# Forest Insect and Disease Conditions in the Southwestern Region, 2015





Forest Service

Southwestern Region

Forest Health PR-R3-16-15

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Cover Photo: Mosaic of various forest health issues and activities found in the Southwestern Region (Top left: Melampsora rust on aspen; top right: white fir mortality; middle left: Pandora moth defoliation; middle right: insect and disease training; bottom: pine needle cast.

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### **Conditions in Brief**

### **Weather Summary**

For the second year in a row, precipitation increased across much of the Southwestern Region. Accumulation of rain and snowfall was near or above average with parts of eastern and northern New Mexico experiencing "much above average" precipitation and temperature was "much above average" for the year (Figures 1 and 2). For Arizona, the statewide precipitation for the year was "near average" to "above average" and temperature was "much above average" (Figures 1 and 2). According to the NOAA annual summary three themes were apparent:

"The early-year warmth in the West as accompanied by below-average precipitation and record low mountain snow packs, contributing to crippling summer drought and a record-breaking wildfire season in the region."

"By the end of the year, that pattern had flipped, with record and near-record temperatures across most of the East and near-to below-average temperatures for much of the West, associated with much needed above average precipitation across the region."

"Beneficial precipitation began to fall across the region by the end of the year, consistent with the strong El Niño that developed during 2015."

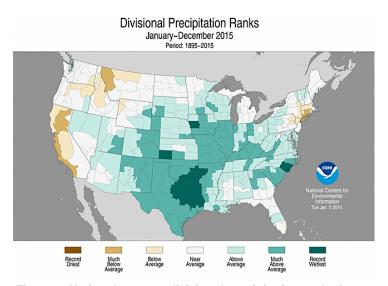


Figure 1. National average divisional precipitation ranks for 2015 (https://www.ncdc.noaa.gov/sotc/national/201513).

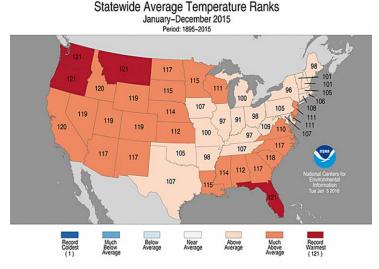


Figure 2. National average divisional temperature ranks for 2015 (https://www.ncdc.noaa.gov/sotc/national/201513).

# Forest Insect and Disease Summary

The area covered by the annual forest health aerial detection surveys (ADS) remains approximately consistent from year to year across the Region. In 2015, aerial surveyors flew 22 million acres (Figures 3 and 4). The number of acres affected (e.g., mortality, defoliation, etc.) by insects that were observed during aerial detection surveys decreased from 636,000 acres in 2014 to 436,000 acres in 2015. Varying levels of defoliation attributed to western spruce budworm account for most of the acres of tree injury. The acres of tree mortality decreased from 396,000 to 194,000 in the Region. Bark beetles were linked to the majority of this mortality. Root diseases and mistletoes are not mapped via aerial surveys and we report their incidence and severity based on ground estimates, thus the numbers are essentially consistent from year-to-year at approximately 5 million acres across the Region. In total, approximately 5.46 million acres were affected by some sort of insets and/or disease in 2015.

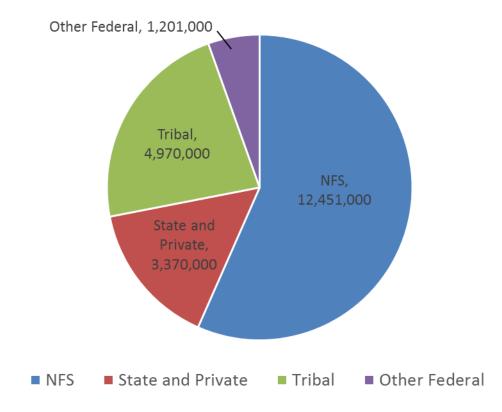


Figure 3. 2015 Aerial detection survey acres flown by land ownership (Total acreage flown =21,992,000).

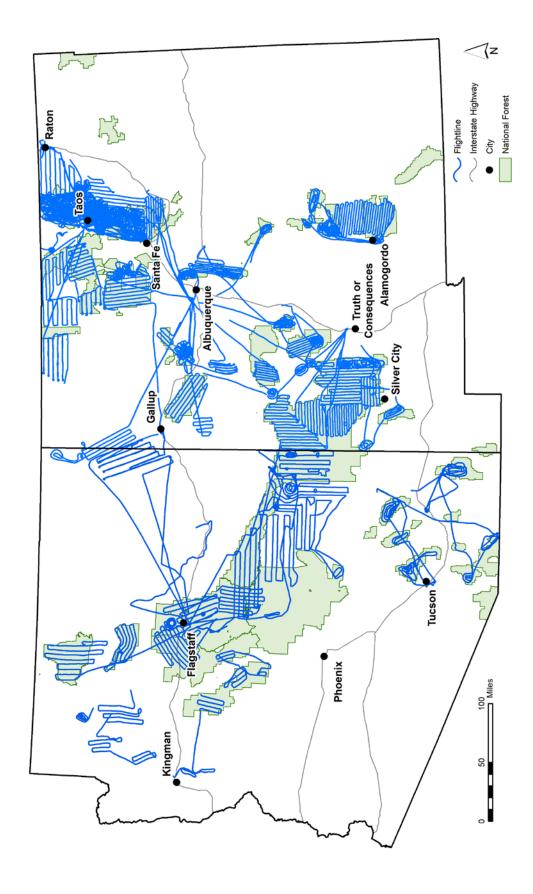


Figure 4. Flightlines recorded during 2015 aerial detection surveys in the Southwestern Region.

Aerial detection surveys mapped just over 160,000 acres of bark beetle activity across all forest types in the Region (Table 1). This represents the third straight year of a decrease in acres with bark beetle activity mapped, down from 500,000 in 2013. The most abrupt change in acres of mapped tree mortality from 2014 to 2015 was noted in the pinyon-juniper forest type where only 460 acres of mortality were mapped in 2015 compared to more than 46,000 acres in 2014. In forests dominated by ponderosa pine, insect-caused tree mortality also decreased by three-fold from 161,000 acres in 2014 to 56,000 acres in 2015. Tree mortality in the mixed conifer forest type followed a similar trend with a reduction from 127,000 in 2014 to 74,000 in 2015. Tree mortality remained relatively constant in the spruce-fir type due in part to a reduction in spruce engraver beetle-caused mortality in Arizona and building populations of spruce bark beetle in northern New Mexico.

Dwarf mistletoe is the most common and widespread pathogen in the Southwest. Because we are unable to estimate dwarf mistletoe from ADS and yearly ground estimates are limited, overall estimated acreage affected does not change radically from year to year. Our current estimates are based on historical records. 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 due to lack of surveys. However, the incidence and severity of infection may be increasing in stands or on individual trees. Ponderosa pine stands severely infected with dwarf mistletoe have higher levels of tree mortality than uninfested stands. Root diseases are also widely distributed across the Region but poorly documented. 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 solidipes* (formerly, *A. ostoyae*) is the most common and damaging root disease to spruce, true firs, Douglas-fir, ponderosa pine, and aspen in the Southwest.

