United States Department of Agriculture

Forest Insect and Disease Conditions in the Southwestern Region, 2017

Forest Service | Southwestern Region | Forest Health PR-R3-16-17 | June 2018

Cover Photo: Recent and older white fir mortality (top picture) associated with Heterobasidion root disease (middle left picture: resin staining in the wood of infected root, bottom left picture: fruiting body of *Heterobasidion occidentale*) and subsequent attack from fir engraver bark beetle (bottom right picture).

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Conditions in Brief

2017 Weather Summary for the Southwestern U.S.

The Southwestern Region (Arizona and New Mexico) experienced its warmest year on record and recorded below-average precipitation during 2017. In the early part of the year, Arizona measured more than normal snow pack totals. However, drier conditions and much-warmer-than-average conditions were experienced during the spring in both states. Warmer than average conditions persisted during the summer in the Southwest. Dryness (warm temperatures and below-average precipitation) returned to the region during the latter part of the year (September to November) especially in Arizona, where record warm temperatures were reported (Source: NOAA National Centers for Environmental Information, State of the Climate: National Climate Report for Annual 2017, published online January 2018, retrieved on January 17, 2018 from https://www.ncdc.noaa.gov/sotc/national/201713). These dry conditions likely led to increased bark beetle activity in ponderosa pine on the southern edge of the Gila National Forest. If these dry conditions persist throughout the 2017/2018 winter season, elevated tree mortality from bark beetles is likely in 2018 throughout the region.

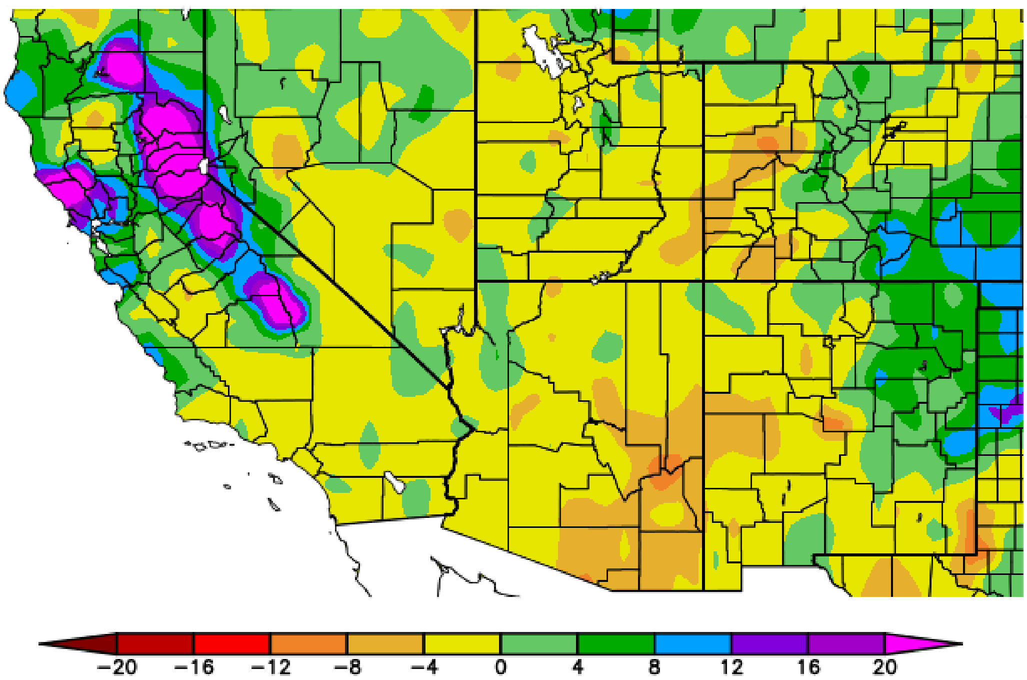

Figure 1. Departure from normal precipitation (inches) recorded from 2017 in the Southwestern U.S. Most of southeastern Arizona and the central western region of New Mexico experienced moderate drought conditions in 2017 (Source: High Plains Regional Climate Center, www.hprcc.unl.edu/).

Regional Forest Insect and Disease Summary

In 2017, aerial detection surveys covered approximately 21,783,800 acres in the Southwestern Region. Slightly more forested lands (11,751,400 acres) were flown than pinyon-juniper woodlands (10,032,000 acres) in the region (Table 1). Aerial surveys primarily covered national forest land followed by tribal, state and private, and other federal lands (Table 1, Figure 2). Special aerial detection surveys were conducted to assess the state of aspen on the Coconino and Kaibab National Forests; defoliation from a pandora moth outbreak on the Kaibab National Forest; spruce aphid injury on the White Mountain Apache Tribal Lands and Apache-Sitgreaves National Forests; and to test aerial detection survey protocols on the Cibola National Forest.

Table 1. Aerial detection survey acres flown in 2017 in the Southwestern Region.*

Land ownership	State	Forested	Pinyon-Juniper	Total
National Forest Lands	AZ	3,387,200	2,134,900	5,522,000
Bureau of Land Management	AZ	10,900	127,600	138,500
Department of Defense	AZ	37,500	9,000	46,500
National Park Service	AZ	134,400	130,800	265,200
Tribal	AZ	1,132,800	2,021,200	3,154,100
State and Private	AZ	202,800	302,200	505,000
Arizona Total		**4,724,000**	**6,860,000**	**11,584,500**
National Forest Lands	NM	4,228,200	1,908,300	6,136,500
Bureau of Land Management	NM	33,500	123,700	157,200
Department of Defense	NM	1,400	500	1,900
National Park Service	NM	86,500	10,800	97,300
Tribal	NM	794,600	370,500	1,165,200
State and Private	NM	1,882,600	757,900	2,640,600
New Mexico Total		**7,027,400**	**3,172,000**	**10,199,300**

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

Total tree mortality attributed to bark beetles was mapped on almost 131,000 acres (Table 2), a decrease from 202,690 acres in 2016. Bark beetle activity in ponderosa pine stands since 2013 remains fairly low for the region (Appx. 1.A). Ponderosa pine mortality accounted for most of the bark beetle activity in the region with the majority of the 56,800 acres mapped in Arizona on the Apache-Sitgreaves and Coconino National Forests (Tables 2 and 4). Bark beetle activity decreased in ponderosa pine and mixed conifer forests throughout the Region (Table 2, Appx. 1.A, B). Pinyon ips, western balsam bark, and cedar bark beetles continued to occur at low levels (< 2,000 acres) across the region (Table 2, Appx. 1.C). Spruce beetle-caused tree mortality accounted for the majority of bark beetle affected acres in New Mexico, an increase of approximately 6,000 acres from 2016 and a continued increase of tree mortality from 2012 (Tables 2 and 4, Appx. 1.D). Surveyors mapped the majority of spruce beetle-caused tree mortality on the Carson and Santa Fe National Forests and adjacent state and private land. Tree mortality associated with fir engraver continued to decline from the mortality mapped in 2013 (Table 2).

Defoliation continues to be the largest disturbance event from insects and diseases with 265,200 acres mapped across the region (Tables 3 and 4), remaining fairly consistent from 2016 defoliation levels. Western spruce budworm and various insects on aspen were the primary defoliators in New Mexico (Tables 3 and 4, Appx. 1.E), whereas dramatic pandora moth and spruce aphid feeding contributed the most to defoliation acres in Arizona. Western spruce budworm defoliation increased 30% from 2016 to 2017 (Tables 3 and 4). The majority of defoliation was mapped on the Carson and Santa Fe National Forests and state and private land. Defoliation from spruce aphid decreased 83% in Arizona, but the exotic insect continued to injure trees across > 5,000 acres (Table 3, Appx. 1: F). Ground surveys have found significant impacts to overstory and understory trees, and limited spruce beetle activity in the injured stands. Pandora moth caterpillars defoliated ponderosa pine trees across almost 20,000 acres in 2017 on the Kaibab National Forest. No defoliation was reported in 2016 due to the two-year life cycle of the insect. Douglas-fir tussock moth populations reached outbreak status on the Cibola National Forest, affecting over 1,700 acres (Table 3). A Douglas-fir tussock moth outbreak on the Santa Fe National Forest collapsed in 2017 (Table 3); as a result, only approximately 1,200 acres with defoliation were mapped on the Santa Fe National Forest in 2017, a decrease from the over 10,000 acres mapped there in 2016. Tamarisk leaf beetle, an introduced biological control agent of tamarisk or salt cedar, defoliated 4,400 acres on several tribal lands in the northeastern part of Arizona, but this may only represent a portion of the defoliated acres since tamarisk leaf beetle activity is not mapped in its entirety.

Dwarf mistletoe is the most common and widespread pathogen in the Southwest. Because we are unable to estimate dwarf mistletoe from aerial detection surveys, yearly ground estimates are limited, and overall estimated acreage affected does not change from year to year. Our current estimates are based on historical records (Table 4), 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 dwarf mistletoe infections along roadways on several of the national forests in New Mexico. Root diseases are also widely distributed across the region, but poorly documented (Table 4). Heterobasidion root disease and Armillaria root disease are the most prominent root diseases in the 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.

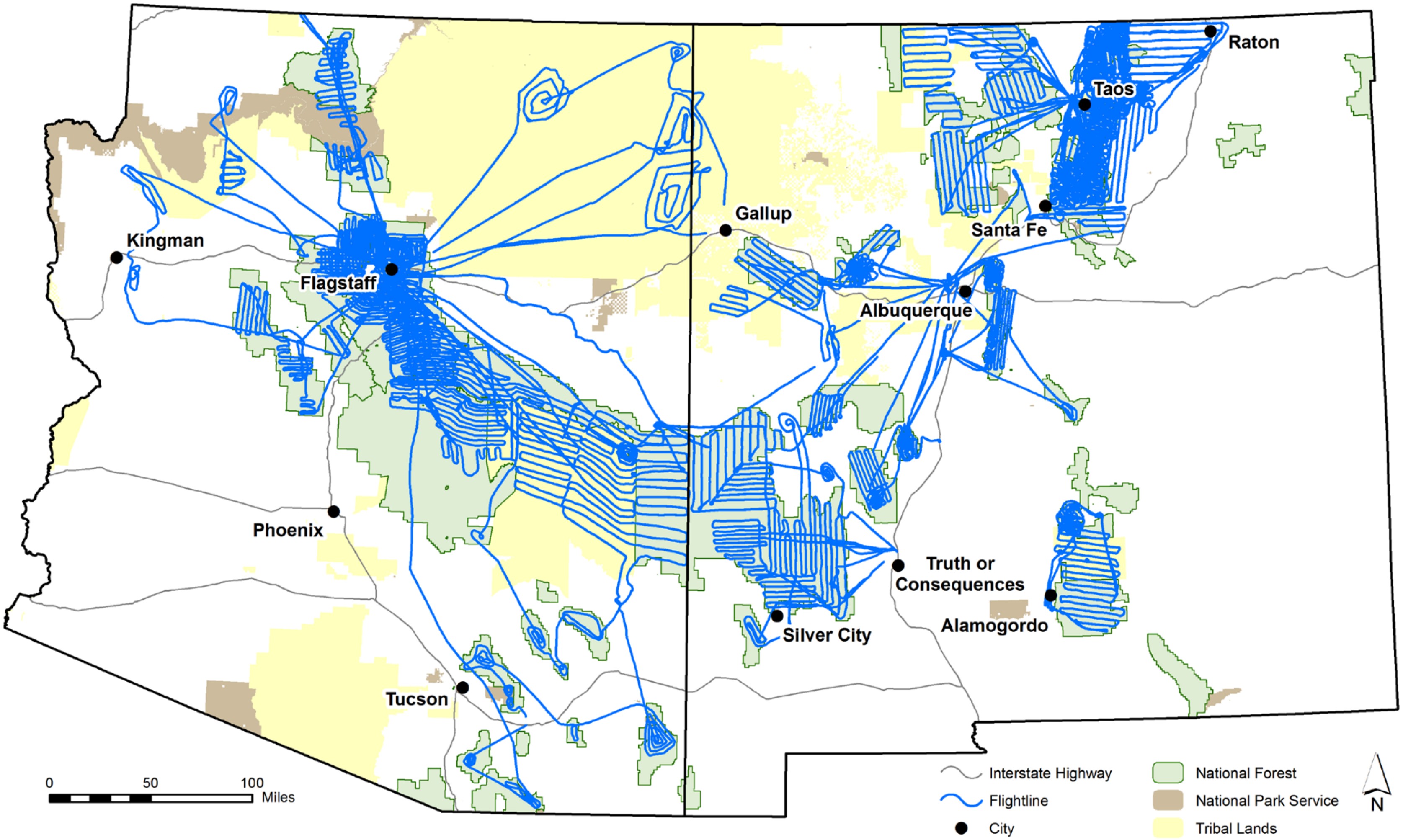

Figure 2. Flightlines recorded during 2017 aerial detection surveys in the Southwestern Region.

Table 2. Bark beetle[1] incidence by ownership (acres) from aerial detection surveys in 2017 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	17,150	10	220	10	120	160	< 5
Coconino NF	11,230	< 5	110			200	< 5
Coronado NF	20		< 5			<5	30
Kaibab NF	4,600	< 5	20	< 5	< 5	10	< 5
Prescott NF	560	< 5	< 5			< 5	< 5
Tonto NF	140	10					< 5
BLM	520	< 5					< 5
Fort Huachuca							
Navajo Army Depot	10						
Grand Canyon NP	2,570						
Canyon De Chelly NM			40				
Saguaro NP	< 5						
Sunset Crater NM	< 5						
Walnut Canyon NM							
Wupatki NM							
White Mtn. Apache	3,170	540	100	10	< 5	130	< 5
Hopi Tribal							
Hualapai Tribal	770	< 5					
Navajo Nation (AZ side only)	980	< 5	20		< 5	< 5	
Navajo-Hopi JUA		< 5					< 5
San Carlos Apache	1,180	< 5					< 5
State & Private	430	< 5				< 5	< 5
Arizona Total	**43,330**	**560**	**510**	**20**	**120**	**500**	**30**
Carson NF	270	< 5	2,090	9,450	50	1,730	
Cibola NF	1,400	10	870		10	340	< 5
Gila NF	7,720	10	340			20	< 5
Lincoln NF	460	10	30	210	20	10	
Santa Fe NF	360		11,840	24,770	740	620	
BLM	10	30	< 5				
Bandelier NM	< 5		< 5				
El Malpais NM	10						
Valles Caldera NP	< 5		1,560	< 5			
Acoma Pueblo	10	< 5					
Isleta Pueblo	10	< 5	< 5				
Jemez Pueblo	< 5						
Jicarilla Apache	10		710	1,070		< 5	
Mescalero Apache	120	< 5	10	410	90	20	
Navajo (NM side only)	1,810	< 5	10			< 5	
Other Tribal	< 5						
Picuris Pueblo	< 5						
Santa Clara Pueblo	< 5		40	30			
Taos Pueblo	< 5		210	50		50	
Zuni Pueblo	10	< 5	< 5				
State & Private	1,270	30	2,510	9,360	290	1,040	< 5
New Mexico Total	**13,480**	**90**	**20,210**	**45,350**	**1,200**	**3,840**	**< 5**
SW Region Total	**56,800**	**650**	**20,720**	**45,370**	**1,320**	**4,340**	**30**

[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.

Table 3. Defoliation[1] incidence by ownership (acres) from aerial detection surveys in 2017 in Arizona and New Mexico[2].

Owner[3]	Western spruce budworm	Aspen damage[4]	Douglas-fir tussock moth	Pinyon needle scale	Pandora moth	Spruce aphid
Apache-Sitgreaves NFs	90	70	100			730
Coconino NF		680	20			110
Coronado NF		130	140			
Kaibab NF	340	160		770	19,690	
Prescott NF		20		70		
Tonto NF						
BLM						
Fort Huachuca						
Grand Canyon NP				70		
Saguaro NP						
Sunset Crater NM						
Walnut Canyon NM						
Wupatki NM						
Canyon De Chelly NM						
White Mtn. Apache		460				4,860
Hopi Tribal				310		
Hualapai Tribal				50		
Navajo Nation (AZ side only)	40	1,570				
Navajo Army Depot						
Navajo-Hopi JUA				10		
San Carlos Apache						
State & Private		60	10	55		
Arizona Total	**470**	**3,150**	**270**	**1,340**	**19,690**	**5,700**
Carson NF	50,220	18,560				
Cibola NF	9,330	2,890	1,710			
Gila NF	70	340		< 5		
Lincoln NF	870	1,300		90		
Santa Fe NF	59,910	4,420	1,220	50		
BLM	150					
Bandelier NM						
El Malpais NM						
Valles Caldera NP	1,380	20				
Acoma Pueblo						
Isleta Pueblo						
Jemez Pueblo						
Jicarilla Apache	590	3,510				
Mescalero Apache	800	340		300		
Navajo Nation (NM side only)	40	260				
Other Tribal	330	20				
Picuris Pueblo						
Santa Clara Pueblo						
Taos Pueblo	2,040	100				
Zuni Pueblo						
State & Private	50,450	15,480	140	890		
New Mexico Total	**176,170**	**47,250**	**3,070**	**1,330**		
SW Region Total	**176,640**	**50,400**	**3,340**	**2,670**	**19,690**	**5,700**

[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.

