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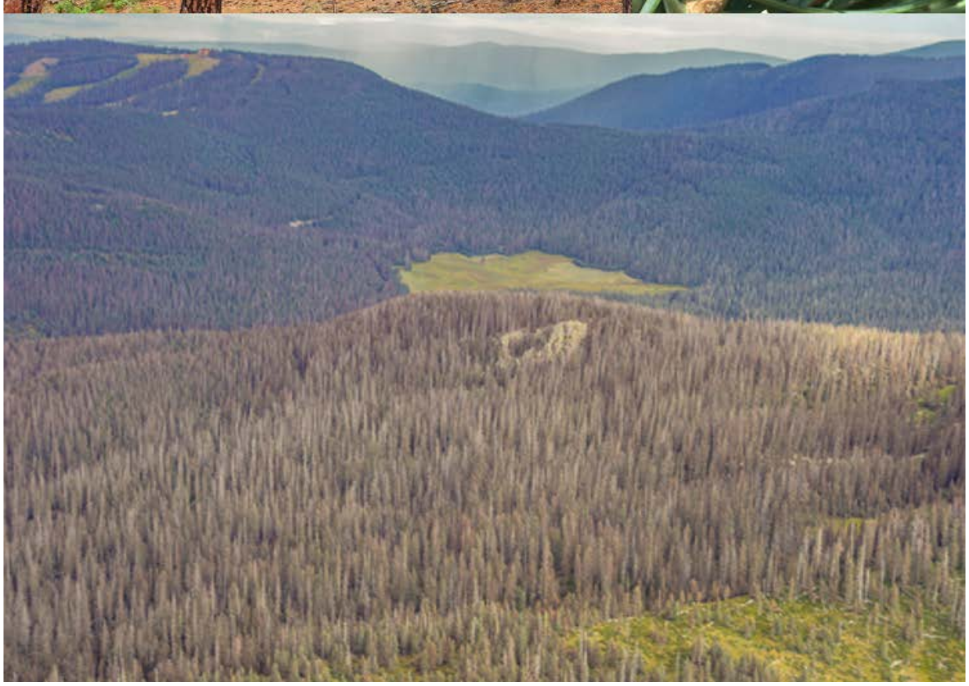
Forest Insect and Disease Conditions in the Southwestern Region, 2016





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Cover Photo: Mosaic of active defoliators in the Southwestern Region. Top left: Severe Douglas-fir tussock moth outbreak on the Santa Fe National Forest in northern New Mexico. Top right: Close up of Douglas-fir tussock moth larvae. Bottom photo: Landscape scale spruce aphid damage on White Mountain Apache Tribal Lands, eastern Arizona.

Forest Insect and Disease Conditions in the Southwestern Region, 2016

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Conditions in Brief

Weather Summary

Arizona and New Mexico recorded the second warmest year in 2016, with record high temperatures along the U.S./Mexico border. According to NOAA, Arizona and New Mexico experienced "above average" to "much above average" statewide temperature ranks during 2015 to 2016 (Figure 1A). A strong *El Nino* delivered much needed precipitation that continued to bring the Southwestern Region back to "near normal" precipitation levels; however, the Four Corners region remains dry relative to surrounding western states (Figure 1B).

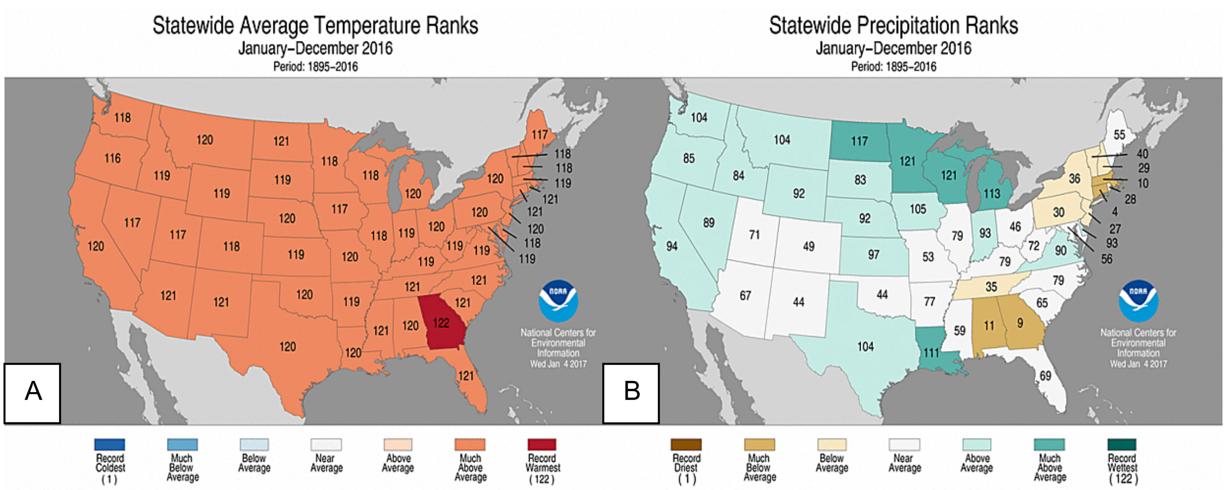

Figure 1 A. National average divisional temperature and B. precipitation ranks recorded for 2016 ***(https://www.ncdc.noaa.gov/sotc/national/201613).***

Mountain Snowpack

The dry and warm conditions at the end of winter quickly depleted mountain snowpack across the Region (Figure 2). In January, much of the west and southwest had above normal snow cover. However, by February most of the western U.S. was warmer and drier than normal. By April 1st many monitoring locations across the Mogollon Rim in Arizona and northern New Mexico recorded less than 25 percent of normal snowpack (Figure 2). April snowpack deficits have been documented in the Southwestern Region from 2012 to 2016 (USDA, NRCS Western Snowpack Conditions). These dry conditions facilitated various responses across forest insect guilds and disease types in 2016.

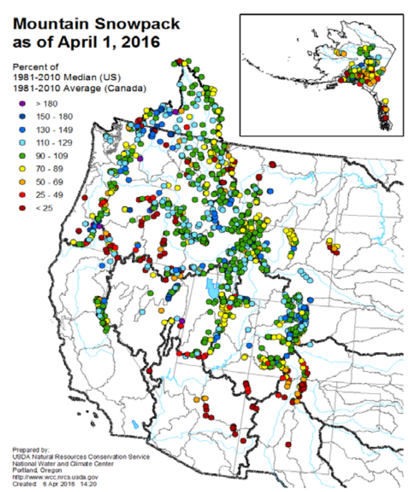

Figure 2. Mountain snowpack by April 1, 2016 was less than 25 percent of normal at many monitoring sites throughout the Region ***(https://www.wcc.nrcs.usda.gov/cgibin/westsnow.pl).***

Forest Insect and Disease Summary

The area covered by the annual forest health aerial detection surveys (ADS) remains relatively consistent from year-to-year across the Region. This approach maintains integrity of trend data, but provides flexibility to cover new client based forest health concerns across the Region. In 2016, aerial surveyors covered approximately 28 million acres (Figures 3 and 5). This is a slight increase in acres flown in 2015 due to special surveys for exotic plants (buffelgrass) and insects (spruce aphid and tamarisk leaf beetle) occurring in Arizona. Many of these special surveys occurred on tribal lands.

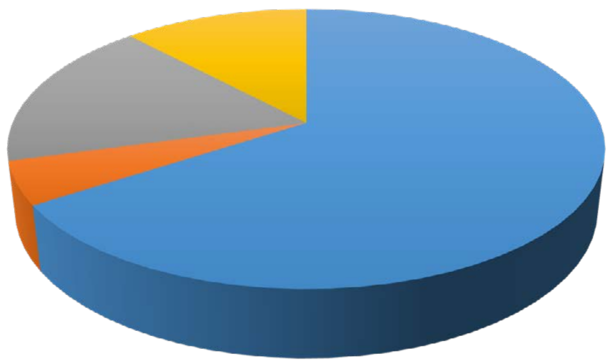

Figure 3. Aerial detection survey acres flown by land ownership in 2016, Southwestern Region (total acreage flown = 28,146,900).

The number of acres with damage (e.g., tree mortality, defoliation, discoloration, etc.) caused by insects and diseases that were observed during ADS increased from 436,000 acres in 2015 to slightly over 482,000 acres in 2016 (Tables 1-3). Western spruce budworm (WSBW) continues to affect more acres than any other agent in the Southwestern Region (Table 1). However, the number of acres detected in 2016 (135,000) with defoliation from WSBW was the lowest recorded during the past decade. Over 200,000 acres with bark beetle activity were detected during aerial surveys across all forest types in the Region (Table 1). This represents a slight increase in bark beetle activity mapped, up from 161,700 in 2015. Most of the damage occurred in ponderosa pine forests of eastern Arizona.

Tree damage detected in spruce-fir forests continued to increase across the Region. In Arizona, the spruce aphid outbreak increased in severity and extent from nearly 9,000 acres observed in 2015 to over 34,000 acres detected in 2016. Spruce beetle damage detected in northern New Mexico continued to increase from 28,770 acres detected in 2015 to over 39,000 acres in 2016. Most of this damage was mapped on the Santa Fe National Forest (NF). A 10,000 acre Douglas-fir tussock moth (DFTM) outbreak was also detected on the Santa Fe NF. Results from ground surveys indicate the population is declining.

Tree mortality in the mixed conifer forest type continued to decrease from 74,240 acres mapped in 2015 to 36,900 acres in 2016. Nearly all of the bark beetle damage recorded in the mixed conifer type was detected in New Mexico and attributed to Douglas-fir beetle.

In 2016, the most dramatic increase in number of acres mapped with tree mortality occurred in ponderosa pine forests of Arizona. In 2015, aerial surveyors observed 22,600 acres in Arizona with ponderosa pine mortality caused by bark beetles. In 2016, the number of acres with observed tree mortality in Arizona increased to nearly 100,000 acres. Urban forests in southern Arizona also suffered losses from bark beetle activity in 2016. Several years of drought conditions and ips bark beetle activity contributed to the death of many mature urban conifers in Tucson, Arizona. High levels of ponderosa pine mortality caused by bark beetles and several years of drought conditions continued on the Gila NF in New Mexico. Over 16,000 acres with ponderosa pine mortality were mapped across the Gila NF this year.

Mistletoe and root disease are not mapped via aerial surveys and we report their incidence and severity based on ground estimates, thus the numbers are consistent from year-to-year at approximately 5 million acres across the Region. Dwarf mistletoe is the most common and widespread pathogen in the Southwest. Over one-third of the ponderosa pine acreage and about one-half of the mixed conifer acreage has some level of infection and overall estimated acreage affected does not change radically from year-to-year. However, the incidence and severity of infection may be increasing in stands or on individual trees due to fire suppression and subsequent overstocked stands.

Root diseases are also widely distributed across the Region. Tree mortality associated with this group of diseases is generally found in higher elevation forests where environmental conditions are more conducive to disease expansion. *Armillaria* spp. is the most common and damaging root disease to conifers in the Southwest. Heterobasidion root disease was recently associated with elevated white fir mortality on the Sandia Ranger District (RD), Cibola NF.

White pine blister rust, caused by the exotic invasive fungal pathogen *Cronartium ribicola*, continues to cause severe damage to southwestern white pine on the Sacramento Mountains of southern New Mexico. We continue to find new areas affected by this exotic disease, primarily on higher elevation moist sites. The disease has now been documented in parts of every National Forest in New Mexico with the exception of the Carson NF. In Arizona, the rust has only been detected in the eastern portion of the state on the White Mountains.

Table 1. Prominent 2016 forest insect and disease activity (acres) observed during annual aerial detection survey in Arizona and New Mexico*.

Agent	State	National Forest	Tribal Lands	Other Federal	State & Private	Total
Ponderosa Bark Beetles	AZ	52,990	41,720	3,080	840	98,630
Mixed Conifer Bark Beetles	AZ	2,910	990	10	-	3,910
Spruce-Fir Bark Beetles	AZ	720	1,280	-	10	1,960
Western Spruce Budworm	AZ	330	-	-	-	330
Aspen Damage**	AZ	1,610	7,100	230	20	8,960
Ponderosa Bark Beetles	NM	20,090	190	150	1,050	21,480
Mixed Conifer Bark Beetles	NM	20,640	1,030	1,710	9,590	32,990
Spruce-Fir Bark Beetles	NM	33,780	1,090	20	5,540	40,430
Western Spruce Budworm	NM	94,480	3,570	300	36,320	134,670
Aspen Damage**	NM	11,180	2,960	20	10,840	25,000

* Values rounded to the nearest 10; sum of individual values may differ from totals due to rounding.

** Aspen damage includes a combination of insect defoliation and other biotic and abiotic factors causing aspen decline or mortality. See text for additional information.

