling.

Armillaria root rot is the most common root disease in the Southwest, where it is estimated to account for up to 80% of root disease-associated mortality (Figure 21). 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, but *A. mellea* has been found in oaks, especially live oaks in southern Arizona. *Armillaria gallica* has also been identified in mixed conifer forests in Arizona. It is typically considered a saprophyte of dead trees. Previous surveys in mixed conifer forests on the North Kaibab RD, Kaibab NF found *Armillaria* spp. on about 30% of standing live trees. *Armillaria* samples from throughout the region are being identified to species by Dr. Jane Stewart at Colorado State University as part of a west-wide special technology development program project.

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 wet 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* is found in ponderosa pine, and although it does not commonly cause disease in the Southwest, the pathogen is widely distributed throughout the region. Like *Armillaria* spp., *Heterobasidion* spp. are known as saprophytes or nutrient recyclers of dead woody material as well as pathogens and may thus persist 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 ponderosa pine, southwestern white pine, white fir, and spruce. Tomentosus root disease, caused by *Onnia tomentosa*, is found on spruce and Douglas-fir. Black stain root disease, caused by *Leptographium wageneri*, appears to be rare in the Southwest but has been reported in pinyon pine in northern New Mexico and in Douglas-fir on Mescalero Apache Tribal Lands. Ganoderma root rot, caused by *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; however, aspen of all ages are affected. More mesic aspen stands on the Carson NF seem to a have higher incidence compared to other NFs in New Mexico. Monitoring is ongoing to assess damage caused by this disease through a network of semi-permanent plots located in Arizona and New Mexico.

Stem Decays

Figure 22. Fruiting body (conk) of the stem decay Indian paint fungus, *Echinodontium tinctorium*, on a white fir.

Stem decays are common in older trees throughout the 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 in the Southwest is red belt fungus, *Fomitopsis pinicola*, cause of a brown rot on various 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; Indian paint fungus, *Echinodontium tinctorium*, on true fir and occasionally Douglas-fir or spruce (Figure 22); false tinder conk, *Phellinus tremulae*, on aspen; pouch fungus, *Cryptoporus volvatus*, a sap rot found on bark beetle-killed conifers; and *Phellinus everhartii* and *Inonotus dryophilus* on oak.

Stem Rusts

White Pine Blister Rust

Figure 23. Aecia growing on a white pine blister rust canker on a southwestern white pine seedling.

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

White pine blister rust (WPBR), caused by *Cronartium ribicola*, is the only known exotic invasive forest disease in the region. In the Southwest, thousands of acres of mesic mixed conifer forest have severe WPBR infection, while more xeric sites generally have low to moderate infection. Top-kill is very common in severely affected areas. Though Rocky Mountain bristlecone pine is susceptible, WPBR has not yet affected this species within the region.

In New Mexico, this disease continues to cause heavy damage to white pines on the Sacramento Mountains of southern New Mexico, where the disease has been established for about 40 years (Figure 23). 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 (Figure 24). In 2019, a new infection center was found on the Magdalena Mountains of Cibola NF, the first time this disease was found in Socorro County (see front cover).

In Arizona, WPBR was first detected in 2009 on White Mountain Apache Tribal Lands and neighboring Apache-Sitgreaves NFs, which are still the only land management units affected in this state (Figure 24). Age estimation of older cankers suggest the WPBR 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, there are many areas where disease is still absent in both states.

In collaboration with Northern Arizona University, permanent monitoring plots have been established throughout the host type in the region. Several strategies to conserve genetic resistance against WPBR are being implemented. More information can be found in the "Other Entomology and Pathology Activities in 2019" section of this document under "White Pine Blister Rust Genetic Resistance".