Table 4. Prominent 2017 forest insect and disease activity (acres) observed during annual aerial detection survey in Arizona and New Mexico[1].

Agent	State	National Forest	Tribal Lands	Other Federal	State & Private	Total
Ponderosa pine bark beetles	AZ	33,700	6,100	3,100	430	43,330
Mixed conifer bark beetles	AZ	720	250	40		1,010
Spruce-fir bark beetles	AZ	130	10			140
Pandora moth	AZ	19,690				19,690
Spruce aphid	AZ	840	4,860			5,700
Pinyon needle scale	AZ	840	370	70	60	1,340
Aspen damage[2]	AZ	1,060	2,090		60	3,210
Root disease[3]	AZ	219,000	***	***	***	219,000
Dwarf mistletoes[3]	AZ	1,174,000	674,000	***	25,000	1,873,000
Ponderosa pine bark beetles	NM	10,220	1,970	20	1,270	13,480
Mixed conifer bark beetles	NM	17,890	1,050	1,560	3,550	24,050
Spruce-fir bark beetles	NM	34,750	1,640	< 5	9,650	46,050
Western spruce budworm	NM	120,400	3,790	1,530	50,450	176,170
Aspen damage[2]	NM	27,520	4,230	20	15,480	47,250
Root disease[3]	NM	860,000	***	***	***	860,000
Dwarf mistletoes[3]	NM	1,144,000	348,000	***	581,000	2,073,000

[1]Values rounded to the nearest 10; sum of individual values may differ from totals due to rounding.
[2]Aspen damage includes a combination of biotic and abiotic factors causing aspen decline or mortality
[3]Significant activity observed/known, but acreage not determined.

Pest Highlights

Spruce Beetle in Northern New Mexico

Since 2011, spruce beetle populations have caused elevated levels of tree mortality in northern New Mexico, impacting primarily the Carson and Santa Fe National Forests (Figures 3 and 4). Aerial surveyors have mapped approximately 69,400 acres affected during this time period across the two national forests and on adjacent state and private land. Spruce beetle favors large-diameter Engelmann spruce, and greater risk of tree mortality is associated with larger diameter trees, the location of stands, stand index, stand density (i.e., basal area), and proportion of spruce in a stand (Table 5). The 2013-2027 National Insect and Disease Risk Map predicted 35% risk of basal area loss from spruce beetle on both the Carson and Santa Fe National Forests. Tree mortality in these spruce-fir stands, which are commonly located at the headwaters of watersheds, has the potential to impact stand conditions downstream.

Table 5. Risk of tree mortality associated with spruce beetle.

Risk factor value	Physiographic location/site index	Average diameter of live spruce > 10" DBH	Stand basal area (sq ft/acre)	Proportion of stand that is spruce (%)
high	Spruce on well-drained sites in creek bottoms	> 16	> 150	> 65
moderate	Spruce on sites with site index 80–100	12–16	100–150	50–65
low	Spruce on sites with site index 40–80	< 12	< 100	< 50

Source: Schmid, J.M., R.H. Frye. 1976. Stand ratings for spruce beetle. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Research Note RM-309. Fort Collins, CO. 4 pp.

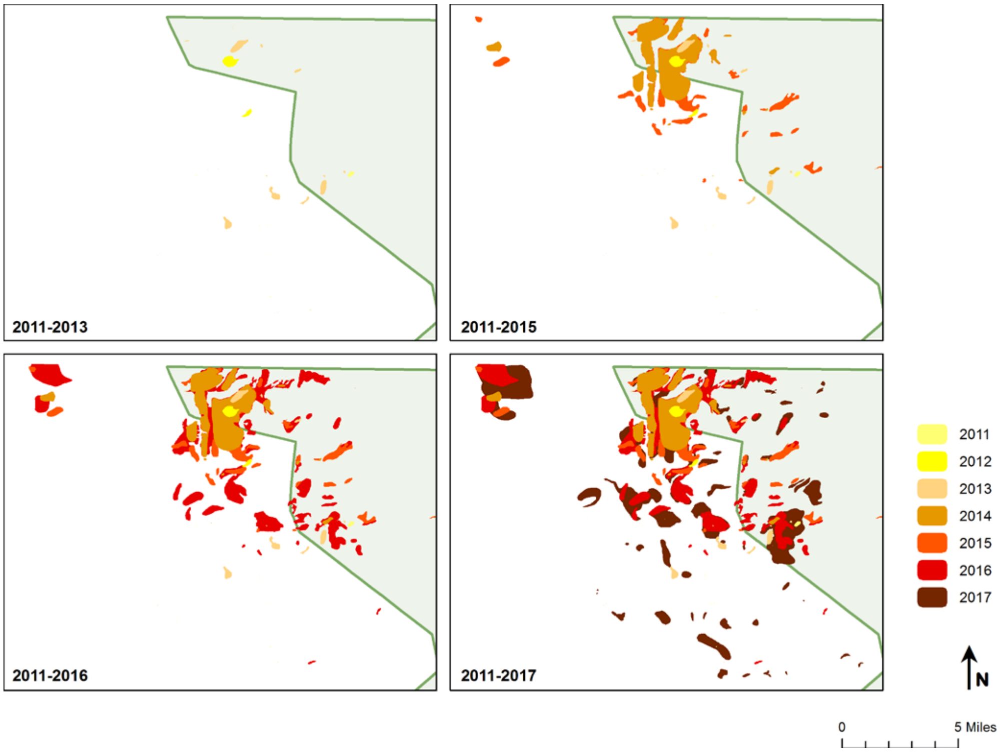

Figure 3. Progression of spruce beetle-caused tree mortality in Engelmann spruce mapped from 2011 to 2017 during aerial detection surveys on and adjacent to the northwest corner of the Tres Piedras Ranger District, Carson National Forest and immediately south of the Colorado state border.

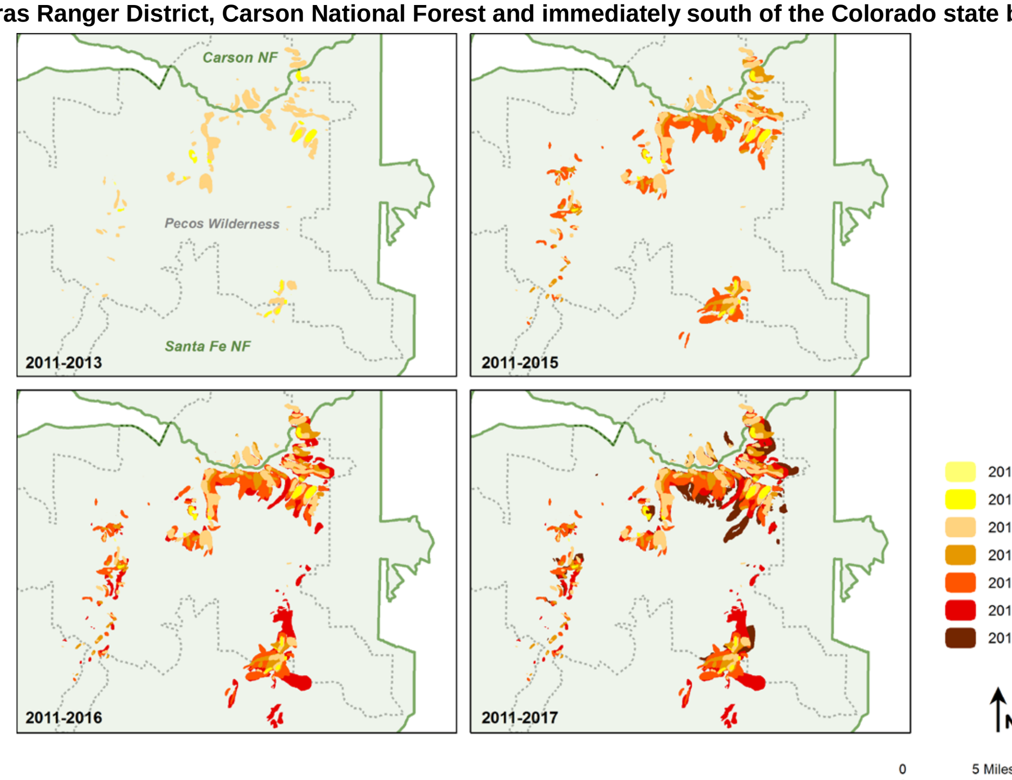

Figure 4. Engelmann spruce mortality from spruce beetle mapped from 2011 to 2017 during aerial detections surveys near the Pecos Wilderness on the Santa Fe National Forest.

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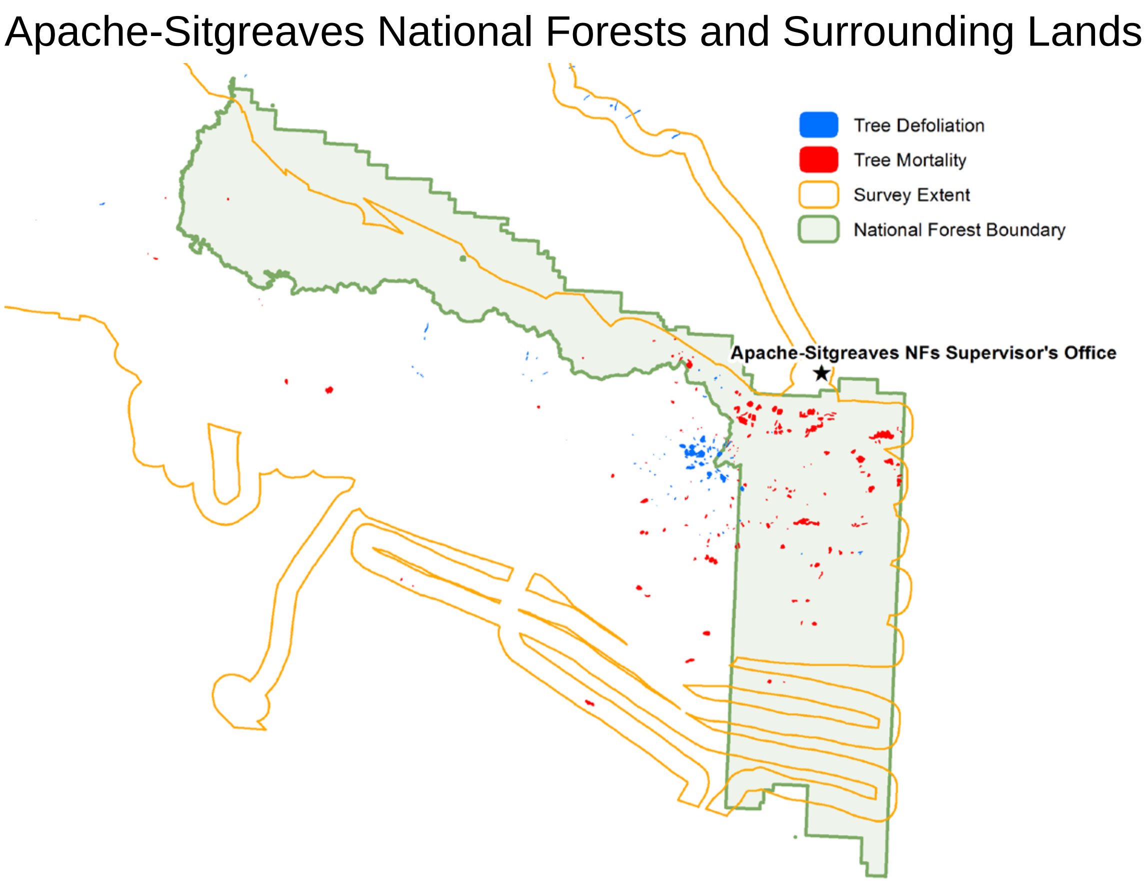


Figure 5. Tree defoliation and mortality mapped in 2017 during aerial detection surveys on the Apache-Sitgreaves National Forests.

Douglas-fir mortality, mostly caused by Douglas-fir beetle, was detected across 220 acres in 2017. Mortality rates have steadily dropped since the Wallow Fire in 2011 and for the past two years have been at levels that were historically present before the fire (Table 2).

A decrease of bark beetle activity in ponderosa pines was observed in 2017 (Figure 5). Roughly, 17,150 acres were mapped this year compared to 42,580 acres in 2016. Of the total acreage, 93% (16,000 acres) was categorized as having very light mortality (1-13%) in aerial survey polygons.

Since the Wallow Fire, Forest Health Protection conducted various suppression projects for Douglas-fir, mountain pine, and spruce beetles 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 2017, pheromone traps were used to monitor spruce and Douglas-fir beetles and ground surveys were conducted in several campgrounds to look for beetle-attacked trees for all species. This was the first year spruce beetle was monitored with pheromone traps. Monitoring of spruce beetle was done due to concerns that beetle populations might be increasing as a result of widespread defoliation of Engelmann spruce from spruce aphid. Moderate trap catches of spruce beetle (high of 60 beetles/trap/day during peak flight) were collected and no acres of tree mortality were recorded for spruce beetle from aerial surveys within the Wallow Fire perimeter. Ground surveys found seven spruce trees infested in the campgrounds, equal to the number recorded in 2016. Douglas-fir beetle trap catches continued to decline from the highs we recorded in 2015 (814 beetles/trap/day and 212 beetles/trap/day for 2015 and 2017, respectively). During campground inspections, Douglas-fir beetle attacked six Douglas-fir trees, down from the 18 recorded in 2016. For 2017, campground surveys identified a total of 71 attacked trees (all species), up from the 68 total trees documented for 2016. Attacks on ponderosa pine by bark beetles were primarily responsible for this increase, with 43 trees recorded in 2016 versus 56 in 2017. The majority of the ponderosa pine trees (40) were located in the campgrounds along the East Fork of the Black River. Most of the trees were relatively small diameter (5-10”) and attacked by a combination of western and roundheaded pine beetles, two beetle species documented to generally favor larger trees. The forest plans to remove infested trees by spring of 2018.

Spruce aphid damage decreased across the White Mountains (Table 3, Figure 5). Aerial surveyors detected approximately 730 acres with damage in 2017 compared to 3,660 acres detected in 2016 on the Apache-Sitgreaves National Forests. Collectively, across the Apache-Sitgreaves National Forests and White Mountain Apache Tribal Land, we mapped 5,600 acres with spruce defoliation, which is a significant decrease from the 32,000 acres mapped during the 2016 aerial survey (Appx. 1.E). A high level of spruce mortality occurred following the 2016 defoliation event. Thirty percent of spruce monitored in ground plots around Mount Baldy were dead in 2016, and approximately 10 acres of spruce beetle-caused tree mortality were mapped within the spruce aphid impacted area in the Mount Baldy Wilderness. Douglas-fir tussock moth monitoring was conducted in the Bear Canyon Lake Recreation Area, Black Mesa Ranger District; near Alpine, Alpine Ranger District; and near Greer, Springerville Ranger District. The Bear Canyon Lake site was the only site to catch moths in traps on the Apache-Sitgreaves National Forests. The average trap catch was 2.7 moths per trap, far below the 25 moths per trap threshold that predicts visible defoliation during the next two years.

Needlecast impacted 70 acres of pines on the Apache-Sitgreaves National Forests. The damage was observed on Rattlesnake Ridge of Black Mesa Ranger District. Favorable weather conditions are a major driver for when and where needlecast diseases occur. Needles are infected during rainy periods by rain splashed spores. Several consecutive years of severe infection may result in reduced tree growth or mortality.

