United States Department of Agriculture

Forest Insect and Disease Conditions in the Southwestern Region, 2018

Forest Service | Southwestern Region | Forest Health PR-R3-16-18 | September 2019

Cover photos: Clockwise from top left: Douglas-fir trees defoliated by Douglas-fir tussock moth; Engelmann spruce trees impacted by needle cast; Defoliation from Janet's looper; Ponderosa pine mortality.

Forest Insect and Disease Conditions in the Southwestern Region, 2018

Southwestern Region
Forest Health Protection

Clifford Dils, Director

Donald Vandendriesche, Deputy Director

Allen White, Regional Coordinator for Invasive Species & Pesticides

Arizona Zone
John Anhold, Zone Leader
Daniel DePinte, Forest Health Specialist
Monica Gaylord, Entomologist
Amanda Grady, Entomologist
Nicholas Wilhelmi, Plant Pathologist

2500 South Pine Knoll Drive
Flagstaff, AZ 86001

New Mexico Zone
Tom W. Coleman, Zone Leader
Andrew Graves, Entomologist
Gregory Reynolds, Plant Pathologist
Daniel Ryerson, Forest Health/GIS Specialist
Crystal Tischler, Forest Health Coordinator

333 Broadway Blvd., SE
Albuquerque, NM 87102

http://www.fs.usda.gov/goto/r3/foresthealth

State Insect and Disease Specialists

Arizona: Steve McKelvey

New Mexico: John Formby

Contents

List of Tables

List of Figures

Conditions in Brief

2018 Weather Summary for the Southwestern U.S.

In 2018, the Southwestern Region (Arizona and New Mexico) experienced above average temperatures (Figure 1). Arizona had its second warmest year on record and New Mexico had its third warmest year on record. Although a few areas in the Southwest had above normal precipitation, on average the Southwest was drier than normal (Figure 2). In particular, the winter and early spring of 2018 was very dry, with snowpack on April 1, 2018, in the Southern Rockies well below average. Most areas in Arizona and New Mexico reported below 25% of average winter snowpack (Figure 3).

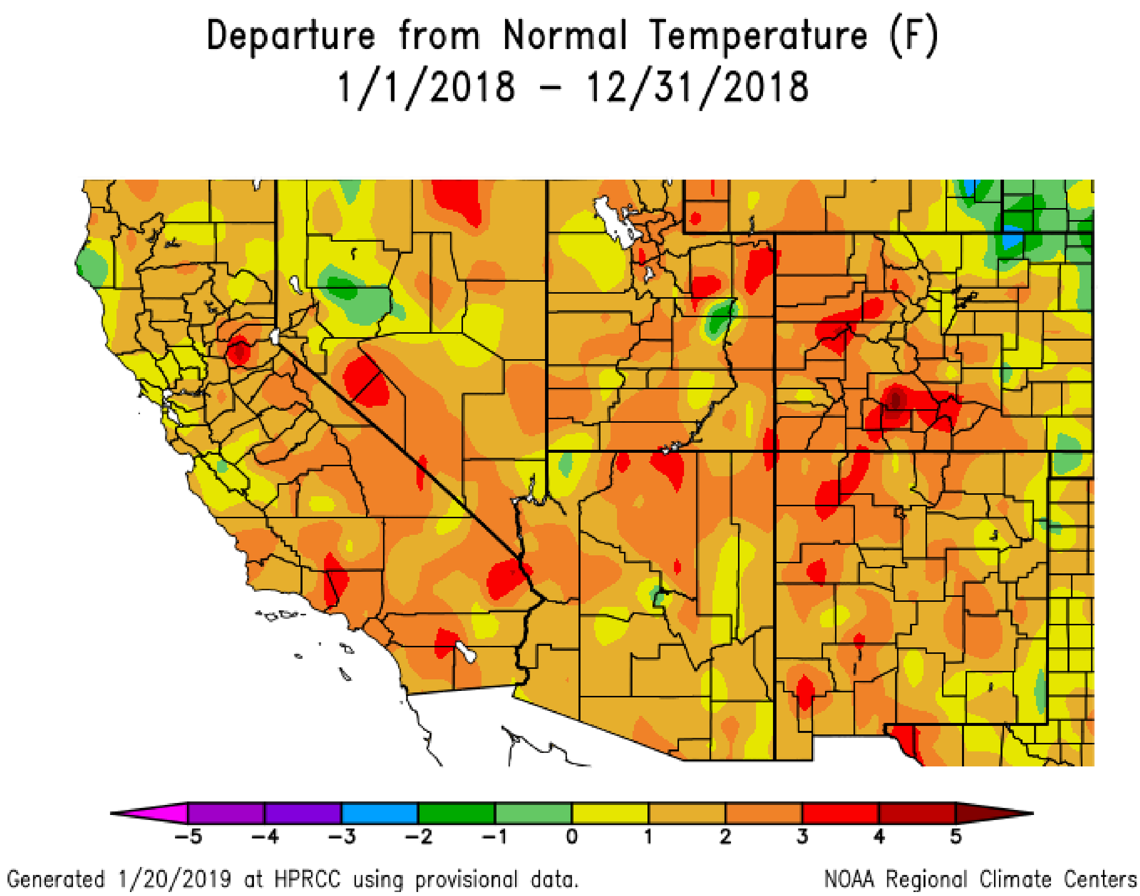

Figure 1: Departure in degrees (F) from normal temperature in the Southwestern U.S. for 2018. (Source: High Plains Regional Climate Center, https://hprcc.unl.edu/maps.php?map=ACISClimateMaps).

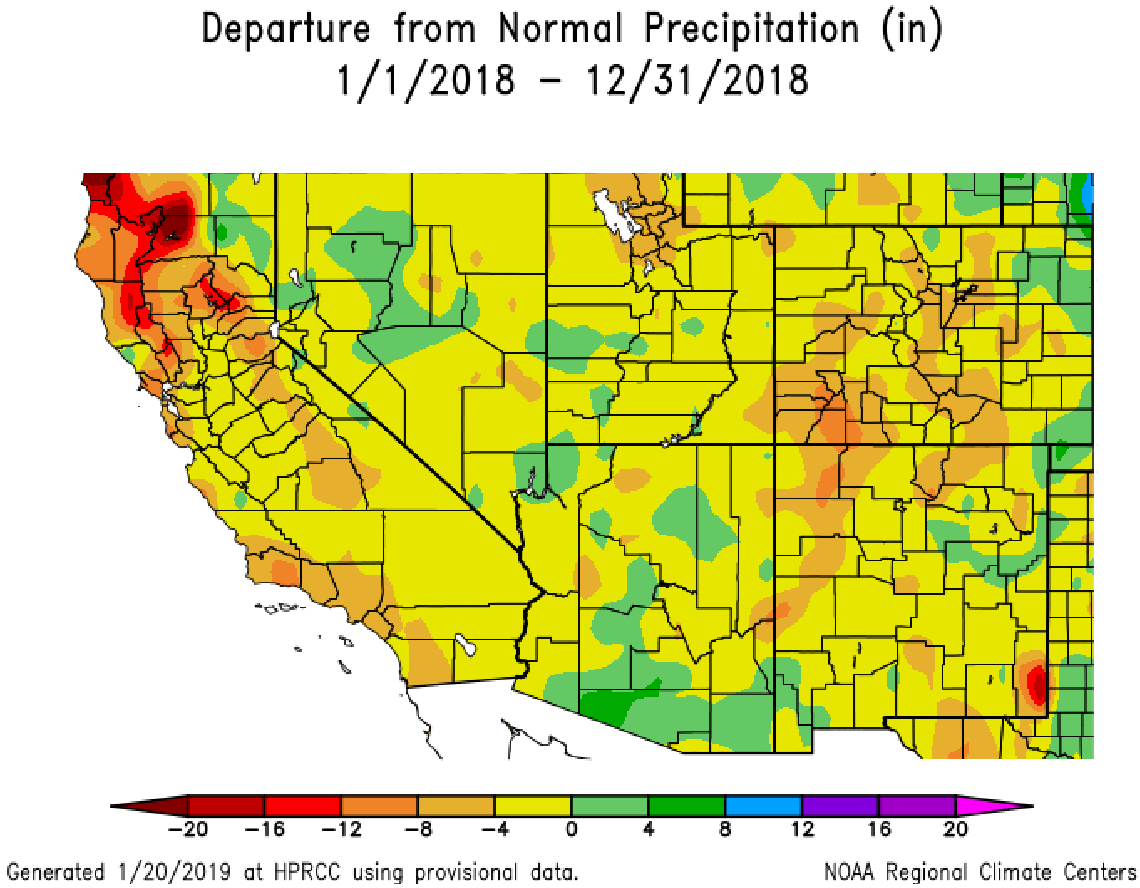

Figure 2: Departure from normal precipitation (inches) in the Southwestern U.S. for 2018. (Source: High Plains Regional Climate Center, https://hprcc.unl.edu/maps.php?map=ACISClimateMaps).

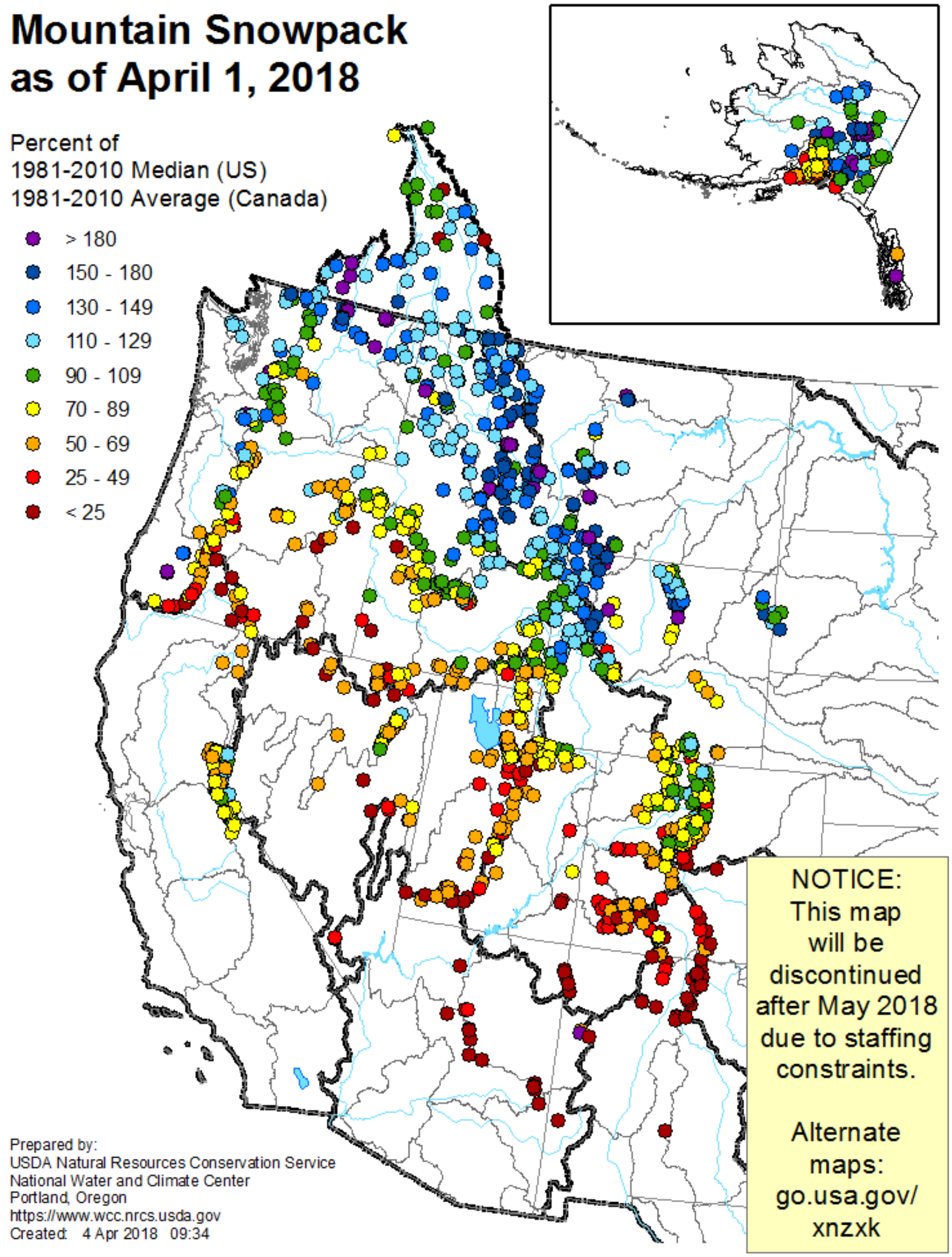

Figure 3. Mountain snowpack for western U.S. for the winter of 2017-2018. (Source: NOAA National Centers for Environmental Information, State of the Climate: National Climate Report for Annual 2018, published online January 2019, retrieved on February 13, 2019 from https://www.ncdc.noaa.gov/sotc/national/201813).