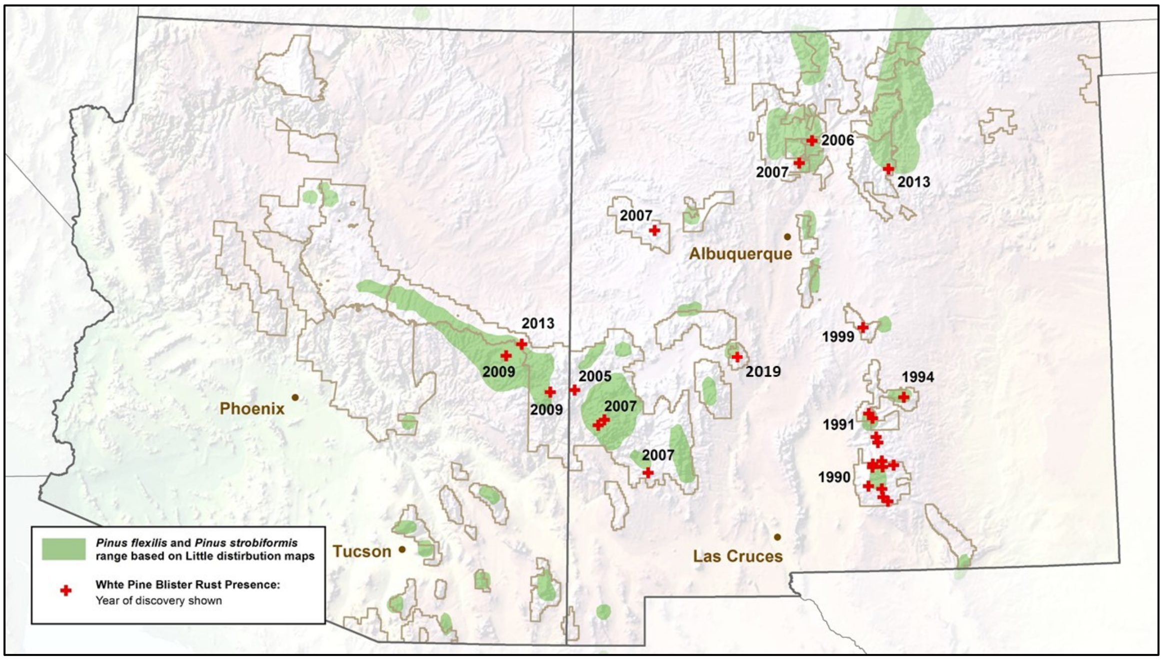

Figure 24. Distribution of known white pine blister rust infection centers within the Southwest Region and the year in which they were discovered.

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)

Figure 25. Witches' broom associated with fir broom rust on a young white fir.

There are two species of broom rust that occur at relatively low levels on their respective hosts in the Southwest (Figure 25). However, higher infestations of fir broom rust occur on the Sandia and Manzano Mountains of central New Mexico and a few other locations. Damage from this easily recognized disease has not been well quantified; however, infection can result in top-kill, especially in spruce. Falling brooms or stem breakage at the point of infection present a hazard in developed recreation sites.

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 region. The most common variety 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 (barber pole), caused by *Encoelia pruinosa*, is the most lethal canker of aspen, while Cytospora canker, caused by the weak secondary pathogen *Cytospora chrysosperma*, is the most common. Cytospora canker also infects several other conifer and hardwood species and has been observed killing alder in riparian areas in New Mexico.

An unidentified *Biscogniauxia* species has been observed affecting Emory oaks in southeastern Arizona on the Coronado NF since 2018. It has been associated with trees impacted by gold-spotted oak borer in large pockets of new mortality and decline. This canker disease has also been associated with drought-stressed trees and may be caused by an undescribed species of the genus. Samples are currently being identified to species by Dr. Jane Stewart at Colorado State University.

Foliar Diseases

Figure 26. Fruiting bodies of *Bifusella saccata* on a pinyon pine needle.

Foliar diseases in the Southwest may occur in conifers (needle casts) or hardwoods. Fungal species causing these diseases generally overwinter in old leaf litter from the previous year. Outbreaks are sporadic and highly dependent on favorable weather conditions. 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 (Figure 26). Foliar diseases in hardwoods are most commonly 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 2019, about 8,000 acres with needle cast were mapped during aerial surveys in New Mexico on Mescalero Apache Tribal Lands. On state and private lands within the area affected by pine needleminer, ground surveys in the spring identified red band needle blight (*Dothistroma septosporum*) in nearby pinyon pine based on morphological identification of fruiting bodies and conidia. Widespread symptoms on ponderosa pine were also observed during these ground surveys. Although the needleminer likely accounted for most of the 47,000 acres of discoloration mapped by aerial survey, this foliar disease may have played a role in causing the observed signature (see Pine Needleminer). Other minor needle pathogens identified in New Mexico during ground surveys in 2019 include *Bifusella saccata* on pinyon pine, *Bifusella linearis* and *Lophodermium nitens* on limber pine, and *Davisomycella ponderosae* on ponderosa pine. These pathogens were not causing extensive damage.