White pine blister rust, caused by the exotic invasive fungal pathogen *Cronartium ribicola*, continues to cause severe damage to southwestern white pine in the Sacramento Mountains of southern New Mexico. Forest health staff in Arizona and New Mexico continues 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 National Forest. In Arizona, the rust has only been detected in the eastern portion of the State on the White Mountains.

Table 1. Prominent 2015 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	14,440	6,260	1630	270	22,600
Ponderosa Bark Beetles	NM	27,310	2,440	610	2,120	32,470
Mixed Conifer Bark Beetles	AZ	12,570	3,770	610	20	16,970
Mixed Conifer Bark Beetles	NM	35,400	3,920	1420	16,530	57,270
Spruce-Fir Bark Beetles	AZ	10	240	< 5		250
Spruce-Fir Bark Beetles	NM	27,720	960	460	3,010	32,150
Western Spruce Budworm	AZ	0	400	0	0	400
Western Spruce Budworm	NM	145,430	11,270	2800	82,670	242,170
Aspen Damage**	AZ	6,160	4,860	800	230	12,050
Aspen Damage**	NM	19,590	1,990	220	10,190	31,990
Root Disease***	AZ	219,000	***	***	***	219,000
Root Disease***	NM	860,000	***	***	***	860,000
Dwarf Mistletoes***	AZ	1,174,000	674,000	***	25,000	1,873,000
Dwarf Mistletoes***	NM	1,144,000	348,000	***	581,000	2,073,000

<sup>\*</sup> Values rounded to the nearest 10; sum of individual values may differ from totals due to rounding.

<sup>\*\*</sup> Aspen damage includes a combination of insect defoliation and other biotic and abiotic factors causing aspen decline resulting in mortality. See text for additional information.

<sup>\*\*\*</sup> Significant activity observed/known, but acreage not determined.

Table 2. Bark beetle incidence by ownership (acres) from aerial detection surveys in 2015 in Arizona and New Mexico<sup>1</sup>.

Owner <sup>2</sup>	Ponderosa pine bark beetles	Mountain pine beetle <sup>3</sup>	Pinyon ips	Douglas-fir beetle	Spruce beetle	Western balsam bark beetle	Fir engraver
Apache-Sitgreaves NFs	8,550	50	< 5	8,880	< 5	< 5	5,540
Coconino NF	2,050	260	< 5	670	< 5	< 5	30
Coronado NF	1,090	60	70	280			160
Kaibab NF	2,200		< 5	50	< 5	< 5	40
Prescott NF	560		< 5	300			50
Tonto NF	40			< 5			20
BLM	400		< 5				
DOD	10						
NPS	1,230		< 5	520		< 5	180
White Mtn. Apache	800		< 5	2,130	< 5	240	2,020
Hopi Tribal							
Hualapai Tribal	170		< 5				
Navajo Nation	110		60	160			360
Navajo-Hopi JUA							
San Carlos Apache	5,540		110	70			
State & Private	340		< 5	10			20
Arizona Total	23,090	370	250	13,060	10	240	8,430
Carson NF	700		< 5	3,320	5,410	1,020	1,390
Cibola NF	590		30	930		400	9,340
Gila NF	21,480		< 5	4,820			1,580
Lincoln NF	3,210		< 5	790	70	480	2,040
Santa Fe NF	1,330		< 5	7,950	20,250	760	4,020
Valles Caldera NP	430			1,180	460		80
BLM	30		40				< 5
BOR	20		< 5				
NPS	120			200			
Acoma Pueblo	850		30				
Isleta Pueblo	< 5		30	20			
Jemez Pueblo	< 5						
Jicarilla Apache	10			300	20		50
Laguna Pueblo	< 5						
Mescalero Apache	1,000			690	60	520	2,460
Navajo Nation	550		< 5	90		260	
Other Tribal	< 5						
Ramah Tribal	< 5			20			
Picuris Pueblo							
Santa Clara Pueblo	< 5			250			< 5
Taos Pueblo	< 5			110	90	< 5	< 5
Zuni Pueblo	10		10				
State & Private	2,120		70	3,480	2,410	690	13,310
New Mexico Total	32,470		210	24,150	28,770	4,130	34,270
SW Region Total	55,560	370	460	37,210	28,780	4,370	42,700

<sup>&</sup>lt;sup>1</sup> 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.

<sup>&</sup>lt;sup>2</sup> Values based on landownership, thus any inholdings are summarized with their ownership category.

<sup>&</sup>lt;sup>3</sup> Hosts are southwestern white pine and/or limber pine.

Table 3. Defoliation incidence by ownership (acres) from aerial detection surveys in 2015 in Arizona and New Mexico<sup>1</sup>.

Owner <sup>2</sup>	Western spruce budworm	Aspen damage <sup>3</sup>	Douglas- fir tussock moth	Pine sawfly ponderosa	Pinyon needle scale	Pandora moth	Spruce aphid
Apache-Sitgreaves NFs		2,610					1,320
Coconino NF		1,600	40				
Coronado NF		180	60				
Kaibab NF		1,710				7,420	
Prescott NF					340		
Tonto NF		60					
BLM							
DOD							
NPS		800					
White Mtn. Apache		3,250					7,530
Hopi Tribal					70		
Hualapai Tribal							
Navajo Nation	400	1,610					
Navajo-Hopi JUA					10		
San Carlos Apache					1,280		
State & Private		230	40		210		
Arizona Total	400	13,720	140	0	1,900	7,420	8,840
Carson NF	81,350	7,790					
Cibola NF	6,490	2,250	180	80			
Gila NF	,	10					
Lincoln NF		970	700				
Santa Fe NF	57,600	8,570	100				
Valles Caldera NP	2,690	170					
BLM	110	10					
BOR							
NPS		30					
Acoma Pueblo							
Isleta Pueblo							
Jemez Pueblo							
Jicarilla Apache	3,460	100					
Laguna Pueblo							
Mescalero Apache		310					
Navajo Nation	330	1,530					
Other Tribal	460						
Ramah Tribal	10						
Picuris Pueblo							
Santa Clara Pueblo		50	90				
Taos Pueblo	7,020						
Zuni Pueblo							
State & Private	82,670	10,190	490	50			
New Mexico Total	242,170	31,990	1,570	140	0	0	0
SW Region Total	242,570	45,710	1,710	140	1,900	7,420	8,840

<sup>&</sup>lt;sup>1</sup> 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.

<sup>&</sup>lt;sup>2</sup> Values based on landownership, thus any inholdings are summarized with their ownership category.

<sup>&</sup>lt;sup>3</sup> 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 2015, approximately 170,000 acres of bark beetle-caused tree mortality was mapped across all forest types in the Southwestern Region (Figures 5 and 7). This represents the third straight year where a significant decrease in acres with bark beetle activity was mapped in New Mexico and Arizona and is likely due to increased precipitation. In New Mexico, acres mapped with bark beetle activity was nearly half of the amount observed in the previous year; a similar trend was observed in Arizona.