Regional Forest Insect and Disease Summary

Aerial Survey Summary

In 2018, aerial detection surveys (ADS) covered approximately 20.5 million acres of the Southwestern Region. Aerial surveys primarily covered National Forest land (58% of area surveyed) followed by tribal (22%), state and private (16%), and other federal lands (4%) (Table 1, Figure 3).

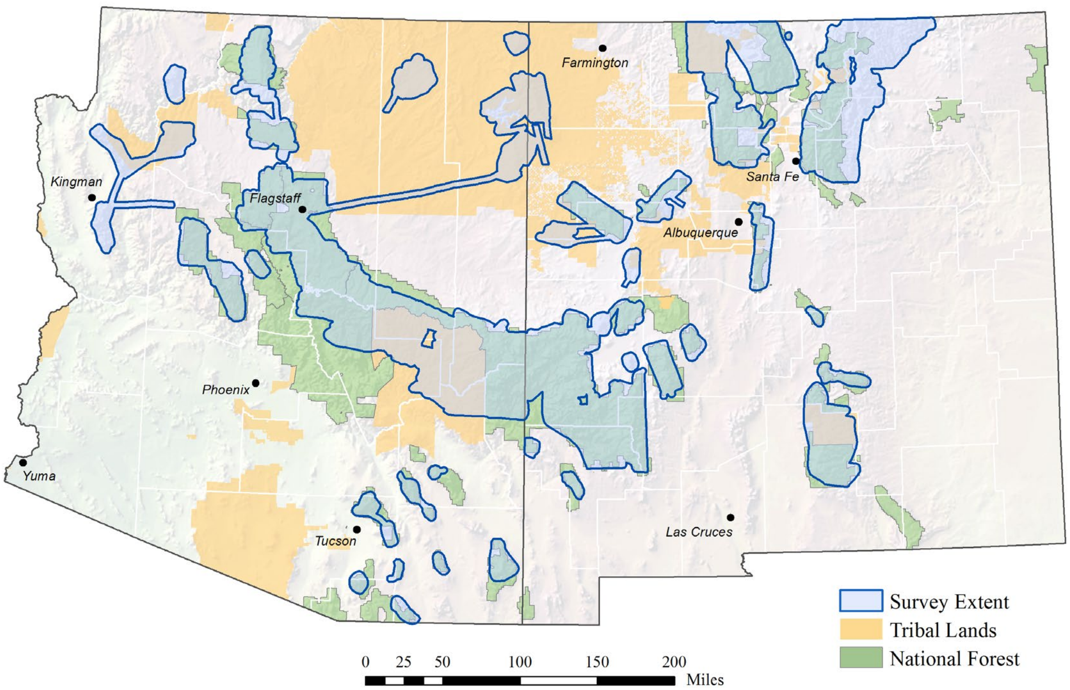

Figure 4: Areas surveyed during 2018 ADS flights.

Table 1. Aerial detection survey acres flown in 2018 in the Southwestern Region.*

Land ownership	State	Forested	Woodlands	Total
National Forest Lands	AZ	3,422,000	2,091,000	5,513,000
Bureau of Land Management	AZ	11,500	157,100	168,600
Department of Defense	AZ	39,400	9,200	48,600
National Park Service	AZ	141,600	163,900	305,500
Tribal	AZ	1,131,200	2,036,500	3,167,700
State and Private	AZ	214,000	344,000	558,000
Arizona Total		**4,959,600**	**4,801,600**	**9,761,200**
National Forest Lands	NM	4,300,400	2,053,700	6,354,100
Bureau of Land Management	NM	34,200	147,900	182,100
Department of Defense	NM	2,600	1,100	3,600
National Park Service	NM	85,800	9,800	95,500
Tribal	NM	854,900	456,700	1,311,600
State and Private	NM	1,893,300	892,300	2,785,600
New Mexico Total		**7,171,900**	**3,561,400**	**10,733,300**

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

Special Survey Arizona Zone

Due to elevated levels of tree mortality detected across Arizona during the normal survey flights and ground observations in 2018, a late season aerial detection survey was conducted in October by the Arizona Zone to estimate the amount of additional, late summer tree mortality. The survey covered the north and south edges of the Mogollon Rim. Across the pinyon-juniper and ponderosa forest types an increase of 100-200% mortality was observed (Figure 4). Based on the findings of this late survey, we suspect the acreage with tree mortality that occurred in Arizona in 2018 was higher than what was captured during our normal aerial survey.

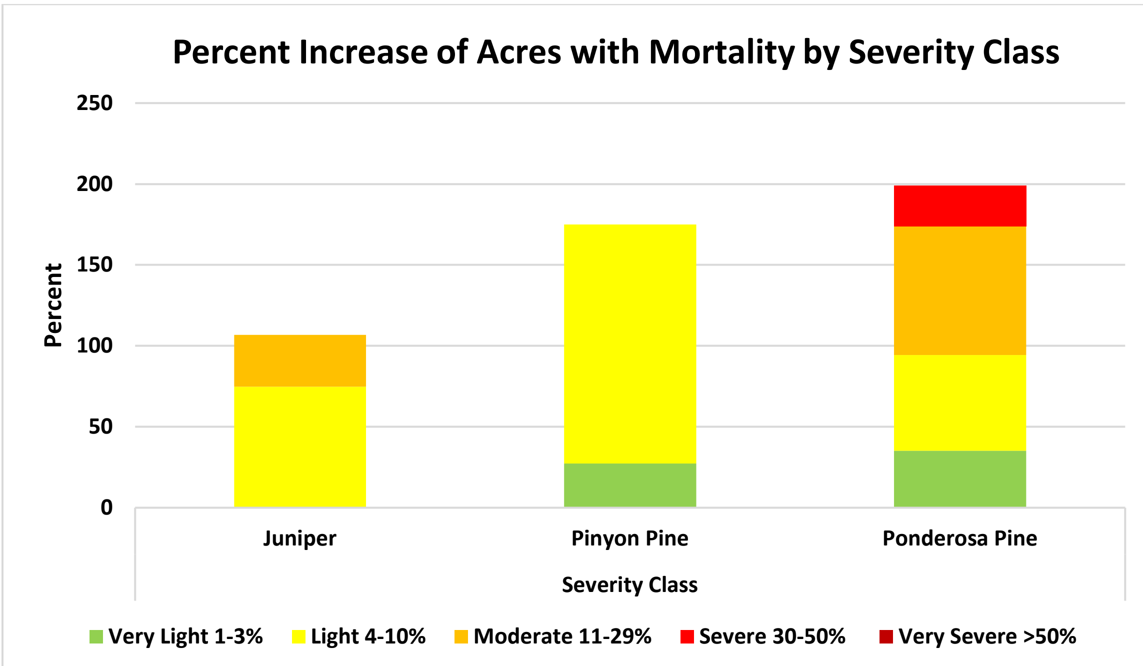

Figure 5: Percent increase between the summer and fall ADS flights of acres recorded with tree mortality. The fall flight only flew a limited flight line (north and south edges of the Mogollon Rim) and was targeted for areas where high amounts of mortality had been previously recorded. Other areas of northern Arizona likely experienced a similar increase in mortality, but not to the same extent.

Special Survey New Mexico Zone

The New Mexico Zone conducted a special early season survey in May 2018 to document damage caused by Janet's looper on the Santa Fe National Forest (NF) (Figure 5). During this survey, 9,970 acres with defoliation were observed. During the regular survey additional looper activity was observed and mapped.

Figure 6: Defoliation damage caused by Janet's looper. The defoliation occurred during the winter of 2017-2018 on the Santa Fe NF.

Bark Beetle Summary

Region-wide, total acres mapped with tree mortality attributed to bark beetles was over 394,500 acres in 2018 (Table 2). This is triple the acres (131,000) mapped in 2017. This sharp increase in activity occurred primarily in Arizona ponderosa pine forests (63% of all beetle mortality recorded) and was likely driven by the lack of winter precipitation and warm spring temperatures. Previous drought events in the region have also been correlated with increases in bark beetle attributed pine mortality. In Arizona, the ponderosa pine mortality was widespread on multiple forests and across all ownerships, but was concentrated in the transition zones between ponderosa pine and pinyon-juniper forests. In 2018, ponderosa pine bark beetles also accounted for the most tree mortality in New Mexico (44% of the total acres mapped with mortality in the state) with the majority of ponderosa pine beetle-caused tree mortality on the Gila NF. In New Mexico, spruce beetle was also a significant damage agent in 2018 with 38% of all acres mapped with mortality in the state attributed to this agent. Most of this damage was recorded on the Santa Fe and Carson NFs and adjacent state and private land. The acreage with spruce beetle attributed mortality in New Mexico in 2018 was similar to 2017 with 45,570 compared to 45,350, respectively. Region-wide we mapped an increase in acreages with beetle mortality from 2017 values for woodland and ponderosa forests and decreases for mixed conifer and spruce-fir (Figures 6, 7, 10, 11).

Table 2. Bark beetle[1] incidence by ownership (acres) from aerial detection surveys in 2018 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	91,550	600	40		10	40	940
Coconino NF	33,780	930	30	<5	<5	<5	2,060
Coronado NF	930	1,230	<5				440
Kaibab NF	4,780	2,360	80	<5		<5	360
Prescott NF	3,900	100	10			<5	<5
Tonto NF	18,910	1,320	20				180
BLM	870	20	<5				<5
Fort Huachuca	<5	1,100					60
Navajo Army Depot	10						
Grand Canyon NP	930	10	<5			<5	<5
Canyon De Chelly NM	10	<5	20				30
Saguaro NP	30	<5					<5
Sunset Crater NM	<5						
Walnut Canyon NM							
Wupatki NM							
Hopi Tribal		10					<5
Hualapai Tribal	150	10					<5
Navajo Nation (AZ side only)	1,690	520	10		<5	<5	860
Navajo-Hopi JUA		10					<5
San Carlos Apache	30,700	330					130
White Mtn. Apache	49,760	2,260	110	50	40	10	100
State & Private	10,380	7,490	<5				3,210
Arizona Total	**248,380**	**18,300**	**330**	**50**	**50**	**50**	**8,370**
Carson NF	310	<5	1,600	12,190	60	620	
Cibola NF	7,020	260	3,500		<5	50	
Gila NF	30,800	1,440	30			30	150
Lincoln NF	2,000	190	10	100	60	<5	
Santa Fe NF	2,500		7,370	19,560	<5	590	
BLM	90	360	<5	30			
Bandelier NM	<5		<5				
El Malpais NM	120						
Valles Caldera NP	400		830	30		<5	
Acoma Pueblo	60	<5					
Isleta Pueblo	160	<5	<5				
Jemez Pueblo	10		<5				
Jicarilla Apache	10		570	1,200			
Laguna Pueblo	220	<5					
Mescalero Apache	250	10	10	320	<5	<5	<5
Navajo (NM side only)	2,460	160	<5		<5	<5	<5
Picuris Pueblo	<5		20			<5	
Ramah Tribal	<5	70					
Santa Clara Pueblo	<5		30				
Taos Pueblo	40	<5	240	50		<5	
Zuni Pueblo	10	10					
State & Private	6,130	250	1,960	12,080	20	420	70
New Mexico Total	**52,590**	**2,760**	**16,160**	**45,570**	**150**	**1,720**	**220**
SW Region Total	**300,970**	**21,060**	**16,490**	**45,620**	**200**	**1,770**	**8,600**

[1]Only major bark beetle and mortality agents show. 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 decreased from 265,200 acres mapped across the region in 2017 to 210,950 in 2018 (Table 3). The majority of the defoliation (185,870 acres) occurred in New Mexico and was primarily attributed to western spruce budworm (48%) and various insects on aspen (8%) (Table 3). Spruce aphid feeding contributed the most (72% of recorded total) to acres with defoliation in Arizona. Defoliation from spruce aphid increased substantially in Arizona from 5,700 acres recorded in 2017 to 17,940 mapped in 2018. Most of the damage was mapped on the White Mountain Apache Tribal Lands. Western spruce budworm defoliation decreased from 176,640 acres mapped across the region in 2017 to 90,710 in 2018 (Table 3). The majority of the western spruce budworm defoliation was mapped on the Carson and Santa Fe NFs and state and private land in New Mexico. In New Mexico, over 10,000 acres were also mapped with defoliation from Janet's looper. The most recent outbreak of this insect was recorded in 2007 near Cloudcroft, NM. Douglas-fir tussock moth continued to be in outbreak status on the Cibola NF, affecting over 1,800 acres in 2018, up slightly from the 1,700 acres mapped in 2017 (Table 3). Douglas-fir tussock moth activity also increased in Arizona on the Coconino NF with 1,020 acres with defoliation mapped in 2018, up from 20 acres reported in 2017. Lastly, approximately 240 acres with defoliation were detected along the upper section of Oak Creek in the Red Rock RD. The defoliation was caused by alder leaf beetle feeding. Complete defoliation caused crown dieback in a few Arizona alder.