Carson National Forest and Surrounding Lands

Since 2011, spruce beetle has continued to cause Engelmann spruce mortality on the Carson National Forest, causing more injury than any other mortality agent (Table 2). Spruce beetle impacted 9,450 acres in 2017 (Figure 6) and has been most active in the northwestern part of the Forest and on the adjacent Chama Land Grant, along the Santa Barbara Divide bordering the Pecos Wilderness area, San Antonio Mountain, and a growing population of insects in the Columbine Hondo Wilderness. The majority of the impacted spruce area (4,500 acres) mapped by aerial surveyors had moderate levels of tree mortality (11-29%).

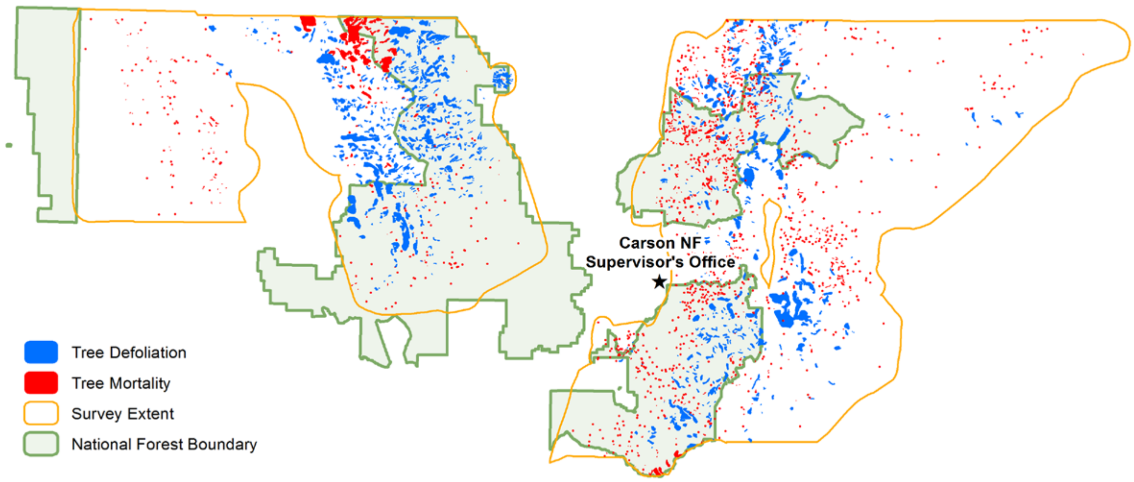


Figure 6. Tree defoliation and mortality mapped in 2017 on the Carson National Forest. Western spruce budworm and western tent caterpillar caused the majority of defoliation on the Forest. Spruce beetle continued to kill Engelmann spruce in the northwest and southern edge of the forest.

Bark beetles killed ponderosa pine across 270 acres, with most of the damage mapped on the Camino Real and Questa Ranger Districts (Table 2). Ponderosa pine mortality remained fairly consistent from 2016, where 280 acres were affected. Douglas-fir mortality caused by Douglas-fir beetle was recorded on 2,100 acres, a small decrease from 2,410 acres in 2016. Douglas-fir mortality was mapped north of Red River, NM and into the Latir Peak Wilderness, and to a lesser extent along the Rio Pueblo drainage. Fir engraver killed white fir on 1,730 acres, primarily on the Questa Ranger District in the Latir Peak Wilderness and surrounding areas. This is an increase from 820 acres mapped in 2016. Acres with corkbark fir mortality fell to 50 acres in 2017, a decline from 320 acres in 2016. Western balsam bark beetle may be interacting with Armillaria root disease to kill trees in these areas. The interaction of bark beetles and root disease is commonly found killing subalpine fir just to the north in Colorado. Aspen mortality, likely from a suite of insects and diseases, decreased from 990 acres in 2016 to 370 acres in 2017, primarily on the Canjillon Ranger District.

Western spruce budworm defoliation continued in mixed conifer stands, primarily impacting Douglas-fir, on the Carson National Forest (Table 3). Activity declined from 60,120 acres in 2016 to 50,220 acres in 2017. Trees in the understory of densely stocked stands are impacted most by continued defoliation. This year western tent caterpillar and other insects defoliated 18,400 acres of aspen, a dramatic rise from 5,700 acres in 2016. Most of the defoliation was observed on the

Figure 7. Large areas of old (red and gray-colored) and new (yellow-colored) Engelmann spruce mortality along Brazos Ridge in Tres Piedras Ranger District.

west side of the Forest, along the western edge of the Tres Piedras Ranger District. Scattered areas of defoliation increased in 2017 on the east side of the Forest.

On adjacent tribal lands, Douglas-fir mortality from Douglas-fir beetle increased, affecting just over 900 acres that were scattered across the landscape. Spruce beetle-caused tree mortality continued to increase on Taos Pueblo and Jicarilla Apache Tribal Lands (Table 2). Spruce mortality was observed on 1,120 acres across both tribal land areas. White fir mortality caused by fir engraver beetle increased on Taos Pueblo, impacting 50 acres. Western spruce budworm defoliated mixed conifer stands on 3,800 acres of mixed conifer stands, mostly on Taos Pueblo (Table 3). Ponderosa pine mortality from bark beetles remains very low in northern areas of the State.

Cibola National Forest and Surrounding Lands

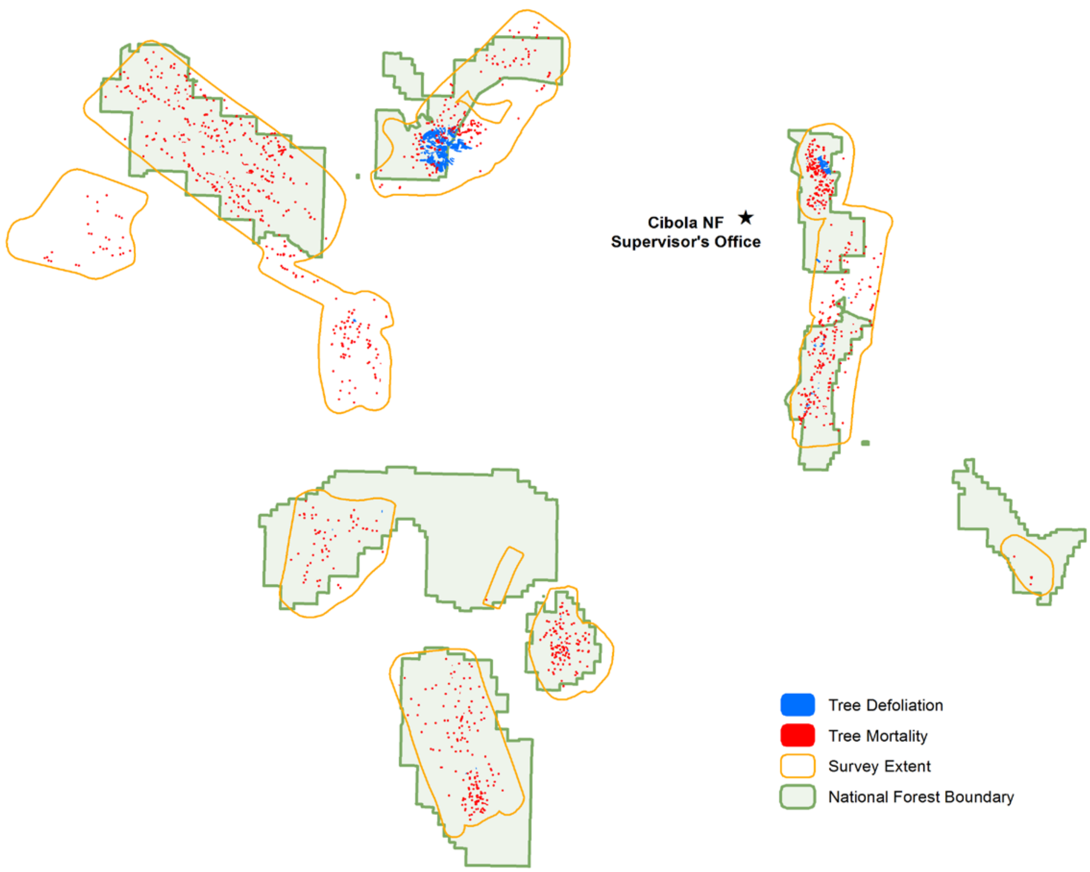


Figure 8. Douglas-fir tussock moth reached outbreak status on the Sandia Ranger District, Cibola National Forest. Western spruce budworm continued to defoliate mixed conifer stands on the Mt. Taylor Ranger District.

Bark beetles killed ponderosa pine on 1,400 acres, an increase from 950 acres in 2016 (Table 2). Bark beetle-caused tree mortality increased on the Mt. Taylor Ranger District and in several thinned areas on the Zuni Mountains (Figure 8). Ponderosa pine mortality expanded from the 2016 Doghead Fire boundary, likely a result of bark beetles attacking adjacent trees. Ponderosa pine mortality continued in the San Mateo Mountains in 2017, but impacted fewer acres than the previous year. Light severity (4-10%) and moderate severity (11-29%) mortality was recorded for

Figure 9. Scattered ponderosa pine mortality (pale orange to red-colored trees) detected by aerial surveyors on Mt. Taylor. Heavy budworm defoliation (right side) and a small patch of aspen defoliation (top left) can be seen in the photograph.

the majority of the areas (400 acres) mapped. Aerial surveyors mapped Douglas-fir beetle activity on 870 acres in scattered pockets in the Zuni, Sandia, Manzano, San Mateo and Magdalena Mountains, a slight increase from 2016 (760 acres). White fir mortality decreased from 1,300 acres in 2016 to 340 acres in 2017. The majority of this tree mortality was mapped on the Sandia Mountains. Aerial surveyors also mapped 70 acres with new overstory aspen mortality on the district. The tree mortality is likely a result of multiple factors such as defoliation, root disease, and attack from secondary insects. Pinyon ips activity remained low across the forest with only 10 acres with pinyon mortality mapped in 2017. Corkbark fir mortality attributed to western balsam bark beetle declined from 70 acres in 2016 to just 10 acres in 2017. Juniper and southwestern white pine mortality from bark beetles remained low, each detected on less than five acres.

The second year of a Douglas-fir tussock moth outbreak occurred on the Sandia Ranger District in 2017, representing the first year of significant tree defoliation (Table 3). The outbreak spanned 1,710 acres on the district along the Crest Highway from around the Dry Camp pullout to Capulin Snow Play area and along slopes and drainages to the north and east (Figure 8). Severe defoliation impacted white fir throughout the area. Low levels of tree mortality were observed in white fir stands with severe defoliation. Based on data collected during fall egg mass surveys, the outbreak will continue in 2018. Tree mortality will likely be highest in stands that received high levels of defoliation in 2017 and 2018. White fir will likely succumb to feeding by Douglas-fir tussock moth and subsequent attack by fir engraver. Western spruce budworm defoliation increased from 1,860 acres in 2016 to 9,330 acres in 2017, primarily impacting Douglas-fir on the Mt. Taylor Ranger District. Needlecast on ponderosa pine was mapped on 20 acres of the Mountainair Ranger District. Pine sawfly defoliation was suspected in ponderosa pines on 10 acres in the Magdalena Mountains, but no ground surveys were able to be conducted to verify the presence of sawflies. Pine sawfly injury has been increasing in the surrounding areas over the past couple of years. Gambel oak was defoliated on 300 acres on the Mountainair and Sandia Ranger Districts, but the causal agent of the oak defoliation could not be confirmed. Aspen defoliation was observed on all ranger districts with a notable increase in activity in 2017 (2,820 acres) from 2016, primarily concentrated on the Mt. Taylor Ranger District. Western tent caterpillar was identifed as the damage agent on Mt. Taylor and is likely the damage agent on the other districts, but this has not been confirmed on the ground. Pockets of Gambel oak saplings had twig death from cicada oviposition sites on the Sandia Mountains.

Drought conditions, Heterobasidion root disease, and fir engraver contributed to increased tree mortality from 2012 to 2014 on the Sandia Ranger District. White fir is a dominant component of these stands, and Heterobasidion root disease has been verified across many of these sites with recent white fir mortality. Preliminary surveys found many white fir killed by fir engraver were also infected with the root disease. The level of tree mortality has declined since the drought conditions diminished, but scattered tree mortality continued to occur in 2017 with 270 acres with tree mortality mapped via aerial detection surveys. Ground surveys conducted from 2016 to 2017 estimate 30% of the white fir has been killed in this area.

Pockets of Douglas-fir beetle activity continued to expand on the Sandia Ranger District along the Crest Highway and near the Sandia Ski Resort. The Douglas-fir mortality commonly covered one to two acres with three to six trees dying each year. Tree mortality was associated with Schweinitzii root and butt rot, caused by the fungus *Phaeolus schweinitzii*. This disease does not typically affect canopy health and may not be noticeable until windthrow of severely affected trees occurs. Schweinitzii root and butt rot disease was also found infecting older white fir that had recently been killed in the same area, and fruiting bodies on this host were found at the base of the infected trees.

Severe stem decay caused by the Indian paint fungus commonly affects white fir on the Sandia Ranger District. A single fruiting body, or conk, indicates that the affected tree’s trunk is significantly decayed, with the decay column typically extending two meters above and 2.5 meters below the conk. Trees decayed by this fungus have high potential for failure and should be considered extremely hazardous where they can impact a target, such as roads or picnic tables.

Spruce needlecast caused understory Engelmann spruce crowns to appear thin and needles to appear chlorotic in Water Canyon on the Magdalena Ranger District. Spruce needlecast likely can be attributed to warm, wet spring conditions experienced in early 2017.

Dwarf mistletoe roadside surveys were conducted on portions of the Cibola National Forest during the summer of 2017. Similar surveys were previously conducted in 1960 and 1987. More areas will be covered in the Magdalena Ranger District in 2018. Preliminary results indicate that uninfected areas have decreased over time (e.g., 79% on the Mount Taylor Ranger District in 1987 vs. 74% in 2017). Lightly, moderately and severely infected areas have increased as infections have spread into new areas or intensified in areas it was previously present. In some cases, reduced mistletoe was observed compared to previous surveys, likely because of thinning treatments selectively targeting infected trees as well as the impacts of wildfire.

Insect and disease activity on the surrounding tribal lands was very low in 2017. The most significant observation was 80 acres on the Acoma Pueblo with suspected pine sawfly-caused defoliation in ponderosa pine on the northern part of Cebollita Mesa. Ponderosa pine mortality stayed at the same level in 2017, affecting 10 acres. Bark beetle-caused mortality in Douglas-fir and pinyon pine remained low. Some branch flagging in ponderosa pine, likely from twig beetle feeding, was observed on less than five acres of the Isleta Pueblo.

Coconino National Forest and Surrounding Lands

Ponderosa pine mortality increased from 7,330 acres mapped in 2016 to 11,230 detected in 2017 (Table 3, Figure 10). Of the 11,230 acres impacted, 5,700 acres were classified as very lightly damaged (1-3% trees injured) and 5,110 acres were classified as light tree mortality (4-10%) in mapped polygons (Figure 11).

A strong wind storm in late 2016 resulted in many downed trees and snapped tops within the boundaries of the Arizona Snowbowl Ski Area on the San Francisco Peaks. Due to concern about spruce beetle outbreaks, the Coconino National Forest received suppression funding to mitigate the likelihood of an outbreak. Arizona Conservation Experience crews were hired to cut downed trees and tops to shorter lengths, and debark downed trees to reduce habitat for spruce beetles. This work was completed in the summer of 2017. Ground surveys during the summer of 2018 will be used to monitor treatment success.