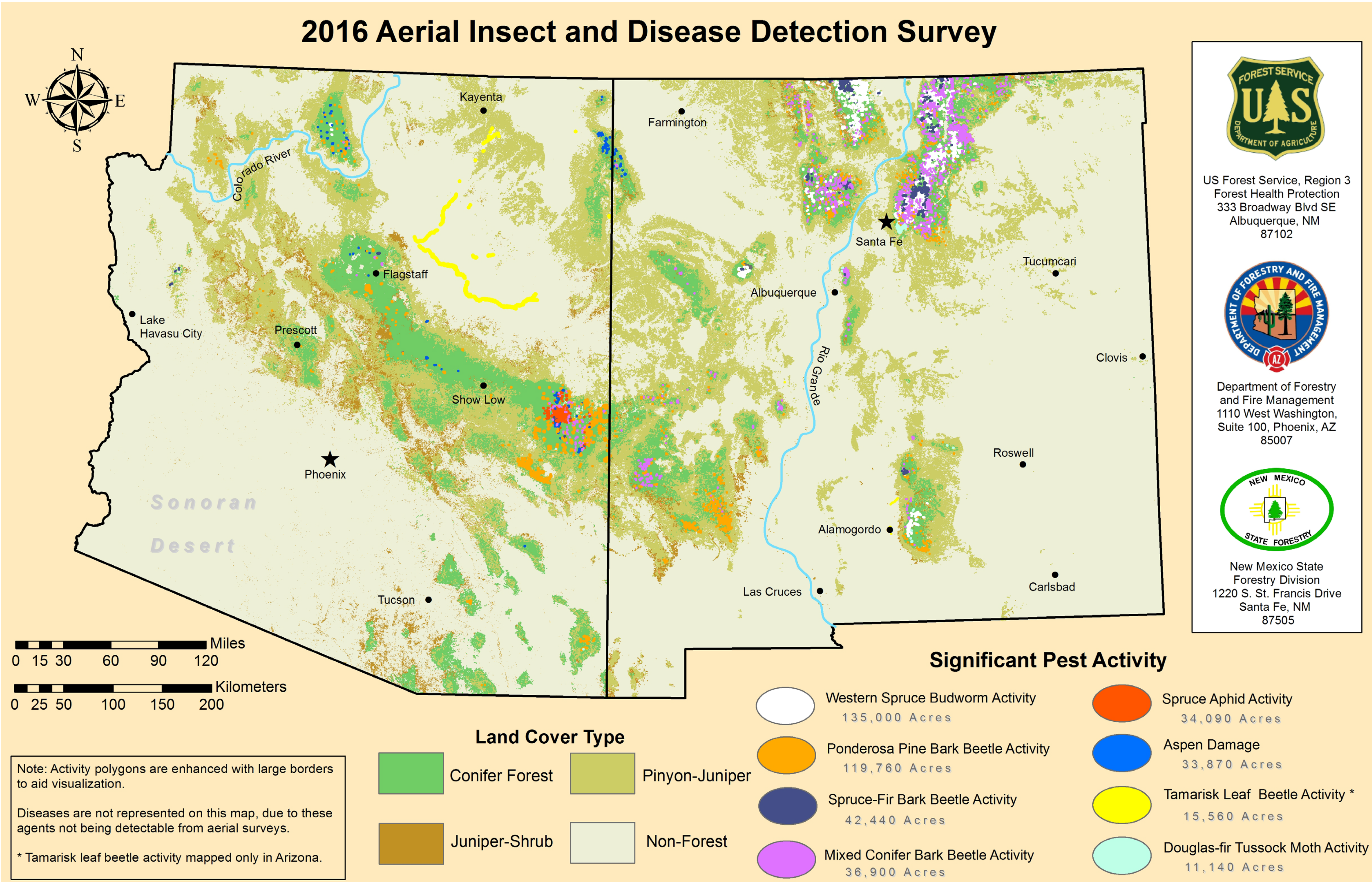

Figure 4. Map of 2016 aerial insect and disease detection survey.

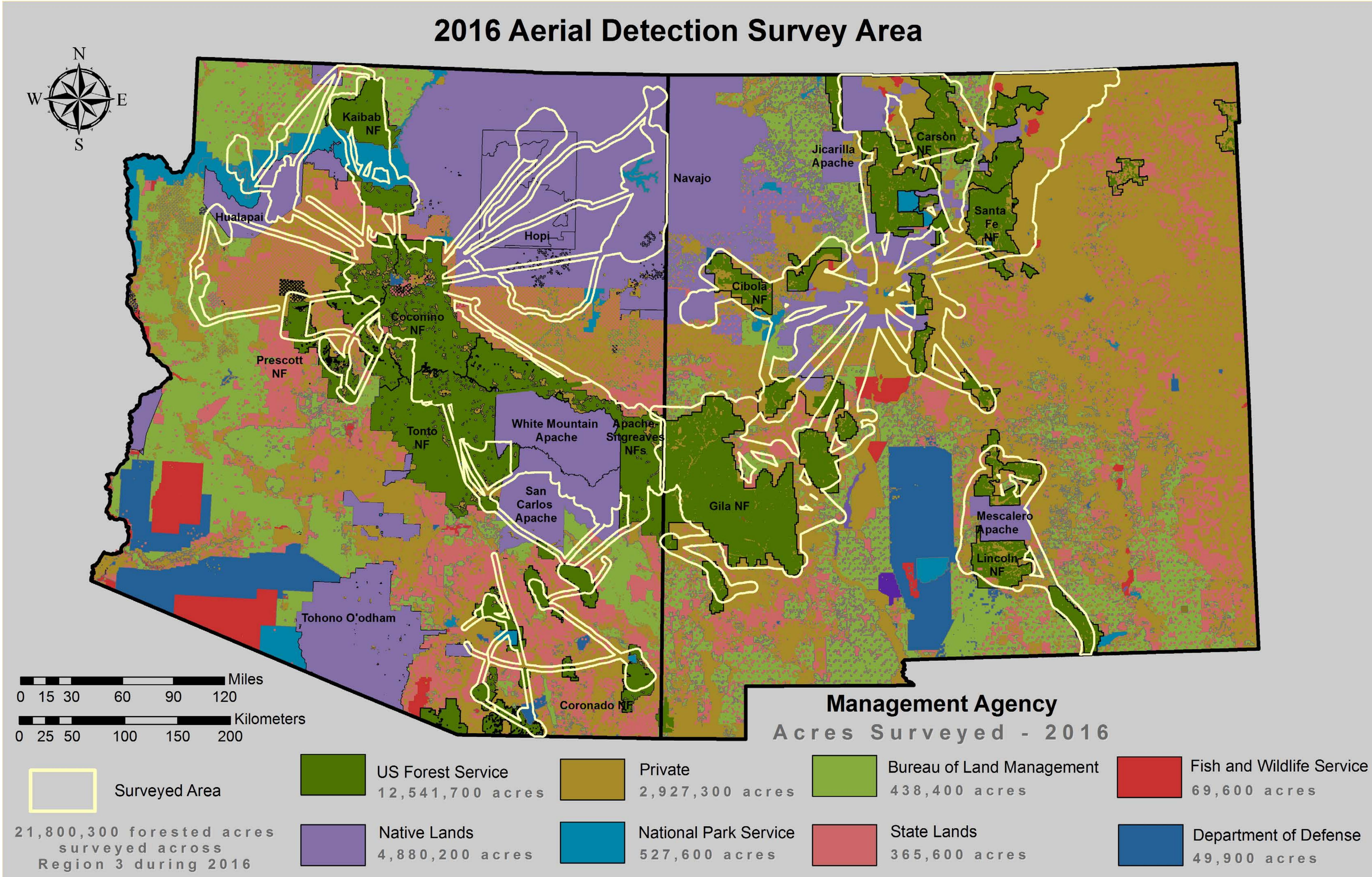

Figure 5. Map of 2016 aerial detection survey area.

Table 2. Bark beetle incidence by ownership (acres) from aerial detection surveys in 2016 in Arizona and New Mexico[1].

Owner[2]	Ponderosa pine bark beetles	Pinyon ips	Douglas-fir beetle	Spruce beetle	Western balsam bark beetle	Fir engraver
Apache-Sitgreaves NFs	42,580		990		120	1,350
Coconino NF	7,330		170		600	370
Coronado NF	2,100					
Kaibab NF	690	90	30			
Prescott NF	140	10				
Tonto NF	150					
BLM	120	20				
DOD						
NPS (other)	320	170	< 5			< 5
NPS Grand Canyon NP	1,360		10			
NPS Saguaro NP	1,280		< 5			
White Mtn. Apache	13,210		500		1,280	550
Hopi Tribal						
Hualapai Tribal	20					
Navajo Nation	30	10				
Navajo-Hopi JUA						
San Carlos Apache	28,460					
State & Private	840	20			10	
Arizona Total	98,630	320	1,700		1,960	2,270
Carson NF	230	< 5	2,410	7,330	320	820
Cibola NF	950	< 5	760		70	1,300
Gila NF	16,150	500	2,980			1,200
Lincoln NF	1,400	70	70	140	130	120
Santa Fe NF	1,360		9,520	25,760	150	1,460
BLM	90	1,880				
NPS (Bandelier & El Malpais)	< 5		10			
Valles Caldera NP	60		1,700	20	< 5	
Acoma Pueblo	10	180				
Isleta Pueblo	< 5	< 5	< 5			
Jemez Pueblo	< 5					
Jicarilla Apache	10		540	180		< 5
Laguna Pueblo	< 5					
Mescalero Apache	160	< 5	10	140	300	140
Navajo Nation	10		< 5		< 5	160
Other Tribal	< 5		< 5			
Picuris Pueblo	< 5		30			
Santa Clara Pueblo	< 5		30	300		< 5
Taos Pueblo	< 5		120	290	< 5	< 5
Zuni Pueblo	< 5	< 5	< 5			
State & Private	1,050	40	4,830	4,850	690	4,760
New Mexico Total	21,480	2,670	23,030	39,010	1,660	9,960
SW Region Total	120,110	2,990	24,730	39,010	3,620	12,230

[1] 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.

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

Table 3. Defoliation incidence by ownership (acres) from aerial detection surveys in 2016 in Arizona and New Mexico[1].

Owner[2]	Western spruce budworm	Aspen damage[3]	Douglas-fir tussock moth	Pinyon needle scale	Needle cast ponderosa	Tamarisk leaf beetle	Spruce aphid
Apache-Sitgreaves NFs		920		30			3,660
Coconino NF		190		180			
Coronado NF		60	90				
Kaibab NF	330	440					
Prescott NF							
Tonto NF				490			
BLM						3,950	
DOD							
NPS (other)						30	
NPS Grand Canyon NP		230					
NPS Saguaro NP							
White Mtn. Apache		5,530	50	1,700			30,430
Hopi Tribal						1,420	
Hualapai Tribal							
Navajo Nation		1,570				9,220	
Navajo-Hopi JUA						620	
San Carlos Apache				70	60		
State & Private		20	130				
Arizona Total	330	8,960	270	2,470	60	15,210	34,090
Carson NF	60,120	6,480					
Cibola NF	1,860	950	60	850	250		
Gila NF		140					
Lincoln NF	6,240	450	260	40			
Santa Fe NF	26,260	3,160	10,190		320		
BLM	140	< 5				20	
NPS (Bandelier & Malpais)							
NPS (Valles Caldera NP)	150	20					
Acoma Pueblo						< 5	
Isleta Pueblo							
Jemez Pueblo	20						
Jicarilla Apache	1,090	1,140					
Laguna Pueblo							
Mescalero Apache	420	50	60				
Navajo Nation		1,690					
Other Tribal	440						
Picuris Pueblo							
Santa Clara Pueblo							
Taos Pueblo	1,590	70					
Zuni Pueblo							
State & Private	36,320	10,840	290		11,500	330	
New Mexico Total	134,670	25,000	10,870	890	12,070	350	0
SW Region Total	135,000	33,960	11,140	3,360	12,130	15,560	34,090

[1] 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.

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

[3] Aspen damage includes a combination of insect defoliation and other biotic and abiotic factors causing aspen decline and in some cases mortality. See text for additional information.

Status of Major Insects

Bark Beetles

In 2016, ADS detected more than 200,000 acres with bark beetle-caused tree mortality across all forest types in the Southwestern Region (Table 1). This is a slight increase from the nearly 162,000 acres detected in 2015. A substantial increase in acres with ponderosa pine mortality was documented in eastern Arizona (Figure 4). Half of the damage occurred on the Apache-Sitgreaves NFs and the remaining half occurred across White Mountain and San Carlos Apache Tribal Lands. Most of this damage was widely scattered on the landscape. In most cases less than 10% of the ponderosa pine included in those damage polygons were killed. In New Mexico, much of the bark beetle-caused tree mortality occurred in spruce-fir and mixed conifer forest types (Figure 4).

