Forest Health Conditions in Arizona - 2021

Arizona Department of Forestry and Fire Management

A publication by the Forest Health Program of the Arizona Department of Forestry and Fire Management

Over 17 million acres surveyed by air	Over 500,000 acres with observed bark beetle damage	Over 400,000 acres of state lands with observed drought damage

Assembled by Aly McAlexander, with technical support from Wolfgang Grunberg

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Introduction

Arizona has an incredibly diverse landscape. From the lower Sonoran desert scrub and pinyon-juniper woodland to the high elevation spruce-fir forests.

Forests cover approximately 27% of the state, which is over 19 million acres. These forests are comprised of 37 species of coniferous and hardwood trees. The majority of forestland is located above the Mogollon Rim. Juniper (*Juniperus* spp.) and pinyon juniper (*Pinus edulis-Juniperus* spp.) woodlands are the most abundant forest type in Arizona, occupying approximately 14.8 million acres, or 20.3% of the state. The rarest and most significant in ecological terms is riparian forest, which occupies less than one-half of 1% of Arizona's land.

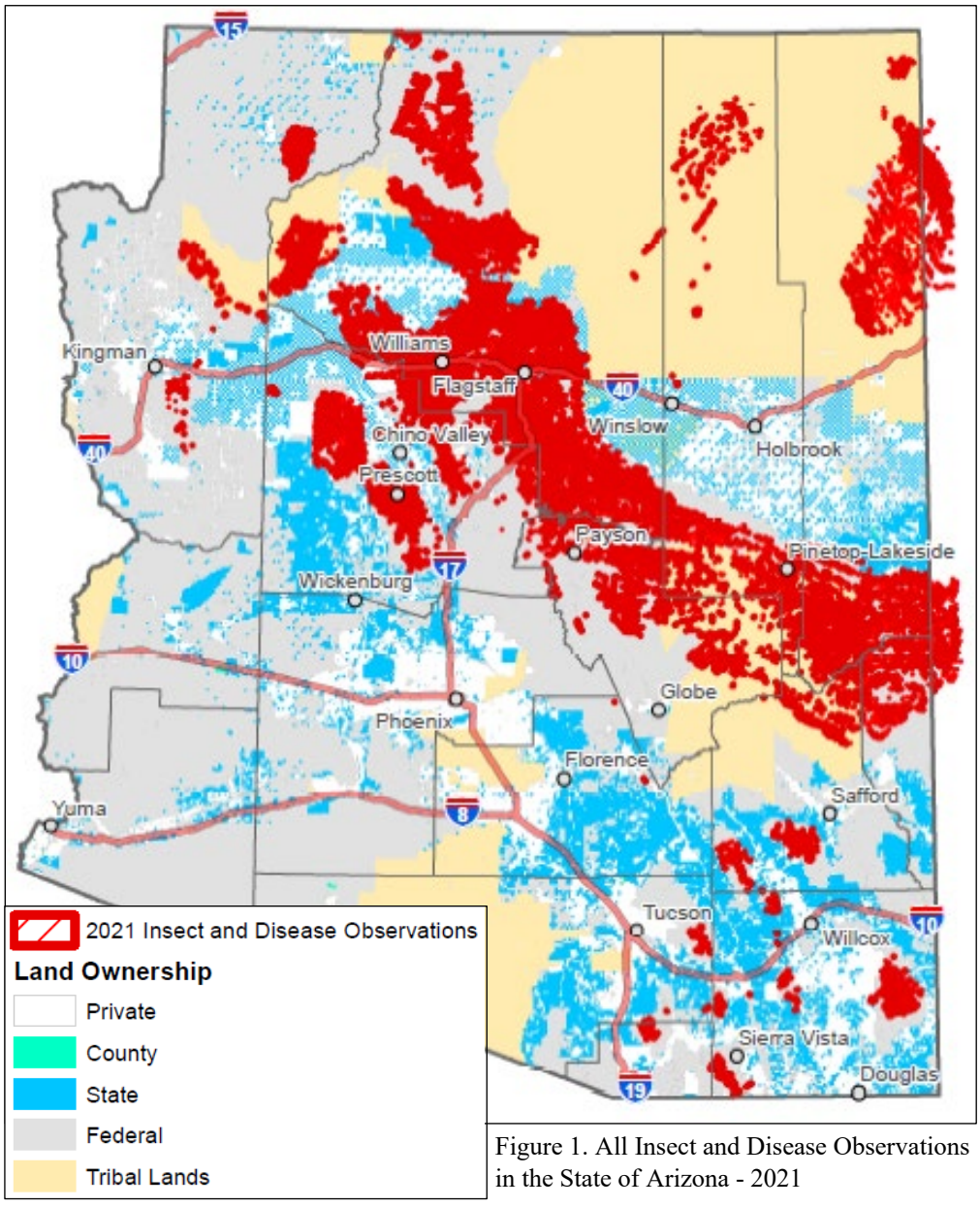


Figure 1. All Insect and Disease Observations in the State of Arizona - 2021

Urban areas include forests that are typically composed of a mix of native and introduced tree species that require various management techniques. Nearly 90% of Arizona's residents live in an urban forest, which provide numerous environmental, economic and social benefits.

With such a broad diversity of forests comes a diverse group of insects and diseases; from native and non-native pine engraver beetles to introduced fungal pathogens such as white pine blister rust. This report includes information on the insects and diseases having significant impacts on Arizona's forested landscapes.

Aerial Survey Summary

Annually, the Department of Forestry and Fire Management (DFFM) partners with the USDA Forest Service, Forest Health Protection (FHP) team, to survey millions of acres with forest and woodland resources from the air; this is called an Aerial Detection Survey (ADS). The ADS provides land managers and the public with information about landscape-level forest and woodland health conditions. This conditions report summarizes the 2021 ADS program and discusses current forest and woodland health issues in Arizona.