Approximately 110 acres with defoliation from spruce aphid were mapped during the 2017 spring flight on the San Francisco Peaks. The damage was on the western slopes of Agassiz Peak, with isolated pockets continuing to the Northeast slopes of Rees Peak. This exotic insect was first reported in the Southwest during the 1980's. Typical damage includes crown

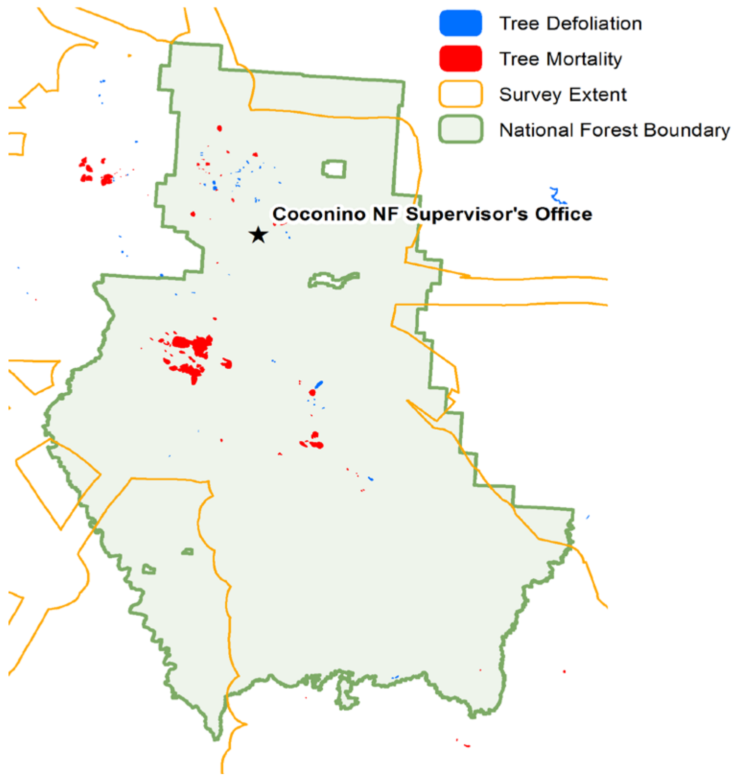


Figure 10. In 2017, aerial detection surveys observed approximately 810 acres with defoliation and 11,540 acres with tree mortality on the Coconino National Forest.

Figure 11. A photo of continued, but decreasing, ponderosa pine mortality attributed to bark beetle activity in the vicinity of the 2014 Slide Fire.

discoloration and premature needle drop. Damage may lead to mortality in severely infested trees (Figure 12). A small patch of Douglas-fir tussock moth defoliation was observed during the aerial detection surveys, and verified by ground surveys on Mount Elden near the radio towers. Aspen defoliation increased in 2017 with 680 acres impacted, compared to 180 acres mapped in 2016. Severe oystershell scale populations contributed to the decline of many aspen stands on the Coconino National Forest, particularly at lower elevations. Aspen stands within elk exclosures were also infested. This persistent and mostly sessile insect can cause chronic damage, and infested stands may not recover without management action.

Figure 12. Discoloration of Engelmann spruce due to spruce aphid feeding over the 2016 to 2017 winter on the San Francisco Peaks.

Over the 2016/2017 winter, a major wind event occurred on the Flagstaff Ranger District. Roughly 340 acres were impacted by the wind event between O’Leary Peak and Black Mountain. A significant number of ponderosa pines were toppled over. Monitoring will continue in the area for any increase in bark beetle activity associated with the mortality event.

Coronado National Forest

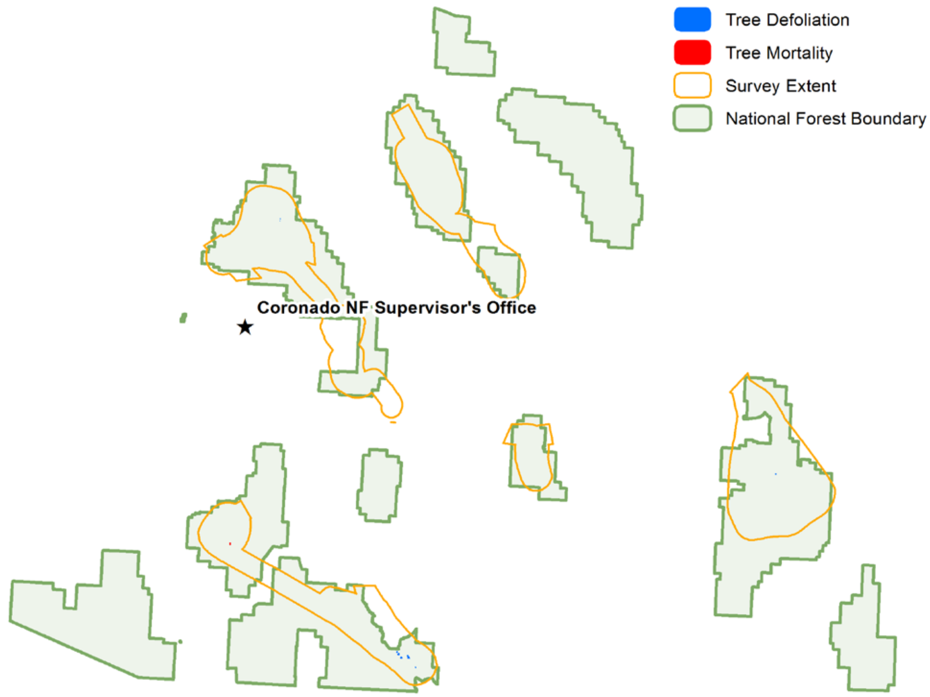


Figure 13. Low levels of tree defoliation and mortality were detected in 2017 by aerial detection surveys on the Coronado National Forest.

The acres of pine species (Apache, Chihuahua, ponderosa, and Arizona pine) with tree mortality attributed to bark beetles mapped on the Coronado NF decreased from 2,100 acres in 2016 to 20 acres in 2017 (Table 2). The bark beetle-caused tree mortality was mapped as small, scattered pockets (1-15 trees per pocket) across all ranger districts (Figure 13).

Figure 14. Douglas-fir defoliation observed on the Santa Catalina Mountains during the 2017 aerial detection survey.

In 2017, defoliation attributed to Douglas-fir tussock moth increased on the Coronado National Forest. Approximately 140 acres were mapped in 2017 compared to 90 acres in 2016 (Table 3, Figure 14). Defoliation from Douglas-fir tussock moth was observed impacting 10 acres in 2017 on Marble Peak west of the Oracle Ridge. Additionally, four new areas of Douglas-fir tussock moth activity were detected in 2017 on the Coronado National Forest. One area (10 acres) was observed just west of Rustler Park on the Douglas Ranger District. The remaining three areas (130 acres total) were observed between Pat Scott Peak and Granite Peak in the Huachuca Mountains, Sierra Vista Ranger District.

Gila National Forest and Surrounding Lands

Ponderosa pine mortality attributed to bark beetles was the most prominent forest health-related event observed in 2017 on the Gila National Forest (Table 2). Ponderosa pine mortality was mapped across 7,720 acres during aerial detection surveys, a decline of about half from 2016 (Figure 15). Tree mortality continues to decline across the forest since a peak in bark beetle activity was observed in 2011. Ponderosa pine mortality primarily occurred at moderate levels (11-29%) in mapped areas, spanning slightly over 4,000 acres.

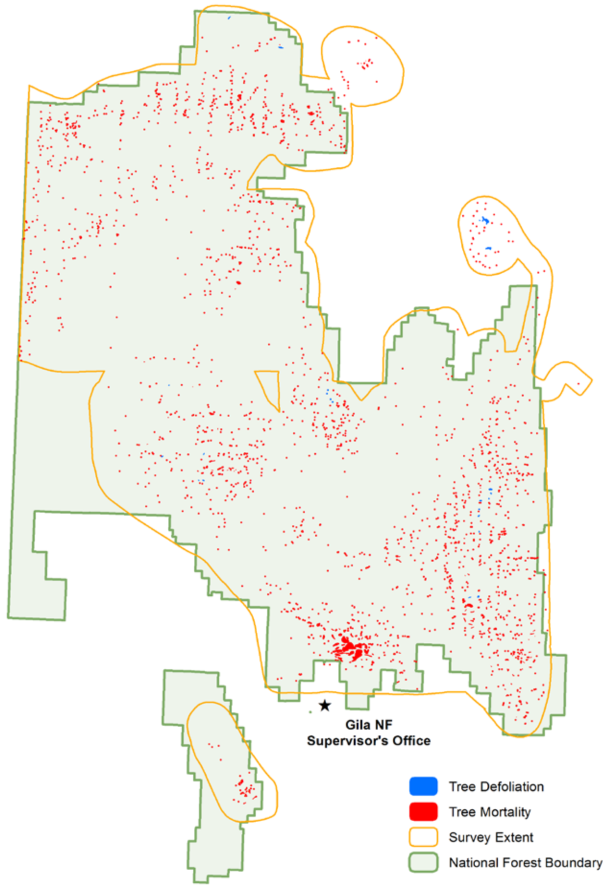


Figure 15. Tree injury and mortality mapped in 2017 during aerial detection surveys on the Gila National Forest.

Western pine beetle activity expanded across Signal Peak in 2017, causing the highest concentration of bark beetle-caused tree mortality on the forest, impacting 4,820 acres (Table 2, Figure 16). Roundheaded bark beetle and pine engravers were also found in recently attacked trees. Tree mortality experienced in 2017 can likely be attributed to moderate drought conditions and high stand densities in the southwest part of the state. Bark beetles continued to kill scattered ponderosa pines previously injured in the Signal, Silver, and Whitewater-Baldy Complex Fire areas. However, the tree mortality in higher elevation forests affected by the wildfires declined substantially. Douglas-fir beetle and fir engraver activity decreased to background levels, affecting 340 acres and to negligible levels, respectively. Pinyon ips bark beetle remained at low levels, killing trees across only 10 acres on the forest. Only trace amounts of cedar bark beetle-caused juniper mortality were observed on the Gila NF.

Figure 16. Ponderosa pine mortality increased from 2016 to 2017 across Signal Peak.

Aspen damage from western tent caterpillar and other agents increased from 140 acres in 2016 to 340 acres in

2017 (Table 4). Aspen defoliation was mapped primarily in the area around Diamond Peak.

Dwarf mistletoe roadside surveys were conducted on the Quemado Ranger District during the summer of 2017. Similar surveys were previously conducted in 1960 and 1987. More areas will be covered in the Reserve, Glenwood, Silver City, Black Range, and Wilderness Ranger Districts in 2018. Preliminary results indicate that uninfected areas have declined over time from 67% in 1987 to 61% in 2017. Lightly, moderately and severely infected areas have increased as infections have spread into new areas or intensified in areas it was previously present.

Defoliation of ponderosa pine across 400 acres on the Luera Mountains was observed during aerial surveys and was likely caused by pine sawfly feeding. This was the second year of defoliation mapped in the area. In 2016, New Mexico State Forestry officials found injury indicative of sawfly feeding.

Kaibab National Forest and Surrounding Lands

Ponderosa pine mortality increased in 2017, with 4,600 acres mapped compared to 690 acres mapped in 2016 (Table 2). Of the 4,600 acres, about 53% (2,550 acres) of the mortality was categorized as very lightly damaged (1-3%). Tree mortality was evenly distributed among all three Ranger Districts (Figure 17). Overall tree mortality, however, is low.

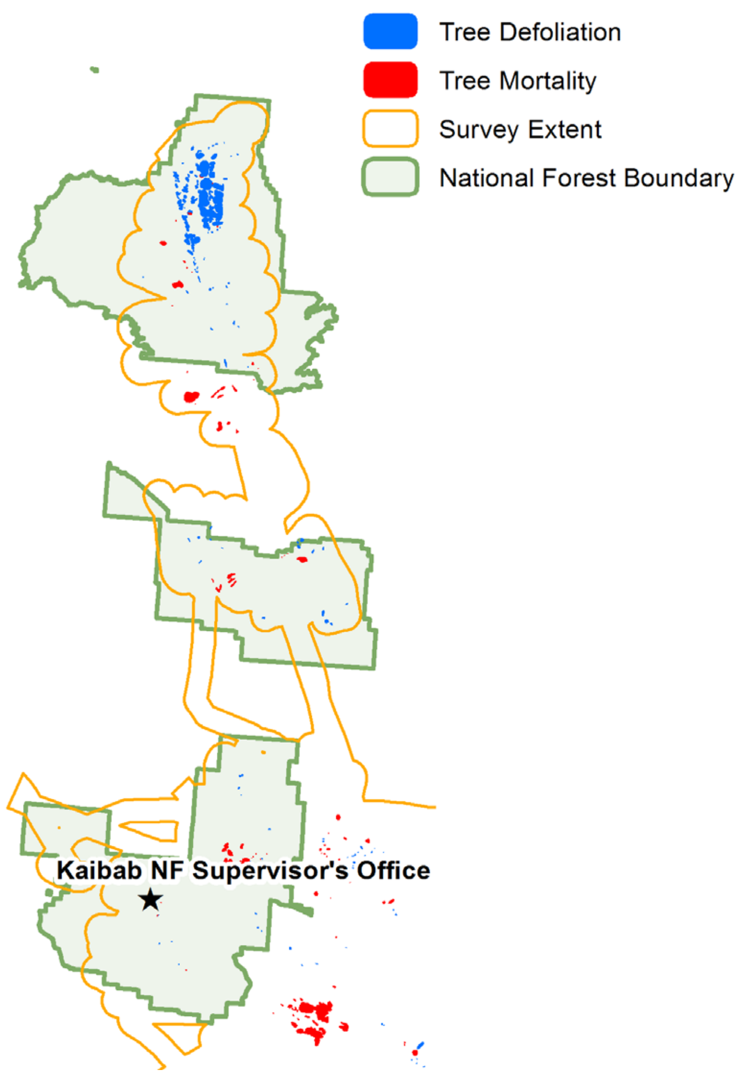


Figure 17. Defoliation from pandora moth was the most significant injury event in 2017 on the Kaibab National Forest.

The extent of the pandora moth outbreak in 2017 increased while the severity of the defoliation decreased on the North Kaibab Ranger District. Defoliation was very light and scattered compared to previous events in 2013 and 2015. We mapped approximately 19,700 acres with ponderosa pine defoliation compared to ~8,000 acres in 2015 (Table 3). Of the total acres impacted, 29% was very light, 19% was light, 45% had moderate damage, and the remaining 7% had severe defoliation. Monitoring of the adults will continue next year during the flight period with light traps. The population will likely start to decrease in 2018 due to the spread of the nucleopolyhedrosis virus, which was observed during larval density collections in 2017.

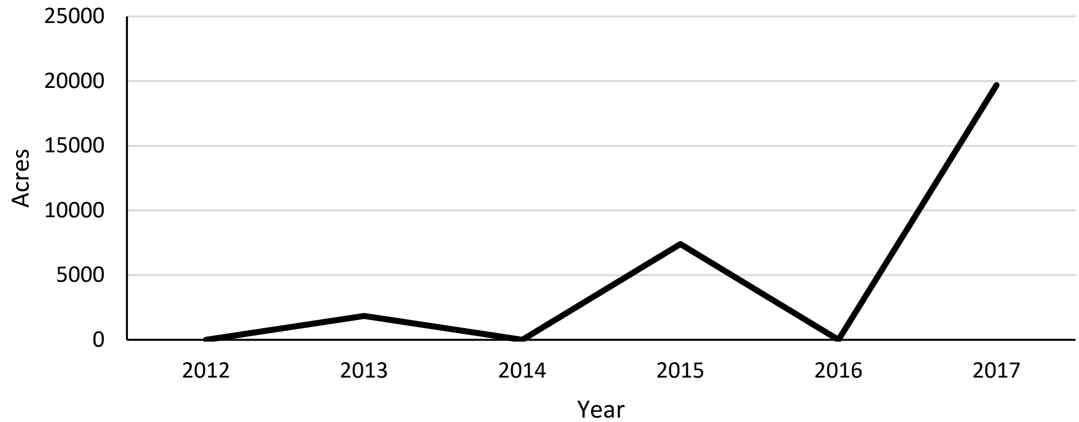


Figure 18. Pandora moth defoliation observed on the North Kaibab Ranger District. The current outbreak has been ongoing since 2013.

Aspen damage decreased from 440 acres in 2016 to 160 acres impacted in 2017. Oystershell scale contributed to the decline of many lower elevation aspen stands on the Kaibab National Forest. Western spruce budworm defoliation increased across 340 acres on the North Kaibab Ranger District, compared to 330 acres in 2016 (Table 3). Pinyon needle scale defoliation was detected on 770 acres on the Tusayan Ranger District, whereas no damage was detected during the 2016 aerial survey.

Figure 19. A ponderosa pine observed with moderate levels (11-29%) of defoliation from pandora moth on the North Kaibab Ranger District.

Lincoln National Forest and Surrounding Lands

In 2017, total tree mortality continued to decrease across the Lincoln National Forest (Figure 20). Ponderosa pine mortality was limited to scattered individual or small groups of trees and some low severity (4-10% of the trees affected) areas. Ponderosa pine mortality was mapped on 460 acres in 2017 compared to 1,400 acres in 2016 (Table 2). Douglas-fir, white fir, and corkbark fir mortality all decreased to almost background mortality levels (< 30 acres). Engelmann spruce mortality increased on Sierra Blanca, impacting 210 acres in 2017 compared to 140 acres in 2016 (Figure 21).