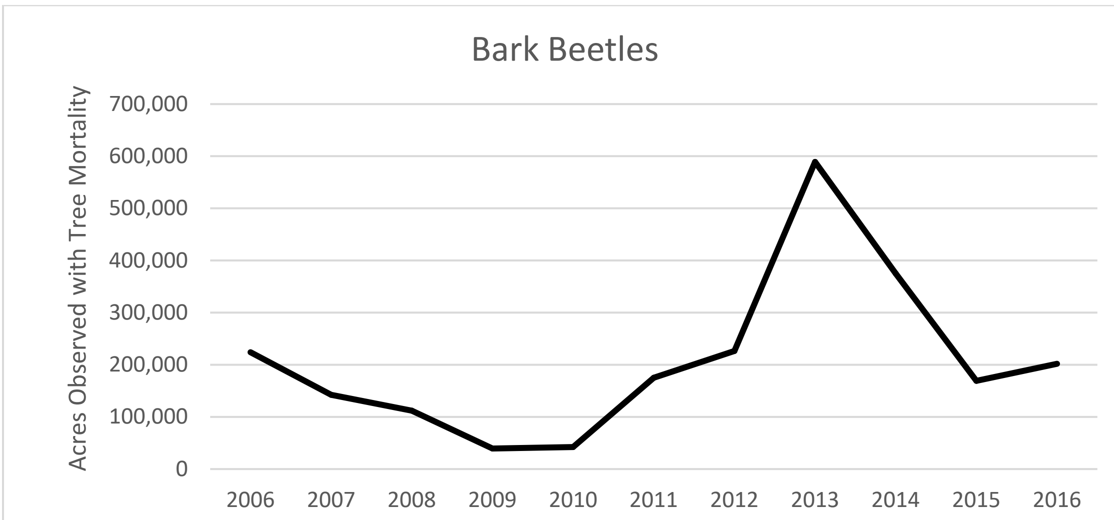

Figure 6. Acres observed with tree mortality from all bark beetles in the Southwestern Region from 2006 to 2016.

Pinyon Juniper Forest Type

The pinyon juniper forest type experienced a Region-wide decrease in tree mortality beginning in 2015. The number of acres observed with tree mortality in this forest type are now back to endemic levels (Figure 7).

Pinyon Ips

Ips confusus
Host: Pinyon Pine

Pinyon ips activity remained low in 2016 (Figure 7, Table 2). The decrease followed an upswing in activity that primarily affected woodlands in New Mexico during 2013 to 2014. In 2016, 2,990 acres had pinyon mortality Region-wide (Figure 7). Most of this damage was detected on Bureau of Land Management (BLM) woodlands in New Mexico. In Arizona, there were approximately 350 acres with pinyon mortality. Most of the damage was mapped in the northwest portion of the state over Lake Mead National Recreation Area and BLM lands. Approximately 100 acres were mapped in central Arizona on the Williams RD, Kaibab NF.

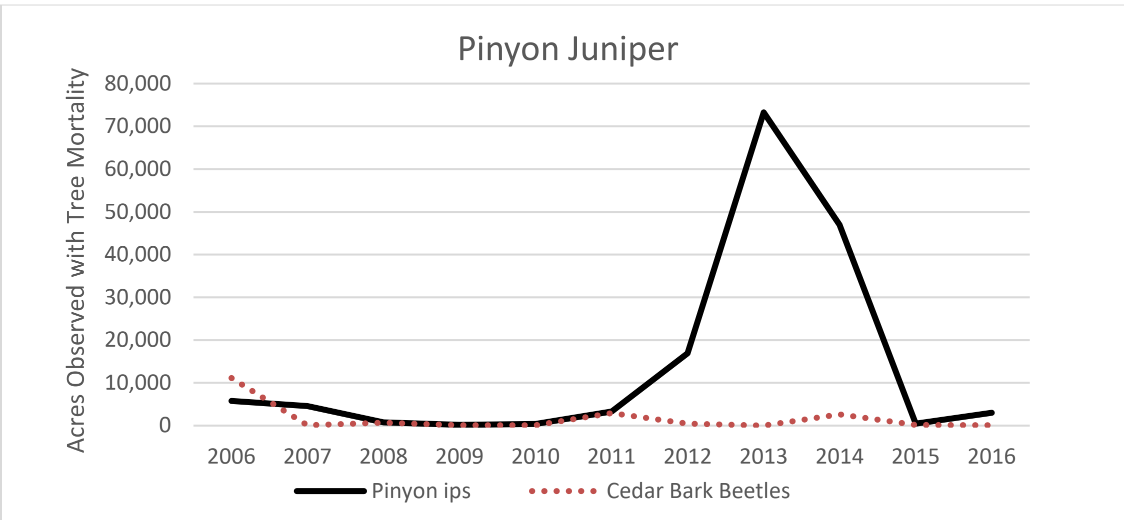

Figure 7. Acres observed with tree mortality in pinyon juniper forests caused by bark beetles in the Southwestern Region from 2006 to 2016.

Cedar Bark Beetles

Phloeosinus spp.
Host: Arizona cypress and junipers

Approximately 100 acres with juniper mortality were documented in 2016, nearly all of that damage occurred in Arizona with a few scattered individuals mapped in New Mexico (Figure 8). In Arizona, most of the observed damage was recorded on the Williams RD, Kaibab NF.

Ponderosa Pine Forest Type

In the Southwestern Region, ponderosa pine supports a diverse complex of bark beetles that cover many genera and species. For example, within a single area engraver beetles and western pine beetle may be active on different sized trees or co-occurring within the same trees. Therefore, as of 2015, we no longer specifically identify specific bark beetle species with ponderosa pine mortality during the ADS. Additionally, as of the 2013 ADS season, surveyors attribute damaged areas with a severity code to describe the proportion of vegetation affected within the polygon.

The number of acres detected with ponderosa pine mortality more than doubled from 55,500 acres in 2015 to slightly over 120,000 acres in 2016 (Table 2). A significant increase in acres with bark beetle-caused pine mortality occurred in Arizona. A total of 98,630 acres were affected in 2016 statewide (Figure 8). Approximately 70 percent of the damage was detected in eastern Arizona on the Apache-Sitgreaves NFs and San Carlos and White Mountain Apache Tribal Lands, where fire injured trees were subsequently attacked by bark beetles (Table 2). Although the number of acres with damage has increased, much of the activity was limited and widely scattered over the landscape (Figure 9). In New Mexico, the number of acres with observed ponderosa pine mortality continued to decrease from 32,470 acres in 2015 to 21,480 acres reported in 2016 (Tables 1 and 2). Most of the ponderosa pine mortality occurred on the Gila NF (Figures 4 and 9).

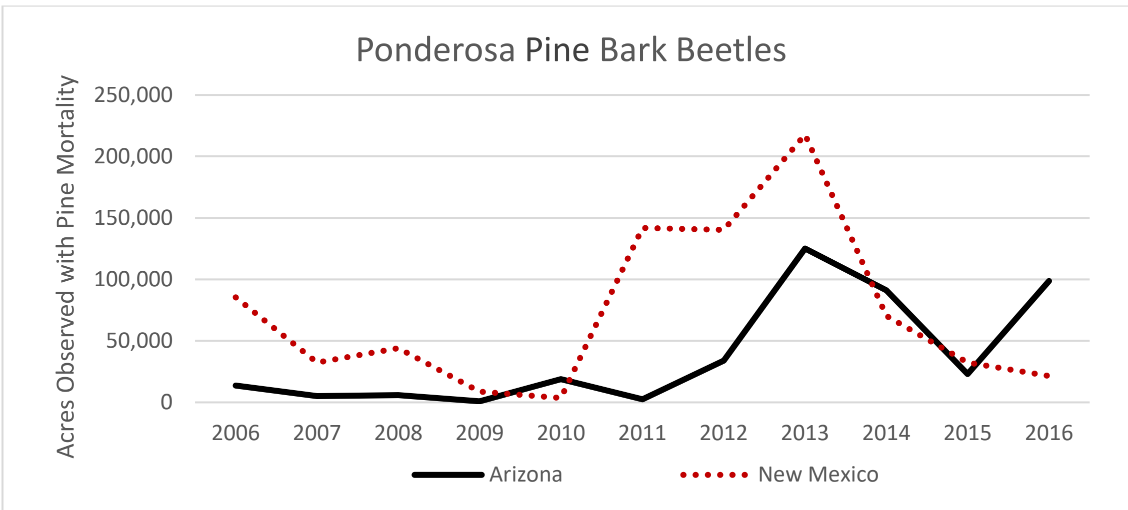

Figure 8. Acres observed with tree mortality caused by ponderosa pine bark beetles in the Southwestern Region from 2006 to 2016.

Figure 9. Left: Light severity ponderosa pine mortality associated with the Slide Fire, Coconino NF. Right: Moderate severity mortality associated with persistent drought and bark beetle damage, Gila NF.

Mixed Conifer Forest Type

Region-wide, the number of acres with tree mortality observed in mixed conifer forests continued to decline from 74,240 acres detected in 2015 to 36,900 acres in 2016 (Table 1, Figure 10). Nearly all of the tree mortality occurred in New Mexico and was attributed to Douglas-fir beetle in the northern part of the state (Table 2).

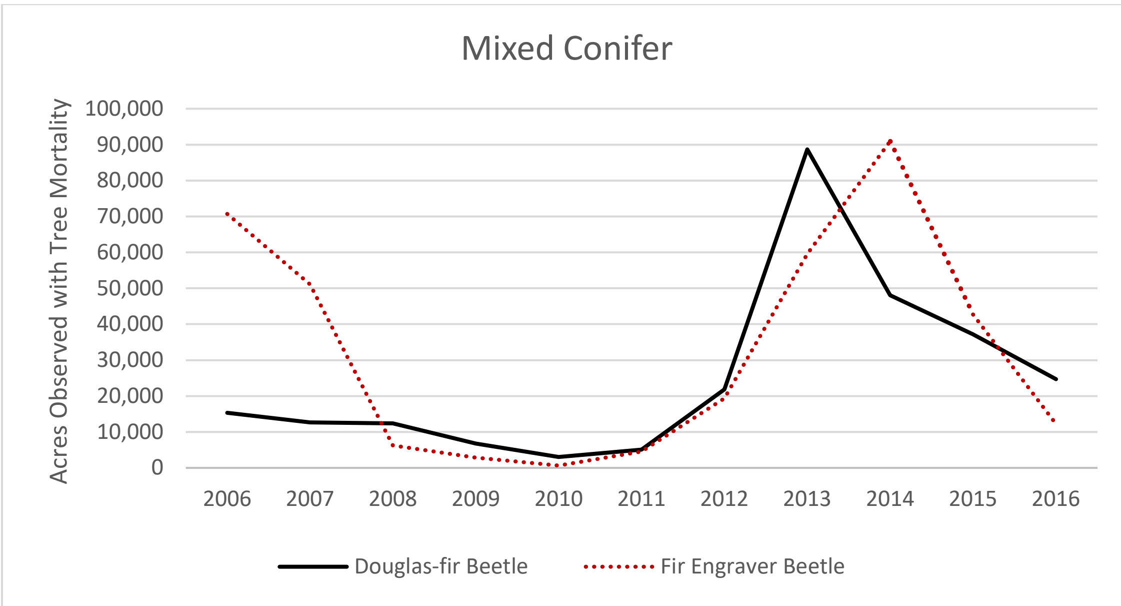

Figure 10. Acres observed with Douglas-fir and white fir mortality in mixed conifer forests across the Southwestern Region.

Douglas-fir Beetle

Dendroctonus pseudotsugae
Host: Douglas-fir

In 2016, acres impacted by Douglas-fir beetle (DFB) declined to a four year low for the Region (Figure 10). This decline followed several years of escalated activity. In Arizona, the number of acres mapped with Douglas-fir mortality declined from 13,000 acres detected in 2015 to only 1,700 acres mapped in 2016. Most of the damage was mapped within the Wallow Fire perimeter (Figure 11). After four years of monitoring and suppression projects in this area, the DFB populations appear to be declining.

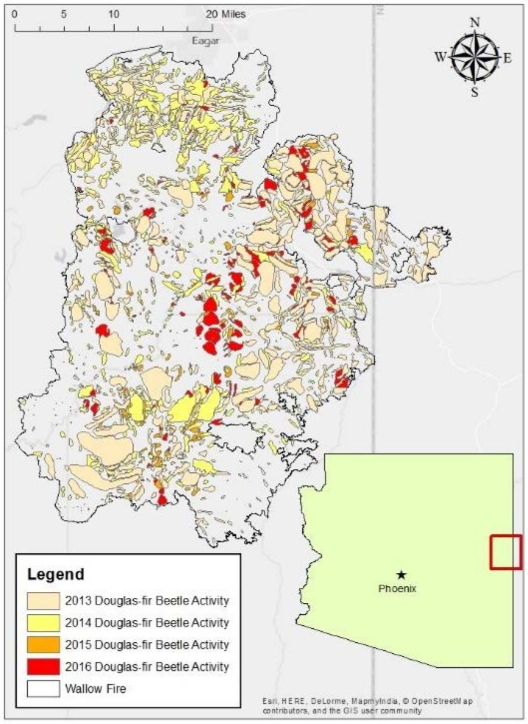

Figure 11. Douglas-fir mortality has decreased significantly within the Wallow Fire perimeter.