Disease Summary

Dwarf mistletoe is the most common and widespread pathogen in the Southwest. Because we are unable to estimate dwarf mistletoe from aerial detection surveys 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 and New Mexico 2,073,000 acres across all ownerships) are based on historical records, which indicated that over one-third of the ponderosa pine acreage and about one-half of the mixed conifer acreage has 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 and 860,000 acres, across all ownerships for Arizona and New Mexico, respectively), but poorly documented. Armillaria root disease and Heterobasidion root disease are the most prominent root diseases in our region, often interacting with bark beetles, drought, and other tree stressors to cause tree mortality.

White pine blister rust, a disease caused by an introduced fungus, continues to injure and kill southwestern white 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 2018 in Arizona and New Mexico[2].

Owner[3]	Western spruce budworm	Aspen damage[4]	Douglas-fir tussock moth	Pinyon needle scale	Sawfly-Ponderosa	Spruce aphid
Apache-Sitgreaves NFs	120	560	<5			5,200
Coconino NF	620	170	1,020			
Coronado NF						
Kaibab NF	270	<5	<5			
Prescott NF						
Tonto NF						
BLM						
Fort Huachuca						
Navajo Army Depot						
Grand Canyon NP						
Saguaro NP						
Sunset Crater NM						
Walnut Canyon NM						
Wupatki NM						
Canyon De Chelly NM						
Hopi Tribal				10		
Hualapai Tribal				900		
Navajo Nation (AZ side only)	80			40		
Navajo-Hopi JUA				20		
San Carlos Apache						
White Mtn. Apache		50		10		12,720
State & Private	40	80	<5			10
Arizona Total	**1,130**	**860**	**1,020**	**980**		**17,940**
Carson NF	40,290	10,180				
Cibola NF	130	1,070	1,800	<5		
Gila NF		100		60	30	
Lincoln NF	220	290				<5
Santa Fe NF	14,600	3,160				
BLM	60	20				
Bandelier NM						
El Malpais NM						
Valles Caldera NP	170					
Acoma Pueblo					80	
Isleta Pueblo						
Jemez Pueblo						
Jicarilla Apache	310	140				
Laguna Pueblo						
Mescalero Apache	170	20				
Navajo Nation (NM side only)	40					
Santa Clara Pueblo						
Taos Pueblo	740	50				
Zia Pueblo						
Zuni Pueblo						
State & Private	32,870	3,810	90	180	180	
New Mexico Total	**89,580**	**18,860**	**1,890**	**240**	**300**	**<5**
SW Region Total	**90,710**	**19,720**	**2,910**	**1,220**	**300**	**17,930**

[1]Only major defoliator agents show. 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.
[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, tree mortality in ponderosa pine, pinyon pine, and juniper was elevated across the region in 2018. In New Mexico, the increase in ponderosa mortality followed a six-year trend of decreasing mortality. In Arizona, elevated levels of juniper, pinyon pine, and ponderosa pine mortality were evident during the early spring and summer of 2018. Water stress, particularly the lack of winter moisture, is known to weaken trees. Trees may die from outright drought stress, but are also more susceptible to bark beetle attacks. During ground checks in 2018, Arizona FHP personnel found evidence of bark beetles in all of the affected tree species mentioned above; however, it should be noted that for both ponderosa and juniper trees, we also found individual dead trees with no evidence of bark beetle attacks. This was particularly true for ponderosa pine trees that faded early in the summer and junipers throughout the year. Since ground checks were not feasible at the statewide level, and most areas showed some evidence of bark beetles, all mortality has been attributed to bark beetles. Increased bark beetle activity in the higher elevation forests, mixed conifer and spruce-fir, was not detected during our surveys.

Pinyon-Juniper Forest Type

The pinyon-juniper forest type had a region-wide increase in bark beetle attributed mortality (Figure 6). Total acres with mortality in the pinyon-juniper forest type increased from 650 acres reported in 2017 to 29,660 acres in 2018. The majority of the damage was recorded in Arizona (Table 2). Although this acreage is substantial, it is well below what was mapped in 2013 & 2014.

Pinyon Ips

Ips confusus
Host: Pinyon Pine

In 2017, Arizona and New Mexico combined had 650 acres with pinyon ips attributed mortality. In 2018, acres with pinyon mortality jumped to 21,060 (Table 2; Figure 6). The majority of the mortality occurred in Arizona (87%) on the lower elevations of this species' range across all the NFs and other land ownerships (Table 2). Extensive areas with mortality were mapped north of Flagstaff, on the Sky Islands near the southeastern border with Mexico, south of the Grand Canyon on the Tusayan Ranger District (RD) of the Kaibab NF, and on Fort Huachuca lands in the southeastern part of the state. While New Mexico did not have as much acreage impacted by pinyon ips as Arizona, there was still a substantial increase from the 90 acres mapped in 2017 to the 2,760 mapped in 2018. Increased mortality occurred in the central and southern portion of the state, affecting the Cibola, Gila, and Lincoln NFs (Table 2).

Cedar Bark Beetles

Phloeosinus spp.
Host: Arizona cypress and junipers

In 2017, Arizona and New Mexico combined had 30 acres with juniper mortality attributed to bark beetles. In 2018, acres with juniper mortality increased to 8,600 acres (Figure 5), the majority of which occurred in Arizona. Arizona reported over 97% of the juniper mortality with the majority occurring at the lower elevations of this species' range across all the NFs and other land ownerships. Aerial surveys designated juniper in these areas as beetle killed. Ground surveys found evidence of bark beetles in some trees; however, many trees were dead with no apparent damage from insects or disease. We suspect that drought or some other, abiotic event or causal agent, played a significant role in this mortality event. New Mexico had minimal juniper mortality observed in the normal survey areas in 2018.

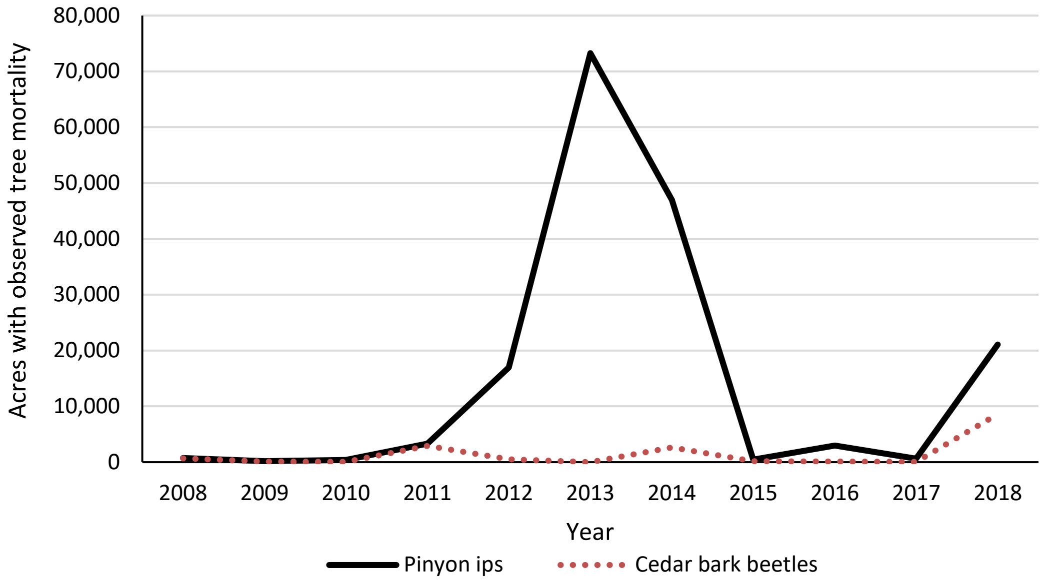

Figure 7: Pinyon-juniper mortality associated with pinyon ips and cedar bark beetles in the Southwestern Region for the last ten years.

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, we no longer identify specific bark beetle species causing ponderosa pine mortality during aerial surveys.

In 2018, we mapped 300,970 acres with ponderosa pine mortality across the region. This is a dramatic increase over the 56,800 acres mapped in 2017 (Figure 7). The majority (83%) of this tree mortality occurred in Arizona (Table 2). Mortality in Arizona was concentrated along the Mogollon Rim in the ponderosa-pinyon/juniper transition zones and spread from the Coconino and Tonto NFs east to the Apache-Sitgreaves NFs and south to the White Mountain and San Carlos Apache Tribal Lands (Figure 8). The tree mortality was particularly noticeable along Highway 260 between Heber-Overgaard and Show Low. Ground surveys found numerous beetle species, including several species of engraver beetles, western pine beetle, roundheaded pine beetle, and red turpentine beetle. Elevated levels of ponderosa pine mortality were also observed on the Prescott NF (Table 2). Most of this damage occurred in the Bradshaw RD near Crown King.

In New Mexico, although the total acres with ponderosa pine mortality was much lower than in Arizona (Table 2), the level almost quadrupled from the 13,480 acres mapped in 2017. This increase occurred after a six-year trend of decreasing mortality (Figure 7). Some of this activity was near previous fires. On the Cibola NF, acres with bark beetle-killed ponderosa pine increased from 1,400 acres in 2017 to 7,020 acres in 2018 in and around the Doghead and North Fire scars and on Mount Taylor. For instance, the Gila NF had 30,800 acres with ponderosa pine mortality, most of which was concentrated on the Pinos Altos Range south of the Signal Fire. Engraver, western pine, and roundheaded beetles have all been found to be active in this area.

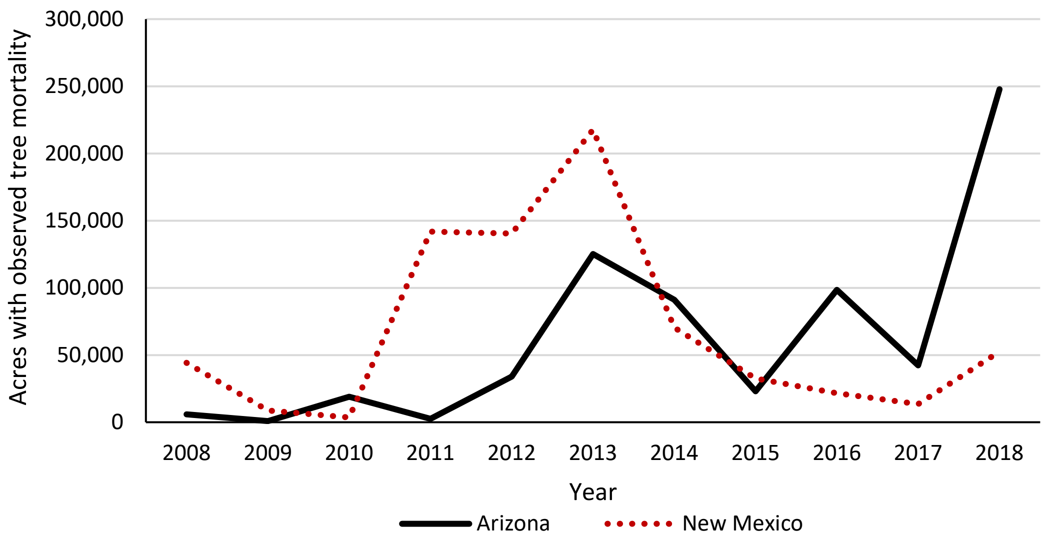

Figure 8: Ponderosa pine mortality attributed to bark beetles in the Southwestern Region for the last ten years.