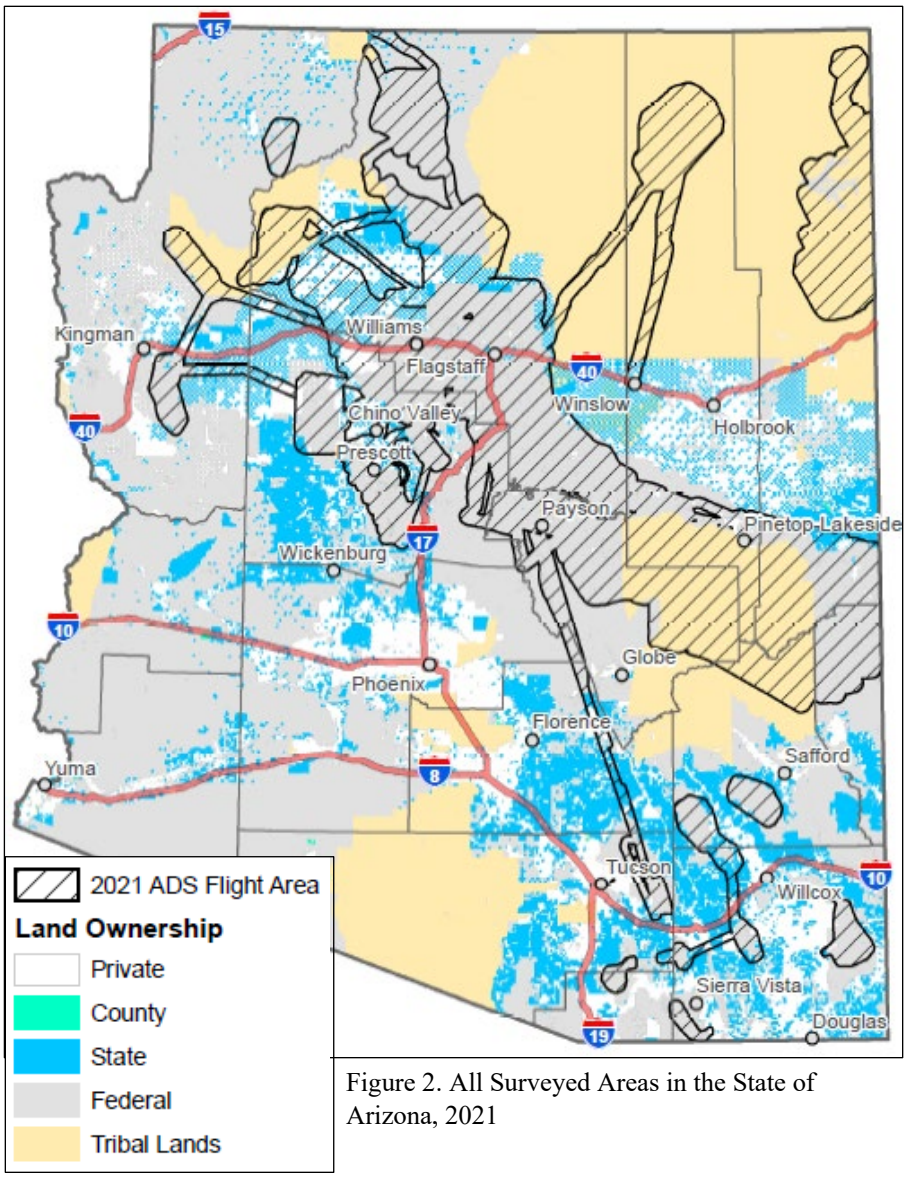


Figure 2. All Surveyed Areas in the State of Arizona, 2021

In the summer of 2021, during the ADS season, over 17 million acres were flown to identify dead, dying, or declining trees (Figure 2). The aerial surveys cover National Forest lands (50% of the area surveyed), tribal lands (32% of the area surveyed), private lands (10% of the area surveyed), state lands (6% of the area surveyed), and county lands (less than 1% of the area surveyed) (Table 1).

Throughout the ADS season, and the rest of the year, USDA Forest Service, DFFM forest health specialists, and District staff verify ADS data by conducting ground surveys and providing landowners with technical assistance.

Photo: (From left to right) Aly McAlexander, Forest Health Specialist, DFFM; Jeff Cardin, Pilot, USDA Forest Service; Amanda Grady, Entomologist, USDA Forest Service, 2021

Surveyed Area by Land Ownership		
Land Ownership*	GIS Acres	%
County	586.57	0.003%
Federal	8,648,241.93	50.67%
Private	1,863,756.71	10.92%
State	1,076,986.60	6.31%
Tribal Lands	5,477,540.87	32.09%
Grand Total	**17,067,112.69**	**100.00%**
* 2021 BLM Surface Management Agency data		

Table 1. Surveyed Area by Land Ownership for the State of Arizona, 2021

Climatic Overview

Relevance

It is important to understand the climatic conditions occurring throughout our state, as precipitation and temperature are two of the biggest environmental factors influencing forest health. When trees are drought stressed from a lack of precipitation, and stressed from increased average temperatures, they become increasingly susceptible to infection and infestation from diseases and insects. In addition, densely packed forest stands increase competition for these resources between trees. Furthermore, prolonged drought stress, which is drought lasting longer than 6 months, can lead to decreased overall tree health and increased likelihood of tree death. According to the Drought Monitor, Arizona has been experiencing continual drought conditions since 2002, nearly 20 years of continual drought stress (Figure 3).

Tree tissues produce and collect more ethanol and terpenes when they are stressed. Many insects, in particular bark beetles, can detect these chemicals. Thus, stressed trees are releasing more ethanol and terpenes into the atmosphere, attracting bark beetles to their location, and rousing their attacks. The connection between stress and increased susceptibility to insects and diseases underscores the importance of understanding the type and severity of stress.