In addition to ADS, DFB activity has been monitored within the Wallow Fire perimeter using pheromone-baited funnel traps and ground surveys since 2012. In 2016, push-pull suppression efforts were also implemented. This technique is designed to keep beetles out of selected areas to prevent them from attacking trees. In this case, anti-aggregation pheromones were deployed in high value campgrounds to push beetles out of the area. Traps with aggregation pheromones were placed around selected campgrounds to pull beetles away from trees in high value areas.

In New Mexico, Douglas-fir mortality remained effectively the same with slight over 24,000 acres detected in 2015 and approximately 23,000 detected in 2016. Most of the observed Douglas-fir mortality was detected in northern New Mexico where approximately 19,000 acres were reported. Nearly half of all Douglas-fir mortality observed in New Mexico occurred on the Santa Fe NF and the Valles Caldera National Preserve (NP), where mortality was associated with large wildfires including the Las Conchas and Thompson Ridge Fires on the Jemez Mountains.

Fir Engraver

Scolytus ventralis
Host: White fir

White fir mortality, attributed to fir engraver beetle, is often driven by factors that weaken trees, such as drought stress, root rots, and high stand densities. The resulting tree mortality is often prominent on drier south- and east-facing slopes, and at lower elevations of north-facing slopes. Mortality associated with fir engraver decreased substantially across the Region from 42,700 acres detected in 2015 to 12,230 acres in 2016 (Table 2, Figure 10).

In Arizona, 2,270 acres of white fir mortality were observed and attributed to fir engraver. All of the damage was mapped over the White Mountains of eastern Arizona, especially on the Springerville and Alpine RDs of the Apache-Sitgreaves NFs and on White Mountain Apache Tribal Lands around Mount Baldy (Table 2).

In New Mexico, fir engraver populations continue to kill white fir at high levels on the Sandia RD, Cibola NF, where several years of severe drought conditions occurred from 2007 to 2012. High stand density, heterobasidion root disease, and years of persistent drought have contributed to the elevated white fir mortality (Figure 12). These stands also lie within and adjacent to a developing DFTM outbreak.

Figure 12. High stand densities, root disease and years of persistent drought have contributed to the elevated white fir mortality in the Sandia Mountains of the Cibola NF.

Mountain Pine Beetle

Dendroctonus ponderosae
Host: Southwestern white pine

Tree mortality caused by mountain pine beetle (MPB) has returned to endemic levels. During the past few years, MPB has caused mortality in southwestern white pine (SWWP) following wildfires in Arizona. All of the MPB damage reported over the past decade has been associated with wildfires and is generally limited to fire-injured trees. In Arizona, the number of acres with SWWP mortality caused by MPB decreased, from nearly 4,000 acres in 2014 to less than five acres in 2016. Individual dead SWWP trees were observed on the San Francisco Peaks and on Mount Graham. Although we did not detect many acres with SWWP mortality on the San Francisco Peaks during the 2016 ADS, a small population of MPB is still quite active in the area. Several MPB experiments including phenology studies are underway within the area. For more on MPB projects, see the Special Projects Section (Page 33).

Spruce-Fir Forest Type

All of the acres with spruce beetle-caused tree mortality were mapped in New Mexico. Most of the mortality was reported in northern New Mexico where the number of acres impacted has increased for the past six years (Table 2, Figure 13). Corkbark fir mortality, caused by the western balsam bark beetle has remained relatively consistent from 2015 to 2016 (Figure 13).

Spruce Beetle

Dendroctonus rufipennis
Host: Spruce

Engelmann spruce mortality caused by spruce beetle increased in 2016 (Figure 13). Approximately 39,000 acres with Engelmann spruce mortality were mapped during the 2016 ADS season (Table 2). This is an increase from the nearly 29,000 acres mapped in 2015. The majority of the damage was mapped over the northern portion of the Tres Piedras RD, Carson NF and on the Pecos Wilderness on the Carson and Santa Fe NFs.

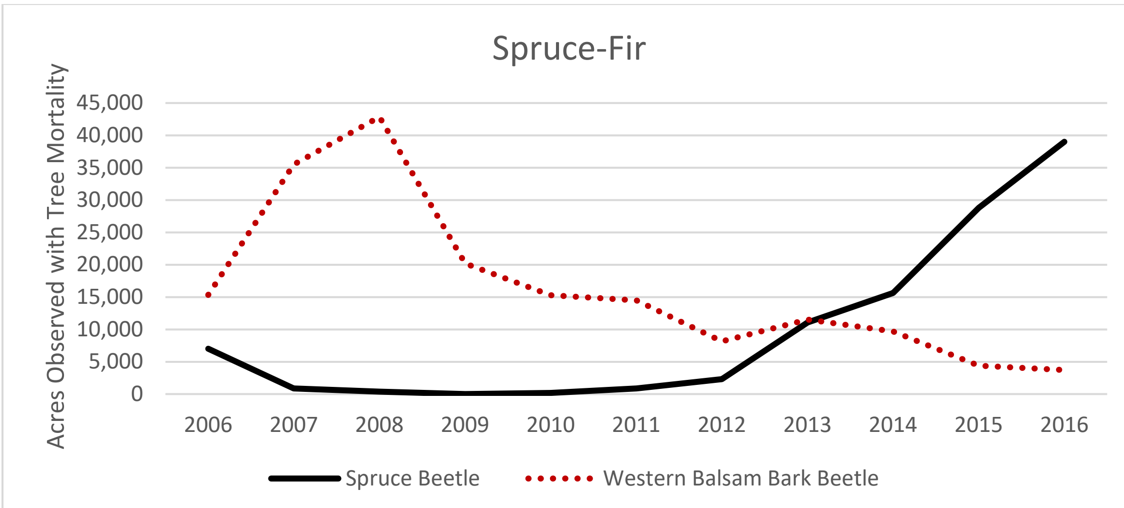

Figure 13. Acres observed with tree mortality caused by spruce beetle and western balsam bark beetle in the Southwestern Region from 2006 to 2016.

Ground surveys on the White Mountains around Alpine and on Mount Baldy have recorded a few (1% of surveyed trees) recent spruce beetle attacks. All attacked trees had more than 75% of their foliage removed by spruce aphid feeding.

Spruce Engraver Beetle

Ips spp.
Hosts: Engelmann and blue spruce

Ground surveys also identified spruce engraver activity in Arizona and New Mexico. In Arizona, spruce engraver beetles attacked 1% of surveyed trees in plots around Hannagan Meadow and KP Cienega Campground, on the Alpine RD, Apache Sitgreaves NFs. These trees were severely defoliated by spruce aphid in 2014 and 2015. Engraver beetles were also found attacking small diameter spruce trees in northern New Mexico.

Western Balsam Bark Beetle

Dryocoetes confusus
Hosts: Subalpine and corkbark fir

In New Mexico, the number of acres observed with WBBB-caused mortality decreased again for the fourth straight year. Activity was primarily in high elevation areas along the Sangre de Cristo Mountain Range, affecting the Carson and Santa Fe NFs as well as on Sierra Blanca Peak on the Lincoln NF (Figure 14). In Arizona, damage caused by WBBB increased from 240 acres mapped in 2015 to over 2,000 acres detected in 2016 (Table 2). Most of the mortality was observed on White Mountain Apache Tribal Lands and on the San Francisco Peaks, Coconino NF.

Figure 14. Corkbark fir mortality likely associated with western balsam bark beetle on Sierra Blanca, Lincoln NF.

Defoliators

Damage caused by defoliators decreased Region-wide, from 318,000 acres in 2015 to 247,170 acres in 2016, with most of the decrease occurring in New Mexico where acres of WSBW damage decreased by 50%. Highlights of defoliator activity include outbreaks of native and nonnative insects, such as DFTM in New Mexico and spruce aphid in eastern Arizona (Figure 4). In 2016, the two most widespread defoliators in the spruce-fir forest type were spruce aphid in Arizona and WSBW in New Mexico (Figure 15).

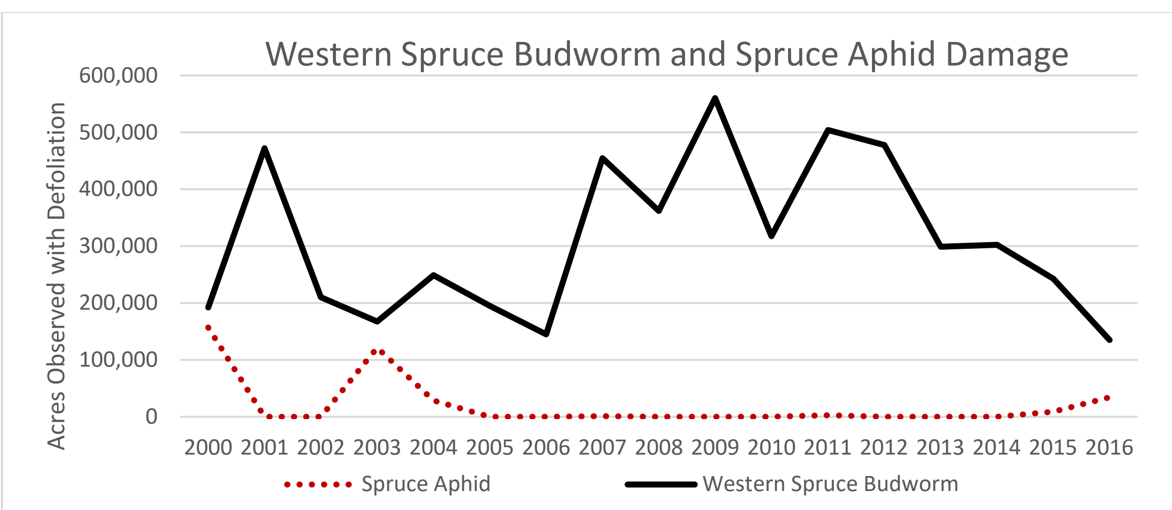

Figure 15. Acres observed with defoliation by western spruce budworm and spruce aphid in the Southwestern Region since 2000.

Sawflies defoliated ponderosa pine in both New Mexico and Arizona. A pandora moth outbreak continues in Arizona north of the Grand Canyon on the Kaibab NF, where it has been active since 2010. At lower elevations, defoliators such as pinyon needle scale and the tamarisk leaf beetle caused observable damage in the Southwestern Region.

Western Spruce Budworm

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

Defoliation by WSBW continues to be the most widespread damage caused by a single agent that is observed during ADS across the Southwestern Region. Most of the WSBW activity occurred in northern New Mexico, which has a greater proportion of susceptible host type. Damage is generally abundant on the Carson and Santa Fe NFs and on adjacent state and private lands. In 2016, aerial observers recorded the fewest number of defoliated acres documented during the past decade (Figure 15). The number of acres with defoliation mapped in New Mexico decreased from over 242,000 acres in 2015 to slightly less than 135,000 acres in 2016 (Table 3). No defoliation was mapped in the southern portion of the state. For the first time in several years there were 330 acres of WSBW damage detected in Arizona on the North Kaibab RD, Kaibab NF.

Spruce Aphid

Elatobium abietinum
Hosts: Engelmann and blue spruce

As regional climatic conditions continue on the predicted trajectory of warmer and drier, spruce aphid outbreaks are expected to increase in frequency and duration. This potential will result in increased levels of tree mortality in the Southwestern Region, where Engelmann spruce occurs at the southern end of its distribution.

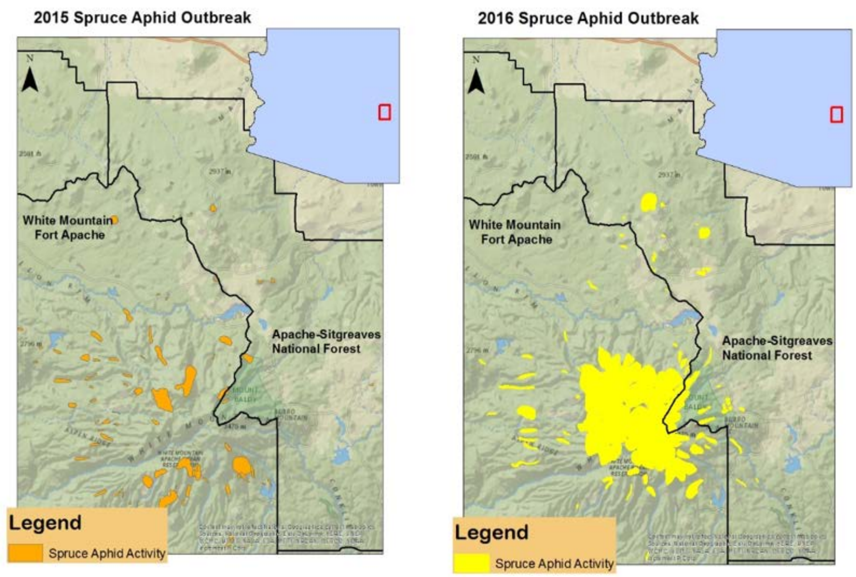

Figure 16. The amount of spruce aphid damage recorded during the ADS increased substantially from 8,840 acres observed in 2015 to 34,430 acres identified in 2016.