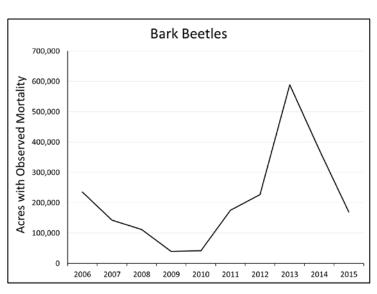


Figure 5. Acres with observed tree mortality from all bark beetles in the Southwestern Region from 2006 to 2015.

# Pinyon-Juniper Forest Type

Pinyon-juniper woodlands can exist as high as 7,000 ft. in elevation, with tree species composition and densities varying widely among individual sites. The pinyon-juniper forest type experienced a Region-wide decrease in pinyon ips and cedar bark beetle activity between 2014 and 2015.

### Pinyon Ips

*Ips confusus*, Host: Pinyon pine

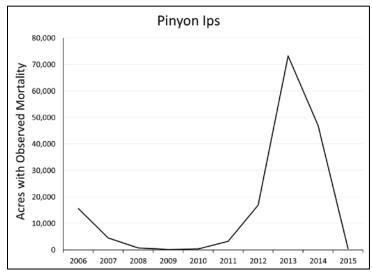
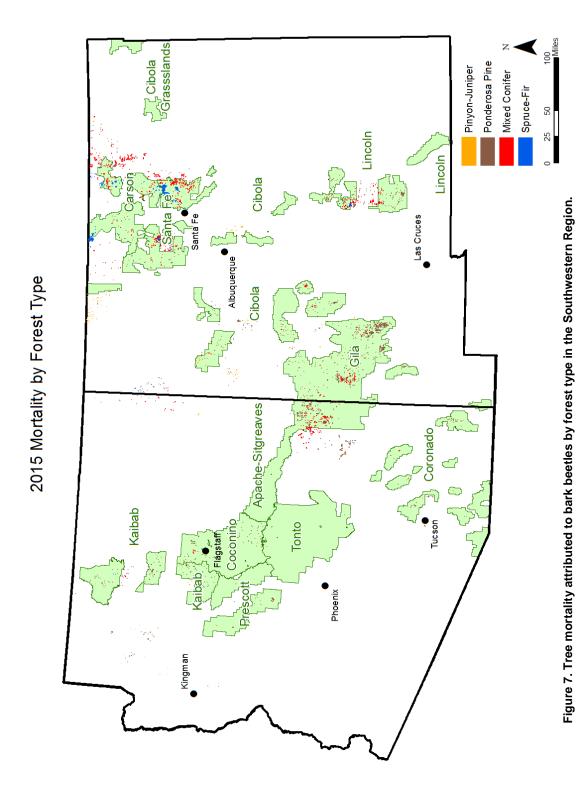


Figure 6. Acres with observed pinyon pine mortality caused by pinyon ips in the Southwestern Region from 2006 to 2015.

Pinyon ips activity fell to nearly endemic levels in 2015 (Figure 6) with only 460 acres with mortality across the whole Region. In 2014, 990 acres of pinvon pine mortality were mapped in Arizona, whereas in 2015 this number declined to 250 acres and was mostly located on San Carlos Apache tribal lands. In New Mexico, only 210 acres of pinyon ips mortality were mapped in 2015 compared to more than 46,000 acres in 2014 and were located primarily on BLM, State, and private land ownerships.



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### **Ponderosa Pine Forest Type**

The ponderosa pine forest type in the Southwestern Region generally ranges from 6,000 feet to 9,000 feet in elevation. Mortality of ponderosa pine by bark beetles in the Southwest is often caused by a combination of bark beetle species. For example, *Ips* spp. and western pine beetle may be active on different sized trees within the same area or co-occurring within the same trees. As of the 2015 aerial survey season, we are no longer labeling specific bark beetle species due to the lack of accuracy in this assessment. All observed bark beetle activity in ponderosa pine forests during ADS is coded simply as "bark beetle." The amount of tree mortality attributed to bark beetles in the ponderosa pine forest type decreased for the second straight year (Figure 8) and often occurring scattered across the landscape (Figure 9). Overall, 55,500 acres were mapped

with some level of bark beetle morality in this forest type. Of this, 23,000 acres were mapped in Arizona, whereas nearly 32,500 acres were mapped in New Mexico (Tables 1 and 2). Some of the more notable decreases in bark beetle-caused tree mortality in Arizona were on the Apache-Sitgreaves National Forests and White Mountain Apache tribal lands. In New Mexico, generally, all land ownerships saw a reduction in acres of mapped bark beetle-caused tree mortality. Only the pueblos of Laguna and Acoma and part of the Navajo Nation had increases in bark beetle activity in the ponderosa pine forest type.

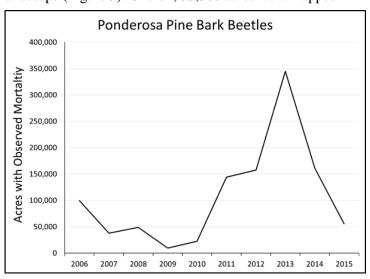


Figure 8. Acres with observed tree mortality caused by ponderosa pine bark beetles in the Southwestern Region from 2006 to 2015.



Figure 9. Ponderosa pine mortality observed during aerial detection surveys south of the Signal Fire on the Gila National Forest.

### **Mixed Conifer Forest Type**

Mixed conifer forests in the Southwestern Region are generally located from 8,000 to 10,000 ft. in elevation. They are primarily composed of Douglas-fir, white fir, and southwestern white pine along with pockets of aspen. Ponderosa pine is intermixed at lower elevations and spruce and subalpine fir trees are intermixed in higher elevations. The amount of tree mortality observed in the mixed conifer forests across the Southwest declined substantially in 2015. The greatest decrease was in white fir mortality associated with fir engraver, but Douglas-fir mortality caused by Douglas-fir beetle also decreased across the Southwest.

Douglas-fir Beetle

Dendroctonus pseudotsugae

Host: Douglas-fir

In 2015, acres impacted by Douglas-fir beetle declined to a three year low for the Region. In Arizona, the number of acres mapped with Douglas-fir mortality during aerial surveys remained relatively consistent from 2014. Most of the activity was within the half a million acre 2011 Wallow Fire in the White Mountains. Since Douglas-fir beetle populations are known to have outbreaks after beetle populations builds up in trees weakened by fire-injury, a large scale monitoring and suppression project was initiated within the Wallow Fire perimeter in 2012. In addition to ADS, Douglas-fir beetle activity has been monitored within the fire perimeter using pheromone-baited funnel traps and ground surveys in selected areas since 2012. In 2015, aerial surveys noted that the acres affected by Douglas-fir beetle were relatively consistent from 2014 within the fire perimeter, tree mortality documented from ground surveys decreased, but trap collections during peak flight periods doubled from 2014 to 2015. It should be noted that, in the case of Douglas-fir beetle, aerial survey data captures beetle activity from the previous year, while ground surveys and traps are designed to capture current year activity. The number of beetles collected in traps during 2015 suggest there were still an abundance of beetles searching

for new hosts. In 2015, suppression efforts included use of anti-aggregation pheromones (MCH) in campgrounds and Mexican spotted owl protected activity centers as well as traps and pheromone lures to decrease local Douglas-fir beetle populations around the campgrounds. The project seems to be successful in many of the implementation areas, but there are some areas where we observed significant concentrations of Douglas-fir beetle activity, particularly around Hannagan Meadow on the Alpine Ranger District of the Apache-Sitgreaves National Forests (Figure 10).