In Arizona, chronic white pine needle cast (*Lophodermella 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. In addition, sycamore anthracnose (*Apiognomonia veneta*) continues to affect several riparian areas throughout Arizona. This foliar disease was particularly noticeable in Oak Creek Canyon near Sedona where the infection appears to be a chronic issue. Large areas of aspen in Arizona with black leaf spot were also recorded during aerial detection surveys in 2019 (see Aspen Defoliation and Mortality).

Abiotic Damage

Salt

De-icing salt use has contributed to increasing ponderosa pine mortality along state highways over the last decade. Approximately 90 acres with mortality and/or crown discoloration were mapped in Arizona. The damage was observed along Interstate 40, Interstate 17, and Arizona State Route 89A in the Kaibab and Coconino NFs. About 200 acres of salt damage were mapped in New Mexico in 2019, primarily on the Carson, Cibola, and Santa Fe NFs. Damage has also been observed along county and city roadways as municipalities increase their use of de-icing salts. Use of dust abatement salt is also associated with mortality of ponderosa pine along dirt roads in rural housing areas.

Hail

In New Mexico, hail damage was observed on about 370 acres of ponderosa pine in Valles Caldera NP. Also, during a ground visit to West Mountain of the Capitan Mountains (Lincoln NF) to confirm defoliation detected during aerial surveys, it was discovered that the defoliation was caused by significant hail damage to ponderosa pine and Douglas-fir across 800 acres.

Drought

Because of improved snowpack during the winter of 2018-2019 and subsequent spring precipitation, mortality events associated directly with drought were not mapped in the Southwest Region in 2019, although some of the mortality mapped in northeast Arizona and during the special pinyon survey in New Mexico may have been drought-related.

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.

Table 4 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 4. Major invasive species and diseases threatening national forests and grasslands in Arizona and New Mexico.

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

Buffelgrass

Figure 27. Buffelgrass (USDI National Park Service photo).

Buffelgrass (*Cenchrus ciliaris*) is the single greatest invasive threat to the Sonoran Desert in the Southwestern Region (Figure 27). The 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. Arizona Zone Forest Health Protection (FHP) assisted multiple agencies with aerial detection of buffelgrass in 2019. More information can be found in the “Other Entomology and Pathology Activities in 2019” section of this document under “Buffelgrass Survey: Detection & Monitoring Support”.

Yellow Bluestem

Figure 28. Yellow bluestem panicle (courtesy photo by Billy Warrick; Soil, Crop and More Information).

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 28). The 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). The species is currently listed on Arizona's noxious weed list but has not been listed by New Mexico. Yellow bluestem is practically impossible to eradicate once established. Control becomes progressively more difficult and expensive the longer yellow bluestem is allowed to grow and spread. Only non-selective herbicides (glyphosate and imazapyr) are available for yellow bluestem control if manual removal or tillage is not an option. It is therefore necessary to eradicate or contain new populations when possible; otherwise, intensive management measures will eventually be needed to adequately control the species.

Saltcedar

One of the most widely distributed invasive species in the Southwestern Region is saltcedar (*Tamarix* spp.), which occurs as a shrub or a 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 (Figure 29). Adult tamarisk leaf beetles and larvae both consume saltcedar foliage, which can damage or kill the plant over a number of years. Feeding by the beetle causes saltcedar leaves to dry out and turn brown while still remaining on the stem; thus, a brown coloration is commonly seen in affected saltcedar stands.

Figure 29. Saltcedar leaf beetle (USDA APHIS photo by Robert Richard).

Since their release, different species of *Diorhabda* have migrated throughout much of Arizona and New Mexico. Further information on the *Diorhabda* 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.).