During the past several years, the Region has experienced warm winter and spring conditions resulting in low snowpack. These weather conditions likely facilitated increases in spruce aphid activity in Arizona. Ground observations of spruce aphid activity were reported near Hannagan Meadow on the Alpine RD, Apache-Sitgreaves NFs during the spring of 2015, indicating it had been active there since the fall of 2014. Aerial observers began documenting damage caused by spruce aphid in 2015 when approximately 9,000 acres of damage were mapped in eastern Arizona (Figure 16). Then in 2016, the number of acres with damage grew to 34,090 acres (Figure 16). Ninety percent

(30,430 acres) of the damage was detected on White Mountain Apache Tribal Lands while the other 10% was mapped on the Springerville and Alpine RDs, Apache-Sitgreaves NFs (Table 3).

Ground surveys indicate aphid populations also increased on the Pinaleno Mountains, Coronado NF. Scattered spruce with aphid damage were also observed on the San Francisco Peaks, Coconino NF. The best time to locate live spruce aphids is during the fall (Figure 17).

Figure 17. Live spruce aphids are most easily identified during the fall.

Douglas-fir Tussock Moth

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

Damage from DFTM increased in the Southwest, especially in high density stands of white fir or Douglas-fir. In 2016, several small spots of localized damage were mapped across the Region and one widespread outbreak of approximately 10,000 acres occurred on the Pecos/Las Vegas RD, Santa Fe NF.

Approximately 220 acres with damage were observed in southern Arizona. Damage was mapped on Mount Lemmon and the Chiricahua Mountains of the Coronado NF. The defoliation on Mount Lemmon and adjacent private lands impacted more than 50% of the vegetation. A small 50 acre patch with severe defoliation was also observed on White Mountain Apache Tribal Lands. All occurrences of DFTM in Arizona were small patches of defoliation on the upper slopes of mountains with steep terrain.

Figure 18. Severe defoliation observed from Douglas-fir tussock moth on the Santa Fe NF. Ground surveys suggested the population was declining.

In northern New Mexico, aerial observers mapped a severe and widespread DFTM outbreak on the Pecos/Las Vegas RD of the Santa Fe NF. Based on follow-up ground and egg mass surveys, we estimate this was the final year of the outbreak. The outbreak was aerially mapped over 10,000 acres (Table 3, Figure 4). Douglas-fir and white fir were the primary species affected. However, due to the high caterpillar densities in these stands, non-hosts, including ponderosa pine, also experienced defoliation (Figure 18). The outbreak was visible to several communities in the southwest corner of the district. Severe defoliation (>90%) occurred in the forested stands around Shaggy Peak. As a result, tree mortality will likely be heaviest in these stands.

In New Mexico, aerial observers also identified small persistent patches with DFTM damage on the Cibola and Lincoln NFs and on Mescalero Apache Tribal Lands. A new DFTM outbreak was detected on the Sandia RD, Cibola NF. Fall egg mass surveys indicate damage is likely to increase in 2017 along the Sandia Crest Highway near Balsam Glade Picnic Area, Indian Springs Trailhead, and along Highway 165. Incidence of tussockosis, an allergic reaction to hairs of DFTM caterpillars, may increase where caterpillar densities increase in recreation areas. Fir engraver bark beetles have been killing white fir throughout the Sandia Mountains for many years, and will likely attack trees weakened by DFTM defoliation.

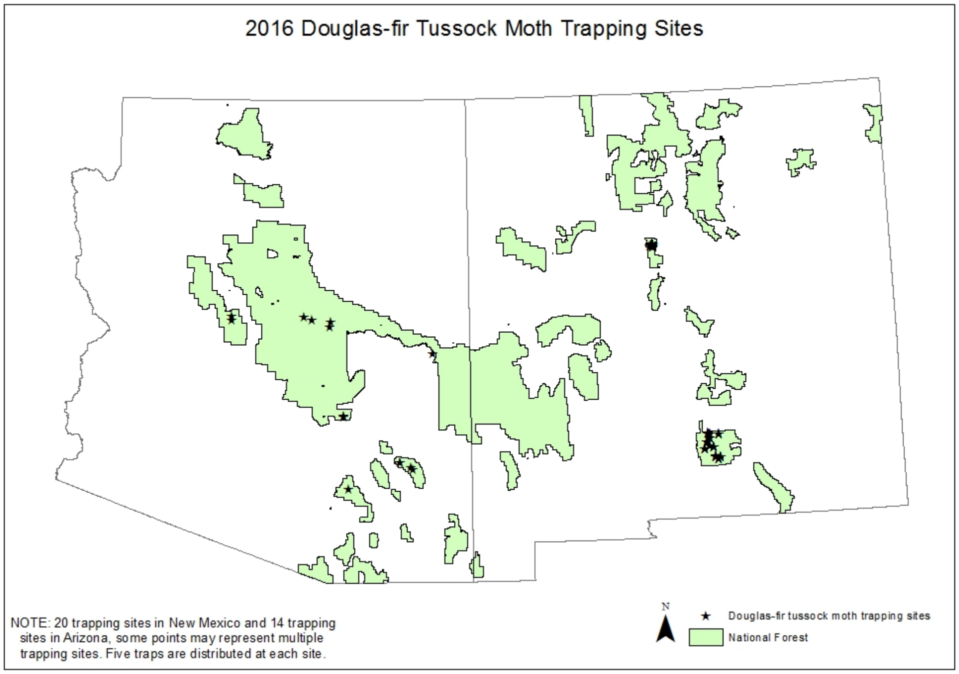

Figure 19. In 2016, Douglas-fir tussock moth was monitored on eight National Forests in the Southwestern Region.

In addition to aerial detection surveys, the Southwestern Region participates in the Early Warning Trapping program to monitor DFTM populations (Figure 19). The objective of the monitoring system is to identify areas with increasing DFTM populations prior to visible defoliation, allowing land managers time to apply a mitigation treatment before extensive damage occurs. Early warning trapping indicated an increase in populations on the Sandia Mountains near Albuquerque, NM.

Pine Sawflies

Neodiprion spp., *Zadiprion* spp.
Hosts: Ponderosa and pinyon pines

Pine sawfly defoliation increased slightly from less than 200 acres across the Region in 2015 to 650 acres detected in 2016. Nearly all of the damage was recorded on the Luera Mountains in southcentral New Mexico on state and private lands. Ground surveys discovered older needles had been injured, indicative of sawfly feeding. No tree mortality was associated with the needle feeding in the area. This is the second year defoliation has been mapped in this area. In Arizona, on the Coconino NF, ten acres with defoliation caused by sawfly feeding were mapped in the vicinity of Friedland Prairie. No new defoliation was mapped around the *Neodiprion. fulviceps* outbreak on Kendrick Mountain that occurred from 2009 to 2014 in northern Arizona. However, stressed individual pines that incurred consecutive years of severe defoliation continue to be killed from defoliation stress and by bark beetles in the Bull Basin area, Kaibab NF.

Pandora Moth

Coloradia pandora
Host: Ponderosa pine

Defoliation caused by pandora moth larval feeding was not detected during aerial surveys in 2016. This is due to the two year life cycle where larvae and defoliation occur in odd numbered years and alternate with adult (moth) populations in even numbered years. The 2016 adult flight was the largest documented during the outbreak thus far (Figure 20). A total of 97,025 pandora moths were caught in light traps at three standard locations on the North Kaibab RD, Kaibab NF. We have monitored the adult population at the same locations since 2010. Early season aerial surveys will be conducted in late May of 2017 to determine the number of acres affected.

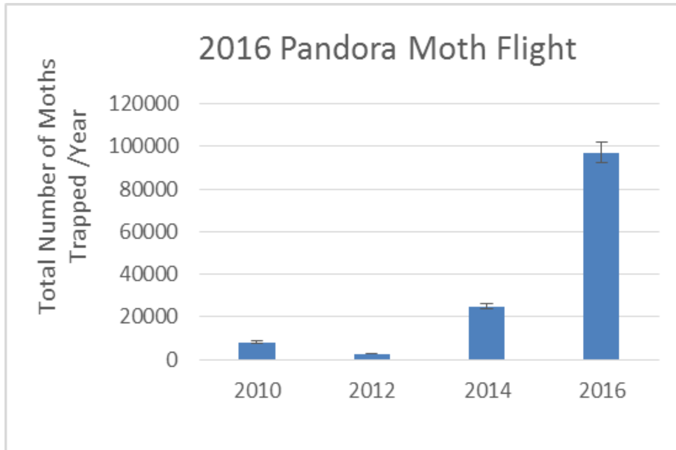

Figure 20. Total number of adult pandora moths caught in light traps at three locations.

Pinyon Needle Scale

Matsucoccus acalyptus
Host: Pinyon pine

Pinyon needle scale (PNS) is a chronic defoliator of pinyon pine that impacts the woodlands of Arizona and New Mexico. Approximately 3,500 acres with pinyon pine defoliation were recorded Region-wide in 2016, an increase from 140 acres observed in 2015. In New Mexico, nearly all of the damage was observed on the Cibola NF. In Arizona, most of the damage was mapped on White Mountain Apache Tribal Lands (Table 3). The aerial detection of this pest is confounded by drought, as drought-thinned crowns are often indistinguishable from the effects of needle scale. Additionally, the timing of peak visible damage does not correspond with the surveys. According to ground surveys in Arizona, PNS is beginning to spread from urban Sedona into the surrounding woodlands. Other locations with chronic damage in Arizona include San Carlos Tribal Lands, Prescott and Payson.

Aspen Defoliation and Decline

Western tent caterpillar, *Malacosoma californicum*
Large aspen tortrix, *Choristoneura conflictana*
Black leaf spot, *Marssonina pouli*

Oystershell scale*, Lepidosaphes ulmi*
Complex of drought and other insects and diseases

Acres with observed aspen defoliation continued to decrease this year from 45,000 acres mapped in 2015 to 31,100 acres mapped in 2016. The cause of aspen defoliation is not specified because aerial observers cannot determine the exact cause from the air. This defoliation is generally caused by western tent caterpillar, but injury can also be caused by the large aspen tortrix. Foliar diseases also contributed to aspen defoliation in 2015 and 2016 across the Southwest. Black leaf spot and Melampsora rust impacted several stands. Although this damage will not commonly cause tree mortality, forest visitors were alarmed when fall foliage was absent. Approximately one-third of the damage was mapped in Arizona and the remaining two-thirds were observed in New Mexico. In Arizona, most of the damage occurred on tribal lands, particularly on Navajo (1,570 acres) and on White Mountain Apache (5,530 acres) Tribal Lands in the eastern part of the state. Smaller patches were recorded on NFS lands throughout Arizona. On the North Kaibab RD, Kaibab NF, much of the aspen defoliation was caused by Melampsora rust. In central Arizona, around Flagstaff, many aspen stands were affected by black leaf spot.

In New Mexico, 22,140 acres of aspen damage were reported (Table 3). The majority of the defoliation was caused by western tent caterpillar. Damage was greatest on the Carson and Santa Fe NFs, especially on the Canjilon and Tres Piedras RDs of the Carson NF where western tent caterpillar activity has been chronic (Figure 21).

Figure 21. Left: Severe aspen defoliation observed east of Canjilon Lakes, Carson NF. Right: A photo of young aspen stems covered with oystershell scale.

In addition to the previously listed agents, oystershell scale has become a concern for land managers in northern Arizona (Figure 21). Oystershell scale and other biotic and abiotic factors are contributing to aspen decline in several stands, especially those below 7,500 feet.

Figure 22. Gambel oak damage caused by adult feeding of the western rose chafer was widespread on the Mogollon Rim, Arizona.

Oak and Hardwood Defoliation

Western rose chafer, *Macrodactylus uniformis*

In Arizona, over 4,000 acres of Gambel oak discoloration and defoliation were mapped across the Mogollon Rim (Figure 22). Most of the damage occurred on Gambel oaks, but aspen, willows, locust, and other hardwoods were also damaged. Ground visits and forest personnel verified the damage was caused by the adult feeding of the western rose chafer, a small light green scarab beetle. Three quarters of the damage occurred on the Black Mesa RD, Apache-Sitgreaves NFs, where damage had been noticed for the past two years. Approximately 1,000 acres with oak damage were observed on White Mountain Apache Tribal Lands during the 2016 ADS over the Rim Country. Small patches of damage were also mapped on the Tonto (90 acres) and Coconino NFs along the Rim. In New Mexico, aerial surveyors mapped 200 acres of oak defoliation from unknown causes.