Figure 10. American Conservation Experience crew member protecting stands with anti-aggregation pheromones at Big Lake Recreation Area, Apache-Sitgreaves National Forests.

In New Mexico, Douglas-fir beetle-caused tree mortality has decreased the past couple of years. Declines in activity were observed on all National Forests in New Mexico with the exception of the Gila National Forest. Beetle activity on the Gila National Forest was related to the Whitewater Baldy Complex Fire that occurred in 2012. The Carson and Santa Fe National Forests, while having a reduction of Douglas-fir beetle activity, still had significant Douglas-fir tree mortality. In the Santa Fe National Forest, this activity is associated with recent fires.

Fir Engraver

Scolytus ventralis

Host: White fir

White fir mortality attributed to fir engraver beetle activity in the Southwest is often driven by drought stress and high stand densities that favor fir engraver success. The resulting tree mortality is seen throughout all age classes, particularly on drier south- and west-facing slopes, and the lower elevations of north facing slopes.

In Arizona, white fir mortality decreased to one-sixth of the levels recorded in 2014. A wet spring followed by a wet monsoon may have facilitated the decrease in the number of acres of white fir mortality. Mortality was still present in the White Mountains especially on the Alpine Ranger District where most of the activity was mapped. White Mountain Apache tribal lands around Mount Baldy also had a large portion of the area affected. Canyon de Chelly and Navajo Nation lands in the northeastern part of the State had some white fir mortality with majority of the damage detected in drainages on the Defiance Plateau.

In New Mexico, the amount of tree mortality attributed to fir engraver beetle decreased slightly from the levels observed in 2014. Decreased activity was observed in many locations, particularly



Figure 11. White fir mortality in Las Huertas Canyon on the Sandia Mountains, Cibola National Forest.

on the Carson and Santa Fe
National Forests; however,
increased beetle activity was
observed on the Cibola and
Lincoln National Forests.
Over 90% of the activity
mapped on the Cibola
National Forest was on the
Sandia Mountains where
widespread mortality of white
fir is occurring on the eastern
slopes. White fir mortality has
been occurring across the
Sandia Mountains for at least
the past 5 years (Figure 11).

### **Spruce-Fir Forest Type**

At around 9,000 ft. elevation mixed conifer forests start to transition to spruce-fir forests. Engelmann spruce and corkbark fir are the primary trees species, but blue spruce, limber, bristlecone pines, and aspen may also be present. In Arizona, only endemic levels of spruce beetlecaused tree mortality are occurring in high elevation spruce-fir forests. In New Mexico spruce beetle-caused tree mortality increased from, 11,000 acres in 2013 to over 15,000 acres in 2014; with a continued increase to more 20,000 acres in 2015 (Figure 12), with some activity concentrated near the Colorado border.

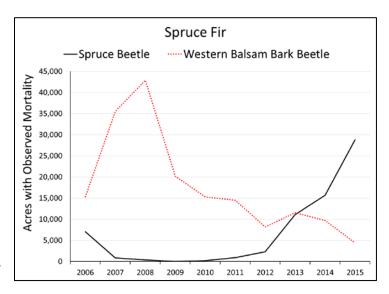


Figure 12. Acres with observed tree mortality caused by spruce beetle and western balsam bark beetle in the Southwestern Region from 2006 to 2015.

### Spruce Beetle

Dendroctonus rufipennis

Host: Spruce

In Arizona, spruce beetle activity was reported on less than 5 acres of the Kaibab National Forest. A few individual dying spruce trees were mapped in the White Mountains of eastern Arizona, north of the Grand Canyon, and on the San Francisco Peaks north of Flagstaff. In New Mexico, tree mortality in the spruce-fir type increased substantially in 2015 mainly due to spruce beetle activity. The Santa Fe National Forest had over two-thirds of the spruce beetle activity with most of the remaining activity on the Carson National Forest (Figure 13). Some activity was noted on the Tres Piedras Ranger District of the Carson National Forest adjacent to the Colorado border where a large spruce beetle outbreak has been occurring on the Rio Grande and San Juan National Forests. As in the past few years, activity in New Mexico has primarily been in the Pecos Wilderness on the Sangre de Cristo Mountains of the Santa Fe National Forest. These areas are in the vicinity of a large windthrow event that occurred in 2007 and is thought to have triggered this outbreak. Site visits to areas of mapped spruce mortality in the vicinity of Elk Mountain located on the Pecos/Las Vegas Ranger District of the Santa Fe National Forest found spruce beetle has caused 10% to over 50% spruce mortality in the affected stands. Additionally, suspected spruce beetle activity was observed on Sierra Blanca in the southern portion of the State. Spruce beetle activity remains a concern in northern New Mexico, especially with the large landscape scale outbreak that has been occurring on the Rio Grande National Forest in southern Colorado.



Figure 13. Previous and recent spruce beetle-caused tree mortality on Elk Mountain on the Santa Fe National Forest.

Spruce Engraver Beetle

Ips hunteri

Hosts: Engelmann and blue spruce.

No new acres of *Ips hunteri* damage were mapped during the 2015 ADS in Arizona.

### Western Balsam Bark Beetle

Dryocoetes confusus Hosts: Subalpine/corkbark fir

In New Mexico, the number of acres observed with western balsam bark beetle (WBBB) activity decreased again for the third straight year. Activity was primarily in high elevation areas along the Sangre de Cristo mountain range, affecting the Carson and Santa Fe National Forests as well as on Sierra Blanca Peak on the Lincoln National Forest. (Figure 14). In Arizona, damage caused by WBBB was limited to 240 acres mapped on the White Mountain



Apache tribal lands. Overall, while the amount of spruce beetle activity increased throughout the Region, acres of WBBB activity decreased (Figure 14).

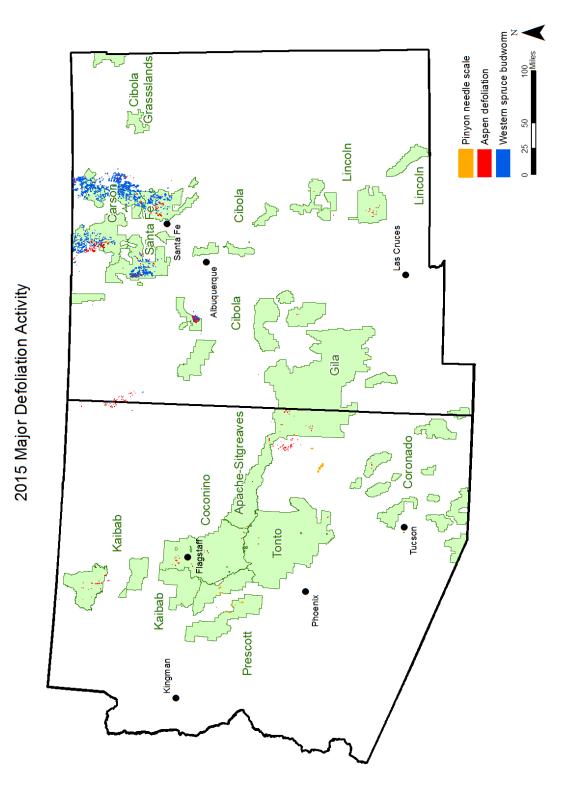


Figure 15. Tree defoliation by forest type in the Southwestern Region.