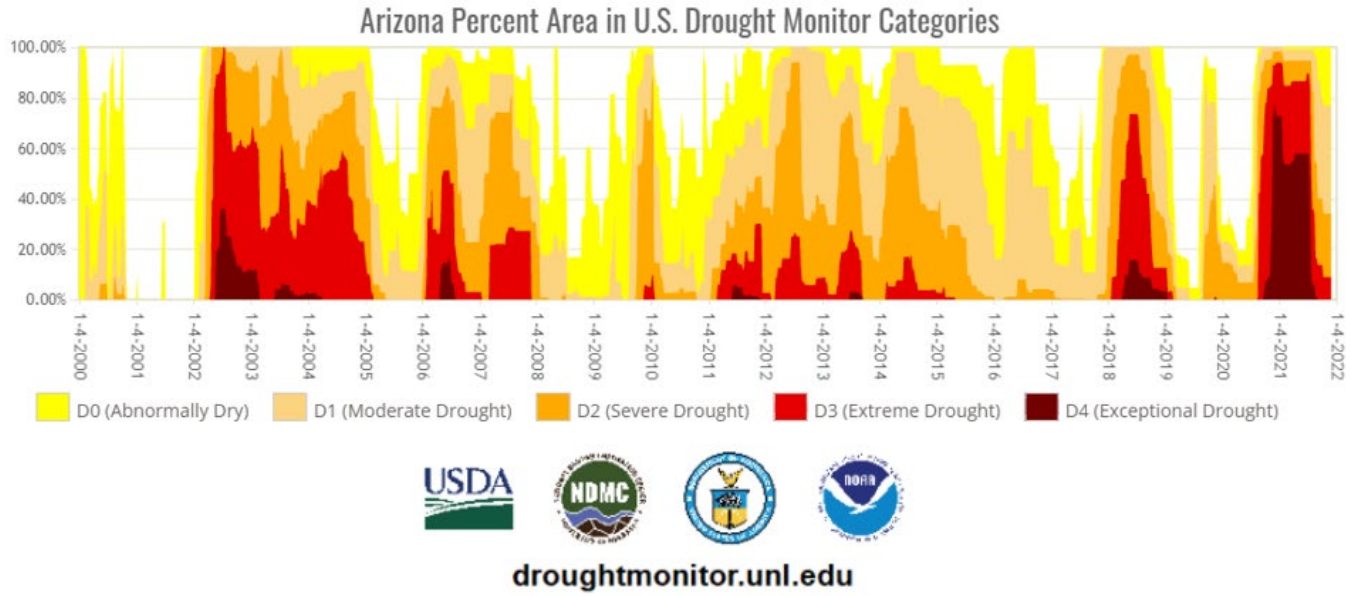


Figure 3 – Percent Area in US Drought Monitor Categories for the state of Arizona, 2000-2022, obtained from droughtmonitor.unl.edu

Photo: Juniper die back due to drought, Coconino National Forest, 2021

Review of Arizona's Drought Conditions

The period between Fall 2020 and January 2021 was extremely dry, with nearly 73% of the state experiencing Exceptional drought levels (D4), which is the highest and most severe level of drought according to the Drought Monitor. Precipitation from cold weather storms at the end of January led to slightly improved drought conditions throughout Arizona. By February there was a 19% decrease, with 54% of the state experiencing Exceptional drought levels. In addition, La Niña conditions were intensifying in the Pacific Ocean, which made the spring drier than normal.

In March, northern Arizona, including the Mogollon Rim, received much needed precipitation; however, it was not enough to improve drought conditions. Some snowpack accumulated in a few areas, but it was short lived, and any potential run-off was reduced by the already dry soils. Stream flows and inflows into reservoirs were low as a result of these dry conditions. By the end of March, 54% of the state was still experiencing Exceptional drought levels (Figure 4).

Continuing into April, Arizona was still very dry, with most of the state receiving less than 25% of its average precipitation. Due to these warm and dry conditions, wildfires had already begun showing up around the state. Although several counties received a half inch of rain in May 2021, it was not enough to improve drought conditions, leaving nearly 56 % of the state in Exceptional drought. Despite a moderate amount of precipitation in June, overall drought severity increased, with approximately 90% of the state experiencing either Exceptional (D4 at 58%) or Extreme (D3 at 32%) drought conditions (Figure 4). By this point, the precipitation outlook for the monsoon season was showing chances for near-normal precipitation amounts. However, summer precipitation does not typically alleviate long-term drought conditions.

By July, a fairly active monsoon system brought significant amounts of precipitation across much of the state; with many locations along the Mogollon Rim receiving up to 200% of their normal amounts of rain. This amount of precipitation led to debris flows and flash flooding in many wildfire impacted areas around Arizona. Even with all this moisture, the entire state still remained at some level of drought. By the end of July, a La Niña watch was issued for the fall and winter of 2021, leading to another cool season of below average precipitation.