Tamarisk Defoliation

Tamarisk leaf beetle, *Diorhabda carinulata*

Tamarisk (salt cedar) defoliation caused by the tamarisk leaf beetle (TLB) has been extensive in the northern part of the Region since 2008. Due to client requests, the Arizona and New Mexico Zones began mapping tamarisk defoliation in 2012. The Arizona ADS program covers more lands affected by the TLB during normal surveys than NM, particularly over tribal lands in the northeastern part of Arizona. Special riparian surveys have also occurred in priority areas such as along the Little Colorado. In 2016, defoliation was observed just south of Interstate 40, where the Little Colorado runs through Holbrook, Arizona (Figure 23). In 2016, roughly 15,590 acres with tamarisk defoliation were mapped in the northeastern part of the state. Approximately 10,000 acres with defoliated tamarisk were documented on Navajo Tribal Lands and 4,000 acres were mapped over riparian areas on the Gila District of BLM administered lands.

In New Mexico, 350 acres of tamarisk defoliation were observed. TLB activity is only recorded when observed during ferry flights, there are no special detection flights for this activity; therefore acres mapped is not comprehensive for the state of New Mexico.

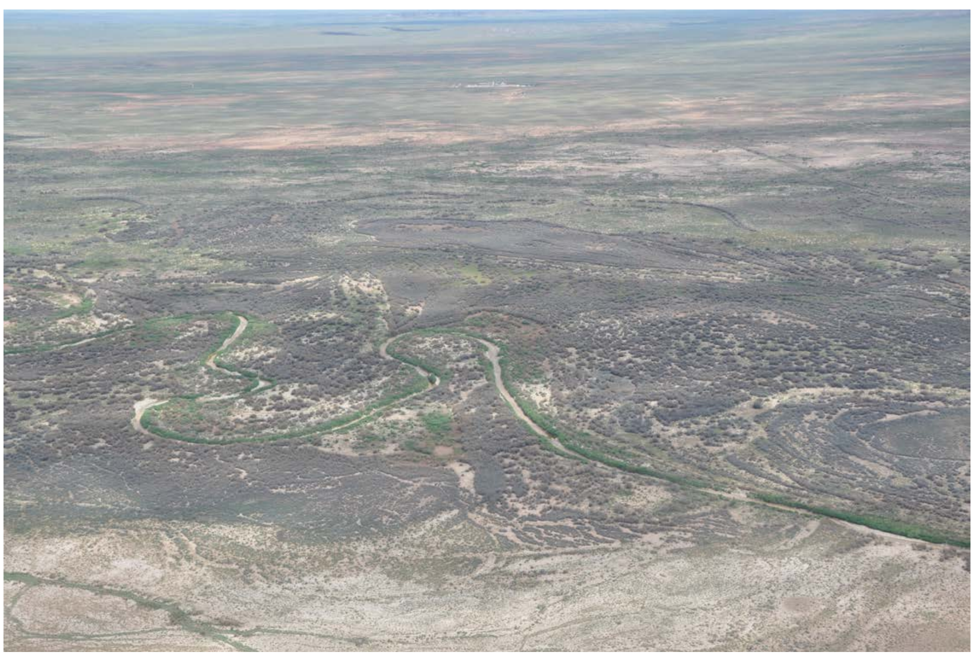

Figure 23. Tamarisk leaf beetle defoliation mapped along the Little Colorado River flood plain, north of Holbrook, Arizona.

Status of Major Diseases

Mistletoes

Dwarf Mistletoes

Arceuthobium spp.
Hosts: All conifers

Figure 24. Ponderosa pine with a dwarf mistletoe bole infection and pitch tubes caused by bark beetle attacks within the Marshall Gulch Recreation Area, on Mount Lemmon, Coronado NF.

Dwarf mistletoes are the most widespread and damaging forest pathogens (disease-causing organisms) in the Southwest; over one-third of the ponderosa pine type, and up to one-half of the mixed conifer type, has some level of infection. Damage from dwarf mistletoe infection includes growth reduction, deformity (especially the characteristic witches' brooms), and decreased longevity. Severely infested areas have much higher tree mortality rates than uninfected areas. Weakened trees can be killed by other damaging agents, like bark beetles or root disease (Figure 24). Dwarf mistletoes have an ecological role, as they provide bird roosting habitat and a food source for some mammals and birds.

There are eight species of dwarf mistletoe in the Southwest, each with a primary tree host. The three species affecting ponderosa pine, pinyon pine, and Douglas-fir are found throughout most of their respective host's range, while the other species have more limited distributions.

True Mistletoes

Phoradendron spp.
Hosts: Junipers and various hardwoods

Figure 25. True mistletoe infecting oak on the Red Rock RD, Coconino NF.

Eight species of true mistletoe occur in the Southwest. These mistletoes are less damaging to their hosts than dwarf mistletoes, but heavy infestations reduce host longevity during periods of drought. *Phoradendron juniperinum* on Utah juniper is probably the most widespread and abundant species. Big leaf mistletoe (*P. macrophyllum*) is ubiquitous throughout most riparian areas in the Southwest, infecting most riparian hardwood species excluding oaks. Southwestern oak mistletoe (*P. coryae*) is common on oaks in lower elevations (Figure 25) and in southern portions of the Region and desert mistletoe (*P. californicum*) can be abundant on mesquite and palo verde in desert woodlands. There is one true mistletoe known to infect white fir (*P. pauciflorum*), which is limited to southern Arizona.

Root Diseases

Root diseases are fairly common in forests of the Southwest. They can predispose trees to root failure, a concern in campgrounds and other recreation areas. In the Southwest, root diseases are usually more common in mixed conifer and spruce-fir forests than in ponderosa pine forests, and can also be common in hardwood trees. Root diseases spread slowly, so overall extent changes little from year to year. Root disease is often described as a "disease of the site" as it continues to exist in the soil after host trees are removed or killed by fire.

Armillaria Root Disease

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

Figure 26. Rhizomorphs of *Armillaria* sp. discovered under the bark of a dead ponderosa pine on the Santa Fe NF.

Armillaria root rot is the most common root disease in the Southwest (Figure 26), where it is estimated to account for up to 80 percent of root disease associated mortality. Although all conifer species and size classes can be infected, root disease is more common in old growth mixed conifer and spruce-fir forests. *Armillaria solidipes* (syn. *A. ostoyae*) is the major *Armillaria* species in southwestern coniferous forests, but *A. mellea* has been found in oaks, especially live oaks in southern Arizona. *Armillaria gallica* has also been identified in mixed conifer forests in Arizona. It is typically considered a saprophyte of dead trees. Previous surveys in mixed conifer forests on the North Kaibab RD, Kaibab NF found *Armillaria* spp. on about 30 percent of standing live trees.

Heterobasidion Root Disease (Formerly Annosus Root Disease)

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

Heterobasidion root disease is the second most common root disease in the Southwest, where it is found in higher elevation ponderosa pine and wet mixed conifer forests throughout Arizona and New Mexico. Fruiting bodies are commonly found inside stumps and sometimes on downed logs and upturned roots. *Heterobasidion occidentale* is common in white fir in the Southwest, but also occurs on subalpine fir and Engelmann spruce. *Heterobasidion irregulare* is found in ponderosa pine, and although not common, it is widely distributed throughout the Region. Like *Armillaria* spp., *Heterobasidion* spp. are known as saprophytes or nutrient recyclers of dead woody material as well as pathogens.

Other Common Root Diseases

Other common root diseases in the Southwest include Schweinitzii root and butt rot, caused by the fungus *Phaeolus schweinitzii*, which is often found on older Douglas-fir and occasionally ponderosa pine, southwestern white pine and spruce; Tomentosus root disease, caused by *Onnia tomentosus* (syn. *Inonotus tomentosus*), is found on spruce and Douglas-fir. Black stain root disease, caused by *Leptographium wageneri,* appears to be rare in the Southwest.

Ganoderma root rot, caused by *Ganoderma applanatum*, is the primary root disease affecting aspen in the Southwest. The disease causes crown dieback, windthrow and mortality, especially in older aspen stands, however, aspen of all ages are affected. More mesic aspen stands on the Carson NF seem to a have higher incidence compared to other National Forests in New Mexico. Collection of *G. applanatum* fruiting bodies, commonly known as artist's conk, occurred throughout the Region in 2015 and 2016. Specimens will be used in a collaborative project with University of Minnesota to assess population genetics in the region and compare it to western and eastern isolates. We are also assessing damage caused by this disease through a network of semi-permanent plots located in Arizona and New Mexico.

Stem Decays

Stem decays are common in older trees throughout the Region. Decay represents an economic loss in terms of timber production and can increase hazard on developed sites, but decayed trees provide important cavity habitat for many wildlife species, especially birds. The most common stem decays in the Southwest include red rot, *Dichomitus squalens*, of ponderosa and pinyon pines; red ring rot, *Porodaedalea pini* (syn. *Phellinus pini*), affecting most conifers; Indian paint fungus, *Echinodontium tinctorium*, on true fir and occasionally Douglas-fir or spruce; false tinder conk, *Phellinus tremulae*, on aspen (Figure 27); and *Phellinus everhartii* and *Inonotus dryophilus* on oak.

Figure 27. Fruiting bodies of *Phellinus tremulae* are commonly found in older aspen stands around Hart Prairie on the San Francisco Peaks, Arizona.

Echinodontium tinctorium (ET) (Indian paint fungus) is an important stem decay which can lead to cryptic hazard trees in recreation areas. The crown may be green while the main column is decayed and wood is compromised. During the 2016 hazard tree training on the Safford RD, Coronado NF, we identified and then cut down a large diameter white fir tree that was infected with ET (Figure 28). Several large conks occurred along the tree bole. Once cut down it was apparent that only a couple inches of sound wood provided structural support.

Figure 28. During the 2016 hazard tree training, students experienced drilling through the sound outer column to the decayed center of a fallen white fir that had an infection by *Echinodontium tinctorium*.

Stem Rusts

White Pine Blister Rust

Cronartium ribicola
Hosts: Southwestern white pine, limber pine, bristlecone pine, and *Ribes* spp.

Figure 29. White pine blister rust aecia found on southwestern white pine on the Lincoln NF.

White pine blister rust (WPBR) continues to cause heavy damage to white pines on the Sacramento Mountains of southern New Mexico, where the disease has been established for about 40 years (Figure 29). Based on a set of representative monitoring plots, roughly 45% of the white pines in this area, which includes Mescalero Apache Tribal Lands and most of the Lincoln NF, are infected. WPBR also occurs on the Gila, Cibola, and Santa Fe NFs of New Mexico. The Apache-Sitgreaves NFs and White Mountain Apache Tribal Lands are currently the only land management units affected in Arizona. Thousands of acres of mesic mixed conifer forest have severe WPBR infection, while more xeric sites generally have low to moderate infection. Top-kill is very common in severely infected areas. Though bristlecone pine is susceptible, WPBR has not yet affected stands within the Region.

In Arizona, WPBR was first detected in 2009 on White Mountain Apache Tribal Lands and neighboring Apache-Sitgreaves NFs. Age estimation of older cankers suggest the WPBR pathogen may have been present for 20 years, but at undetectable levels. Since 2009, favorable weather conditions for the pathogen have allowed for continued disease expansion into new areas, including into more moderate hazard sites throughout most of the White Mountains. However, there are many areas where disease is still absent in both states. In collaboration with Northern Arizona University, permanent monitoring plots have been established throughout the host type in the Region. Southwestern white pine cones and seeds have been collected from 2012 through 2016 for gene conservation and white pine blister rust resistance programs implemented at the Dorena Genetic Resource Center in Oregon.

Broom Rusts

Melampsorella caryophyllacearum
Hosts: True fir and chickweed

Chrysomyxa arctostaphyli
Hosts: Spruce and kinnikinnick

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

Limb Rust and Western Gall Rust

Cronartium arizonicum and *Peridermium harknessii*
Hosts: Ponderosa pine

There are two rust diseases on ponderosa pine in the Region. The most common variety in the Region is *Cronartium arizonicum,* the cause of limb rust. Limb rust is common in portions of Arizona and can be quite damaging to individual trees. Limb rust incidence in New Mexico is infrequent. The fungus causes orange colored pustules on dying branches with progressive upward and downward branch mortality, generally initiating from the center of the crown. Waves of new infection typically occur at intervals of several years.

Western gall rust, caused by *Peridermium harknessii*, deforms, but seldom kills older trees. Infection typically causes the growth of large galls on infected branches. Occasionally, during wave infection years, this pathogen has caused mortality in seedlings and saplings. A white-spore race of western gall rust infects ponderosa pine in the Southwestern Region. Unlike the traditionally orange spores of *P. harknessii,* this race produces white-spore pustules on spindle-shaped galls that form on branches and main stems of infected trees traditionally orange aecia of *P. harknessii*. This disease is uncommon in the Southwestern Region.

Canker Fungi

Canker fungi are often the primary cause of aspen mortality due to the soft living tissue of the bark, which makes it extremely susceptible to wounding and subsequent infection. Regional disturbances such as drought, or local activities like selective logging, campsite construction, and carving injury can increase the incidence of canker disease in aspen. Sooty bark (barber poll) canker, caused by *Encoelia pruinosa,* is the most lethal canker of older mature aspen trees.

Figure 30. Cytospora canker exposed on a small alder stem, Carson NF.