### **Defoliators**

Defoliating insects damage trees by eating leaves or needles, removing the photosynthetic tissue critical for plant maintenance and growth. A significant loss of leaves or needles results in growth loss, increased susceptibility to attack by other insects and pathogens, and sometimes tree mortality. Across the Southwestern Region more than 318,000 acres of defoliation were mapped during 2015 with the majority of the damage being caused by the western spruce budworm (Figure 15).

The impact of defoliation on individual trees is dependent on a variety of factors. Tree species vary in their tolerance to defoliation. In general, hardwood species can sustain repeated defoliation over several years because they store large food supplies and can refoliate in the same year. The timing of the defoliation relative to seasonal growth phenology is also important. For example, late season defoliation of hardwoods has a lower impact than does late season defoliation of conifers. A single late season defoliation of pines often results in tree mortality.

### Western Spruce Budworm

Choristoneura freemani

Hosts: True firs, Douglas-fir and spruce

Defoliation by western spruce budworm continues to be the most widespread defoliation observed during aerial detection surveys in the Southwest. Most of the western spruce budworm activity in the Southwest occurs in New Mexico, which has a greater proportion of susceptible host type (Figure 16). The acres of defoliation mapped in New Mexico during 2015 (242,500 acres) decreased slightly from 2014 (302,500 acres). The majority of western spruce budworm caused defoliation occurs in the forests in the northern part of the state, particularly on the Carson and Santa Fe National Forests and adjacent state and private lands. This western spruce budworm "outbreak" has been at high levels for 30 years. No defoliation was mapped in the southern

portion of the state. The only area in Arizona where western spruce budworm activity was mapped was on the Chuska Mountains on the Navajo Nation. Some areas such as the North Kaibab Ranger District of the Kaibab National Forest, however, have chronic budworm activity that has not been visible during aerial detection surveys.



Figure 16. Douglas-fir moderately defoliated by western spruce budworm.

### **Douglas-fir Tussock Moth**

Orgyia pseudotsugata

Hosts: White fir, Douglas-fir, and spruce

Several areas with Douglas-fir tussock moth (DFTM) activity were observed in the Southwest in 2015. In Arizona, DFTM activity was mapped on Mount Lemmon near Tucson and along the Mogollon Rim. Both occurrences were small patches of defoliation on the upper slopes of steep terrain. Early warning trapping locations near these areas also trapped active DFTM populations. The defoliation on Mount Lemmon was quite severe in intensity and observed on both the Coronado National Forest and on adjacent private lands. In New Mexico, DFTM activity continued in several locations. Some of the previous outbreaks that were first observed in 2013 and 2014 continued while others subsided. Most of the activity on the Sacramento Ranger District of the Lincoln National Forest that was first observed aerially in 2013 had waned by 2015, only a few acres of defoliation were recorded in Sacramento Canyon. A new outbreak was suspected



Figure 17. Defoliation caused by Douglas-fir tussock moth near Piedra Lisa Trail in the Sandia Mountains, Cibola National Forest.

across a substantial area on the north side of the Capitan Mountains of the Lincoln National Forest. A site visit has not been made to confirm the insect responsible for the defoliation, but DFTM is suspected. DFTM activity on the Sandia Mountains of the Cibola National Forest (Figure 17) continued in 2015 as well on the Sangre de Cristo Mountains. A few new spots of defoliation were mapped during aerial surveys along Santa Clara Canyon and on the Española Ranger District of the Santa Fe National Forest.

In addition to aerial detections surveys, the Southwestern Region participates in the Early Warning Trapping program to monitor DFTM populations (Figures 18). 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. Sites averaging 25 or more male moths per trap indicate that DFTM populations may cause visible defoliation within 1-2 years.

# Kaibab Kingman Kaibab Kingman Kaibab Kingman Kingma

2015 Douglas-fir Tussock Moth Trapping Sites

# Figure 18. In 2015, Douglas-fir tussock moth was monitored on eight National Forests in the Southwestern Region.

### **Pine Sawflies**

Neodiprion spp., Zadiprion spp.

Hosts: Ponderosa and pinyon pines

Pine sawfly defoliation decreased substantially across the Region from more than 2,500 acres in 201 to less than 200 acres in 2015. In Arizona, no defoliation was mapped. Sawfly defoliation of ponderosa pine in New Mexico was mapped on less than 200 acres in 2015 and located mostly on the Cibola National Forest.

### **Pandora Moth**

Coloradia pandora Host: Ponderosa pine

Defoliation caused by Pandora moth larval feeding was not detected during aerial surveys in 2014, but was mapped on more than 7,000 acres in 2015 on the Kaibab Plateau (Figure 19). This is due to the two year life cycle where larvae and defoliation occur in odd numbered years in the Southwest, followed by adult (non-feeding) insects in even numbered years.

Approximately 1,800 acres of moderate to severe defoliation were mapped on the Kaibab Plateau in 2013. Most of the damage was mapped just east of Orderville Canyon. Since



Figure 19. Severe ponderosa pine defoliation caused by pandora moth larval feeding near Orderville Canyon, North Kaibab Ranger District.

2010 we have monitored the adults and larval populations via a collaborative project with Northern Arizona University. We noted a substantial adult population over many thousands of acres in 2014. As anticipated, a substantial increase in acres defoliated were observed in 2015, relative to what occurred in 2013.

# **Pinyon Needle Scale**

Matsucoccus acalyptus Host: Pinyon pine

Pinyon needle scale is a chronic defoliator of pinyon pine in several locations in the woodlands of Arizona and New Mexico, with intensities varying from year-to-year. Approximately 1,900 acres of pinyon pine defoliation was recorded in 2015, a decrease from nearly 10,000 acres in 2014. In Arizona, alone, a significant decrease from more than 5,000 acres of pinyon needle scale damage was in mapped in 2014 whereas only 1,900 acres was mapped in 2015. No pinyon needle scale activity was recorded in the state of New Mexico in 2015, a decrease from 4,500 acres in 2014. The aerial detection of this pest is complicated by drought, as drought-thinned crowns are often indistinguishable from the effects of needle scale during aerial survey flights.

# **Spruce Aphid**

Elatobium abietinum Host: Engelmann spruce

During the 2014-2015 winter, the below-average precipitation and record low mountain snow packs facilitated the continued increased in spruce aphid activity in many locations of Arizona. Similar mild winter conditions occurred over the 2013-2014 winter. We first began to see localized areas of spruce aphid damage in the White Mountains of eastern Arizona in 2014. During the 2015 ADS we mapped 8,840 acres of spruce aphid activity. All of the damage

occurred in the White Mountains with approximately 85% of the damage occurring on White Mountain Apache tribal lands and the remaining 15% mapped on the Apache-Sitgreaves National Forests. Hannagan Meadow had some of the first documented spruce aphid damage on the Apache-Sitgreaves National Forests (Figure 20).