Most of Arizona remained at or above average levels of precipitation for the month of August. The productive monsoon season improved many ecological and agricultural drought levels across Arizona; all areas of Exceptional drought were eliminated throughout the state. Most of the state was only experiencing Moderate (D1 at 47%) drought conditions. By the end of August La Niña conditions were already starting to develop over the Pacific Ocean; at this point there was a 75% chance of a mature La Niña phase during the winter of 2021-2022. This winter La Niña means drier than average conditions across Arizona.

Several storm systems moved through the state in early and late September; the Mogollon Rim and White Mountains received above average precipitation. A strong cold front brought snow to the higher elevations of the San Francisco Peaks and the White Mountains on September 30th. By the end of September, most of the state was in Moderate (D1 at 42%) to Severe (D2 at 25%) drought conditions (Figure 4).

October is a transitional month in Arizona, often experiencing the progression of the first winter storm systems of the season. In early October, a low pressure system brought moderate amounts of rain to central and southern Arizona. Another cold system across northern Arizona brought small amounts of snow to Flagstaff and other areas on the Kaibab Plateau. Yet another system at the end of October brought more rain to northern Arizona. Drought levels slightly improved through October, with 23% of the state no longer considered to be in drought. By November, Arizona started to dry out and warm back up; with only one measurable rainfall event occurring

in November, and both Tucson and Phoenix had their second warmest November on record. Drought conditions remained constant through November, with 34% of the state in Severe (D2) or Extreme (D3) drought, and 43% of the state in Moderate (D1) drought. December didn't bring much change to Arizona's drought status; only 9% of the state is experiencing Extreme (D3) drought conditions with 34% still experiencing Severe (D2) drought conditions (Figure 3). At this point La Niña conditions are expected to persist through the winter, resulting in drier than normal weather in Arizona.

It is necessary to understand Arizona's drought status throughout the year, as it influences our annual observations during the aerial detection survey season.