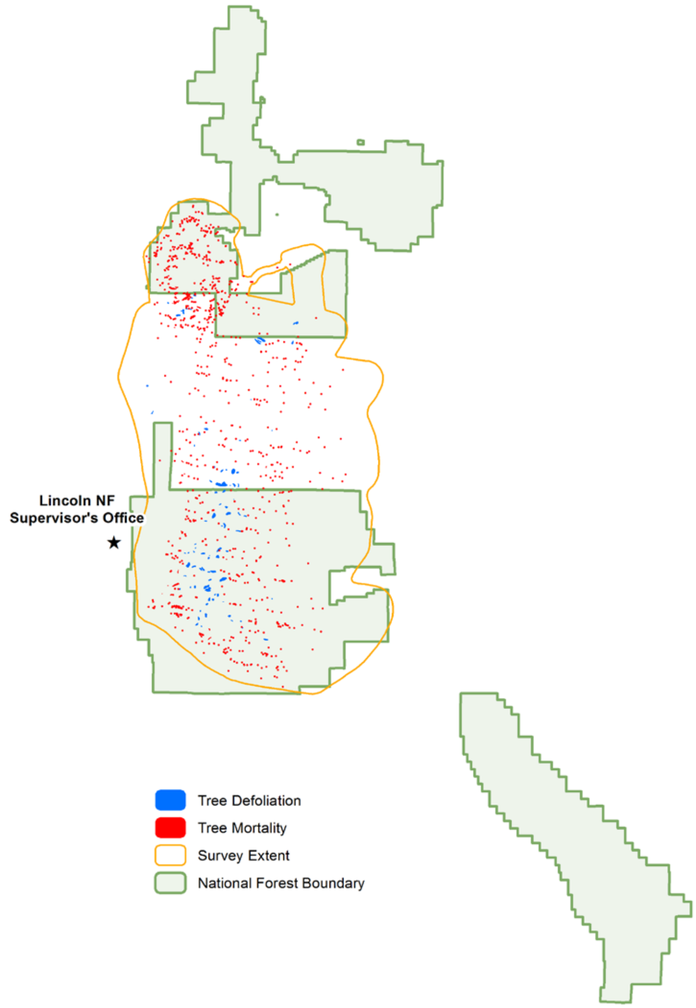


Figure 20. Aerial detection surveys mapped low levels of tree injury and mortality on the Lincoln National Forest. Defoliation of mixed conifer and aspen stands was the most prevalent injury on the forest.

Western spruce budworm defoliation was mapped on less than 870 acres of the Sacramento Ranger District (Table 3). The extent of the damage may not be fully represented due to the late timing of the aerial detection flights, which makes it difficult to observe budworm feeding damage. Aspen defoliation from western tent caterpillar and other agents increased from 410 acres in 2016 to > 1,400 acres in 2017. A small number of acres with pinyon needle scale damage was mapped on the Lincoln National Forest; however, the tree damage caused by this insect is difficult to see from the air, and therefore, likely represents only a fraction of actual pinyon needle scale injury.

The trends in insect and disease activity on the Mescalero Apache Tribal Lands closely reflect those on the neighboring Lincoln National Forest. Tree mortality decreased slightly across Mescalero Apache Tribal Lands from a total in 2016 of 850 acres to 640 acres in 2017 (Table 2). Engelmann spruce mortality caused by spruce beetle on Sierra Blanca comprised 410 acres of the 640 acres on Tribal Lands. Overall, observed defoliation on Mescalero Apache Tribal Lands increased from a total of 560 acres in 2016 to 1,480 acres in 2017 (Table 3). Most of this was defoliation of Douglas-fir and white fir by western spruce budworm on 800 acres. Aerial detection surveys observed lesser amounts of aspen defoliation and pinyon needle scale, but still slightly more than were mapped in 2016.

Figure 21. Spruce beetle-caused mortality (reddish-yellow trees) recorded on Sierra Blanca Peak surrounded by the Little Bear Fire scar.

Prescott National Forest and Surrounding Lands

An increase in ponderosa pine mortality attributed to bark beetle activity was observed during the 2017 aerial detection survey of Prescott National Forest (Table 2). Approximately 560 acres were impacted with tree mortality compared to 130 acres during 2016 (Figure 22). Of the 560 acres affected, 92% (530 acres) were classified as very lightly damaged (1-3% trees injured). (Figure 23). Most of the tree mortality (490 acres) is on Juniper Mesa of the Chino Valley Ranger District.

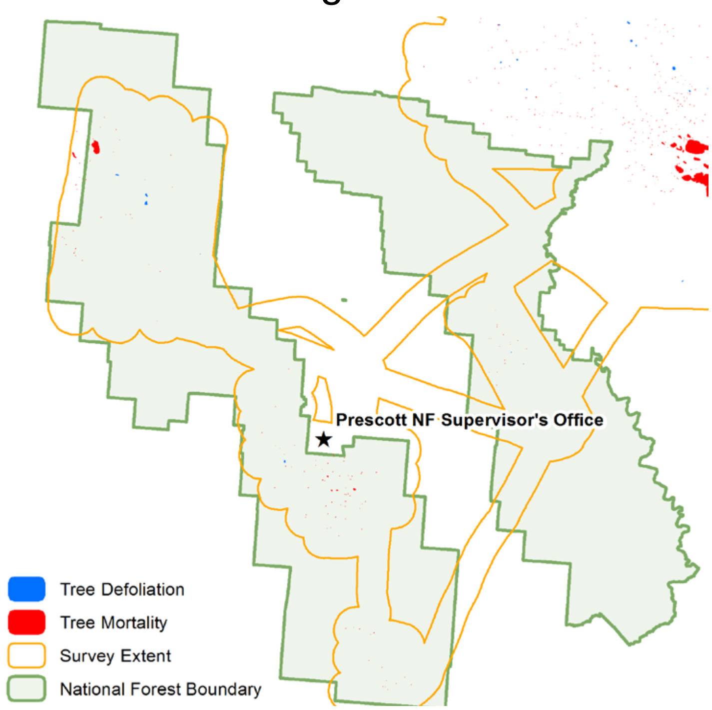


Figure 22. Limited tree defoliation and mortality was observed in 2017 on the Prescott National Forest.

Approximately 70 acres with damage attributed to pinyon needle scale were observed during the 2017 aerial detection survey (Table 3). The damage was observed on the Chino Valley Ranger District, in the Santa Maria Mountains north of Baldy Mountain and along Highway 68. However, chronic infestations have occurred in and around the Prescott area for decades. Infestations can cause needles to yellow and drop. Repeated attacks cause reduced growth and stunted needles. In severe outbreaks, small trees may be killed.

Figure 23. Low levels of ponderosa pine mortality mapped in 2017 on the Prescott National Forest.

Santa Fe National Forest and Surrrounding Lands

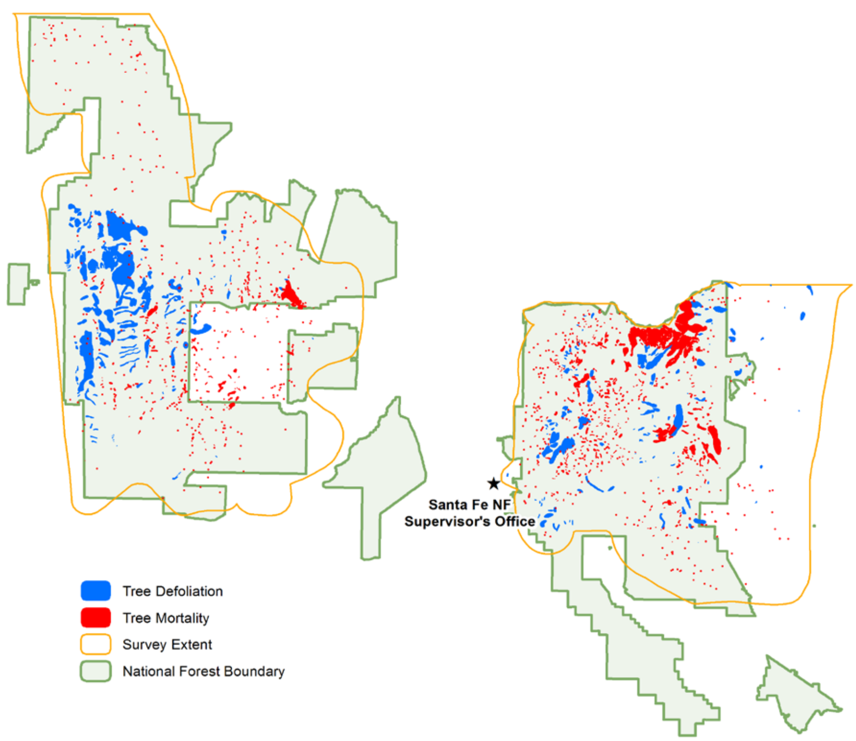


Figure 24. Spruce beetle-caused tree mortality and defoliation from western spruce budworm were the most significant issues detected during aerial detection surveys on the Santa Fe National Forest. Douglas-fir beetle has killed trees near recent wildfire events.

Spruce beetle continued to kill Engelmann spruce in the northern portion of the Pecos Wilderness, between the Pecos Baldy and Santa Fe Baldy Peaks, around Chicoma Peak, and in San Pedro Parks area (Figure 24). Spruce beetle-caused tree mortality was mapped on an estimated 24,770 acres, a slight decline from 2016 (Table 2, Figure 25). The majority of spruce mortality mapped

(20,000 acres) by aerial surveys impacted 11-29% of the polygons. Spruce beetle populations are expanding into surrounding spruce-fir stands, and tree mortality will likely continue in these areas. Preliminary ground surveys recorded 50-100% overstory spruce mortality of the stands in the Elk Mountain area. These areas with > 50% tree mortality had experienced multiple years of tree mortality from spruce beetle.

Figure 25. Old (grey and red trees) and new (yellow trees) Engelmann spruce mortality near Elk Mountain in the Sangre de Cristo Mountains.

Figure 26. Douglas-fir mortality (grey is older mortality) mapped near Hermits Peak.

Douglas-fir beetle activity has been increasing since 2015; this year Douglas-fir mortality was observed on 11,840 acres compared to 9,740 acres in 2016 (Table 2). The heaviest concentration of tree mortality occurred in the vicinity of Bluebell Ridge/Hermits Peak area (Figure 26), whereas scattered areas of tree mortality occurred along the western edge of the Pecos Wilderness and near the north and west edges of the Valles Caldera National Preserve. Douglas-fir beetle populations have built-up in scorched trees from recent wildfires and expanded into uninjured stands. This has been evident around the Las Conchas and Thompson Ridge wildfires. Mortality caused by Douglas-fir beetle was also noticeable on west facing slopes along Highway 4 near the Spence Hot Springs.

Aerial surveyors mapped 360 acres with ponderosa pine mortality in 2017, a decrease from 1,390 acres in 2016 (Table 2). Fir engraver-caused tree mortality decreased from 1,560 acres in 2016 to 620 acres, with a large proportion of the activity occurring east of Spring Mountain in the Sangre de Cristo Mountains. Corkbark fir mortality from western balsam bark beetle increased in 2017 from 150 to 740 acres. Corkbark fir mortality was found in several medium-sized pockets in the northern part of the Pecos Wilderness.

In 2017, trees in mixed-conifer forests, in particular Douglas-fir, were defoliated on 59,910 acres by western spruce budworm, an increase from 26,260 acres in the previous year (Table 3). Although tree mortality was not evident from this insect, repeated defoliation events are likely to have a significant impact on regeneration of understory trees in injured stands. Aspen damage, primarily from western tent caterpillar, increased this year from 2,790 acres in 2016 to 4,420 acres this year. Aspen defoliation was mapped along Aspen Ridge in the Sangre de Cristo Mountain Range, the Pecos Wilderness, and in scattered areas in the northwest Jemez Mountains. The Douglas-fir tussock moth outbreak recorded in 2016 on the Pecos/Las Vegas Ranger District crashed, and only 1,220 acres of defoliation were observed in 2017 down from 10,190 acres in 2016. It's not uncommon to observe low levels of defoliation in the final year of a Douglas-fir tussock moth outbreak. Premature needle loss from severe pinyon needle scale infestations was observed from the ground for the first time in several years on 50 acres along Forest Road 10 near Paliza Campground and Forest Road 376 in the Jemez Mountains, and along the eastern edge of the city of Santa Fe. Gambel oak seedlings had distinct twig death (i.e., flagging) from cicada oviposition sites on the Jemez Ranger District along Forest Road 376. Injury was abundant on seedlings, causing death of the terminal leader or lateral twigs. Needlecast in ponderosa pine was observed on 100 acres, a decrease from 330 acres the previous year, near the eastern boundary of the Forest, south of Mora.

A late-spring hail storm injured pines, white fir, aspen, and Douglas-fir near the community of La Cueva on the Santa Fe National Forest, Pecos/Las Vegas Ranger District. Hail caused the loss of needles to many tree species. Although the injury was minor to individual trees, the abundance of green needles on the ground was quite dramatic.

Dwarf mistletoe roadside surveys were conducted on the Cuba, Jemez and Pecos-Las Vegas Ranger Districts of the Santa Fe National Forest during the summer of 2017. Similar surveys were previously conducted in 1950s and 1980s. Preliminary results indicate that uninfected areas have increased over time from 59% in 1960 to 69% in 2017. Reduced mistletoe may have been observed compared to the previous survey because of thinning treatments selectively targeting infected trees and the impacts of fire, although a greater geographic area was covered in 1960 that may have included more severely infested acreage. Additional areas on the Española and Coyote Ranger Districts will be surveyed in 2018 to determine more accurately how dwarf mistletoe infections have changed over time on the forest.

On the adjacent Valles Caldera National Preserve, spruce mortality decreased from 460 acres to less than five acres. Douglas-fir mortality increased on the Valles Caldera National Preserve and can be linked to recent fire injury and expansion of Douglas-fir beetle populations from nearby scorched Douglas-fir. Of specific concern are the remaining Douglas-fir trees in the History Grove located on the western side of the Valles Grande where Forest Health Protection and Park staff have been using a "push-pull" strategy with repellents and attractant-baited traps to discourage attacks on the remaining, healthy Douglas-fir trees. Douglas-fir mortality fell to less than five acres on the Bandelier National Monument. Ponderosa pine mortality decreased on both lands, and white fir mortality was not detected on either property. Western spruce budworm defoliated 1,380 acres in mixed conifer stands, an increase from last year's 150 acres. Defoliation of aspen remained at the same levels as last year.