Figure 20. Severe spruce aphid damage along scenic highway 191 near Hannagan Meadow Lodge, Alpine Ranger District.

In 2015, Forest Health Protection, Forest Management, the Washington Office, and the Alpine Ranger District began planning a project to evaluate unmanned aircraft systems (UAS) utility for forest health and forest management missions. A primary focus is to develop an aviation services contract for acquisition of forest health conditions, biomass, UAS production, and cost data within an approximate 200 acre pilot project in the

Southwestern Region on the Alpine Ranger District. The project will evaluate spruce aphid impacts and differentiate between live and dead biomass around Hannagan Meadow. This will be the first contracted USA flight in the Forest Service and will be implemented in 2016 near the biological window to collect spruce aphid damage.

# Aspen Defoliation and Decline

Western tent caterpillar, *Malacosoma californicum* Large aspen tortrix, *Choristoneura conflictana* Complex of drought and other insects and diseases

Aspen damage decreased substantially across the Region in 2015 to 45,000 acres, compared to 73,000 acres in 2014 (Figure 21). Total acreage in Arizona was up slightly from 2014 (10,900 acres) with just over 12,000 acres detected. The damage was attributed to a combination of western tent caterpillar defoliation and foliar diseases such as *Marssonina*, black leaf spot and Melampsora rust. Most of this damage was localized on the Apache-Sitgreaves National Forests and on the nearby White Mountain Apache tribal lands. Other area with substantial damage were mapped on the Coconino and Kaibab National Forests and on Navajo Nation Lands in the northeast portion of the state.

Approximately 32,000 acres of aspen damage was detected in 2015 in New Mexico, which is slightly more than half the acres mapped in 2014 (62,560 acres). The majority of damage was defoliation by western tent caterpillar, which was greatest on the Carson National Forest and Santa Fe National Forest, especially the Canjilon and Tres Piedras Ranger Districts of the Carson National Forest. A quite dramatic defoliation event occurred around Aspen Vista on the Santa Fe National Forest and grabbed the public's attention. A second flush of leaves in the area reduced the visibility of this outbreak later in the season. Aspen mortality occurred in small patches, spread throughout the state, especially on the Cibola and Santa Fe National Forests.

An increase in the incidence and severity of aspen foliar disease (largely caused by leaf spot fungi in the genus *Marssonina*) was observed throughout the Southwestern Region in 2015. This disease led to widespread early defoliation of aspen clones and contributed to subdued fall color in many areas.



Figure 21. Aspen defoliation, likely caused by western tent caterpillar, was ubiquitous in the San Pedro Parks Wilderness Area, Santa Fe National Forest.

# **Status of Major Diseases**

### Mistletoes

### **Dwarf Mistletoes**

Arceuthobium spp. Hosts: All conifers

Dwarf mistletoes are the most widespread and damaging forest pathogen (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 uninfested areas. Weakened trees can be killed by other damaging agents, like bark beetles or root disease. Dwarf mistletoes have an ecological role (e.g., providing bird roosting habitat and as a food source for some mammals and birds). Of seemingly greater importance, dwarf mistletoes provide an indirect food source for birds that 1) feed on insects that feed on the mistletoe shoots, and 2) that feed on bark beetles that attack weakened infected trees.

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 (Figure 22) are found throughout most of their respective host's range, while the other species have more limited distributions.

### True Mistletoes

Phoradendron spp. Hosts: Junipers and various hardwoods

Eight species of true mistletoe occur in the Southwest. These mistletoes are less damaging to their hosts than dwarf mistletoes, but heavy infestations reduce host longevity during periods of drought. *Phoradendron juniperinum* on Utah juniper is probably the most widespread and abundant species. True mistletoes are also common on oaks in southern portions of the Region, abundant on mesquite and palo verde in desert woodlands, and common on most hardwood species in lower elevation riparian areas.



Figure 22. Douglas-fir mistletoe found on the Mount Taylor Ranger District, Cibola National Forest.

There is also a true mistletoe species on white fir that, in the Southwest, only occurs in the Santa Catalina Mountains on the Coronado National Forest in Arizona. True mistletoes have also been observed on juniper in the El Malpais Recreation Area in New Mexico.

### **Root Diseases**

Root diseases are fairly common in forests of the Southwest, and are often associated with mortality attributed to bark beetles. They also 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. Like dwarf mistletoes, root diseases spread slowly, so overall incidence 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 solidipes (= A. ostoyae) Hosts: Spruce, true firs, Douglas-fir, ponderosa pine, and aspen

Armillaria root rot is the most common root disease in the Southwest, where it is estimated to account for up to 80 percent of root disease associated mortality (Figure 23). Although all conifer



Figure 23. Rhizomorphs of *Armillaria* sp. growing under the bark of a dead ponderosa pine on the Santa Fe National Forest.

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 maior *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 found *Armillaria* spp. on about 30 percent of standing live trees.

# **Heterobasidion Root Disease (Formerly Annosus Root Disease)**

Heterobasidion irregulare and H. occidentale Hosts: Most conifers

Heterobasidion root disease is the second most common root disease in the Southwest, where it is found in higher elevation ponderosa pine forests 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, decayers of dead woody material, as well as pathogens.

### Other Common Root Diseases

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

# 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 pine; red ring rot, Porodaedalea pini (syn. Phellinus pini) (Figure 24), affecting most conifers; Indian paint fungus, Echinodontium tinctorium, on white fir; aspen trunk rot, Phellinus tremulae; on aspen; and *Phellinus* everhartii and Inonotus dryophilus on oak.



Figure 24. Fruiting body of *Phellinus pini* on Douglas-fir. This fungus causes a heart rot of the infected conifer which degrades lumber quality and can lead to stem failure.

### Stem Rusts

### White Pine Blister Rust

Cronartium ribicola

Hosts: Southwestern white pine, limber pine, and Ribes spp.

White pine blister rust (WPBR) continues to cause heavy damage to white pines in the Sacramento Mountains of southern New Mexico. where the disease has been established for about 40 years (Figure 25). Based on a set of representative monitoring plots, roughly 45 percent of the white pines in this area, which includes the Mescalero-Apache Reservation and most of the Lincoln National Forest. are infected. WPBR also occurs in the Gila, Cibola, and Santa Fe National Forests of New Mexico. The Apache-Sitgreaves National Forests and White Mountain Apache Tribe are currently the only infected areas in AZ. Many 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.

In Arizona, WPBR was first detected in 2009 on the White Mountain Apache tribal land and neighboring Apache-Sitgreaves National Forests. Age estimation of older cankers suggest the WPBR pathogen may



Figure 25. White pine blister rust aecia found on Southwestern white pine on the Lincoln National Forest.

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. The 2011 Wallow Fire burned through some of the established plots, and the reproduction of both southwestern white pine and orange gooseberry, the alternate host, is being monitored.