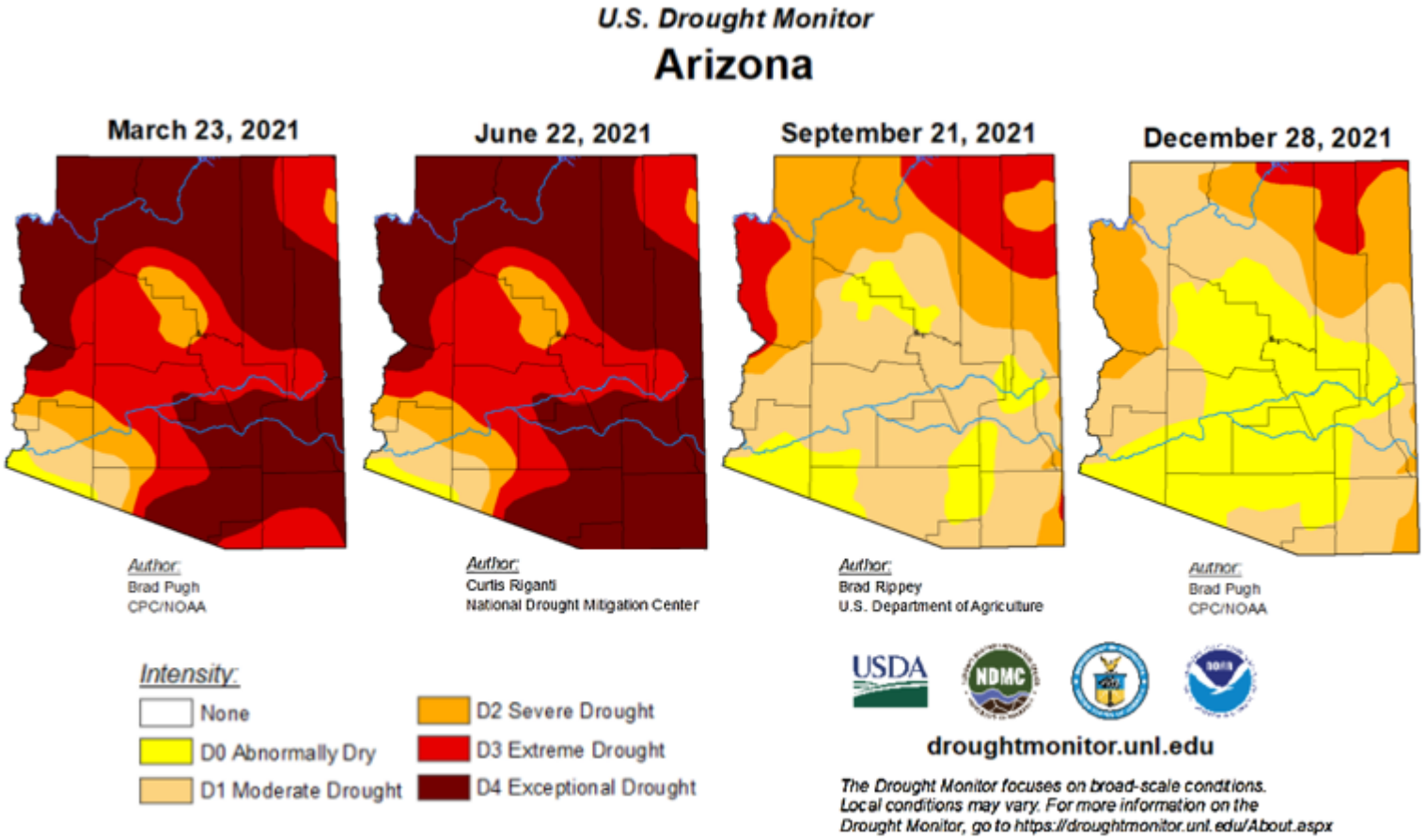


Figure 4 – U.S. Drought monitor maps of Arizona in March, June, September, and December, 2021; obtained from droughtmonitor.unl.edu

Statewide Highlights

Bark Beetle Update

Forest health professionals around Arizona began noticing an increase in tree mortality caused by bark beetles in the fall and winter of 2020. This led to a supplemental aerial survey flight in early February, 2021. Daniel Depinte, the Forest Health Specialist at the time for the Arizona Zone FHP team, conducted survey flights over portions of the Prescott National Forest. This supplemental survey confirmed that ponderosa pine mortality increased from what was mapped during the 2020 ADS season. Only a few areas of tree mortality caused by

bark beetles were identified during the 2020 ADS season; by February of 2021, there was a significant increase in areas with mortality cause by bark beetles (Figure 21).

Photo: Credit, Daniel DePinte, Forest Health Specialist, USDA Forest Service, ponderosa pine mortality on the Prescott NF in February, 2021

When we compare the acres with bark beetle caused tree mortality throughout Arizona, between 2020 and 2021, we see a significant increase in acreage. During the summer of 2020, over 81,000 acres with bark beetle caused mortality were observed; in the summer of 2021, that number jumped to 528,108 acres with observed bark beetle caused mortality (Table 3). This is a 551% increase in bark beetle caused tree mortality statewide.