Figure 9: Ponderosa pine mortality in the Blue Ridge Community on the Mogollon Rim District of the Coconino NF.

Mixed Conifer Forest Type

Unlike the pine forest types, we did not detect increased bark beetle activity in the mixed conifer forests in 2018. In 2017, we mapped just over 25,000 acres with mortality from Douglas-fir and fir engraver beetles (Figure 9). In 2018, the acreage was less, at around 18,260 acres. Most recently, beetle activity in the mixed conifer in the Southwestern Region has been associated with wildfires. The decline in acres mapped with damage is correlated with a decline in recent fire activity in these areas.

Douglas-fir Beetle

Dendroctonus pseudotsugae
Host: Douglas-fir

In 2018, acres with Douglas-fir mortality from Douglas-fir bark beetles declined from 20,720 acres to 16,480 acres across the region. This continued the trend which started after a peak in activity in 2013 (Figure 9). 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 on the Apache-Sitgreaves NFs in 2011. In 2018, aerial surveys only mapped 40 acres with Douglas-fir beetle activity across the Apache-Sitgreaves NFs and activity from this beetle across Arizona was at reduced levels, although small patches of tree mortality attributed to Douglas-fir beetle were still observed throughout the state (Table 2). We have also noticed ongoing activity in Canyon de Chelly National Monument with Douglas-fir mortality continuing to spread down Wheatfields Creek. The mortality has been slowly expanding over the last few years. Approximately 20 acres of new tree mortality was mapped in 2018**,** down from 40 acres mapped in 2017.

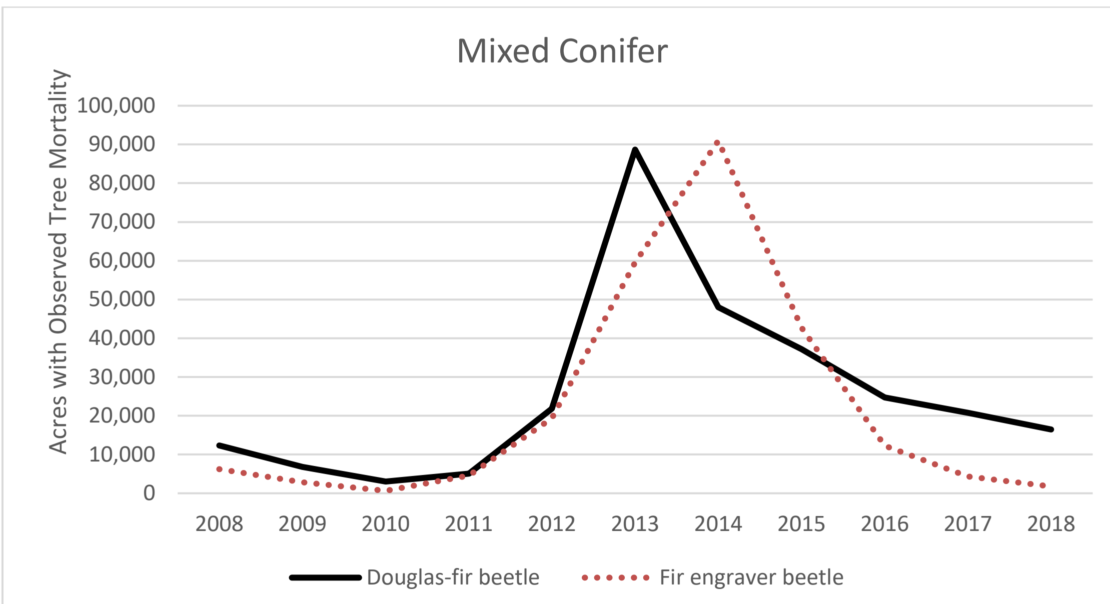

Figure 10: Mixed conifer mortality associated with two species of bark beetles in in the Southwestern Region in the last ten years.

In New Mexico, Douglas-fir mortality from Douglas-fir bark beetles decreased from 20,210 acres in 2017 to 16,160 acres in 2018 (Table 2). Douglas-fir beetle-caused tree mortality in 2018 occurred on the Cibola and Santa Fe NFs (Figure 10). 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 was still at an elevated level in 2018, but decreased from 2017 amounts. The Sangre de Cristo Mountains had the majority of the activity with some activity still occurring on the Jemez Mountains. In contrast to the regional trend of declining acres, aerial surveyors mapped Douglas-fir beetle activity on 3,500 acres on the Cibola NF in 2018; an increase over the 870 acres affected in 2017. The increased activity observed on the Cibola NF was primarily on the San Mateo Mountains in and adjacent to areas affected by the North and Red Canyon Fires.

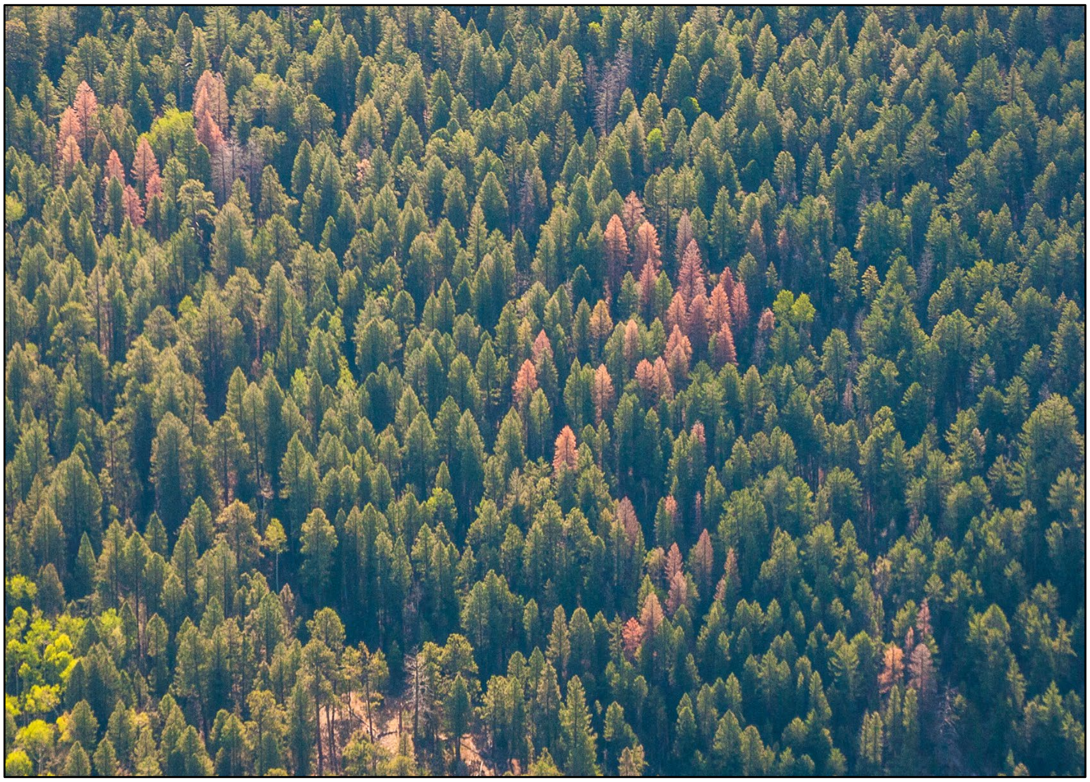

Figure 11: Douglas-fir tree mortality attributed to the Douglas-fir beetle on the Santa Fe NF.

Fir Engraver

Scolytus ventralis
Host: White fir

White fir mortality from fir engraver beetles often happens when trees are exposed to a previous stressor such as drought, increased competition due to high stand densities, defoliation, and 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 decreased from 4,340 acres mapped in 2017 to 1,780 acres mapped in 2018 (Figure 9). In Arizona, fir engraver was minimal, with only 50 acres mapped in 2018, the majority of which was mapped on the Apache-Sitgreaves NFs. New Mexico had more fir engraver activity than Arizona (Table 2). The majority of the white fir mortality in 2018 was on the Sangre de Cristo Mountains affecting the Questa RD of the Carson NF and the Pecos-Las Vegas RD of the Santa Fe NF. Fir engraver activity on the Sandia Mountains of the Cibola NF, where activity had been prevalent in prior years, has declined to background levels. Defoliation by Douglas-fir tussock moth in this area, however, may trigger future fir engraver activity on trees weakened by the feeding.

Ips sp.

Ips bonanseai
Host: Southwestern white pine

During the summer of 2018, ground surveys found *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. While mountain pine beetle was occasionally present in some of these dead trees, the vast majority of the identified beetles were this small *Ips.* Pitch tubes were also generally lacking on the attacked trees. Mortality occurred across all tree size classes. These beetles are not considered aggressive tree killers and we suspect they were exploiting trees stressed by the drought and the 2017 fire. We will continue to monitor this area with ground surveys in 2019 as part of the beetle suppression project occurring in the Frye Fire. For more details on this project please see the "Other Entomology and Pathology Activities" section on Beetle Suppression Projects after Wildfires. Because it is difficult to determine if bark beetles, fire, or other agents killed trees from the air, aerial surveys typically do not record damage for two years after a fire has occurred and no aerial survey data will be available for the Frye Fire area until 2020.

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 trees species, but blue spruce, limber, bristlecone pines, and aspen may also be present.

Spruce Beetle

Dendroctonus rufipennis
Host: Spruce

Region-wide, acres mapped with spruce beetle mortality stayed fairly consistent with 45,370 acres mapped in 2017 and 45,620 acres in 2018 (Figure 11). In Arizona, acres mapped with spruce beetle mortality have been consistently low, with 20 acres mapped in 2017 and 50 acres mapped in 2018. Most of the activity was in a few small areas on White Mountain Apache Tribal lands in the White Mountains of east central Arizona. These are the same areas where spruce aphid has been active in recent years. In New Mexico, spruce beetle continued to kill Engelmann spruce in the northern part of the state, primarily on the Carson and Santa Fe NFs and adjacent lands. Aerial surveyors mapped roughly the same overall acreage in 2018 (45,570) as in 2017 (45,350), however some expansion of activity into unaffected areas was observed. Some of the stands that have experienced several years of bark beetle activity have recorded >90% spruce mortality and little new activity was observed in these already severely affected areas. Spruce beetle continues to expand in stands near Elk Mountain, the Pecos Wilderness area, and on the Tres Piedras RD, Carson NF. A small amount of spruce beetle activity continues on Sierra Blanca in the southern part of the state, affecting the Ski Apache ski area and nearby Mescalero Apache Tribal lands.

Western Balsam Bark Beetle

Dryocoetes confusus
Hosts: Subalpine and corkbark fir

Acres with fir mortality attributed to western balsam bark beetle declined from 1,320 acres mapped in 2017 to 200 acres mapped in 2018 (Figure 11). As with 2017, the majority of the activity was reported in New Mexico (150 acres), primarily on the Carson (60 acres) and Lincoln

(60 acres) NFs. Western balsam bark beetle is likely interacting with Armillaria root disease 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. The Santa Fe NF had a large decrease in acres with beetle-caused mortality; from 740 in 2017 to less than 5 in 2018. In Arizona, the Apache-Sitgreaves NFs saw a similar decline in acres with beetle-caused mortality. In 2017, 120 acres were recorded while, in 2018 only 10 acres were observed with mortality. In contrast, on the neighboring White Mountain Apache Tribal Lands, there was a slight increase from less than 5 acres in 2017 to 40 acres in 2018.