FHP Programs and Information for Managing Invasive Species

Invasive Plant Grants

The FHP program of the Forest Service's State and Private Forestry (S&PF) branch provides grant funding for assistance with local management of invasive plants on state and private lands. In the Southwestern Region, funding for the invasive plant grant program is made through FHP grants to State Forester offices in Arizona and New Mexico, which are responsible for administering the grants. Funding from the FHP grant program has been used to treat buffelgrass, thistles, saltcedar, knapweeds, toadflaxes, and other invasive weeds found on noxious weed lists of the two states. Applicants for treatment projects involving invasive plants typically include Cooperative Weed Management Areas and Soil and Water Conservation Districts. Other organizations, such as non-governmental organizations, may also qualify if they are able to treat invasive plants on a cooperative basis. Priority for funding is given to applicants with proposed projects that will treat invasive plants that threaten forests and woodlands. Applicants should contact Cori Dolan (520-262-5519) in Arizona or Shannon Atencio (505-425-7472) in New Mexico for further information.

In addition to the FHP invasive plant grants, broad-scale projects for management of invasive species on state and private lands may be funded through FHP's Landscape-Scale Restoration program, which focuses on projects at a landscape level. For further information on S&PF grant programs for invasive plants, contact the state forestry offices located in Phoenix, Arizona (602-771-1400) or Santa Fe, New Mexico (505-476-3325).

Regional Website for Invasive Species

The Southwestern Region has a website for invasive species in the Southwest, which can be found at http://www.fs.usda.gov/main/r3/forest-grasslandhealth/invasivespecies. In addition to invasive plants, the website provides information on other invasive species including aquatic species, terrestrial animals, diseases affecting fish and wildlife, and insects and diseases affecting forest health. The booklet *Invasive Plants and Weeds of the National Forests and Grasslands in the Southwestern Region* is available on the website and can be used to identify invasive weed species in the Southwest. A series of field guides for managing many invasive and common weed species according to principles of integrated weed management are also available. The field guides are intended to be used by private landowners, governmental agencies, tribal nations and other organizations for managing invasive weeds in the Southwestern Region.

Other Entomology and Pathology Activities in 2019

Forest Health Regional Training

The FHP staff provides annual training opportunities to resource managers that enhance forest health knowledge on insect and disease identification, effects, and management, as well as hazard tree identification and mitigation. In 2019, the regional insect and disease training was held in Ruidoso, New Mexico on the Smokey Bear Ranger District of Lincoln National Forest (see front cover). Field trips were conducted on the Lincoln NF and neighboring Mescalero Apache Tribal Lands. Annually, the location of the training alternates between Arizona and New Mexico. *For more information, contact Gregory Reynolds.*

Prescribed Fire Effects on Southwestern Dwarf Mistletoe

A series of plots established in the mid- to late-1990s to determine the impacts of prescribed fire on incidence and severity of southwestern dwarf mistletoe was remeasured in 2019 with assistance from the Rocky Mountain Youth Corps. Five sites were visited in the Jemez Mountains of Santa Fe NF with one to three plots per site for a total of 11 plots. Two sites (five plots) were on the Jemez RD, and three sites (six plots) were on the Española RD. The initial plot network also included plots on the Manzano Mountains that were effectively destroyed by the Dog Head Fire in 2016, and these sites were not revisited. Data were collected on tree status (live or dead), severity of infection (dwarf mistletoe rating or DMR), stem diameter, and crown class. Basal area was also measured at multiple locations within each plot. In general, average DMR for each plot had risen to near or above pre-fire levels 20+ years after treatments were applied. *For more information, contact Gregory Reynolds.*

Frye Fire, Coronado National Forest

Figure 30. ACE crews training for pheromone deployment in 2019.