Bark beetle damage will be broken down by District, with detail provided on each bark beetle. One type of bark beetle mortality is identified as "Unknown Bark Beetle", which represents all ponderosa pine bark beetles. As there are more than a dozen bark beetles that attack and kill ponderosa pine trees in Arizona, there is often more than one species within a single tree; thus, ponderosa pine mortality is represented by the "Unknown Bark Beetle" type within our ADS data.

Invasive Insect Update

Tamarisk leaf beetles (*Diorhabda spp.*) were identified in the 1990's as a potential bio-control for the invasive tamarisk plant (*Tamarix* spp.), also known as salt cedar. Salt cedar was introduced into the southwest in the 1800s; thus, it had centuries to become established and begin taking over native habitat. For example, one to two cottonwoods can grow per acre along the river beds in Arizona, but three to four thousand salt cedar plants can attempt to grow on a single acre.

Photo: Close up of a Tamarisk leaf beetle on salt cedar, along the Gila River, north of Safford, AZ, 2021

Tamarisk leaf beetles were released in hopes it would help abate the salt cedar invasion, and allow native plants to move back into their native habitat. However, as the salt cedar became establish, and native riparian habitat declined, the endangered Southwestern Willow Flycatcher began using the salt cedar for its nesting grounds. The extent of control that

the beetle will exert on tamarisk and the affect that will have on Southwestern Willow Flycatcher habitat is unknown. Tamarisk leaf beetles were not expected to persist below the Arizona-Utah border; however, they have been consistently moving south along the Colorado River, and into the rivers and riparian areas of Arizona.