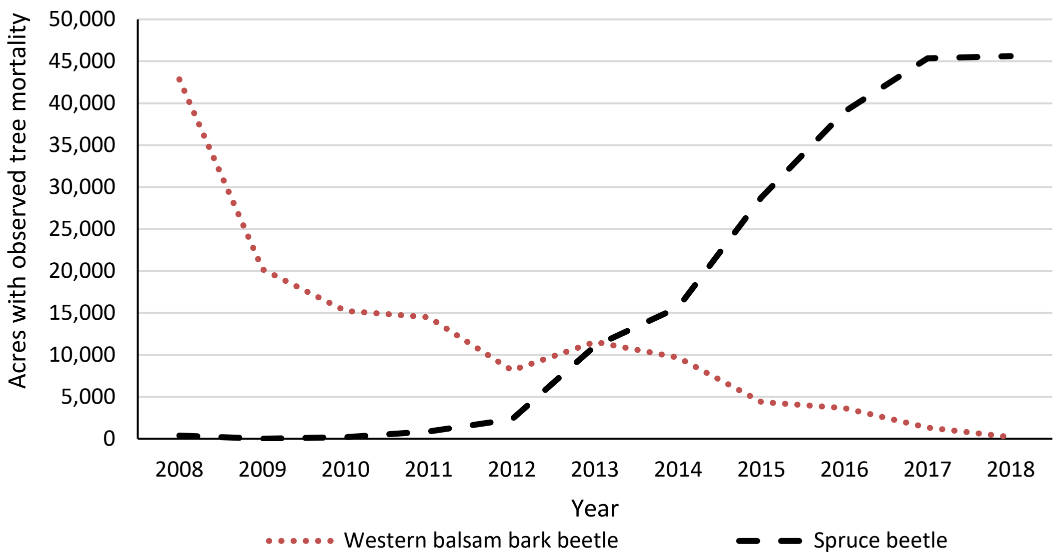

Figure 12: Tree mortality in spruce-fir forests attributed to two species of bark beetles in the Southwestern Region in the last ten years.

Defoliators

In 2018, acres mapped with damage from prominent defoliators declined from 2017. In 2017, aerial surveys mapped 262,340 acres whereas in 2018 only 210,950 acres were mapped. Regionally, with the exception of spruce aphid, acres with defoliation from all agents individually declined.

Pinyon-Juniper Forest Type

Pinyon pine sawfly

Neodiprion edulicolis and *Zadiprion rohweri*
Host: Pinyon pine

No sawfly damage was reported or detected in 2018 on pinyon pines.

Pinyon Needle Scale

Matsucoccus acalyptus
Host: Pinyon pine

Damage from pinyon needle scale declined across the region in 2018. In 2017, 2,670 acres were mapped with defoliation. In 2018, 1,220 acres were mapped. The majority of the defoliation in

2018 was mapped in Arizona (980 acres) and most of this was on the Hualapai Tribal Lands (900 acres) an increase from the 50 acres mapped there in 2017. On the Kaibab NF, pinyon needle scale defoliation was not detected during the 2018 aerial survey compared to 770 acres mapped in 2017. On the Prescott NF in 2017, aerial surveys mapped approximately 70 acres with damage attributed to pinyon needle scale. No acres were mapped on the Prescott NF in 2018 (Table 3). In New Mexico, most of the damage from this insect occurred on state and private lands. Repeated attacks from this insect can cause reduced growth and stunted needles. In severe outbreaks, small trees may be killed. 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 the actual incidence on the landscape.

Ponderosa Pine Forest Type

Pandora Moth

Coloradia pandora
Host: Ponderosa pine

A significant pandora moth outbreak has been occurring in Arizona on the Kaibab Plateau north of the Grand Canyon for the past several years. The visible damage from this insect is caused by feeding during the caterpillar stage. Since this insect has a two-year life cycle, caterpillars are mainly present every other year. In Arizona, the caterpillars are present in odd years. Thus, the adult, non-feeding moth stage, was predominant in 2018. Little feeding occurred and no damage was mapped during aerial surveys. In 2017, 19,690 acres were mapped with defoliation on the North Kaibab RD on the Kaibab NF. While the extent of the pandora moth outbreak increased in 2017, the severity of the defoliation decreased. Since 2010 Arizona FHP has monitored the adults and larval populations via a collaborative project with Northern Arizona University. Although ground surveys in 2018 indicated there was still pandora moth activity, we suspect the population will start to decrease due to the spread of the nucleopolyhedrosis virus, which was observed during larval density collections in 2017. Permanent plots indicated that less than 2% of the ponderosa pine were killed as a result of this outbreak.

Pine Sawflies

Neodiprion spp., Zadiprion spp.
Host: ponderosa pine

In 2018, sawfly damage on ponderosa pine was mapped at 300 acres, with all of the damage occurring in New Mexico. This was a decrease from the 520 acres affected in 2017. In 2018, only 30 acres of sawfly feeding was mapped on the Gila NF (Figure 12). This damage was mapped on the Black Range RD. No feeding was mapped in the Luera Mountains in 2018. In 2017, defoliation of ponderosa pine across 400 acres on the Luera Mountains was observed.

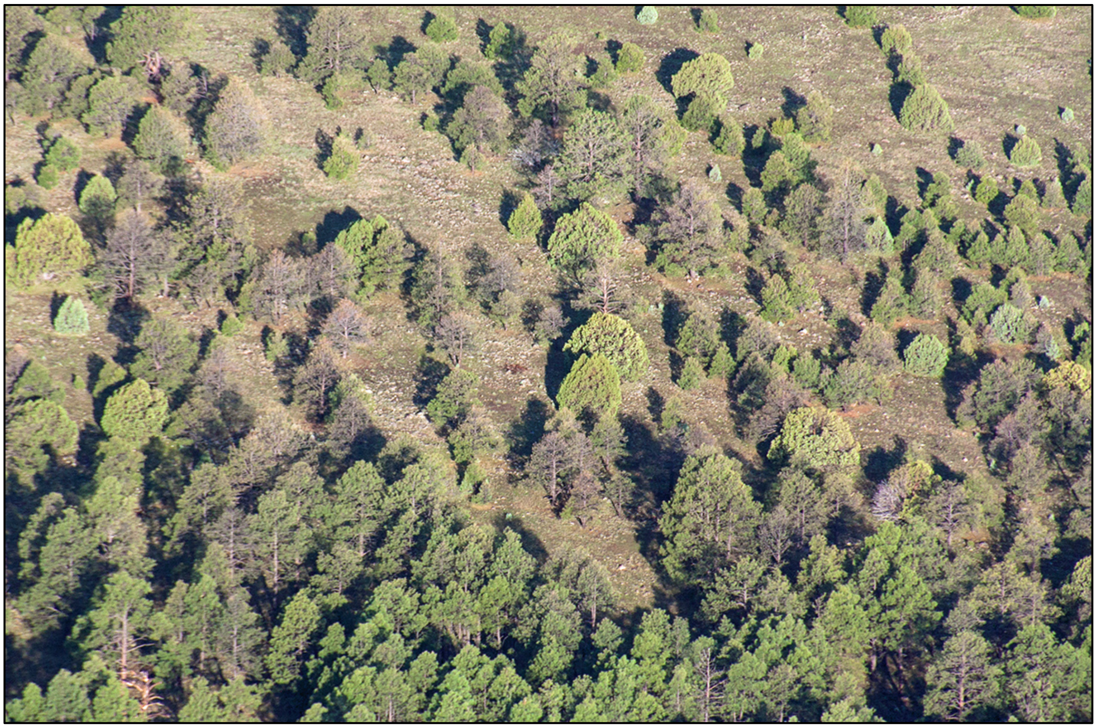

Figure 13: Defoliation of ponderosa pine suspected to be caused by pine sawflies on a small area north of the Gila Wilderness, Gila NF.

Pine needle miner

Coleotechnites ponderosae
Host: ponderosa pine

In New Mexico, on the Carson NF, large areas of discolored ponderosa pine were observed on state and private lands east of the Questa and Camino Real RDs in Colfax County (Figure 13). Over 54,000 acres were mapped with this discoloration in 2018, with much of the damage located on Vermejo Park Ranch. Ground surveys identified the ponderosa pine needle miner as potentially responsible for the discoloration, although the aerial signature had dissipated by the time these ground surveys occurred. Red band needle blight may have been related to cause of the discoloration (See Foliar Pathogens). No acres of pine needle miner were mapped in Arizona.

Figure 14: Ponderosa pine with a yellow cast on the Carson NF.

Mixed Conifer Forest Type

Aspen Defoliation and Mortality

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

In 2018, aspen damage, a combination of defoliation and other biotic and abiotic damage, decreased across the region. In 2017, 50,400 acres were mapped with damage. This acreage dropped to 19,720 acres in 2018. In both years, the majority of the damage was mapped in New Mexico (Table 3). On the Carson NF, aspen damage was mapped on 10,180 acres, a decrease from 18,560 acres mapped in 2017. Most of the defoliation was observed on the west side of the Carson NF, along the western edge of the Tres Piedras RD. Scattered areas of defoliation also continued in 2018 on the east side of the Carson NF. On the Santa Fe NF, aspen damage, primarily from western tent caterpillar, decreased from 4,420 acres in 2017 to 3,160 acres in 2018, and most of the damage occurred on the Espanola and Pecos/Las Vegas RDs.

In Arizona, although little aspen damage was mapped during aerial surveys, ground surveys on the Kaibab and Coconino NFs 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. This insect has been observed for decades, but widespread, severe impacts of aspen in forest settings has only recently been documented. For more on this insect, and other activities in aspen stands in Arizona, see the “Aspen Monitoring Project”, in the “Other Entomology and Pathology Activities” section.

Douglas-fir Tussock Moth

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

Douglas-fir tussock moth activity decreased in Arizona and New Mexico from 3,340 acres with defoliation in 2017 to 2,910 acres in 2018. Arizona had slightly less activity than New Mexico with 1,020 acres mapped. In Arizona, defoliation increased substantially on the Mogollon Rim RD, Coconino NF where a new outbreak was mapped during aerial detection surveys. We observed large patches with top kill and whole tree mortality in mixed-conifer stands in the vicinity of Buck and Dane Ridges (Figure 14). White fir is the main host species being affected. The defoliation that was mapped north of Flagstaff and on the sky islands in southeastern Arizona in 2017 has subsided.

In New Mexico, severe defoliation of white fir from Douglas-fir tussock moth continued on the Sandia Mountains of the Cibola NF in 2018. The outbreak affected roughly the same acreage and footprint as in 2017. This was the third year of the outbreak and the second year of clearly visible defoliation during aerial detection surveys. Severe defoliation (>75%) has occurred in several recreation sites along the Crest Highway. Although 2018 trap catches were high, fall egg mass surveys did not predict outbreaks at all the locations where current defoliation was mapped. A carbaryl spray project was conducted at recreation sites within the area of heavy defoliation to reduce bark beetle attacks on trees weakened by the defoliation. Trap catches on the Carson, Lincoln, and Santa Fe NFs were low.

Figure 15: Defoliation from Douglas-fir tussock moth on the Mogollon Rim RD of the Coconino NF.

Western Spruce Budworm

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

Western spruce budworm activity declined in the region, from 176,640 acres mapped with defoliation in 2017 to 90,710 acres mapped in 2018 (Figure 15). Historically, most of the damage in the Southwestern Region occurs in New Mexico which has a greater proportion of susceptible host type. In 2018, Arizona had minimal activity, with a total of 1,130 acres mapped primarily on national forest lands in northern Arizona (Table 2). On the Kaibab NF, western spruce budworm defoliation decreased from 340 acres mapped in 2017 to 270 acres in 2018. In New Mexico, defoliation by western spruce budworm has been decreasing since it peaked during 2009-2012. The continued drought conditions and dry winter of 2017-2018 may have contributed to the lower level of defoliation observed in 2018. 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. Elevated levels of defoliation have been observed in this area for three decades in both dry and wet mixed conifer forest stands. Douglas-fir, white fir, 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 the continuous defoliation and understory regeneration has been significantly affected in some stands. Notably the severe activity that normally occurs on Mount Taylor of the Cibola NF was nearly absent in 2018 and the lack of activity was confirmed by ground visits.