The Frye Fire was started by lightning on June 7, 2017 and burned close to 48,500 acres on Mt. Graham in the Pinaleño Mountains on the Safford RD, Coronado NF. This mountain range is home to the endangered Mt. Graham red squirrel. Douglas-fir tree cones form a major portion of the squirrels' diet. Concerns about the potential for a Douglas-fir beetle outbreak prompted the Coronado NF, in conjunction with staff from Arizona FHP, to initiate a pheromone (MCH) project, designed to protect surviving Douglas-fir trees from bark beetle attacks in the remaining squirrel habitat. In addition, after fall site visits in 2018 noted mountain pine beetle attacking fire-injured southwestern white pines (SWWP), verbenone was also included in the project to protect residual SWWP. Both pheromones were deployed across ~500 acres of critical squirrel habitat in both 2018 and 2019. The verbenone was deployed as single tree protection on SWWP greater than 18 inches diameter at breast height while the MCH was deployed in a grid pattern. In both years contract crews with the American Conservation Experience (ACE) deployed the pheromone packets (Figure 30). Surveys in September of 2019 were similar to those conducted in 2018 and indicated that Douglas-fir and mountain pine beetle activity was minimal, both inside and outside of treated areas. SWWP was being attacked by *Ips bonanseai*, likely due to the abundance of fire-stressed trees. Continued pheromone protection is planned in 2020. *For more information, contact Monica Gaylord.*

White Pine Blister Rust Genetic Resistance

Figure 31. Forest Health Protection personnel climb a southwestern white pine with genetic resistance to white pine blister rust to collect scion.

In 2019, FHP continued work to sustain southwestern white 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. In 2019, site preparation for the second of two long-term southwestern white pine test sites was completed. These are long-term, fenced test sites that will be used to evaluate the durability of various disease resistance mechanisms. The first site was established in 2017 on Mescalero Apache Tribal Lands in the Sacramento Mountains of New Mexico where 278 seedlings were planted. This planting experienced over 30% mortality in its first year, in part due to a major flooding event; additional plantings to replace killed seedlings and increase the diversity of genotypes being tested on the site will occur in 2020 or future years. The second site, located on the Apache-Sitgreaves NFs, will eventually include 40 seedlings per family from 25 families with varying levels of disease resistance or susceptibility. Planting will occur in 2020. In addition, FHP collected scion from five parent trees throughout the region which have shown some level of resistance, major gene or quantitative, to white pine blister rust (Figure 31). This scion material is being grafted into a seed orchard in Mora, NM and will eventually be used to provide disease resistant seed to our clients for future reforestation efforts. 2019 collections enhanced the geographic and genetic diversity of this orchard by expanding collections into Arizona. Additional southwestern white pine seed collections also occurred in 2019 in the Sangre de Cristo Mountains; these new sources will be tested for genetic resistance at DGRC. Seed from this collection will also be placed in long term storage as part of the gene conservation program. *For more information, contact Gregory Reynolds or Nicholas Wilhelmi.*

White Pine Health in Northern New Mexico

In a collaborative project with Adams State University and also with assistance from the Rocky Mountain Youth Corps, health of white pine ecosystems in northern New Mexico was assessed during the summer of 2019. Five plots were established on the Questa RD of Carson NF in areas where white pines comprised at least 20% of stems. Potential white pine blister rust hosts included Rocky Mountain bristlecone pine (*Pinus aristata*) as well as southwestern white pine (*P. strobiformis*), limber pine (*P. flexilis*), and hybrids of those two species. Minor needle cast damage on one white pine associated with *Bifusella linearis* was found within one plot, but most pathology issues were associated with other hosts (e.g., Douglas-fir dwarf mistletoe). No infections by white pine blister rust were found in any plots during this work. *For more information, contact Gregory Reynolds.*

Aspen Monitoring in Northern Arizona

Forest Health Protection has been monitoring changes in Arizona's aspen via aerial survey and intensive site monitoring since the early 2000s. Monitoring plot networks have been installed on the Flagstaff (2008) and Mogollon Rim (2017) RDs, Coconino NF and the Williams RD, Kaibab NF (2012). Results from this work indicate extensive overstory mortality and high browse pressure inhibiting successful regeneration. More recent monitoring indicates that oystershell scale (OSS), an invasive and emergent pest, is widespread in northern Arizona and contributing to aspen mortality on the Coconino, Kaibab, Apache-Sitgreaves, and Prescott NFs (Figure 32). Monitoring projects have been initiated by the Coconino and Kaibab NFs to evaluate the effectiveness of different silvicultural treatments to control OSS. Treatments include: 1) thinning to a 10x10 ft spacing removing the most heavily infected trees, 2) a coppice removing all overstory trees, and 3) a control with no management activities. Pre-treatment data were collected in 2019. All treatments will be implemented by 2020. These projects were funded with FHP Prevention Suppression funds and implemented with technical assistance from FHP. Results will guide future management within OSS-infected stands and evaluate the long term effects of OSS on infected aspen.