### **Broom Rusts**

Melampsorella caryophyllacearum Hosts: True fir and chickweed

Chrysomyxa arctostaphyli
Hosts: Spruce and kinnikinnick

There are two species of broom rust that occur in relatively low incidence in their respective hosts in the Southwest. However, higher infestations of fir broom rust occur in 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. Locally, 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 Arizona and New Mexico is *C. arizonicum*. 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, *P. 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-spored race of western gall rust of ponderosa pine occurs in the Southwestern Region. This disease is uncommon. White-spored pustules form on spindle-shaped galls that form on branches and main stems of infected trees in contrast to the traditionally orange aecia of *P. harknessii*.

# 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.

# Needle Cast

Needle cast fungi infect conifer needles causing them to die prematurely and drop earlier than they normally would be. Generally, needles become infected in late summer of the year prior to when symptoms are observed, although the exact timing of infection for many of the needle cast fungi is unknown or variable. Following bud break, green current year needles and brown previous year needles give the tree a distinctive appearance. Successive years of infection occur only with favorable weather and results in thin crowned trees and is thus not commonly observed year to year.



Figure 26. Needle cast fungi on ponderosa pine detected during an aerial detection survey flight on the Lincoln National Forest. Note discolored (tan-brown) crowns.

A favorable monsoon in 2014 led to an increase in the occurrence of needle cast in several tree species across New Mexico, but most notably in ponderosa and pinyon pine (Figure 26). Most of this activity was observed during aerial surveys in northern New Mexico and ground surveys in southern New Mexico, on state and private lands and to a lesser extent the Carson and Lincoln National Forests. Ponderosa pine needle cast was observed on just over 4,000 acres on the Carson, Santa Fe, Lincoln and

Cibola National Forests. Presence of the fungi was also observed on nearly 500 acres of mixed conifer along the eastern boundary of Carson and Santa Fe National Forests. In spruce-fir forests, more than 100 acres of spruce were observed with what appeared to be needle cast symptoms near Santa Fe Ski Area though ground surveys were unable to definitively identify a pathogen.

# 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; and Highways 180 and 89A near Flagstaff. Deicing 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**

For the past few years, scattered mortality of small ephedra trees were observed on the northwest side of the Hualapai Mountains near Kingman, Arizona. Most of the tree mortality has occurred at the lower elevations on the slopes of the mountain. Drought may be the principal stressor triggering the tree mortality but other causal agents have not been ruled out.

# **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 also conducts ground surveys and trap monitoring for invasive insect species such as the European gypsy moth. 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.

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

Probably the greatest threat to the Southwestern Region by an invasive species is buffelgrass which was introduced as a forage grass from Africa into the southwestern U.S. 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. In addition, the grass forms a dense, continuous fuel during wildfire, leading to more widespread and hotter fires. Sonoran plants are generally unadapted to this new fire cycle. The Coronado National Forest and other land management agencies in Arizona are currently engaged in intensive management projects to control buffelgrass on a landscape basis.

# FHP Programs and Information for Managing Invasive Species

FHP invasive plant grants – 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 program is accomplished through consolidated FHP grants to State Forester's offices in Arizona and New Mexico, which are responsible for administering the grants. For FY15, FHP provided \$148,000 for invasive plant management in Arizona and New Mexico. Funding through the FHP grant program has been used to treat buffelgrass, starthistles, thistles, saltcedar, knapweeds, toadflaxes, and other invasive weeds within the two states. Applicants for treatment projects involving invasive plants may include Cooperative Weed Management Areas (CWMAs), resource conservation districts (RCDs), or Soil and Water Conservation Districts (SWCDs). However, other organizations apart from these may 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. A LSR grant of \$250,000 was obtained in 2015 by the Verde River Coalition for restoration of the Verde River watershed in Arizona. For further information on S&PF grant programs for invasive plants, State forestry offices located in Phoenix, Arizona (602-771-1400) or Santa Fe, New Mexico (505-476-3325) should be contacted.

Regional website for invasive species – The Southwestern Region has a website specific for invasive species in the Southwest (http://www.fs.usda.gov/main/r3/forest-grasslandhealth/invasivespecies). In addition to invasive plants, the website provides information on invasive species topics such as aquatic invasive species, terrestrial invasive animals, invasive diseases affecting fish and wildlife, and invasive 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 for identifying 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 is also available. The field guides are intended to address management of weeds on public and private lands in the Southwestern Region and may be used by private landowners, government agencies, tribal nations, and organizations such as CWMAs.

# Other Entomology and Pathology Activities in 2015

Protecting Southwestern White Pine Trees from Attacks by Mountain Pine Beetle

Southwestern white pine (SWWP) mortality from mountain pine beetle (MPB) has been increasing across the southwest. In particular, we have noted increased mortality after large wildfires such as the Wallow Fire which burned over 500,000 acres in 2011 in eastern Arizona. Verbenone, a pheromone produced by MPB to signal that a host tree has been fully colonized, has been used with varying degrees of success to prevent mountain pine beetle attacks in ponderosa, lodgepole, and some five-needled pines; however, its efficacy has not been tested in southwestern white pine. Furthermore, different application methods of this pheromone are now available for operational use and it is unknown if efficacy of the methods differs under our specific climate conditions. During the summer of 2015 we partnered with a researcher from the Pacific Southwest Research Station to (1) evaluate the efficacy of verbenone in protecting SWWP from MPB attacks and (2) evaluate if there was any difference in the efficacy of the traditional deployment method versus a newer application called SPLATverb (Figure 27). In the traditional plastic pouch deployment, pouches were stapled to the bole of the tree. Depending on tree size, the number of pouches ranged from two to four. Alternatively, if a large area needed to be protected the pouches could be placed in a grid pattern with one pouch hung on a vertical target





Figure 27. Application of verbenone to protect trees from bark beetles using the traditional pouch (left) and the new SPLATverb application method (right).

every forty feet. SPLATverb is a product which is deployed in a caulk-like form, using caulk guns. The product is applied in four dollops around the bole of the tree, or, can also be applied in a grid at 47 foot intervals.

In early June of 2015 we selected and treated 180 trees (60 with pouches, 60 with SPLATverb, and 60 receiving no treatment) at two study sites within the Wallow fire perimeter on the Apache-Sitgreaves National Forests. The trees were resurveyed in October for evidence of beetle attacks. Out of 180 study trees we found four trees with beetle attacks. Three of these trees were control trees (no protection) and one tree with verbenone pouches was also attacked. Although these results suggest that SPLATverb is an effective method of protecting SWWP from MPB attacks, there is too little data for a robust evaluation. During our fall surveys we also noted that at one site, close to 25% of the pouches had fallen off the trees, whereas at the other site over 96% of the pouches were still on the tree bole. Pouches at the two sites were from two different manufactures, and it appears that one packaging material is more resilient under field conditions. SPLATverb dollop retention was similar at the two sites (85% and 81% retention).