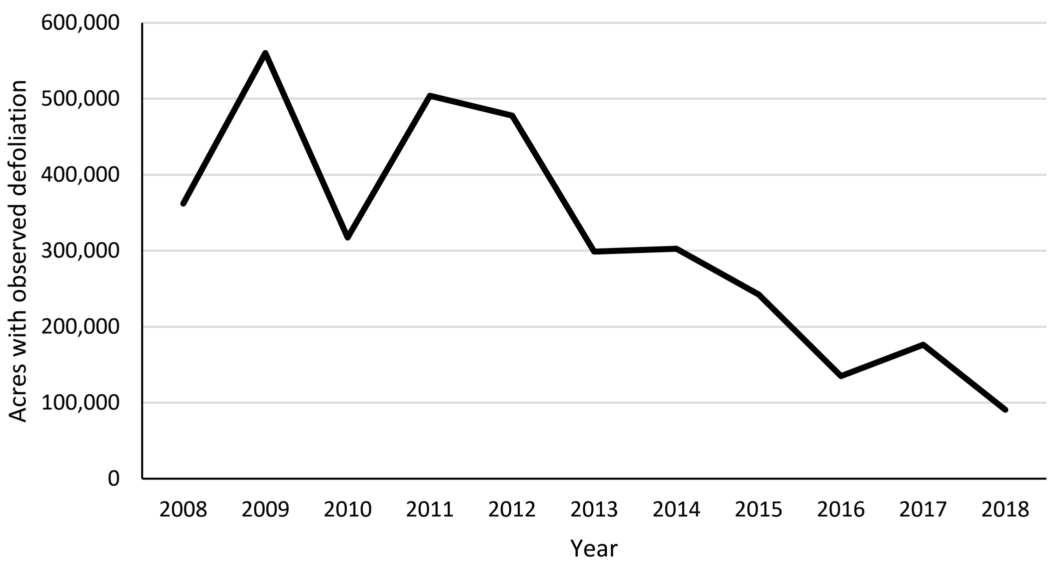

Figure 16: Defoliation attributed to western spruce budworm in the Southwestern Region for the last ten years.

Janet’s Looper

Nepytia janetae
Hosts: Douglas-fir, white fir, occasionally spruce, corkbark fir and white pine

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 mainly defoliates Douglas-fir and white fir, but can be found also causing damage to spruce, corkbark fir, bristlecone pine, and southwestern white pine. Since it is a winter feeder, a special flight was conducted in May of 2018 to determine and map the area affected to avoid confusion with defoliation caused by western spruce budworm. Defoliation was mapped on 10,670 acres along the east side of Hyde Park Rd, in the Santa Fe Watershed extending in the Pecos Wilderness up to the Stewart Lake area, northeast of Elk Mountain, and from Black Mountain north along the ridge to Spring Mountain.

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 Engelmann spruce. Damage from this insect increased substantially across the region in 2018 with damage recorded almost exclusively in Arizona, primarily on the Apache-Sitgreaves NFs and White Mountain Apache Tribal Lands (Table 3). In 2017, 5,700 acres with defoliation were mapped and in 2018, 17,940 acres were mapped (Figure 16). In addition, for the first time, the Arizona Zone also documented the severity and extent of cumulative spruce mortality resulting from the spruce aphid outbreak on Mount Baldy during the regular flights in 2018 (Figure 17).

Of this total area with defoliation, 10,000 acres already have spruce mortality in the 30-50% range. This repeated damage to spruce is causing significant levels of tree mortality.

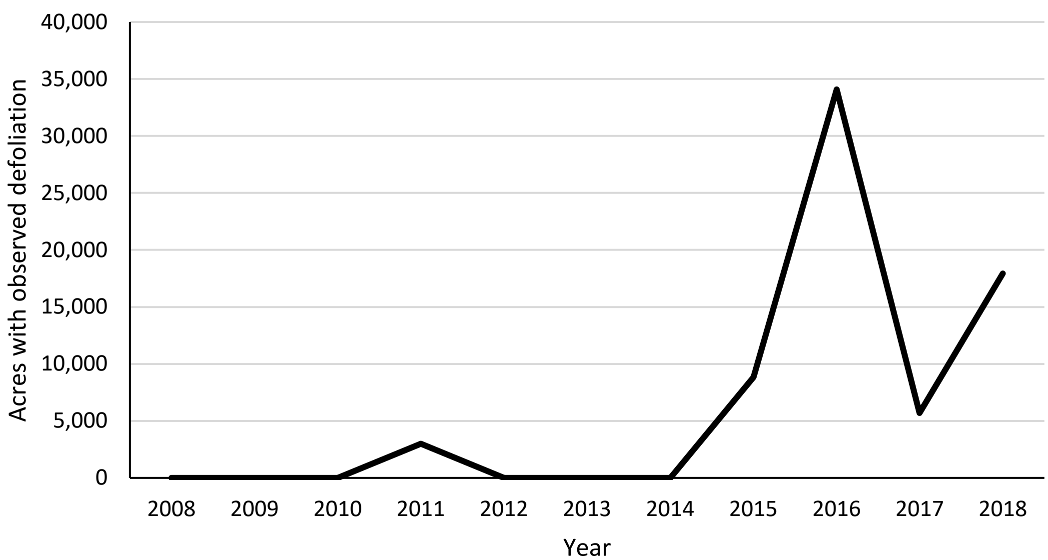

Figure 17: Defoliation attributed to spruce aphid in the Southwestern Region for the last ten years.

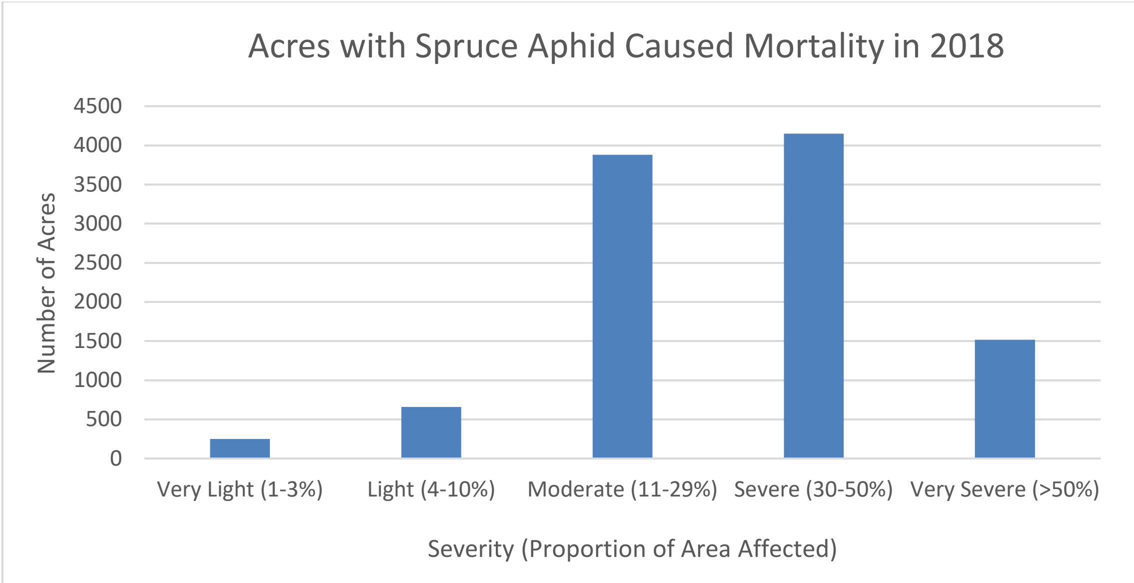

Figure 18: Acres of cumulative spruce mortality by severity class surveyed over Mount Baldy during the 2018 aerial detection surveys.

Status of Major Diseases

Mistletoes

Dwarf Mistletoes

Arceuthobium spp.
Hosts: All conifers

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, 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's range, while the other species have more limited distributions.

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, infecting most riparian hardwood species excluding oaks. Southwestern oak mistletoe (*P. coryae*) is common on oaks in lower elevations (Figure 25) 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.

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 exist in the soil after host trees are removed or killed by fire.

Armillaria Root Disease

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

Armillaria root rot is the most common root disease in the Southwest, where it is estimated to account for up to 80 percent of root disease associated mortality. 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 ostoyae* is the major *Armillaria* species in southwestern coniferous forests, but *A. mellea* has been found in oaks, especially live oaks in southern Arizona. *A. 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 percent of standing live trees. *Armillaria* spp. 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 not common, it 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.

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 tomentosus* is found on spruce and Douglas-fir. Black stain root disease, caused by *Leptographium wageneri,* appears to be rare in the Southwest. 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. We are also assessing damage caused by this disease through a network of semi-permanent plots located in Arizona and New Mexico.

Stem Decays

Stem decays are common in older trees throughout the region. Decay represents an economic loss in terms of timber production and can increase hazard on developed sites, but decayed trees also provide important cavity habitat for many wildlife species, especially birds. The most common stem decays in the Southwest include the red belt fungus, *Fomitopsis pinicola,* on various conifers and aspen; 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; 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

Cronartium ribicola
Hosts: Southwestern white pine, limber pine, Rocky Mountain bristlecone pine, *Ribes* spp., *Castillija* spp., and *Pedicularis* spp.

White pine blister rust (WPBR) 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. 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. WPBR also occurs on the Gila, Cibola, and Santa Fe NFs of New Mexico. The Apache-Sitgreaves NFs and White Mountain Apache Tribal Lands are currently the only land management units affected in Arizona. 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 infected areas. Though Rocky Mountain bristlecone pine is susceptible, WPBR has not yet affected stands within the region.

In Arizona, WPBR was first detected in 2009 on White Mountain Apache Tribal Lands and neighboring Apache-Sitgreaves NFs. 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. Southwestern white pine cones and seeds have been collected from 2012 through 2016 for gene conservation and white pine blister rust resistance programs implemented at the Dorena Genetic Resource Center (DGRC) in Oregon. Scions from trees identified by the DGRC as resistant to WPBR are being collected and grafted into a seed orchard in Mora, NM. More info can be found in "Other Entomology and Pathology Activities in 2018" under "White Pine Blister Rust Genetic Resistance".

Broom Rusts

Melampsorella caryophyllacearum
Hosts: True fir and chickweed

Chrysomyxa arctostaphyli
Hosts: Spruce and bearberry or kinnikinnick

There are two species of broom rust that occur at relatively low levels on their respective hosts in the Southwest. 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*
Hosts: Ponderosa pine

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. A white-spore race of western gall rust infects ponderosa pine in the Southwestern Region. Unlike the traditionally orange spores of *E. harknessii,* this race produces white-spore pustules on spindle-shaped galls that form on branches and main stems of infected trees. 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 the 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 (barber poll) canker, caused by *Encoelia pruinosa,* is the most lethal canker of aspen while *Cytospera chrysosperma*, a weaker secondary pathogen, 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.

Biscogniauxia atropunctatta, commonly referred to as hypoxylon canker of oak, was observed for the first time affecting Emory oaks in southeastern Arizona on the Coronado NF. It was associated with large pockets of new mortality and decline and was commonly associated with trees impacted by gold-spotted oak borer. This canker disease is associated with drought stressed trees. The impacts observed are likely due to the lack of precipitation received through the winter and spring of 2018.

Foliar Diseases

Foliar diseases in the Southwest may occur in both hardwoods and conifers (needle casts). 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. 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 New Mexico, over 54,000 acres with ponderosa pine crown discoloration was mapped during aerial surveys on the eastern slopes of the Sangre de Cristo Mountains on Carson NF and surrounding private lands. Although, as previously mentioned, initial ground surveys primarily found needle miner damage, it appeared that significant needle loss had occurred since aerial surveys identified the discoloration. Ground surveys the following spring did identify red band needle blight (*Dothistroma septosporum*) in the area with morphological identification of fruiting bodies and conidia from nearby pinyon pine and widespread symptoms on ponderosa pine with no new evidence of needle miner. A small outbreak of another foliar disease was noted in a spruce stand during aerial detection surveys on the Lincoln NF, where Rhizosphaera needle cast caused by *Rhizosphaera kalkhoffii* was found to be defoliating Engelmann spruce on about 50 acres in the Capitan Mountains. The pathogen was identified morphologically based on asexual fruiting bodies and conidia found associated with affected needle stomata. *Rhizosphaera kalkhoffii* infections have been associated with drought stress, which was likely a factor in the disease development due to exceedingly dry conditions throughout the spring of 2018. There was a significant precipitation event in the area in late spring 2017, which could have facilitated initial infection by the pathogen; shedding of infected needles typically occurs 12-15 months after initial infection. Septoria leaf spot of cottonwood was also detected and identified morphologically during ground surveys in riparian forests along the Rio Grande.

In Arizona, acres observed with needle cast damage due to *Dothistroma septosporum,* decreased from 300 acres in 2017 to 0 acres in 2018. Though zero acres were observed via ADS, it is important to note that these diseases are always present at some level on the landscape. White pine needle cast (*Lophodermella arcuata*) was observed impacting southwestern white pine on the San Francisco Peaks and was 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.