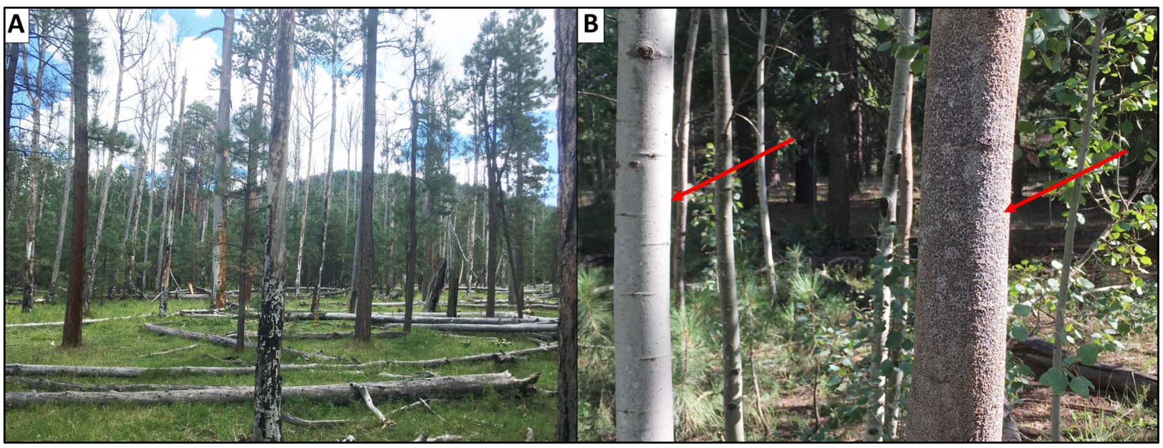

Figure 32. A) Declining aspen stand on the Coconino NF. Note the overstory mortality and lack of regeneration and B) aspen stem infected by oystershell scale (right arrow) and an uninfected aspen stem (left arrow).

A new effort to evaluate aspen decline was initiated in 2019 in collaboration with Drs. Kristen Waring and Margaret Moore of Northern Arizona University (NAU). The study will: 1) assess the health of overstory, regeneration, and recruitment over a range of conditions; 2) assess the extent and severity of OSS across a range of conditions; 3) determine the relationship between current management practices for aspen sustainability and OSS related impacts; and 4) model the impacts of climate change and management on long term aspen sustainability. This project will work closely with the National Forests to build on past monitoring projects and plot networks. Results will provide current information on aspen health and regeneration and update management recommendations. *For more information, contact Nicholas Wilhelmi or Amanda Grady.*

Evaluating a Bio-Pesticide for Spruce Aphid Control in Arizona

The exotic spruce aphid has caused significant ecological damage to Engelmann spruce in high elevation forests of Arizona since its arrival in 1988. However, little to no information is available on prevention or suppression alternatives at the landscape level or for high value trees in Arizona. Arizona Zone FHP, Northern Arizona University, and Montana Bio-Agriculture have responded by evaluating a bio-pesticide for control of spruce aphid in Arizona. In 2019, the Forest Service Pesticide Impact Assessment Program (FHP Special Grant, FS-PIAP) funded our project to evaluate *Beauveria bassiana*, the active ingredient in BotaniGard® ES, an EPA registered bio-pesticide. Successful high and low dose laboratory assays were conducted in 2017 and 2018, and field monitoring and spray treatments were implemented in 2019. Foliar spray treatments were applied to spruce trees using high pressure, low volume motorized backpack sprayers at Greens Peak, Apache-Sitgreaves NF (Figure 33) and to spruce on the Northern Arizona University campus. Aphid populations and foliar spore concentrations were monitored before and after treatments and at regular intervals thereafter to evaluate longevity of spore concentration on treated vs. untreated trees. Abundance and periodicity of high elevation pollinators was also monitored from June through November to identify potential non-target impacts of proposed fall treatments. *For more information, contact Amanda Grady.*

Figure 33. Application of BotaniGard (*Beauveria bassiana*) treatment on Engelmann spruce at Greens Peak site, Apache-Sitgreaves National Forests.