For more information on this project please contact Andrew Graves or Monica Gaylord

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

The Forest Service has been exploring potential to fly Unmanned Aircraft Systems (UAS) for a variety of natural resource management purposes for several years. Forest Health Protection has traditionally used fixed wing aircrafts to survey millions of forested acres across the nation every year since the 1940's. Several new technologies are being developed that could supplement some of the missions typically monitored via the traditional aerial survey program. In 2015, the USFS Unmanned Aircraft Systems (UAS) Advisory Group selected a joint project that includes development of an aviation services contract for acquisition of forest health conditions, biomass, UAS production and cost data within an approximate 200 acre pilot project in the Southwestern Region. This is the first contract to procure UAS services for resource management missions on FS lands. This project will focus on development of contract specifications and will inform Agency UAS policy and operational procedures development. The project is also designed to test proof of concept to evaluate forest health conditions and to estimate biomass. The pilot project will be implemented on the Alpine Ranger District, Apache-Sitgreaves National Forests in 2016.

For more information, contact Amanda Grady

### Southwestern White Pine Monitoring and Gene Conservation

As part of a continuation of earlier gene conservation seed efforts in the southwest an additional 13 gene monitoring sites were located across the range of southwestern white pine (SWWP) in Arizona, New Mexico and Texas in 2015 (Figure 28). This tree species is being threatened by the introduced pathogen, white pine blister rust. Sites and sample trees are geo-referenced adequately to allow for subsequent monitoring of population-level changes. Data collected describes site physiography, vegetation, stand conditions, and sample trees (condition and size). At each site, 5 cone-bearing trees (min. 200ft. between sample trees, 20-40 cones or >500 seeds per tree) were sampled with cone and foliage collections. Collected cones were air dried and seeds cleaned of

sap and debris. Cone (length, reflex angle) and seed (mass, size) measurements completed. Seed was packaged using bags supplied by FS Seed Lab and shipped to the ARS National Seed Storage Laboratory (Fort Collins) for deposition in the seed conservation archive. Foliage collections were stored in a freezer for genotyping to be conducted in a subsequent collaborative project. A minimum of 10 cones from each tree were sampled for cone and seed insects, as well as insect predators. Selected cones were placed into individual insect rearing chambers and checked weekly until late May for emerging insects.

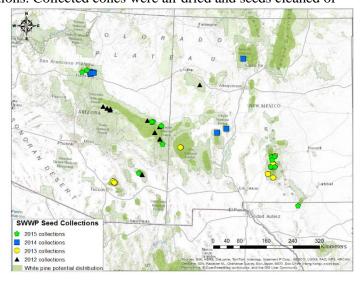


Figure 28. Locations of southwestern white pine (SWWP) seed collections from 2012-2015 across the range of SWWP in Arizona, New Mexico, and Texas.

For more information, contact John Anhold

Pheromone Divergence Among Populations of Western Pine Beetle (*Dendroctonus brevicomis* LeConte) Across its Range in the Western United States.

Pheromone systems of aggressive bark beetles vary substantially with regard to the differing contributions of the two sexes, behavioral effects of compounds and blends, role of host odors, as well as the complexity, chemistry, and apparent ecological roles of the different components. Here we investigate divergence of pheromone compositions within one aggressive species of bark beetle across its range in the western United States. We compared pheromone production and behavioral responses from several populations of western pine beetle, *Dendroctonus brevicomis* LeConte on each side of the Great Basin Desert. Volatiles were collected from individuals and analyzed by coupled gas chromatography-mass spectrometry, gas chromatographyelectroantennographic detection. Field behavioral bioassays investigated response to the isomers of brevicomin and host monoterpenes alpha pinene and myrcene. Analysis of aeration data results in a significant difference in the production ratios of exo- and endo-brevicomin from populations examined on each side of the Great Basin Desert. Populations collected from locations east of the Great Basin Desert had an average ratio of 0.1:1 where as those collected from the western side had an average ratio of 10:1. Furthermore, eastern populations had higher trap responses with a lure combination of frontalin, Endo-brevicomin and alpha pinene while trap responses from western populations preferred the combination of frontalin, exo-brevicomin and myrcene (the standard western pine beetle lure). Our results determined the aggregation pheromone has diverged between the eastern and western populations of the western pine beetle corroborating published evidence that D. brevicomis on either side of the Great Basin are genetically distinct and likely different species.

For more information, contact Amanda Grady Mountain Pine Beetle Phenology

In 2015 we 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 with some additional mortality in five-needled pines. In the southwestern US, we have only recorded tree mortality from this beetle in limited areas, despite the widespread presence of one of its primary hosts, ponderosa pine. In fact, the primary host for MPB in the southwest in recent years 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 SWWPs 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 peaks were successfully attacked and in late fall we attached emergence cages to these attacked trees. In 2016 we will monitor the timing of emerging beetles. In addition, laboratory experiments will be initiated to confirm field results and a model will be developed for thermal requirements of MPB development in the Southwest. In 2015, we also begin field surveys of stands with MPB activity to develop a stand hazard rating for MPB in the southwest. Additional data collection and preliminary analysis for this portion of the study is anticipated for 2016.

For more information, contact Monica Gaylord or Amanda Grady

# **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.

Mary Lou Fairweather (now in Region 5)

(928) 556-2075

Mary Lou became a plant pathologist with the Arizona Zone in 1989, providing technical assistance on forest diseases to land managers. Her current focus is on distribution and impacts of white pine blister rust; aspen regeneration ecology and browse impacts; root disease species distribution and impacts; dwarf mistletoe ecology and management; and hazard tree identification and mitigation training.

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.

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

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

### New Mexico Zone

Debra Allen-Reid (now retired)

(505) 842-3286

Deb was a supervisory entomologist/New Mexico Zone leader since 1996, and retired at the end of 2014. Aside from zone staff supervision and unit management, duties included administrative oversight for the State of New Mexico Cooperative Forest Health program, and Regional point-of-contact for the FHP International Activities program. Debra worked in short-term assignments in Mexico and a long-term assignment with USAID in Haiti.

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

Dan 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. Dan 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 (505) 842-3288

James has been a plant pathologist with the New Mexico Zone since February 2013. Primary responsibility is providing forest disease technical assistance to federal land managers. Current focus: white pine blister rust resistance in southwestern white pine; hazard tree mitigation; root rot distribution and fungal genetic diversity.

# 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 <a href="http://www.fs.usda.gov/goto/r3/foresthealth.">http://www.fs.usda.gov/goto/r3/foresthealth.</a> 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 <a href="http://www.fs.fed.us/foresthealth/">http://www.fs.fed.us/foresthealth/</a> that includes program overviews and publications links.

New forest health information web portal: http://foresthealth.fs.usda.gov/portal

The following information was copied from the Southern Region's website. "A new website is now available making insect and disease information more accessible and timely. This website brings together a wide range of complex tabular and spatial databases via 5 interfaces. The first 3 are accessible by anyone and provide access to insect and disease occurrence data in a consistent fashion with relative ease. The latter two are accessible only by forest health professionals for reporting and using data to enhance their work.

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 through the Insect and Disease Explorer. Other functionality includes:

 Download IDS data, create quad PDF maps, query, navigate, and learn about local level forest pest activity.

Annual insect and disease detection and damage reports are entered in the **Pest Event Reporter** and made accessible via the Forest Pest Conditions interface.

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 aerial sketch mapping system.
- Ability to upload survey data.