Abiotic Damage

Salt

De-icing salt use has contributed to increasing ponderosa pine mortality along state highways over the last decade, especially in central Arizona. The greatest tree decline and mortality occurred along Highway 260 near Forest Lakes; Highway 87 near Clint's Well; Interstate 40 from Flagstaff to Williams; Interstate 17 south of Flagstaff; and Highways 180 and 89A near Flagstaff. De-icing salt 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, during a ground visit to the Laguna Pueblo,near the Cibola NF to confirm defoliation detected during aerial surveys, it was discovered that the defoliation was due to significant hail damage to pinyon pine and ponderosa pine across 640 acres.

Drought

In addition to the elevated levels of tree mortality in pine and juniper species that were observed in 2018, drought had several other impacts on forest health in our region. Chlorotic crowns were detected across the Hualapai Tribal Lands and are likely a result of the drought stress. Approximately 5,800 acres of drought stress was mapped northeast of the Tower of Babylon. Aerial surveyors in 2018 also noted that many of the evergreen oaks located at the base of the southern aspect of the Huachuca Mountains had brown foliage. The damage was estimated to be about 4,000 acres and stretched from Copper Canyon to Merritt Canyon. Ground surveys in the late fall found that while some of the browning was likely due to strictly to drought stress, some of the oaks were also infected with hypoxylon and gold spotted oak borer (GSOB) was also present, likely contributing to some of the mortality. Both of these agents are thought to exploit drought stressed or otherwise weakened trees.

Invasive Species

Invasive species and diseases are increasingly becoming 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 pine, limber pine, Rocky Mountain bristlecone pine
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
	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 19: Buffelgrass (USDI National Park Service photo).

Buffelgrass (*Cenchrus ciliaris*) is the single greatest invasive threat to the Sonoran Desert in the Southwestern Region (Figure 18). The bunchgrass was originally introduced from Africa into the southwestern U.S. as a forage grass, which 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 Southern Arizona Resilient Landscape Collaborative is a project funded by the U.S. Department of the Interior to manage buffelgrass. The project is intended to facilitate coordination by local Federal agencies, State agencies, and private organizations across agency boundaries in the fight against buffelgrass.

Yellow Bluestem

Figure 20: 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 19). 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 alters 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 not currently listed on State noxious weed lists for either Arizona or New Mexico; however, listing of the species on Arizona's noxious weed list is pending. Yellow bluestem is practically impossible to eradicate once established. Control progressively becomes 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 20). 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 21: 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 (CWMAs) and Soil and Water Conservation Districts (SWCDs). Other organizations such as non-governmental organizations (NGOs) 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 John Richardson (602-771-1420) 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 (LSR) 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 (IWM) 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 2018

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 2018, the regional insect and disease training was held in Flagstaff, Arizona at the Gus Pearson Historical Work Station. Field trips were conducted on the Coconino NF. Annually, the location of the training alternates between Arizona and New Mexico. *For more information, contact Nicholas Wilhelmi.*

Beetles and Bundles

The Four Forests Restoration Initiative (4FRI), is a collaborative, landscape level, thinning project occurring across four national forests in northern Arizona. Industry in the region has struggled with the economics of utilizing small diameter ponderosa. Industry had requested that the trees be cut and piled for 30-60 days with limbs and foliage attached before additional handling and transport. The whole-tree “bundling” process was believed to increase the rate of moisture loss in harvested stems through a process known as transpirational drying, thus reducing hauling costs by reducing weight (Figure 21). FHP, in conjunction with Northern Arizona University, designed a project to assess the effect of leaving limbs attached versus removing them on 1) tree drying rates and 2) insect attacks (Figure 4). The project started in July of 2017 and will continue through spring of 2019. Results thus far indicate that leaving limbs on trees increases the number of bark beetle attacks and does not impact tree drying rates. *For more information, contact Monica Gaylord.*

Figure 22: Crew taking measurements on bundle near Flagstaff, AZ.

Dwarf Mistletoe Plot Re-Measure

The Pest Trend Impact Plot System focused on southwestern dwarf mistletoe was established in 1991 and has been re-measured on around a 10-year interval. The fourth re-measure of the plot network was initiated in 2017 in Arizona and continued through 2018. Data collection will likely be completed in 2019. This long-term plot system was established to assess the rate of spread, as well as impacts on growth and survival of ponderosa pine infected by this pathogen. Data are collected on status (live or dead), level of infection, height, diameter, presence of regeneration, and presence of other pathogens which may impact the health of the tree. These data will help to better inform models which predict the behavior of mistletoe infected stands and aid in forest management decisions. *For more information, contact Nicholas Wilhelmi.*

Dwarf Mistletoe Roadside Surveys

Southwestern dwarf mistletoe roadside surveys continued in New Mexico in 2018 after having been conducted on the Cibola, Gila, and Santa Fe NFs during the summer of 2017. Additional areas on these forests as well as on the Carson and Lincoln NFs were surveyed in 2018, and over 230 miles have now been covered over the course of the two-year project. For every 0.1-mile increment of roadway, relative incidence of southwestern dwarf mistletoe in ponderosa pine was assessed to a depth of one chain (66 ft) into the forest on a 0-3 scale, with 0 representing no mistletoe observed, 1 representing less than 33% incidence, 2 representing 33-66% incidence, and 3 representing over 66% incidence. Similar surveys were previously conducted in the 1950s and 1980s with this assessment representing a 30-year remeasure of dwarf mistletoe incidence along these roadways. Lightly, moderately and severely infected areas have increased on several forests as infections have spread into new areas or intensified in previously infected areas. Variable-radius prism plots were established in a subset of areas representing all incidence levels in 2018, and the roadside survey technique was found to be highly accurate with no mistletoe found in 0-rated plots (0.0 DMR), 11% incidence found in 1-rated plots (0.2 DMR), 49% incidence in 2-rated plots (1.3 DMR), and 71% incidence found in 3-rated plots (2.3 DMR). Overall, some level of infection was found in 33.6% of the area assessed, which is consistent with historical records. Georeferenced maps were developed and have been provided to National Forest staff to help select potential future treatment areas. This work was presented at the 2018 International Congress of Plant Pathology meeting in Boston, MA. *For more information, contact Greg Reynolds.*

Aspen Monitoring Project

Aspen decline has been occurring in the western United States for the latter half of the twentieth century. Drought is hypothesized to be the main driver of this decline though ungulate browse, conifer encroachment, fire suppression, as well as insects and diseases play a contributing roll. Although aspen has shown recovery in much of the western United States, accelerated decline, dieback, and mortality continues to occur in northern Arizona. FHP has been monitoring changes in aspen forests since the early 2000s, documenting over-story mortality, impacts from insects and diseases and ungulate browse impacts on regeneration. At the request of the Coconino and Kaibab NFs, FHP mapped the location of aspen stands on both Forests using aerial detection techniques. These data provide valuable information on aspen abundance, distribution and level of conifer encroachment. In addition, monitoring plot networks have been installed on the Flagstaff (2008) and Mogollon Rim (2017) RDs of the Coconino NF and the Williams RD (2012) of the Kaibab NF. A ten-year re-measure was completed in 2018 on Flagstaff RD. Results show extensive over-story mortality and high browse pressure inhibiting successful regeneration. This has led to an abundance of over-mature even aged aspen stands, susceptible to insects, diseases and abiotic stressors.

In addition to extensive over-story mortality and lack of sustainable regeneration, oystershell scale (OSS), an invasive and emergent pest, further threatens aspen resilience in northern Arizona. This is the first report of OSS contributing to over-story and regeneration mortality in wildland aspen stands in Arizona. Aspen mortality associated with severe OSS is occurring in natural stands and within ungulate exclosures on the Flagstaff, Mogollon and Williams RDs. The Coconino and Kaibab NFs surveyed 100% of their aspen exclosures on the Flagstaff and Williams RDs for the presence of OSS in 2018. These Districts also initiated monitoring projects in 2018 to evaluate the effectiveness of different silvicultural treatments on reducing levels of OSS within infected exclosures. These projects were funded by FHP 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 trees. Additional plots were installed throughout the Cibola, Carson, and Santa Fe NFs in New Mexico in 2018. *For more information, contact Nicholas Wilhelmi or Amanda Grady.*

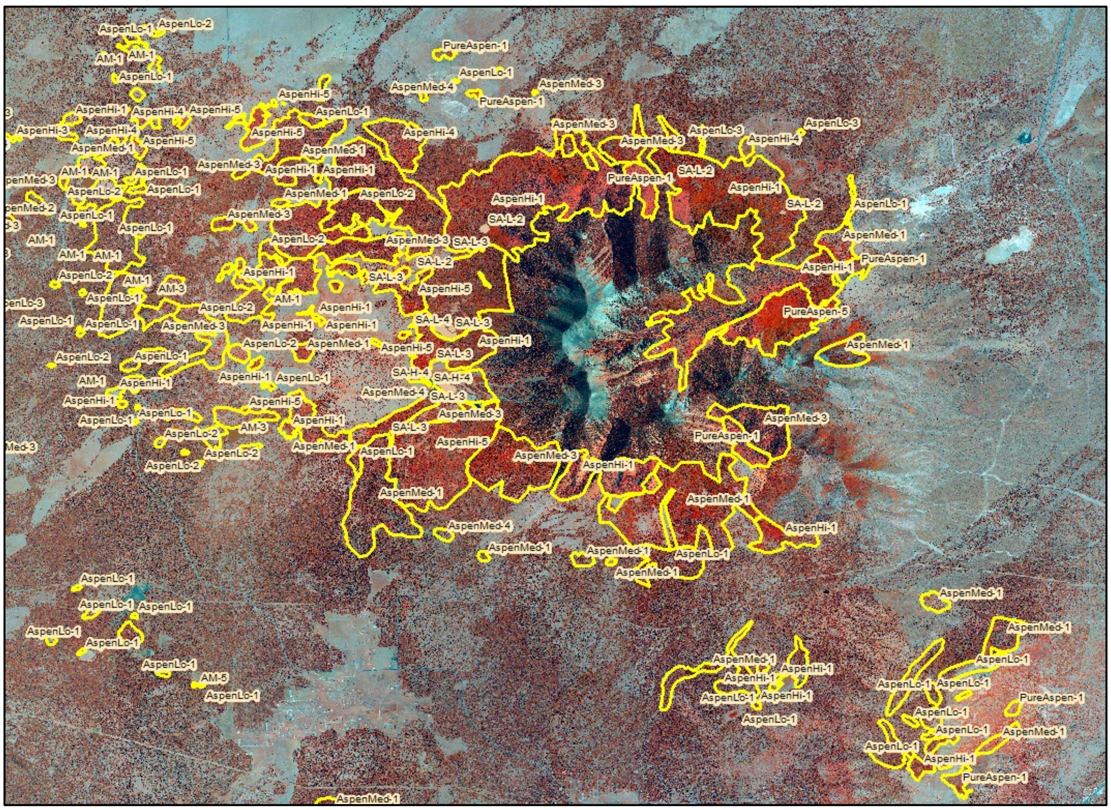

Figure 23: Aspen stands mapped by aerial surveys across the San Francisco Peaks.