Buffelgrass Survey: Detection & Monitoring Support

Invasive buffelgrass grows in dense patches, crowding out and competing with native plants for nutrients, water, and sunshine. Open spaces between native vegetation fill with buffelgrass, occupying areas where wildflowers typically bloom (Figure 34). Dense buffelgrass patches alter the habitat for desert animals and inhibit the growth of native plant forage. With increases in buffelgrass, we stand to lose plant and animal diversity. Additionally, buffelgrass creates heavy, continuous fuel for wildfires which presents a very real threat to habitat, homes, and safety. Desert plants and animals in and around Tucson did not evolve with fire and,

Figure 34. Hillside in Saguaro National Park covered in buffelgrass.

therefore, are not adapted to it. Fire can kill or severely damage much of the Sonoran Desert vegetation upon which animals depend for food and shelter. Typical desert vegetation is sparse, so a fire would not spread and would quickly extinguish itself because of the lack of fuel.

In October of 2019, at the request of the Department of Interior, the FHP staff completed a collaborative aerial mapping project to monitor the location, extent, and intensity of buffelgrass across Saguaro National Park, Buenos Aires National Wildlife Refuge, and adjacent Arizona State Lands. The interagency collaboration was comprised of FHP, U.S. Fish and Wildlife, and Saguaro National Park. The FHP staff trained agency officials to use digital mobile sketch mapping software and process the data utilizing ArcMap software from ESRI (Figure 35). Nearly 118,000 acres were surveyed across multiple jurisdictions. Approximately, 2,000 acres with buffelgrass infestations were identified to be treated. *For more information, contact Daniel DePinte.*

Figure 35. Kara O'Brien conducting an aerial survey for buffelgrass using digital mobile sketch mapping software.

Ips Verbenone Study

In 2019, FHP AZ Zone, in conjunction with Steve McKelvey (Arizona Department of Forestry and Fire Management, retired) and Chris Fettig (Pacific Southwest Research Station, PSWRS), received funding from FS-PIAP to test the efficacy of verbenone for reducing attraction of pine engraver (*Ips pini*) to its aggregation pheromone. First, data from 2018 aerial detection surveys were used to identify an area with high levels of beetle activity (Figure 36). Next, in May of 2019, forty Lindgren funnel traps were installed at this location on the Coconino NF. A trapping bioassay consisting of four treatments was used: 1) control (blank), 2) aggregation pheromone only, 3) aggregation pheromone with verbenone dispensed from traditional plastic pouch, and 4) aggregation pheromone with verbenone emitted from SPLAT formulation. Traps were deployed from May to August of 2019. Collections will be sorted and analyzed at PSWRS. Preliminary results indicate that verbenone, in both SPLAT and traditional release mechanisms, reduces trap catches of pine engravers. The FHP staff anticipates submitting a publication in spring of 2020. *For more information, contact Monica Gaylord.*

Figure 36. Study site for verbenone efficacy study.

Skype a Scientist and Other Outreach Activities

Figure 37. New Mexico Zone plant pathologist Gregory Reynolds speaks with an elementary school class in Connecticut during a Skype a Scientist session.

In 2019, New Mexico Zone plant pathologist Gregory Reynolds participated in eight Skype a Scientist sessions with elementary and high school classes around the United States ranging from 2^{nd} to 12^{th} grade (Figure 37). Basic plant and forest pathology concepts were discussed, and a selection of plant disease samples was shown, including dwarf mistletoe and stem decay fruiting bodies. Outreach activities such as Skype a Scientist promote the cultivation of natural resource interest among children and young adults and assist in future recruitment efforts by advocating for natural resource management as a career choice.

Other FHP outreach activities in 2019 included lectures from AZ Zone staff at Northern Arizona University for their Forest Health and Protection course, running the U.S. Forest Service booth at the New Mexico State Fair, and judging various middle and high school science fairs. *For more information, visit www.skypeascientist.com or contact Gregory Reynolds.*

Biological Evaluations and Technical Assistance

Arizona Zone

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Gaylord, M.L. 2019. Forest health assessment for Scotia Canyon, Sierra Vista Ranger District, Coronado National Forest. AZ-FHP-19-12.