Tonto National Forest and Surrounding Lands

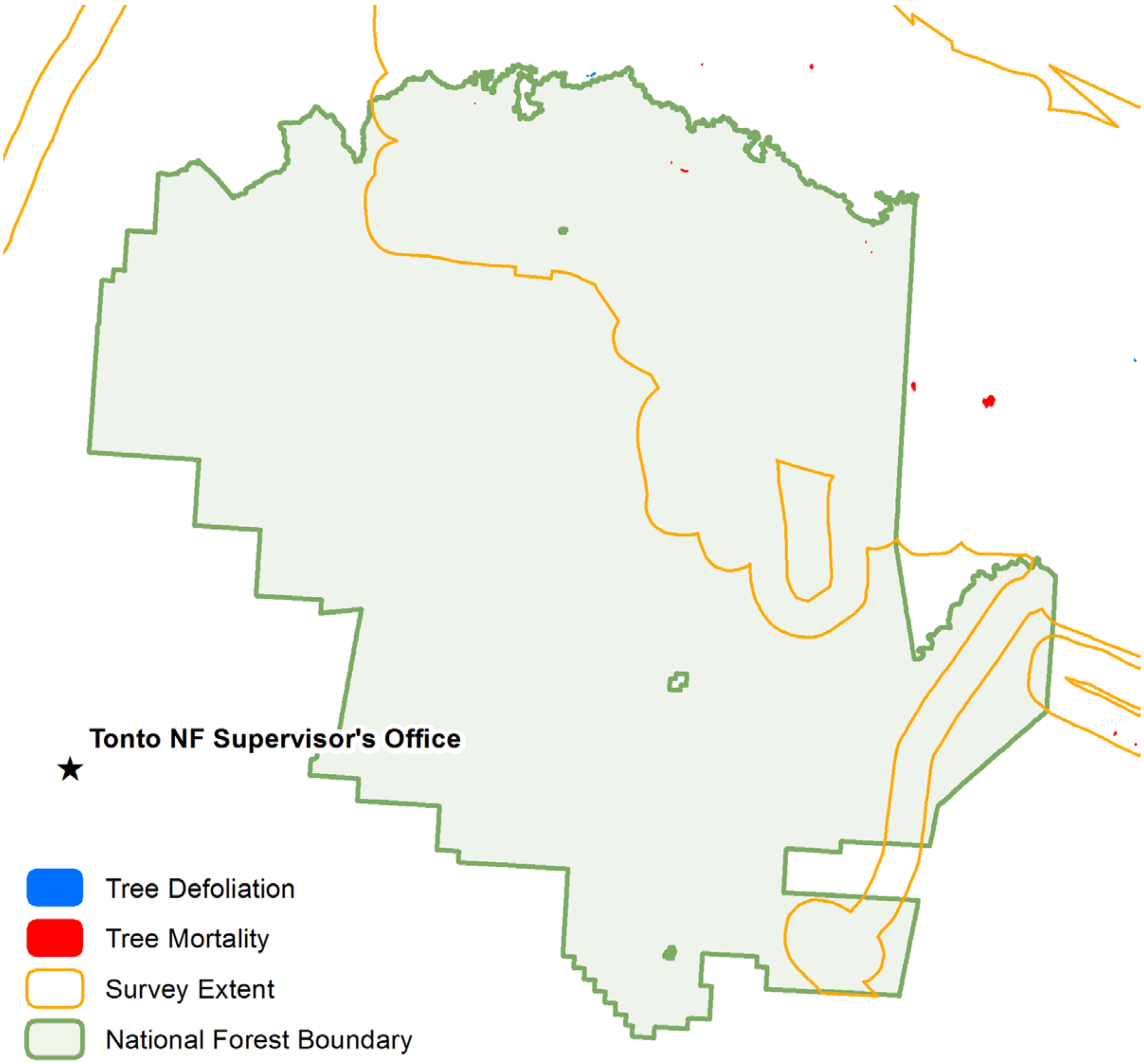


Figure 27. Only small pockets of tree mortality were observed during aerial detection surveys on the Tonto National Forest.

A slight decrease in ponderosa pine and Chihuahua pine mortality attributed to bark beetles was observed during the 2017 aerial detection survey. Approximately 140 acres were impacted with pine mortality in 2017 compared to 150 acres detected during 2016 (Table 2, Figure 27). Of the 140 acres affected, 89% (120 acres) were classified as very lightly damaged (1-3% trees injured) in the aerial survey polygons. The majority of the damage was observed on the Payson Ranger District just west of Tonto Village near Pyeatt Draw.

Only minor amounts of tree mortality were observed on the Tonto in 2017. In pinyon-juniper forests, 10 acres of tree mortality were mapped with most of the mortality impacting the pinyon trees (Table 4). Most of the pinyon damage was mapped as single tree mortality distributed evenly across the Pleasant Valley Ranger District.

Department of Interior and Tribal Lands

Grand Canyon National Park

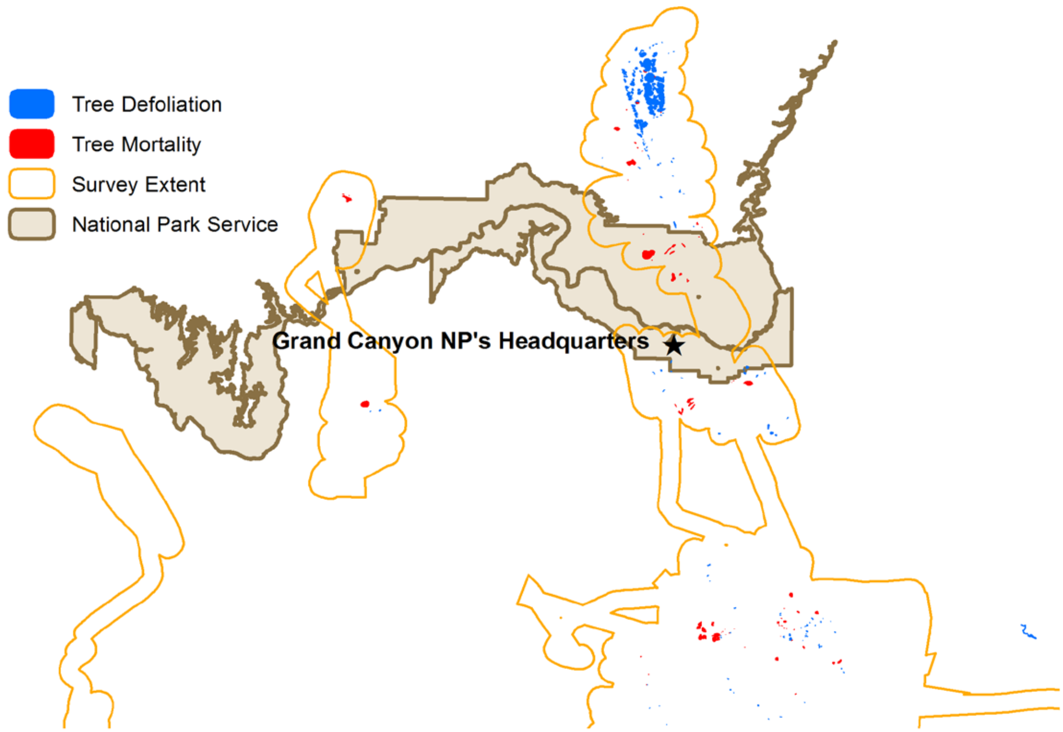


Figure 28. Defoliation caused by pandora moth caterpillars was the largest injury event near the Grand Canyon National Park.

Approximately 2,570 acres within Grand Canyon National Park were recorded with ponderosa pine mortality during the 2017 aerial detection survey (Table 2). This is an increase from the 1,360 acres mapped in 2016. Although tree mortality has increased, it is light and scattered on the landscape (Figure 28). Most of the damage (94%, 2,400 acres) was observed on the Kaibab Plateau east of Kanab Canyon. Of the total ponderosa mortality, 96% of the affected area was classified as very light (1-3% of the trees within the damage area impacted).

San Carlos Apache and White Mountain Apache Tribal Lands and Surrounding Lands

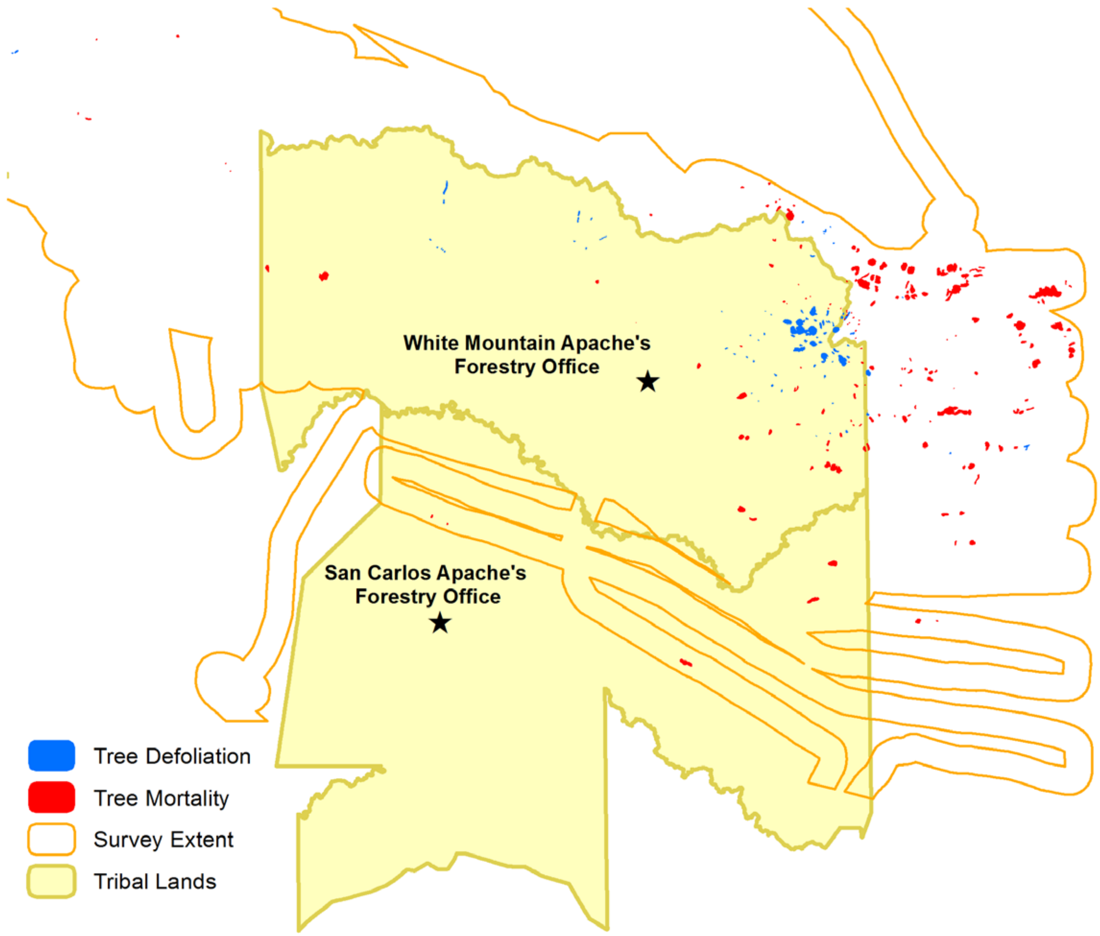


Figure 29. Tree defoliation and mortality mapped on the San Carlos Apache and White Mountain Apache lands. An increase in spruce aphid populations caused high levels of defoliation of Engelmann spruce on White Mountain Apache lands.

The total area impacted with ponderosa pine mortality decreased from 28,460 acres mapped in 2016 to 1,180 acres detected in 2017 on San Carlos Apache Tribal Land (Table 2). The majority of the damage was located on the Natanes Mountains and the Natanes Plateau (Figure 29). Of the total acres impacted, 95% (1,110 acres) were classified as very light, meaning only 1-3% of the trees within the affected area were impacted.

Aerial surveyors mapped 3,170 acres with ponderosa pine mortality on White Mountain Apache Tribal Lands (Table 2). This is a decrease from the 13,210 acres mapped in 2016. From the total acres impacted, 97% (2,360 acres) of the tree mortality was classified as very light (1-3%). White fir mortality was lower in 2017, with 130 acres impacted compared to 550 acres in 2016. Western balsam bark beetle attacks on true firs decreased from 1,280 acres in 2016 to 4 acres recorded in 2017. Douglas-fir beetle-caused mortality on Douglas-fir decreased from 500 acres in 2016 to 100 acres mapped in 2017.

The largest impact to forests on White Mountain Apache Tribal Lands was attributed to spruce aphid (Table 43, Figure 30). Defoliated Engelmann spruce trees were mapped on 4,860 acres of White Mountain Apache Tribal Land. This is a decrease from the 30,430 acres mapped in 2016 (Appx1.F). Of the 4,860 acres impacted, 15% (710 acres) were classified as light, 37% (1,810 acres) had moderate damage, 31% (1,520 acres) had severe damage, and 2% (820 acres) were classified as very severely defoliated. Although the number of acres impacted decreased in 2017, the impacts from 2015 and 2016 were severe. Thirty percent of defoliated spruce trees that were monitored in ground plots around Mount Baldy were dead by fall of 2017. These impacts are also affecting the Sunrise Ski Resort.

Figure 30. Defoliation from spruce aphid (reddish tint on living trees) decreased in 2017 on Mount Baldy.

Other Tribal and Federal Lands in Arizona

Hualapai Tribal Lands

Ponderosa pine mortality increased in 2017 to 770 acres compared to 30 acres mapped in 2016 (Table 2). Approximately 96% (740 acres) of the total pine mortality was observed in Laguna Valley, one mile west of Laguna Lake. The single 740 acre damage area was categorized as very light with only 1-3% of the trees within the polygon impacted. The rest of the damage was observed as single tree mortality evenly distributed across Hualapai Tribal Lands.

Defoliation caused by pinyon needle scale feeding was observed across 50 acres during 2017 (Table 3). The damage was observed roughly 1.5 miles south of Laguna Lake in Laguna Valley. Infestations can cause needles to turn yellow and drop. Repeated attacks can cause reduced growth and stunted needles. In severe outbreaks, small trees may be killed.

Hopi Tribal Lands

Pinyon defoliation attributed to pinyon needle scale was detected across 310 acres on Hopi Tribal Lands. The damage was observed on the eastern slopes of Big Mountain and across Sheep Valley.

On the Navajo-Hopi Joint Use Area, pinyon needle scale was detected on 10 acres in White Neck Valley. This is an increase from last year for both areas because no pinyon needle scale damage was detected during the 2016 aerial detection survey.

Canyon de Chelly National Monument

Red band needle blight was detected across approximately 50 acres of Canyon de Chelly National Monument. The damage extended an additional 300 acres onto neighboring Navajo Tribal Lands. More specifically, the damage is located on Middle Mesa near Black Rock Butte. Climate conditions determine when and where this disease occurs. Needles are infected during rainy periods by rain splashed spores. During wet years, several cycles of infection can occur. Several consecutive years of severe infection may result in reduced tree growth or mortality.

Sunset Crater National Monument

During the 2016/2017 winter, a significant wind event occurred around Sunset Crater National Monument blowing down many ponderosa pines. The majority of the damage (330 acres) occurred just outside of the park between O'Leary Peak and Black Mountain, although several downed trees were observed within the National Monument.

State and Private Lands

Honey locust borer and ash bark beetle were the most prevalent insects injuring and killing honey locust and velvet ash, respectively, in the urban forests of Santa Fe and Albuquerque, New Mexico. Honey locust borer attacks only honey locust, a common ornamental planting in both cities. The wood borer was commonly associated with stressed trees (e.g., lack of water and restricted growing space), causing branch dieback and mortality. Ash bark beetle caused crown dieback and tree mortality primarily in Albuquerque. The bark beetle is the most common pest on ash in the two cities.

Invasive Species

Invasive Species and Disease Threats in the Southwest

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 6 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) can also seriously impact native species. Further information on invasive species associated with national forests in the Southwestern Region may be found at http://www.fs.usda.gov/main/r3/forest-grasslandhealth/invasivespecies.

Table 6. 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*	White pine species
Terrestrial Plants	Buffelgrass, *Cenchrus ciliaris*	Sonoran Desert plant communities
	Cheatgrass, *Bromus tectorum*	Grasslands and shrublands
	Giant cane, *Arundo donax*	Waterways and riparian areas
	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

Buffelgrass (*Cenchrus ciliaris*) is the single greatest invasive threat to the Sonoran Desert in the Southwestern Region (Figure 31). 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 can out-compete 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.

Figure 31. Bufflegrass (USDI National Park Service photo).

The Coronado National Forest 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 32. 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 32). 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 highly aggressive and very adaptable, 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 can also alter soil carbon:nitrogen ratios and the composition of soil microbial communities, including arbuscular mycorrhizae. This transformation in soil properties can inhibit growth of native plant species. In addition, yellow bluestem-infested areas can be relatively unsuitable for nesting, brood rearing or year-round habitat for grassland bird species. The lower bird numbers may reflect decline in arthropod abundance and/or biomass.

Yellow bluestem has become invasive in native grasslands and pastures in the Midwest, southcentral Arizona, and the southern Great Plains (Oklahoma, Texas and eastern New Mexico). Currently, yellow bluestem is not listed on state noxious weed lists for either Arizona or New Mexico. However, the species 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 (mainly, 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


Figure 33. Saltcedar leaf beetle (USDA APHIS photo by Robert Richard).

One of the most widely distributed invasive species in Region 3 is saltcedar (*Tamarix* spp.), which occurs as either a shrub or tree along many waterways and riparian areas. In 2001, several species of the tamarisk leaf beetle (*Diorhabda* spp.) from central Eurasia were released in western states as a host-specific biocontrol agent (Figure 33). 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 the saltcedar leaves to dry out and turn brown while remaining on the stem; hence, the overall brown coloration commonly seen in affected saltcedar stands.