White Pine Blister Rust Genetic Resistance

In 2018, 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, and others. In 2018, site preparation for the second of two long-term southwestern white pine test sites was initiated. 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. The first planting experienced over 30% mortality in the 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 2019 or in future years. Removal of hazard trees and construction of fencing for the second test site, which is located on the Apache–Sitgreaves NFs, occurred in 2018. This site will eventually include 40 seedlings per family from 25 families with varying levels of disease resistance or susceptibility. Additional fence construction and hazard tree removal will occur in 2019. In addition, FHP collected scion from five parent trees throughout the region which have shown some level of resistance to white pine blister rust (major gene resistance or quantitative resistance). This scion material will be grafted into a seed orchard in Mora, NM and used to provide disease resistant seed for future reforestation efforts. *For more information, contact Greg Reynolds or Nicholas Wilhelmi.*

Beetle Suppression Projects after Wildfires

Wallow Fire, Apache-Sitgreaves NFs

In 2011, the Wallow Fire burned over 500,000 acres, mainly on the Alpine and Springerville RDs of the Apache-Sitgreaves NFs. Immediately after the fire, FHP began conducting various suppression projects for Douglas-fir and mountain pine beetle within the fire perimeter. These have included using aggregation pheromones for monitoring and trap-outs, anti-aggregation pheromones in select high-value areas, removal of infested trees, and ground surveys in specific areas. In 2018, all anti-aggregation pheromone treatments were stopped, but removal of infested trees and the use of pheromone traps to monitor spruce and Douglas-fir beetle populations continued. Monitoring of spruce beetles was started in 2017 due to concerns that beetle populations might be increasing as a result of widespread defoliation of Engelmann spruce from spruce aphid. Trap catches of spruce beetle were down in 2018 at 14 beetles/trap/day from 60 beetles/trap/day in 2017 during peak flight and acres recorded with mortality from spruce beetle on the Apache-Sitgreaves NFs decreased from 10 acres recorded in 2017 to zero acres recorded in 2018. Consistent with the decline in acres with mortality mapped by ADS, Douglas-fir beetle trap catches at 74 beetles/trap/day in 2018, were down from the 212 beetles/trap/day recorded in 2017, and well down from the highs we recorded in 2015 (814 beetles/trap/day). *For more information, contact Monica Gaylord.*

Frye Fire, Coronado NF

The Frye Fire was started by lightening on June 7, 2017 and burned close to 48,500 acres on Mt. Graham in the Pinaleño Mountains on the 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 Douglas-fir trees in crucial areas of the remaining squirrel habitat. In addition, after fall site visits noted mountain pine beetle attacking fire-injured southwestern white pines (SWWP), verbenone was also included in the project. Both pheromones were deployed across ~500 acres of critical squirrel habitat. The verbenone was deployed as single tree protection on SWWP greater than 18 inches DBH while the MCH was deployed in a grid pattern (Figure 19). Surveys in August of 2018

Figure 24: ACE crews practicing spacing for deploying MCH in a grid on Mt. Graham, AZ 2018.

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 ongoing drought conditions. We plan to continue pheromone protection in 2019. *For more information, contact Monica Gaylord.*

Forest Pest Proximity Analysis

In the fall of 2017, the Four Forests Restoration Initiative (4FRI) team requested that FHP assist with the monitoring of the landscape scale restoration efforts associated with 4FRI. In 2018, a model was developed by Arizona Zone-FHP and the Geographic Information Systems (GIS) TEAMS to efficiently monitor management actions associated with 4FRI management activity and possible correlations to bark beetle related tree mortality. The model utilizes the Geospatial Interface (GI) of GIS to access the FACTS national database. The model looks at management activity that has taken place over the past two years and recent bark beetle associated tree mortality detected by aerial detection surveys. If tree mortality (> 1 acre) has been mapped in the same area as the management activity then a table of management locations is created. These locations are then ground checked by FHP staff or Forest Service staff near the area of interest to confirm or deny that the bark beetle activity is associated with the management activity. It is known that bark beetle, especially *Ips,* populations can grow significantly from slash piles and other debris piles associated with timber management. Once populations increase, beetles can then start attacking the live standing trees near the slash piles. This unexpected mortality can be in conflict with management goals and may warrant bark beetle suppression efforts. In 2018, the model detected two locations with increased bark beetle activity which were confirmed to be associated with slash piles created during the restoration effort. *For more information, contact Daniel DePinte.*

Biological Evaluations and Technical Assistance

Arizona Zone

DePinte, D. 2018. Apache-Sitgreaves National Forests. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Camp Navajo. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Canyon de Chelly National Monument. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Chiricahua National Monument. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Coconino National Forest. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Coronado National Forest. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Flagstaff Area National Monuments. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Fort Huachuca. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Grand Canyon National Park. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Hopi Tribal Lands. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Hualapai Tribal Lands. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Kaibab National Forest. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Prescott National Forest. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Saguaro National Park. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. San Carlos Apache Tribal Lands. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. Tonto National Forest. 2018 Insect and Disease Aerial Survey Results.

DePinte, D. 2018. White Mountain Apache Tribal Lands. 2018 Insect and Disease Aerial Survey Results.

Gaylord, ML. 2018. Evaluation of Bark Beetle Activity on the Mogollon Rim Ranger District, Coconino National Forest. AZ-FHP-18-9.

Gaylord, M.L. 2018. Evaluation of Bark Beetle Activity and Impacts within the Wallow Fire. 2018. Alpine and Springerville Ranger Districts, Apache-Sitgreaves NFs. AZ-FHP-19-1.

Gaylord, M.L. 2018. Evaluation of Bark Beetle Activity and Impacts within the Frye Fire. 2018. Safford Ranger District, Coronado NF. AZ-FHP-19-2.

Gaylord, ML. 2018. Biological Evaluation for Proposed Oky Flat Thinning Project. Black Mesa Ranger District, Apache-Sitgreaves NFs. AZ-FHP-19-4.

Grady, A. 2018. Gypsy moth monitoring results for Arizona in 2017. Letter to Animal Plant Health Inspection Service.

Grady, A. 2018. Request for 2018 assistance with gypsy moth monitoring in Arizona. Letter to Forest Supervisors.

Grady, A. 2018. Request assistance with Douglas-fir tussock moth monitoring in Arizona. Letter to Forest Silviculturists.

Grady, A. 2018. Heart Prairie Preserve Site Visit to Assess Aspen Health Nature Conservancy, Flagstaff, AZ AZ-FHP-18-7.

Grady, A., Wilhelmi N. 2018. Biological Evaluation for Anita Thompson's Silviculture Certification Stand, Lakeside Ranger District, Apache-Sitgreaves NFs. AZ-FHP-18-8.

Wilhelmi, N., Reynolds, G. 2018. Nursery Monitoring Guidelines for Southwestern White Pine Seedlings and White Pine Blister Rust Prevention Strategies. AZ-FHP-18-6.

Wilhelmi, N., Gaylord, M.L. 2018. Biological Evaluation of Oak Mortality on the Sierra Vista Ranger District, Coronado National Forest and Fort Huachuca. AZ-FHP-19-3.

New Mexico Zone

Coleman, T.W., Graves A.D., Tischler, C., and D. Ryerson. 2018. Looper Outbreak on the Santa Fe National Forest. Biological Evaluation NM-FHP-04-18.

Graves, A.D. 2018. Winter Defoliation Forest Health Assessment. Biological Evaluation. NM-02-18.

Graves, A.D. and Reynolds, G. 2018. Midnight Meadows Forest Health Assessment. Biological Evaluation. NM-FHP-1-18.

Reynolds, G. 2018. Evaluation of FY2018 and FY2019 Forest Health Suppression projects on the Jicarilla Apache Reservation. Biological Evaluation. NM-FHP-11-18.

Reynolds, G. 2018. Forest health and hazard tree issues at Guadalupe Mountains National Park cultural sites. Biological Evaluation. NM-FHP-10-18.

Reynolds, G. 2018. Evaluation of FY2019 Forest Health Suppression project on the Mescalero Apache Reservation. Biological Evaluation. NM-FHP-9-18.

Reynolds, G. 2018. Hazard tree issues in the History Grove and around historic cabins in Valles Caldera National Preserve. Biological Evaluation. NM-FHP-7-18.

Reynolds, G. 2018. Evaluation of FY2019 Forest Health Suppression Project on the Santa Clara Pueblo. Biological Evaluation. NM-FHP-6-18.

Ryerson, D and Tischler, C. 2018. BLM Lands in New Mexico. 2018 Insect and Disease Survey Results.

Ryerson, D and Tischler, C. 2018. Carson National Forest. 2018 Insect and Disease Survey Results.

Ryerson, D and Tischler, C. 2018. Central New Mexico Tribal Lands. 2018 Insect and Disease Survey Results.

Ryerson, D and Tischler, C. 2018. Cibola National Forest. 2018 Insect and Disease Survey Results.

Ryerson, D and Tischler, C. 2018. Gila National Forest. 2018 Insect and Disease Survey Results.

Ryerson, D and Tischler, C. 2018. Lincoln National Forest. 2018 Insect and Disease Survey Results.

Ryerson, D and Tischler, C. 2018. Mescalero Apache Tribal Lands. 2018 Insect and Disease Survey Results.

Ryerson, D and Tischler, C. 2018. Northern New Mexico Tribal Lands. 2018 Insect and Disease Survey Results.

Ryerson, D and Tischler, C. 2018. National Park Lands in the Jemez Mountains. 2018 Insect and Disease Survey Results.

Ryerson, D and Tischler, C. 2018. Santa Fe National Forest. 2018 Insect and Disease Survey Results.

Publications

Peer Reviewed

Coleman, T.W., **Graves, A.D.**, Heath, Z., Flowers, R.W., Hanavan, R.P., Cluck, D.R., and Ryerson, D. 2018. Accuracy of aerial detection surveys for mapping insect and disease disturbances in the United States. Forest Ecology and Management. 430:321-336.

Gazis, R., Poplawski, L., Klingeman, W., Boggess, S.L., Trigiano, R.N., **Graves, A.D.**, Seybold, S.J. and Hadziabdic, D., 2018. Mycobiota associated with insect galleries in walnut with thousand cankers disease reveals a potential natural enemy against *Geosmithia morbida*. Fungal Biology.122: 241-253.

Swett, C.L., **Reynolds, G.J.**, and Gordon, T.R. 2018. Infection without wounding and symptomless shoot colonization of *Pinus radiata* by *Fusarium circinatum*, the cause of pitch canker. Forest Pathology. 48:e12422. DOI: 10.1111/efp.12422

Abstracts

Gazis, R.O. Everhart, S.E., **Graves, A.**, Kamvar, Z.N., Trigiano, R.N., Seybold, S.J., and Hadziabdic, D. 2018. When natives become invasive: Population genetic signatures following range expansion in members of thousand cankers disease complex. Phytopathology 108:S1.91. DOI: 10.1094/PHYTO-108-10-S1.1

Reynolds, G.J. 2018. Mapping the distribution and incidence of southwestern dwarf mistletoe on ponderosa pine in New Mexico National Forests using roadside surveys. Phytopathology 108:S1.85. DOI: 10.1094/PHYTO-108-10-S1.1

Forest Health Staff

Arizona Zone

John Anhold (928) 556-2073

John is the supervisory entomologist/Arizona Zone leader. Duties include: supervisory and managerial duties for Arizona Zone staff, oversight of Arizona Cooperative Forest Health program of the State Forester's office, Regional representative for the National Forest Health Monitoring program. He has interest in western bark beetle technology development and transfer. John's previous work experience is in Region 4, working with bark beetles and coordinator for the Utah gypsy moth eradication project, and in the Northeast Area, working with state cooperators regarding defoliator issues.

Daniel DePinte (928) 556-2071

Daniel has been a forest health specialist for Forest Health and Protection - 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 Gaylord became a forest entomologist with the Arizona Zone in 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 became a forest entomologist with the Arizona Zone in October 2011 from Forest Health Protection, 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 focus: white pine blister rust resistance in southwestern white pine; dwarf mistletoe management and distribution; aspen monitoring.

New Mexico Zone

Tom W. Coleman (505) 842-3286

Tom is the Supervisory Entomologist for the New Mexico Zone since January 2016. His primary responsibilities are managing the New Mexico Zone and providing administrative oversight for the New Mexico Cooperative Forest Health Program. Tom is interested in disturbance ecology, specifically the impact of bark beetles, fire, and exotic insects on forest composition and forest management.

Andrew Graves (505) 842-3287

Andrew has been a forest entomologist, New Mexico Zone since October 2010. Primary responsibility is providing technical assistance on forest insects to federal land managers throughout the state. 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.

Greg Reynolds (505) 842-3288

Greg has been a plant pathologist with the New Mexico Zone since January 2017. His primary responsibility is providing technical assistance on forest disease management to National Forests and Tribal Lands as well as managing the hazard tree program for the region. His current focus is on mapping dwarf mistletoe incidence on national forest lands throughout the state and preserving genetic resistance to white pine blister rust in southwestern white pine.

Daniel Ryerson (505) 842-3285

Daniel has been a forest health and GIS specialist, 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, New Mexico Zone, and Forest Health unit aviation officer. She arrived in the region in September 2008. Responsibilities include aerial detection surveys, aviation safety and training coordination, and field assistance to staff. She is involved with educational outreach and implementation. Crystal is ICS-qualified as a Wildfire Incident GIS Specialist. Her previous work experience is in forest management, fuels reduction, timber sale administration and community wildfire protection planning. Crystal is currently working to obtain a Silviculture certification.

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 needlecast	*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*
Oyster shell 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 needlecast	*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 and may not match field guide

Visit Us Online

In an effort to better serve the Internet user, we continue 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.