Gaylord, M.L. 2019. Forest health evaluation of Barfoot Park, Coronado National Forest. AZ-FHP-19-10.

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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 Region 4 and Entomologist with the Arizona Zone.

Daniel DePinte (928) 556-2071

Daniel has been a forest health specialist for the Arizona Zone since 2015. Responsibilities include GIS program for Arizona, flight manager for aerial detection surveys in Arizona, data analysis, and field assistance. Daniel is also a tree climbing instructor and the technical advisor for tree climbing within Region 3. Forest health interests include understanding the impacts of seed and cone insects on native conifers across the Southwest Region.

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 are providing technical assistance on forest defoliators to land managers across all land ownerships, providing entomological technical assistance on all non NFS lands, conducting insect and disease aerial detection surveys and monitoring native and exotic insects in the state. Technology transfer interests include bark beetle and defoliator semiochemical work, and monitoring forest pest with new detection methods.

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 land managers and hazard tree identification/mitigation training. Current interests include white pine blister rust resistance in southwestern white pine, dwarf mistletoe management and distribution, and aspen monitoring.

New Mexico Zone

Andrew Graves (505) 842-3287

Andrew has been the Zone Leader for the New Mexico Zone since October 2019. 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.

Gregory Reynolds (505) 842-3288

Gregory 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 pathogenic *Fusarium* species in nursery production and preservation of genetic resistance to white pine blister rust in five-needle pines. Gregory previously served as a plant pathologist (identifier) with the Animal and Plant Health Inspection Service in Linden, New Jersey.

Daniel Ryerson (505) 842-3285

Daniel has been a forest health and GIS specialist with the New Mexico Zone since 2003. Responsibilities include GIS program for New Mexico, aerial detection surveys, data analysis, technical support, and field assistance. Daniel is involved with the national insect and disease risk map project modeling future risk of forest mortality from insect and disease activity.

Crystal Tischler (505) 842-3284

Crystal has been the Forest Health Coordinator with the New Mexico Zone since September 2008. She also serves as the regional Forest Health unit aviation officer. Responsibilities include aerial detection surveys, aviation safety and training coordination, and field assistance to staff. She is involved with educational outreach and implementation. Her previous work experience is in forest management, fuels reduction, timber sale administration, and community wildfire protection planning.

Regional Staff

Allen White (505) 842-3280

Allen has been the Regional coordinator for invasive species and pesticide-use since 2006. Duties include coordination and management of Regional programs: (1) National Forest System Invasive Species, (2) State & Private Pesticide-Use, and (3) State & Private Invasive Plant Grants. He also serves as the Region representative for the Biological Control of Invasive Plants (BCIP) grant program managed by the Forest Health Technology Enterprise Team (FHTET). Current work in the Region includes production of field guides and brochures for managing invasive plants and coordination of regional efforts to control yellow bluestem.

Appendix: Species Index

Table 4: 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 casts	*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*	Pouch fungus	*Cryptoporus volvatus*
Pinyon needle scale	*Matsucoccus acalyptus*	Red band needle blight	*Dothistroma septosporum*
Ponderosa pine seedworm	*Cydia piperana*	Red belt fungus	*Fomitopsis pinicola*
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*
Western pine beetle	*Dendroctonus brevicomis*	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 annually based on the USDA Agricultural Research Service's U.S. National Fungus Collections Database (https://nt.ars-grin.gov/fungaldatabases/fungushost/fungushost.cfm) and may not match the regional field guide

Visit Us Online

In an effort to better serve the Internet user, Region 3 FHP continues to expand our online information base. The Forest Service Southwestern Region hosts a Forest Health web site at http://www.fs.usda.gov/goto/r3/foresthealth. Technical information posted on this site includes annual forest insect and disease conditions reports, literature on pest biology and management, and general information on forest health in the Southwest. Additionally, our Forest Health Protection national office maintains a web site at http://www.fs.fed.us/foresthealth that includes program overviews and publications links.