Since their release, different species of *Diorhabda* have migrated throughout much of Arizona and New Mexico. The Arizona and New Mexico FHP Zones began mapping saltcedar defoliations in 2012. The Arizona Zone conducts detection flights for defoliated stands while the New Mexico Zone records them only when observed during commuter flights to and from survey areas. Current distributions of the *Diorhabda* beetle may be found at the website of RiversEdge West (formerly, the Tamarisk Coalition) at https://www.riversedgewest.org/sites/default/files/files/2016_Yearly_Distribution_Map(1).jpg.

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), resource conservation districts (RCDs), 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 integrated weed management (IWM) principles 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 2017

Forest Health Regional Training

Forest Health Protection 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 2017, the regional insect and disease training was held at the Southwestern Regional Office, but the majority of the training was held in the forest on the Sandia and Mountainair Ranger Districts, Cibola National Forest. Annually, the location of the training alternates between Arizona and New Mexico.

For more information, contact Tom W. Coleman

Finding the Balance Between Economic Feasibility and the Risk to Forest Health From in-Forest Drying Practices

In 2017, we began working on a project in coordination with the Four Forest Restoration Initiative monitoring group, Northern Arizona University, The Nature Conservancy, City of Flagstaff, Arizona State Lands, and Campbell Global.

The project is designed to assess the effect of whole tree bundling on drying rates by monitoring moisture content in stem and branch samples from the bundles. Our objective is to determine the optimal drying rates of bundled trees, which either have been delimbed or left intact (branches retained) (Figure 34). We will also assess insect community structure and temporal effects of treatments on potential bark beetle outbreaks. Our goal is to produce management guidelines to optimize seasonally-adjusted drying times while mitigating the risk of bark beetle outbreaks.

Background: Industry has requested that trees be cut and piled with limbs and foliage attached. This material will remain in the field for 30-60 days before additional handling and transport. The whole-tree “bundling” process is 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. However, drying rates may vary depending on species and on environmental variables, such as temperature, precipitation and relative humidity. Further questions remain as to how bundling will affect insect abundances and communities. During the summer, the time period of 30-60 days post-cutting will allow most bark beetle species to complete their development, but the natural enemy and wood borer complex will not complete their development and will be removed with the harvested materials. At a larger landscape scale, the buildup of beetle populations (combined with the likely removal of natural enemies) has the potential to result in beetle outbreaks and increased tree mortality.

Figure 34. In 2017, bundles of trees were monitored at two different sites in northern Arizona. In addition, paired, felled trees with branches and without were monitored for bark beetle attack and drying rates. Preliminary result suggest that beetles prefer shaded areas of the tree and tree moisture remains relatively constant during the monsoon season. Work will continue in 2018.

Products:

1. Determine the optimal drying rates of tree bundles (time of year, length of time in the field)
2. Determine the best time to bundle to reduce insect population build up
3. Produce management guidelines – maximize drying and minimize insect threats
4. Outreach presentations and peer-reviewed publications

For more information, contact Monica Gaylord

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 a 10 year interval. The fourth re-measure of the plot network was initiated in 2017 in Arizona. 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 is collected on status (live or dead), severity of infection, height, diameter, presence of regeneration, and presence of other pathogens which may impact the health of the tree. This 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 Nick Wilhelmi

Aspen Monitoring Project

Figure 35. Aspen sucker displaying signs of repeated browsing.

Figure 36. Uninfested aspen (left) next to an infested aspen (right) with oystershell scale in Arizona.

Aspen decline has been occurring in the western U.S. for the latter half of the twentieth century and continues into the present. 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 role. Although aspen has shown recovery in much of the western U.S., accelerated decline, dieback, and mortality of aspen continues to occur in northern Arizona, raising concern among forest managers. At the request of the Williams Ranger District on the Kaibab National Forest, and the Flagstaff and Mogollon Rim Ranger Districts on the Coconino National Forest, Arizona Zone of Forest Health Protection initiated an aspen monitoring project to map and monitor the health of aspen on those districts. Data were collected using aerial survey techniques, including the location of aspen stands, level of overstory mortality, and level of conifer encroachment. Using these data, a monitoring plot network was established on the Mogollon Rim Ranger District to monitor tree mortality, regeneration and recruitment success, and the impacts of insects/diseases and ungulates on aspen. Monitoring plot networks will be established or expanded as necessary on the Flagstaff and Williams Ranger Districts in the future. Preliminary data from the Mogollon Rim Ranger District indicates a complete lack of recruitment due to heavy browse pressure. Nearly 100% of aspen regeneration was browsed and there was no recruitment over 4 feet (Figure 35). This has led to an even-aged, over-mature aspen component in these forests, which are less resilient to insects and diseases as well as abiotic stressors. Similar trends have been observed on both the Williams and Flagstaff Ranger Districts. In addition, high populations of oystershell scale have been noted on all three of these ranger districts and both inside and outside elk enclosures (Figure 36). If these trends continue, aspen will likely be extirpated from much of its current range on these Forests other than within enclosures or on steep slopes.

For more information, contact Nick Wilhelmi

White Pine Blister Rust Genetic Resistance

Figure 37. Planting white pine blister rust-resistant southwestern white pine seedlings on the Mescalero Apache Indian Reservation for long-term durability monitoring.

In 2017, Southwestern Region Forest Health Protection 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 done in collaboration with Dr. Kristen Waring of Northern Arizona University and Dr. Owen Burney of New Mexico State University. In 2017, the planting of the first of two long term southwestern white pine test sites was completed (Figure 37). These are long term, fenced test sites that will be used to evaluate the durability of various disease resistance mechanisms. There were 278 seedlings planted this year in the test site on Mescalero Apache Tribal Lands in the Sacramento Mountains of New Mexico, with more seedlings to be added in the future. Preparation has begun for the planting of the second test site, which will be located on the Apache–Sitgreaves National Forests. This site will include 40 seedlings per family from 25 families with varying levels of disease resistance or susceptibility. The fence is anticipated to be built in the spring of 2018, and planting will follow in mid to late summer. In addition, FHP collected scion from eight new parent trees 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 Nick Wilhelmi

Biological Evaluations and Technical Assistance

Arizona Zone

Gaylord, M.L. 2017. Risk of Bark Beetle Outbreaks and Mitigation during Thinning Operations, Flagstaff RD, Coconino NF. AZ-FHP-17-2.

Gaylord, M.L. 2017. Post-windstorm Evaluation of Bark Beetle Risks at the Rose Canyon Campground, Coronado NF.

Wilhelmi, N. 2017. Rustler Park Insect and Disease Site Visit, Coronado NF.

Grady, A. 2017. Oystershell Scale Impacts and Mitigation Options on the Kaibab and Coconino NFs. AZ-FHP-17-3.

Wilhelmi, N. 2017. Site Visit Red Rock Ranger District, Coconino NF, Sycamore Anthracnose.

Gaylord, M.L. 2017. Assessment of Bark Beetle Activity and Risk of Outbreak at the Grand Canyon National Park, South Rim Village. AZ-FHP-17-4.

Gaylord, M.L. and N. Wilhelmi. 2017. Biological Evaluation for Joseph Varnado's Silvicultural Certification Stand, North Kaibab RD, Kaibab NF. AZ-FHP-17-5.

Gaylord, M.L. and N. Wilhelmi. 2017. Biological Evaluation for Josh Giles's Silvicultural Certification Exam, Williams RD, Kaibab NF. AZ-FHP-17-7.

Gaylord, M.L. and N. Wilhelmi. 2017. Greens Peak Project Biological Evaluation – Springerville RD, Apache-Sitgreaves NF. AZ-FHP-17-9.

Gaylord, M.L. and N. Wilhelmi. 2017. Biological Evaluation for the Black River Treatment Area, Alpine and Springerville RD's, Apache-Sitgreaves NF. AZ-FHP-17-10.

Gaylord, M.L. 2017. Evaluation of Bark Beetle Activity and Impacts within the Wallow Fire. Alpine and Springerville RD's, Apache-Sitgreaves NF. AZ-FHP-18-1.

Wilhelmi, N. 2017. Hazard Tree Evaluation Post 2017 Frye Fire, Safford RD, Coronado NF. AZ-FHP-18-2.

Gaylord, M.L. 2017. Snowbowl Spruce Beetle Suppression Project, Post-Project Review, Flagstaff RD, Coconino NF. AZ-FHP-18-3.

Grady, A. and N. Wilhelmi. 2017. Biological Evaluation for Mary Price's Silvicultural Certification Stand, Mogollon Rim RD, Coconino NF. AZ-FHP-18-4.

New Mexico Zone

Jacobs, J.J. 2016. Evaluation of Bandelier National Monument Tree Failure Incident. Biological Evaluation. NM-FHP-1-17.

Graves, A.D. and T.W. Coleman. 2016. Assessment of Bark Beetle Activity in Douglas-fir and Ponderosa Pine Trees in the History Grove at the Valles Caldera National Preserve. Biological Evaluation. NM-FHP-2-17.

Graves, A.D. and T.W. Coleman. 2016. Douglas-fir tussock moth activity on Sandia Ranger District. Biological Evaluation. NM-FHP-3-17.

Graves, A.D. and T.W. Coleman. 2016. Follow-up Survey of Douglas-fir Tussock Moth activity on the Santa Fe National Forest, Pecos/Las Vegas Ranger District. Biological Evaluation. NM-FHP-4-17.

Jacobs, J.J. 2017. Tree Risk Assessment and Evaluation of Tree Health in Montezuma Castle National Monument. Biological Evaluation. NM-FHP-5-17.

Graves, A.D. 2017. Assessment of the Bluewater Treatment Area on the Sacramento Ranger District, Lincoln National Forest. Biological Evaluation. NM-FHP-6-17.

Reynolds, G. 2017. Evaluation of insect and disease activity for Marisa Bowen's silvicultural demonstration stand. Biological Evaluation. NM-FHP-7-17.

Reynolds, G. 2017. Evaluation of Southwestern dwarf mistletoe on Brushy Mountain for Acoma Pueblo. Biological Evaluation. NM-FHP-8-17.

Reynolds, G. 2017. Evaluation of Zia Pueblo forest health in Borrego Canyon. Biological Evaluation. NM-FHP-9-17.

Reynolds, G. 2017. Evaluation of FY2018 Forest Health Suppression project on the Mescalero Apache Reservation. Biological Evaluation. NM-FHP-10-17.

Reynolds, G. 2017. Evaluation of insect and disease activity for South Fork Campground, Smokey Ranger District. Biological Evaluation. NM-FHP-11-17.

Graves, A.D. and G. Reynolds. 2017. Evaluation of Ojo Redondo Pines. Biological Evaluation. NM-FHP-12-17.

Graves, A.D. and T.W. Coleman. 2017. Evaluation of Douglas-fir tussock moth outbreak on the Sandia Mountains. Biological Evaluation. NM-FHP-13-17.

Reynolds, G. 2017. Evaluation of FY2017 and FY2018 Forest Health Suppression projects on the Jicarilla Apache Reservation. Biological Evaluation. NM-FHP-14-17.

Graves, A.D. and G. Reynolds. 2017. White Sands Missile Range Forest Health Assessment. Biological Evaluation. NM-FHP-15-17.

Peer Reviewed Publications

Hansen, E.M., A.S. Munson, D.C. Blackford, **A.D. Graves**, **T.W. Coleman**. L.S. Baggett. 2017. 3-methylcyclohex-2-en-1-one for area and individual tree protection against spruce beetle (Coleoptera: Curculionidae: Scolytinae) attack in southern Rocky Mountains. *Journal of Economic Entomology* 110: 2140-2148

Chen, Y. P.L. Dallara, L.J. Nelson, **T.W. Coleman**, S.M. Hishinuma, D. Carrillo, S.J. Seybold. 2017. Comparative morphometric and chemical analyses of phenotypes of two invasive ambrosia beetles (*Euwallacea* spp.) in the United States. Insect Science 24: 647-662

Coleman, T.W., S.L. Smith, M.I. Jones, **A.D. Graves**, B.L. Strom. 2017. Efficacy of systemic insecticides for control of the invasive goldspotted oak borer (Coleoptera: Buprestidae) in California. *Journal of Economic Entomology* 110: 2129-2139

Gordon, T.R. and **Reynolds, G.J.** 2017. Plasticity in plant-microbe interactions: a perspective based on the pitch canker pathosystem. Phytoparasitica 45:1-8 (DOI: 10.1007/s12600-016-0558-6)

H.D. Adams, M.J.B. Zeppel, W.R.L. Anderegg, H. Hartmann, S.M. Landhäusser, D.T. Tissue, T.E. Huxman, P.J. Hudson, T.E. Franz, C.D. Allen, L.D.L. Anderegg, G.A. Barron-Gafford, D.J. Beerling, D.D. Breshears, T.J. Brodribb, H. Bugmann, R.C. Cobb, A.D. Collins, L.T. Dickman, H. Duan, B.E. Ewers, L. Galiano, D.A. Galvez, N. Garcia-Forner, **M.L. Gaylord**, M.J. Germino, A. Gessler, U.G. Hacke, R. Hakamada, A. Hector, M.W. Jenkins, J.M. Kane, T.E. Kolb, D.J. Law, J.D. Lewis, J.M. Limousin, DM. Love, A.K. Macalady, J. Martínez-Vilalta, M. Mencuccini, P.J. Mitchell, J.D. Muss,M.J. O'Brien, A.P. O'Grady, R.E. Pangle, E.A. Pinkard, F.I. Piper, J.A. Plaut, W.T. Pockman, J. Quirk, K. Reinhardt, F. Ripullone, M.G. Ryan, A. Sala, S. Sevanto, J.S. Sperry, R. Vargas, M. Vennetier, D.A. Way, C. Xu, E.A. Yepez and N.G. McDowell. 2017. A multi-species synthesis of physiological mechanisms in drought-induced tree mortality. *Nature, Ecology and Evolution* 1:1285-1291 (DOI: 10.1038/s41559-017-0248-x)

Wilhelmi, N.P., D.C. Shaw, C.A. Harrington, J.B. St.Clair, L.M. Ganio. 2017. Climate of seed source affects susceptibility of coastal Douglas-fir to foliage diseases. Ecosphere 8 (DOI: e02011.10.1002/ecs2.2011)

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.

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

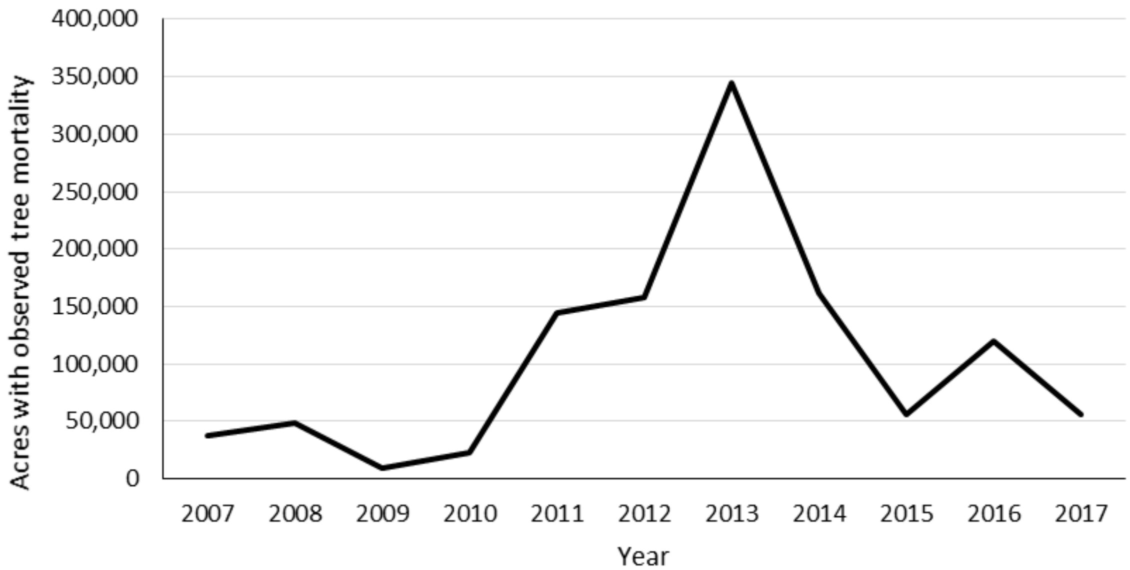
Allen White (505) 842-3280

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. 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 for managing invasive plants and development of methodology to control invasive buffelgrass in southern Arizona.