Cytospora canker, caused by *Cytospora chrysosperma,* infects several hardwoods and was observed killing alder in riparian areas throughout the Carson NF in 2016 (Figure 30). Extensive tree mortality associated with this canker disease has been observed in northern New Mexico for at least the last 10 years. This substantial increase in a native disease is hypothesized to be tied to climatic variables.

Foliar Diseases

Acres impacted by foliar diseases continued to increase in New Mexico, where wet springs and favorable monsoon seasons created conditions conducive to needle cast. Several thousand acres with observed discoloration were mapped over ponderosa pine and mixed conifer forest types. The majority of the damage occurred in the pine type where 12,070 acres were infected by *Lophodermella cerina*. Nearly all of the damage (11,500 acres) was detected on the eastern slopes of the Sangre de Cristo Mountains, especially on state and private lands east of the Carson and Santa Fe NFs (Table 3). Damage was detected south of Mora extending northward past Ocate.

Approximately 2,500 acres of mixed conifer were also impacted by needle cast in this same area and near Chacon.

Acres with needle cast damage decreased in Arizona from over 5,500 acres detected in 2015 to less than 100 acres observed in 2016. This is likely because central Arizona did not receive much spring precipitation where damage occurred the previous year.

Uredinopsis needle rust (*Uredinopsis* sp.) was observed on white fir in mixed conifer forests on the Pinaleno Mountain range near Safford, Arizona. Signs of the rust (white tubes on the underside of one year old needles) were widespread during ground visits in August through October (Figure 31). Southern Arizona received tropical storm moisture following wet monsoon seasons in 2015 and 2016.

Figure 31. White tube like structures on the underside of white fir needles, indicative of Uredinopsis needle rust, occurring in the Pinaleno Mountains near Safford, Arizona.

Foliar disease of hardwoods including Melampsora rust (*Melampsora* spp.) and black leaf spot (*Marssonina populi*) persisted on aspen in northern Arizona, especially on the North Kaibab RD, Kaibab NF. Damage was less pronounced around Flagstaff and on the White Mountains in 2016 compared to 2015. Sycamore anthracnose (*Apiognomonia veneta*) affected several riparian areas throughout Arizona, but was particularly noticeable in Oak Creek Canyon near Sedona where it has occurred for the past two years.

Abiotic Damage

Salt

De-icing salt use has contributed to increasing ponderosa pine mortality along state highways over the last decade, especially in central Arizona. The greatest tree decline and mortality occurred along Highway 260 near Forest Lakes; Highway 87 near Clint's Well; Interstate 40 from Flagstaff to Williams; Interstate 17 south of Flagstaff; and Highways 180 and 89A near Flagstaff. De-icing salt damage has also been observed along county and city roadways as municipalities increase their use of de-icing salts. Use of dust abatement salt is also associated with mortality of ponderosa pine along dirt roads in rural housing areas.

Drought

Despite record high temperatures across the Southwest, precipitation levels returned to near normal in 2016. The Region also received much needed precipitation in 2015, especially in New Mexico where drought had been contributing to juniper, ponderosa, and white fir mortality for several years. The return to near normal precipitation has contributed to the reduction in acres with ponderosa pine mortality on the Gila NF. On the Sandia Mountains a combination of high stocking, and drought conditions has caused a persistent increase in white fir mortality associated with fir engraver beetle and heterobasidion root disease.

Blow Down

A wind event with speeds in excess of 80 mile per hour caused a Douglas-fir blow down on the Sacramento Mountains, Lincoln NF (Figure 32). Other conifer species, including ponderosa pine were impacted as well. Downed material with diminished defense capabilities are preferred brood material that may provide an opportunity for Douglas-fir beetle population increases. *Ips* species have already attacked the downed ponderosa pine material in the same area. In Arizona, high winds on the San Francisco Peaks also led to the blow down of Engelmann spruce. This down material can often lead to spruce beetle population buildups that could subsequently attack trees nearby.

Figure 32. Douglas-fir blown down by high winds on the Sacramento Mountains has created brood material for Douglas-fir beetle and associated insects that may contribute to tree mortality in the future.

Invasive Species

Invasive Species Threats in the Southwest

Invasive species are an all-too-common threat to forests and woodlands throughout the Southwestern Region. Presidential Executive Order 13112 defines an invasive species as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Table 4 shows some of the major invasive species that pose the greatest threats to terrestrial and aquatic systems on National Forest System lands in the Southwestern Region. Many other invasive species found in the Southwest—such as amphibian diseases, crustaceans, and introduced fish species—can also seriously impact native species. Forest Health Protection conducts ground surveys and trap monitoring for invasive insect species such as the European gypsy moth and the Emerald Ash Borer annually. 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 4. Major invasive species threatening National Forest System lands in Arizona and New Mexico.

Type	Species
Terrestrial Plants	Buffelgrass, *Cenchrus ciliaris* Musk thistle, *Carduus nutans* Cheatgrass, *Bromus tectorum*
Vertebrates	Feral hog, *Sus scrofa*
Pathogens	White pine blister rust, *Cronartium ribicola* Whirling disease, *Myxobolus cerebralis*
Aquatic organisms	Quagga mussel, *Dreissena rostriformis bugensis* Rock snot, *Didymosphenia geminata*

Invasive buffelgrass is the greatest threat to the Sonoran Desert in the Southwestern Region. It was introduced as a forage grass from Africa into the southwestern US. The species has since spread into the Sonoran Desert where it presents an extreme fire hazard for saguaro cactus (*Carnegiea gigantea*), palo verde (*Parkinsonia microphylla*), and other native plants. Buffelgrass out-competes native desert vegetation for water, nutrients, and sunlight. The grass forms a dense, continuous fine fuel that perpetuates wildfire, leading to more widespread and intense fires. Sonoran plants are generally not adapted to this new fire regime. 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. A new collaborative effort, the Southern Arizona Resilient Landscape Collaborative, is a project funded by the Department of Interior to address 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. More on page 32.

FHP Programs and Information for Managing Invasive Species

The Forest Health Protection (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 accomplished through consolidated FHP grants to State Forester offices in Arizona and New Mexico, which are responsible for administering the grants. Funding through the FHP grant program has been used to treat buffelgrass, thistles, salt cedar, knapweeds, toadflaxes, and other invasive weeds within the two States. Applicants for treatment projects involving invasive plants include Cooperative Weed Management Areas (CWMAs), resource conservation districts (RCDs), and Soil and Water Conservation Districts (SWCDs). However, other organizations, such as non-governmental organizations (NGOs) can also qualify if they are able to treat invasive plants on a cooperative basis. Priority for funding is given to applicants with projects that propose to treat invasive plants (normally those species found on the State's noxious weed list) that threaten forests and woodlands within the State. 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 consolidated 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).

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 publication, *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 on public and private lands in the Southwestern Region.

Buffelgrass: Detection & Monitoring Support

Our aerial detection survey program has traditionally covered forests and woodlands across the Southwestern Region, recording conifer and hardwood tree damage and mortality since the 1960's. Periodically, our federal clients also request assistance with aerial surveys to map invasive insects or plants occurring in other forest types. In 2016 Forest Health Protection staff, assisted federal land managers in southern Arizona with the detection of invasive and fire prone buffelgrass.

Several federal land managers in southern Arizona including; the Tohono O'odham Nation, Buenos Aires National Wildlife Refuge, Saguaro National Park and the Coronado NF united under the Southern Arizona Resilient Landscape Collaborative to collectively monitor and reduce the occurrence of buffelgrass across land ownerships in southern Arizona.

Figure 33. Mountain Air helicopter used to fly monitoring missions for buffelgrass, Tucson, Arizona.

Forest Health Protection trained agency officials to use digital area sketch mapping hardware and software to document location and number of acres impacted. Later that fall, when the buffelgrass signature became more prominent, we helped implement aerial surveys, providing technical support on all survey flights (Figure 33 and 34). Nearly 170,000 acres were surveyed across four federal jurisdictions. After the buffelgrass extent was mapped, approximately 4,000 acres of infestations were treated across five federal land ownerships in 2016.

Figure 34. Sean Lockwood from the Coronado NF, conducting buffelgrass surveys on the Catalina Ranger District, Coronado NF (left) and small yellow patches of invasive buffelgrass, towards the bottom left portion of the photo, (right).

Other Entomology and Pathology Activities in 2016

Regional Forest Health Training Events

FHP staff provides annual training opportunities to resource managers that enhance forest health knowledge on insect and disease identification, effects, and management as well as hazard tree identification and mitigation. In 2016, these two trainings were combined and hosted by the Safford RD on the Coronado NF (Figure 35). Location of the training alternates between Arizona and New Mexico annually.

Figure 35. Discussion on stem decays led by New Mexico Zone plant pathologist, James Jacobs, at the 2016 Hazard Tree Training.

Mountain Pine Beetle Phenology

Since 2015 we have partnered with researchers from the Rocky Mountain Research Station in Logan, Utah to examine mountain pine beetle (MPB) phenology in the Southwest. MPB is responsible for vast acreages of tree mortality in other regions, particularly in lodgepole and ponderosa pine, with some mortality also recorded in five-needle pines. In the southwestern US, tree mortality from this beetle has been limited, despite the widespread presence of one of its primary hosts, ponderosa pine. In fact, the primary host for MPB in the southwest has been fire-damaged southwestern white pines (SWWP). The objective of our current study is to 1) examine thermal requirements for MPB in the southwest and 2) use this information to better understand the potential for widespread outbreaks of MPB in either SWWP or ponderosa pine under predicted temperature increases. During the summer of 2015 we established two study sites, one on the San Francisco Peaks and the second on White Mountain Apache Tribal Lands. At each study site we baited three SWWP trees to incite MPB attacks. In addition, we installed thermocouples to measure phloem temperatures on the north and south aspects of each of the baited trees and a weather station to measure ambient air temperatures at each site. All of the trees were monitored for attacks. Only the trees on the San Francisco Peaks were successfully attacked and in late fall we attached emergence cages to these attacked trees (Figure 36). In 2016 we monitored the timing of the beetles emerging from these trees. In addition, we baited an additional three trees on the San Francisco Peaks and we plan to monitor these trees through beetle emergence in 2017.

Figure 36. Forest Health Protection and Rocky Mountain Research entomologists are monitoring mountain pine beetle phenology in temperature probed trees on the San Francisco Peaks, Coconino NF.

From these data a model will be developed to parameterize the thermal requirements of MPB development in the Southwest.

For additional information on this study please contact Monica Gaylord (monicalgaylord@fs.fed.us)

Do Pre-Fire Thinning Treatments in the Wildland Urban Interface Reduce Post-Fire Tree Mortality from Bark Beetles?

In 2016 we partnered with the Ecological Restoration Institute (ERI) at Northern Arizona University in Flagstaff, Arizona to examine how thinning treatments, conducted in the wildland urban interface (WUI) prior to the 2011 Wallow Fire in eastern Arizona, impacted post-fire beetle driven tree mortality. In 2012, ERI established paired plots (treated and untreated) in stands burned by the Wallow Fire to examine the influence of pre-fire fuel reduction treatments on increasing stand resiliency and reducing burn severity (Waltz et al. 2014). During the summer of 2016 (5-years post-fire) the ERI planned to reassess the same plots. In addition to verifying resiliency and burn severity metrics, we worked with ERI to assess tree mortality from bark beetles. From data gathered in 2016, we will assess differences in beetle attacks between the thinned and untreated stands and develop guidelines to better predict the risk of bark beetle outbreaks in warm/dry mixed conifer stands after fire. Guidelines will also be developed for future thinning projects to increase stand resiliency in warm/dry mixed conifer stands. Our specific objectives are to 1) compare the frequency of successful bark beetle attacks in several different tree species (primarily southwestern white pine, Douglas-fir, and ponderosa pine) between thinned and untreated stands; 2) compare tree mortality rates in these tree species as a result of bark beetle attacks between thinned and untreated stands; and 3) develop management guidelines for stand density treatments that will promote stand resiliency in dry/warm mixed conifer stands.

For additional information on this study please contact Monica Gaylord (monicalgaylord@fs.fed.us)

Monitoring Spruce Aphid-Caused Damage

Figure 37. Spruce aphid damage on the slopes of Mount Baldy, near Sunrise Ski Resort, White Mountain Apache Tribal Lands.

A trend of warm and wet winters has occurred for the past several years in the Southwestern Region. This weather pattern has facilitated an increase in spruce aphid activity and subsequent damage of Engelmann and blue spruce in eastern Arizona. The number of acres observed with spruce aphid defoliation increased significantly in Arizona, from no impacts observed in 2014 to nearly 9,000 acres detected in 2015, and then increasing to 34,000 acres in 2016. As this increase occurred and severe defoliation became more widespread across the White Mountains (Figure 37), we began working with the Apache-Sitgreaves NFs, Bureau of Indian Affairs, White Mountain Apache resource managers, and an entomologist from Rocky Mountain Research Station to implement intensive ground monitoring. The objective of the program was to better understand correlations between spruce aphid defoliation and mortality, particularly, of spruce regeneration. In addition we continue to monitor overstory mortality. This project was funded with one-year, Evaluation Monitoring funds to establish a permanent plot system. In these plots we collected baseline defoliation and mortality data and will monitor changes in species composition of high elevation spruce-fir and mixed conifer forests.