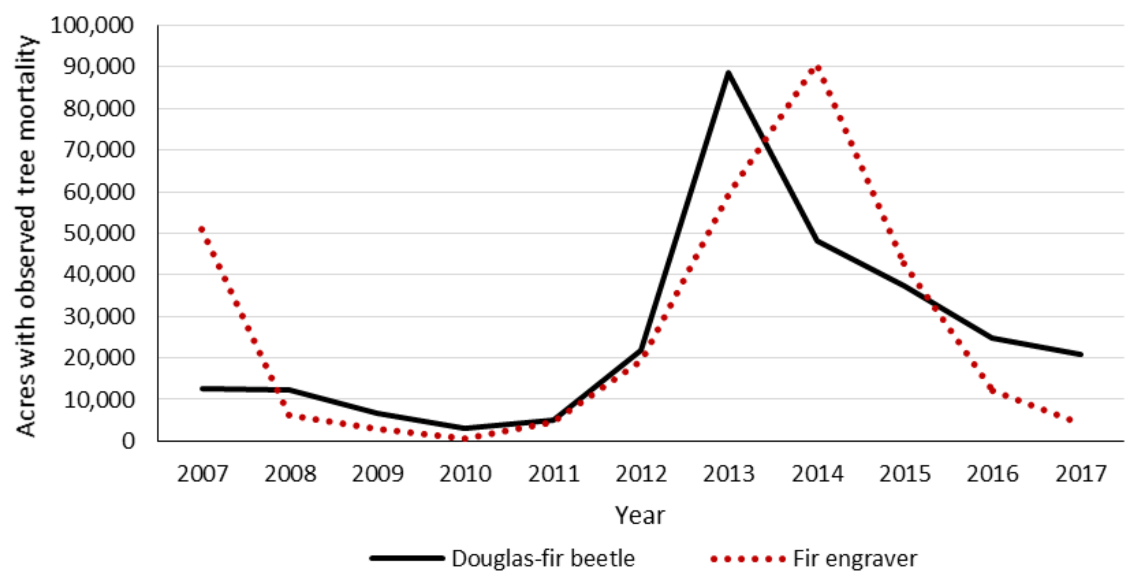
Appendix 1: Historical Pest Trend Data

Tree mortality from bark beetles (A: ponderosa pine, B: mixed conifer, C: pinyon-juniper, and D: spruce-fir) and defoliation (E, F: spruce-fir) observed from 2007 to 2017 in the major forest types in the Southwestern Region.

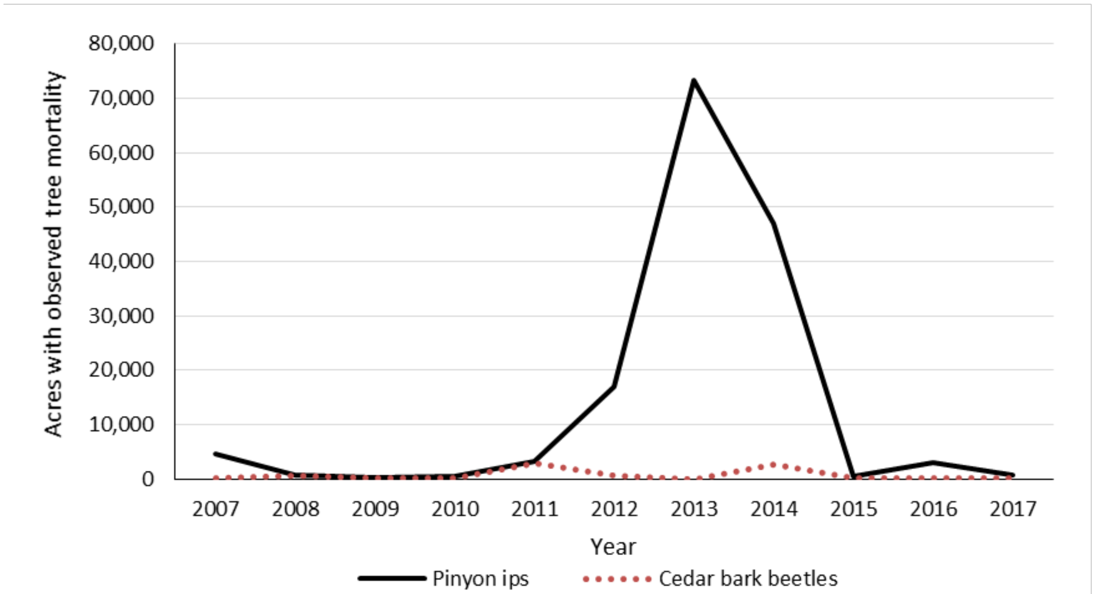
A: Ponderosa pine mortality attributed to bark beetles in the Southwestern Region.



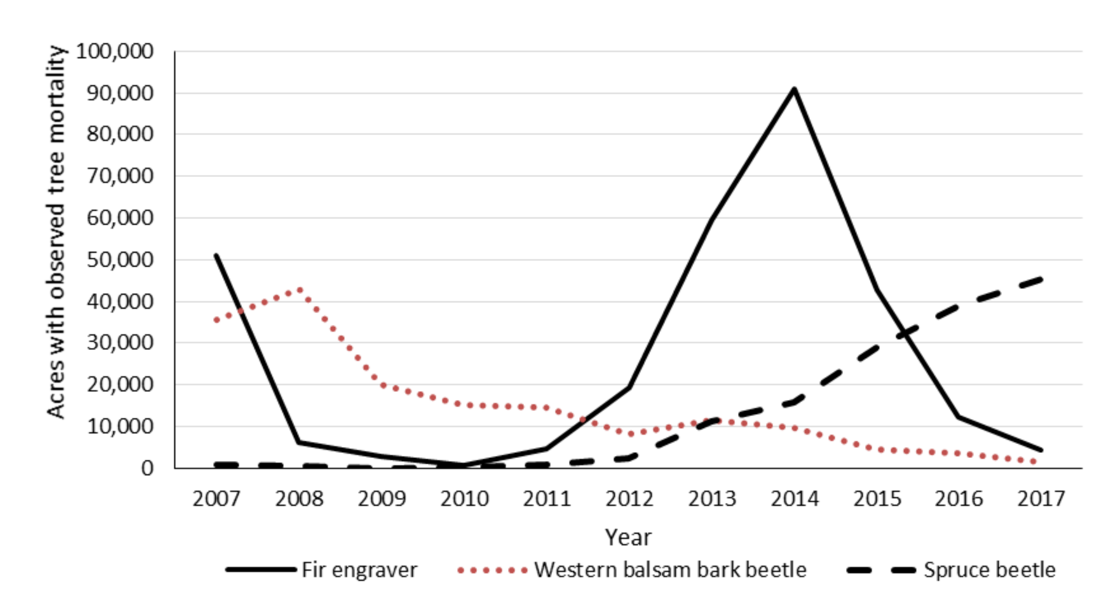
B: Mixed conifer mortality associated with bark beetles in in the Southwestern Region.



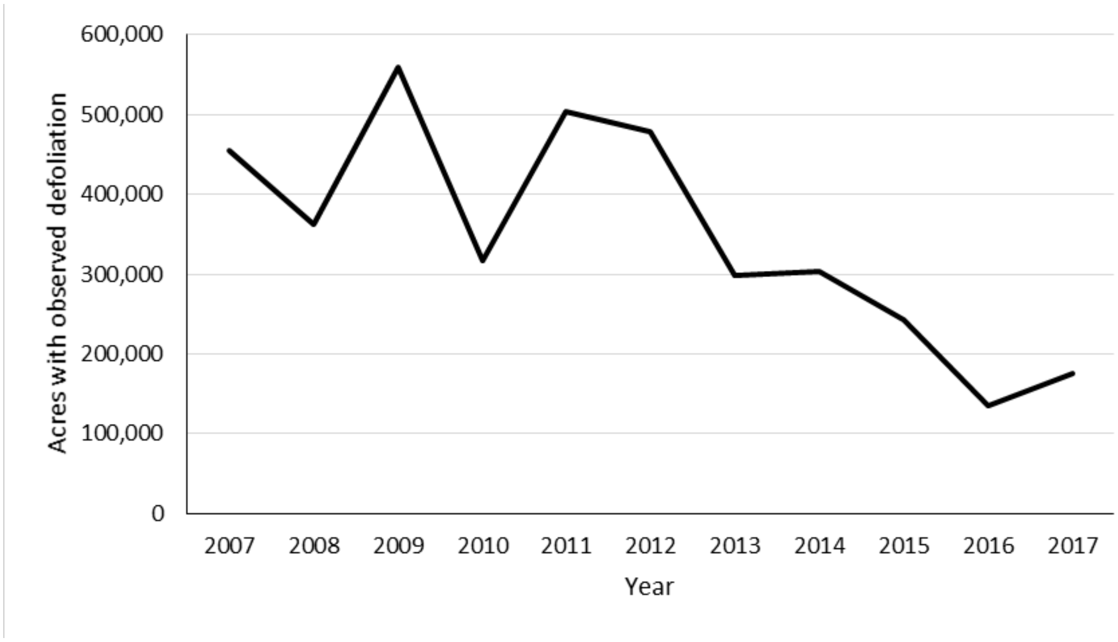
C: Pinyon-juniper mortality associated with pinyon ips and cedar bark beetles in the Southwestern Region.



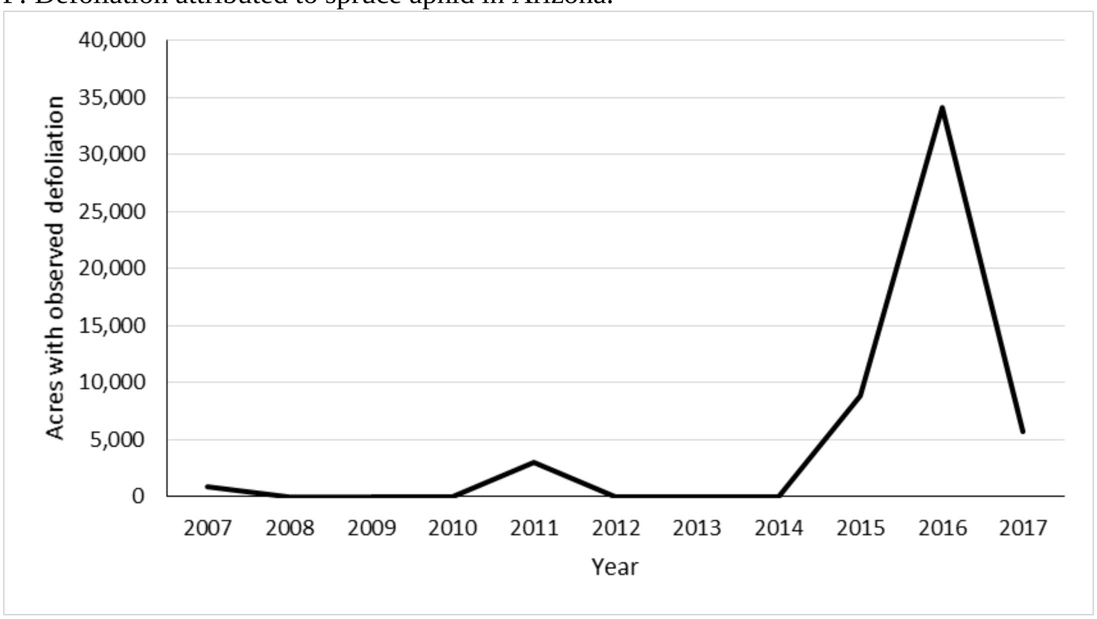
D: Tree mortality in spruce-fir forests attributed to bark beetles in the Southwestern Region.



E: Defoliation attributed to western spruce budworm in the Southwestern Region.



F: Defoliation attributed to spruce aphid in Arizona.



Appendix 2: Species index

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

Insects		Diseases	
Cedar bark beetles	*Phloeosinus* spp.	Armillaria or shoestring root rot	*Armillaria* spp.
Cone beetles	*Conophthorus* spp.	Black canker	*Ceratocystis fimbriata*
Douglas-fir beetle	*Dendroctonus pseudostugae*	Black leaf spot	*Drepanopeziza populorum*
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 lopper	*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 irregular, H. occidentale*
Pandora moth	*Coloradia pandora*	Hypoxylon canker	*Entoleuca mammata*
Pine coneworm	*Dioryctria auranticella*	Indian paint fungus	*Echinodontium tinctorium*
Pine engravers	*Ips* spp.	Ink spot leaf blight	*Ciborinia whetzelii*
Pine needle scale	*Chionaspis pinifoliae*	Limb rust	*Cronartium arizonicum*
Pine sawflies	*Neodiprion* spp., *Zadiprion* spp.	Lophodermella needle casts	*Lophodermella* spp.
Pine-feeding needleminers	*Coleotechnites* spp.	Melampsora rust	*Melampsora* spp.
Pinyon ips	*Ips confusus*	Pinyon needle rust	*Coleopsorium jonesii*
Pinyon needle scale	*Matsucoccus acalyptus*	Pouch fungus	*Cryptoporus volvatus*
Ponderosa pine seedworm	*Cydia piperana*	Red band needle blight	*Dothistroma septosporum*
Red turpentine beetle	*Dendroctonus valens*	Red belt fungus	*Fomitopsis pinicola*
Roundheaded pine beetle	*Dendroctonus adjunctus*	Red ring rot	*Porodaedalea pini*
Roundheaded wood borers	*Cerambycide*	Red rot	*Dichomitus squalens*
Spruce aphid	*Elatobium abietum*	Rhabdocline needlecast	*Rhabdocline* spp.
Spruce beetle	*Dendroctonus rufipennis*	Schweinitzii root and butt rot	*Phaeolus schweinitzii*
Tiger moth	*Lophocampa ingens*	Sooty bark canker	*Encoelia pruinosa*
Twig beetles	*Pityopthorus* spp., *Pityogenes* spp., *Pityoborus secundus*	Spruce broom rust	*Chrysomyxa arctostaphyli*
Western balsam bark beetle	*Dryocoetes confusus*	Sycamore anthracnose	*Apiognomonia veneta*
Western pine beetle	*Dendroctonus brevicomis*	Tomentosus root rot	*Onnia tomentosa*
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*
		White pine needlecast	*Lophodermella arcuata*

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.

Forest Health Mapping and Reporting Web Portal

http://foresthealth.fs.usda.gov/portal

On the portal are a number of applications for accessing forest health related information. The **Forest Pest Conditions** page is designed to be a companion to the annual Major Forest Insect and Disease Conditions reports. It provides

- A mapping interface to view the distribution of damaging forest insect and disease populations and their biological range.
- An overview of biology, current conditions, trends, and survey methods, along with photos and web links for each forest insect and disease.
- The ability to generate reports, maps, and download tabular information.

The **Data Summaries** interface provides the ability to review, query, and download tabular data for all forest insects and diseases recorded across the United States since 1997.

The **Insect and Disease Explorer** provides for download of a wide array of forest Insect and Disease Survey (IDS) maps depicting past, present, and potential future activity across the United States.

The **Forest Disturbance Mapper** (FDM) is designed for the FHP survey community to enhance their evaluation of potential forest disturbance in near real-time (16 day composites updated every 8 days) over large areas and provide critical information for survey resource allocation. The FDM application allows the user to explore and evaluate forest disturbance data and download areas for use in aerial or ground survey. Some of the main elements of the FDM are:

- Simple interface with powerful spatial functions.
- Download of data that can be uploaded into a digital mobile sketch mapping system.
- Ability to upload survey data.

Pesticide Precautionary Statement

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers—out of reach of children and pets—and away from foodstuffs.

Apply pesticides selectively and carefully. Do not apply a pesticide when there is danger of drift to other areas. Avoid prolonged inhalation of a pesticide spray or dust. When applying a pesticide it is advisable that you be fully clothed.

After handling a pesticide, do not eat, drink, or smoke until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If the pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Dispose of empty pesticide containers by wrapping them in several layers of newspaper and placing them in your trash can.

It is difficult to remove all traces of an herbicide (weed killer) from equipment. Therefore, to prevent injury to desirable plants do not use the same equipment for insecticides and fungicides that you use for an herbicide.

NOTE: Registrations of pesticides are under constant review by the Federal Environmental Protection Agency. Use only pesticides that bear the EPA registration number and carry directions for home and garden use.

Tree injury and mortality recorded in 2017 during aerial detection surveys in the Southwestrn Region.