For additional information on this study please contact Amanda Grady (agrady@fs.fed.us)

Evaluation of Unmanned Aircraft Systems Utility for Forest Health and Forest Management: Pilot Project in the Southwestern Region

A project to evaluate unmanned aircraft systems (UAS) utility for forest health and biomass data collection was implemented September 2016 on the Apache-Sitgreaves NFs (Figure 38). The site was chosen specifically to evaluate spruce aphid and native bark beetle caused damage and to test a new cost effective cruising method called two phase remote sensing (2PRS) that had not been implemented in dense mixed conifer stands. This was the first exclusive use aviation contract for UAS services for the Forest Service. The contract was awarded to RYKA UAS. Several lessons learned were documented through this project and recommendations for safe and efficient UAS integration into Agency resource missions are being prepared. Contract specifications, operations plans, and project aviation safety plans have been updated to include UAS. Imagery was collected on approximately 200 acres using red blue green, infrared, near infrared bands and a red edge sensor (Figure 39). In October 2016, we collected ground data to verify forest health conditions and biomass estimates from the acquired imagery.

For more information, contact Amanda Grady (agrady@fs.fed.us).

Figure 38. Matrix-E quad copter in flight

Figure 39. Sample of imagery collected with the red edge frequency band.

Monitoring Ips and Their Impacts Around Urban Tucson

The State operated Western Bark Beetle Initiative grant program funded a project to evaluate the types of bark beetles killing mature urban Mediterranean pines around Tucson, Arizona. Following years of drought and insufficient irrigation, several large diameter pines planted at lower elevations became stressed and subsequently attacked by ips bark beetles (Figure 40). The objective of the project was to identify the bark beetle and wood boring insects attacking the compromised pines, and to identify the adult flight, number of generations occurring at these lower elevations and tree symptoms. Pheromone assisted funnel traps were used to monitor populations around urban Tucson and Green Valley in 2016. *Ips calligraphus* and *I. lecontei* were detected in traps throughout the monitoring areas. Understanding the lifecycle of the beetles and the best management practices needed to protect these high value trees will help reduce the potential of future bark beetle infestations in urban forests of southern Arizona.

Figure 40. Mature Aleppo pine killed by *Ips calligraphus* in urban Tucson, Arizona.

For more information contact John Richardson (JRichardson@dffm.az.gov).

Biological Evaluations and Technical Assistance

Arizona Zone

Post Treatment Evaluation for Bear Canyon Suppression Project, Santa Catalina RD; 1/14/16.

Forest Health Protection Specialist Report for Rim Country EIS, AZ-FHP-16-4; 3/29/16.

Forest Health Specialist Report for: Middle and Lower Oak Creek Watershed Restoration Action Plan, AZ-FHP-16-5; 4/19/16.

Biological Evaluation for Kris Murphy's Silvicultural Certification Stand, AZ-FHP-16-6; 4/25/16.

Assessment of Bark Beetle Activity at Mount Trumbull, Arizona, AZ-FHP-16-7; 6/30/16.

Assessment of Forest Health Conditions at Rustler Campground, Douglas District, Coronado National Forest, Arizona; 7/26/16.

Assessment of Forest Health Conditions at Barfoot Park, Douglas District, Coronado National Forest; 7/27/16.

Assessment of Forest Health Conditions on the South Side of Bill Williams Mountain, Williams Ranger District, Kaibab National Forest; 8/4/16.

Assessment of Forest Health Conditions at the Jacob/Ryan Project Area, North Kaibab Ranger District, Kaibab National Forest; 8/4/16.

Hazard Tree Assessment APS Power Line Right Of Way, Red Rock Ranger District, Coconino National Forest; 9/12/16.

Evaluation of Bark Beetle Activity and Impacts within the Wallow Fire, AZ-FHP-17-01; 10/17/16.

Marshall Gulch Thinning Project-Site Visit Letter, Santa Catalina Ranger District, Coronado National Forest; 11/22/16.

Douglas-fir Tussock Moth Trapping Results in Arizona; 12/12/16.

New Mexico Zone

Evaluation of Hazard Tree Condition on Petrified Forest National Park, NM-FHP-16-1; 12/17/15.

White Fir and Gambel Oak Mortality Assessment on the Sandia Ranger District Cibola National Forest, NM-02-16; 3/4/16.

International Work to Discuss Invasive Ambrosia Beetle Biology, Impact, and Management in Mexico, NM-FHP-16-03.

Assessment of Douglas-fir Tussock Moth defoliation on the Santa Fe National Forest, Pecos/Las Vegas Ranger District, NM-FHP-16-4; 8/23/16.

Tree Risk Assessments and Hazard Tree Mitigation in the Dog Head Fire Burn Scar, NM-FHP-06-16; 9/7/2016.

Evaluation of FY2017 Los Indios Canyon A1 Suppression Project Proposal, NM-FHP-07-16; 9/23/16.

Evaluation of FY2017 Suppression Project and Progress of Southwestern White Pine Resistance Project, NM-05-16; 9/23/16.

Peer Reviewed Publications

Bentz, B., J. Vandygriff, C. Jensen, T. Coleman, P. Maloney, S. Smith, A. Grady, and G. Schen-Langenheim. 2016. Monitoring mountain pine beetle life cycle timing and phloem temperatures at multiple elevations and latitudes in California. Forest Health Monitoring: National status, trends and analysis 2015. Forest Service Research and Development, Southern Research Station, General Technical Report, SRS-213.

Chen, Y., P.L. Dallara, L.J. Nelson, T.W. Coleman, S.M. Hishinuma, D. Carrillo, and S.J. Seybold. 2016. Comparative morphometric and chemical analyses of phenotypes of two invasive ambrosia beetles (*Euwallacea* spp.) in the United States. Insect Science doi: 10.1111/1744-7917.12329

Coleman, T.W. and S.J. Seybold. 2016. Goldspotted Oak Borer in California: Invasion history, biology, impact, management, and implications for Mediterranean forests worldwide. *In:* Insects and Diseases of Mediterranean Forest Systems. T.P. Paine, F. Lieutier (eds.) Springer, DOI 10.1007/978-3-319-24744-1_22

Coleman, T.W., S. Smith, M.I. Jones, A.D. Graves, and B.L. Strom. 2016. Effect of contact insecticides against the invasive Goldspotted Oak Borer (Coleoptera: Buprestidae) in California. Journal of Economic Entomology. doi: 10.1093/jee/tow217

Hoyt, H.M., W. Hornsby, C-H. Huang, J.J. Jacobs, and R.L. Mathiasen. 2016. Dwarf mistletoe control on the Mescalero Apache Indian Reservation, New Mexico. Journal of Forestry doi: 10.5849/jof.16-049

Lopez-Martinez, V., G. Sanchez-Martinez, D. Jimenez-Garcia, N.B. perz-De la O, and T.W. Coleman. 2016. Environmental suitability for *Agrilus auroguttatus* (Coleoptera: Buprestidae) in Mexico using MaxEnt and database records of four *Quercus* (Fagaceae) species. Agricultural and Forest Entomology 18: 409-418.

Negron, J.F., J. McMillin, C.H. Sieg, J.F. Fowler, K.K. Allen, L.L. Wadleigh, J.A. Anhold and K.E. Gibson. 2016. Variables associated with the occurrence of *Ips* beetles, red turpentine beetle and wood borers in live and dead ponderosa pine with post-fire injury. Agricultural and Forest Entomology 18: 313-329.

Ostry, M.E., M.J. Moore, J.J. Jacobs, J.A. Smith, and N.A. Anderson. 2016. Disease biology and histopathology of bronze leaf disease: a threat to cultivated aspens, white poplars, and their hybrids. Forest Pathology doi: 10.1111/efp. 12293

Pureswaran, D.S., R.W. Hofstetter, B.T. Sullivan, A.M. Grady, and C. Brownie. 2016. Western pine beetle populations in Arizona and California differ in the composition of their aggregation pheromones. Journal of Chemical Ecology 42(5): 404-413.

Seybold, S.J., R.L. Penrose, and A.D. Graves. Invasive Bark and Ambrosia Beetles in California Mediterranean Forests Ecosystems. *In:* Insects and Diseases of Mediterranean Forest Systems. T.P. Paine, F. Lieutier (eds.) Springer, DOI 10.1007/978-3-319-24744-1_21

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.

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.

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. Amanda is currently the Forest Health Monitoring representative for the Southwestern 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.

Daniel DePinte (928) 556-2071

Daniel is a forest health specialist who joined Forest Health Protection, Arizona zone in 2015. Responsibilities include GIS program for Arizona, aerial detection surveys, data analysis, and field assistance. Daniel is involved with an evaluation monitoring project concerned with identifying the seed and cone insect guild of Southwestern white pine (*P. strobiformis*).

New Mexico Zone

Tom Coleman (505) 842-3286

Tom is the Zone Leader and 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.

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.

James Jacobs (now in NE Area) (651) 649-5266

Gregory Reynolds (505) 842-3288

Gregory has been a plant pathologist with the New Mexico Zone since January 2017. His primary responsibility is providing technical assistance on forest disease management to National Forests and tribal lands as well as managing the hazard tree program for the region. His current focus is on mapping dwarf mistletoe incidence on national forest lands throughout the state.

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.

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** application is designed to be a companion to the annual national 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 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) data 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 sketchmapping system.
- Ability to upload survey data.

National Insect and Disease Risk Assessment

The **2013-2027 National Insect and Disease Risk Map (NIDRM)** is a regional and landscape level planning tool that evaluates risk of tree mortality caused by insects and disease over a fifteen year period.

For this analysis, areas at risk were defined as those likely to experience mortality in 25% or more of the total standing basal area of live trees over 1 inch in diameter at breast height (DBH) from 2013 through 2027 (Krist et al. 2014)[1]. The main functions of this application include:

- A simple risk map viewer with a variety of base maps.
- Ability to adjust layers that show risk based on: single damage types, the cumulative effects from all individual pest models (composite data), and proportion of treed area at risk by 6th level HUC watershed.
- Ability to print maps

The National Insect and Disease Risk Map application can also be accessed on the forest health web portal from: https://foresthealth.fs.usda.gov/nidrm/

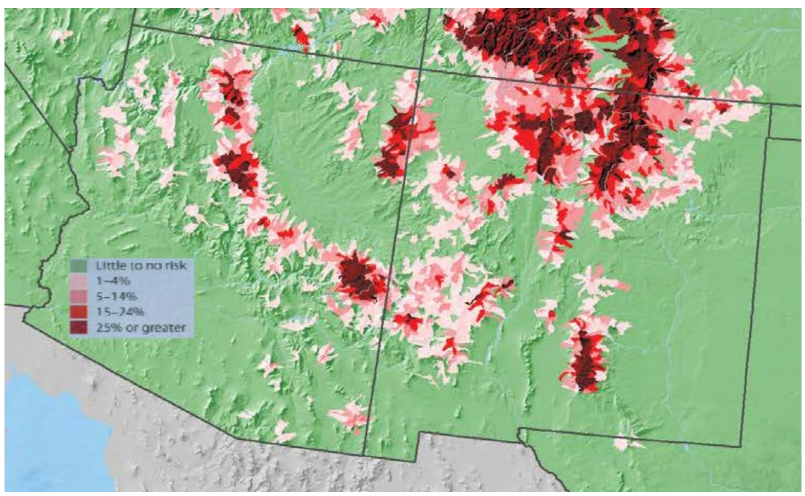

Figure 41. Percentage of treed area at risk by watershed in the Southwestern Region. From the 2013-2027 National Insect and Disease Risk Map composite assessment for all agents.

Individual forest pest models were created by using an extensive set of inventory, terrain, climate and other variables known to influence the ability of that agent to cause tree mortality. Overall risk was developed using a composite of individual agent models. In the Southwestern Region, 7.2% of the forested area or 3,509,000 acres were identified as at risk. Major agents contributing to risk in our Region include: engraver beetles, Douglas-fir beetle, spruce beetle and root disease. The models also summarize risk of tree mortality at the 6th HUC watershed level (Figure 41). Watersheds shown in dark red have at least 25% predicted mortality and meet criteria for insect and disease treatments under Section 602b of the 2014 Farm Bill.

[1] Krist, F.J., Ellenwood, J.R., Woods, M.E., McMahan, A.J., Cowardin, J.P., Ryerson, D.E., Sapio, F.J, Zweifler, M.O., and Romero, S.A. 2014. National Insect and Disease Forest Risk Assessment, 2013-2027. FHTET-14-01. Fort Collins, Colorado: U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team. 106 p. Online at: http://www.fs.fed.us/foresthealth/technology/pdfs/2012_RiskMap_Report_web.pdf