Several Arizona Districts did have observed salt cedar defoliation from Tamarisk leaf beetle, this data will be discussed per District. It is worth mentioning that the acres observed with tamarisk leaf beetle damage are areas we don't typically fly. Thus, these acres were captured only because our flight path took us over or near these riparian areas. Damage from these insects is possibly on additional acres that were not flown during the ADS season, therefore the acres reported are not representative of the entire State.

Noninfectious Disorders (Abiotic Damage)

The symptoms of abiotic disorders can resemble those of some insects and diseases, making it more difficult to determine the cause. Abiotic disorders and damages can become entry points for pathogens, while also increasing the tree's overall stress, making it more susceptible to other insect and disease infestation.

In this report abiotic damage falls into 3 categories: Drought, Human Activities, or Unknown. Drought refers to a water deficit that develops when there is a lack in precipitation or changes to a watering schedule. When the water loss exceeds the rate of water absorption from the soil, chronic injury within the plant host can occur. This injury is expressed through symptoms such as a lack in growth, wilting, discoloration of the foliage, and premature leaf drop. In the Southwest, winter drought is particularly harmful to forests and can render large areas more susceptible to bark beetles and wildfire. The progression of decline in the tree will typically begin from the top down and from the outside in; the roots are usually the last part of the tree to die. The symptoms associated with chronic drought stress and drought damage can look very similar to root disease symptoms. This year, there was a significant increase in tree dieback due to drought, mostly occurring in the pinyon-juniper woodlands of the lower elevations forests throughout the entire state of Arizona.

Photo: Juniper dieback due to drought, Coconino National Forest, 2021

Human Activities is another group of noninfectious disorders dedicated to observed salt and deicer damage along roadways. The uptake of salt by roots is a common issue where sodium chloride, calcium chloride, and magnesium chloride are applied to de-ice highways in the winter or for dust abatement on dirt roads in the spring/summer/fall. The salt leached off the roads in heavy rains goes into drainages where trees will capture

the water, resulting in damage and even mortality. Often the symptoms associated with salt damage look insignificant, and appear as tip burn. Mortality can often occur when magnesium chloride or calcium chloride is applied right before heavy rainstorms.

Unknown abiotic damage is a catch-all group for damage we could not identify from the air and were unable to confirm on the ground. The majority of this unknown damage are areas identified for having a general discoloration to their crowns. Many areas that were checked on the ground that had this aerial signature of crown discoloration, appeared to be suffering from drought stress. The Unknown category also includes defoliation, general mortality or dieback, and occasionally branch flagging that was not able to be verified by ground-truthing.

Disease Identification during Aerial Detection Surveys

Many of the signs and symptoms associated with tree diseases can be difficult to identify from the air, as the aerial signatures can look very similar to insect activity. For this reason, USDA Forest Service and Arizona DFFM forestry professionals ground truth, and verify that the damage observed from the air is the same agent that is causing the damage on the ground. Due to the complexities with identifying diseases from the air, there were not many acres with observed disease damage. The majority of observed disease damage is found on the ground by forestry professionals working in the field.

Arizona's Five Districts

The Arizona Department of Forestry and Fire Management divides the state into five (5) distinct Districts (Appendix I). Each District shares similar forest and woodland health issues while experiencing a varying degree of tree damage from insects and disease. Each District will be reviewed individually to more accurately show which insects and diseases are impacting the state, and where their damage can be found throughout the state.

It is important to note that the acreages for each District may look inflated due to the fact that some acres are counted twice because more than one damage agent was found on those acres.

Northern District (A1S) Update – 2021

Status of Insects

The Northern District (A1S) is composed of the Kaibab National Forest, Coconino National Forest, Grand Canyon National Park, and Navajo, Hualapai, Havasupai, and Kaibab Reservations; these areas are surrounded by scattered county, state, and military reservation lands (Appendix I).

Figure 5 is a map showing all insect and disease observations within the Northern District. The majority of insect observations occurred on Federal lands

Photo: Observed ponderosa pine, Douglas-fir, and western balsam bark beetle damage, Kaibab National Forest, 2021

(Table 2). In total, more than 314,000 acres were observed with bark beetle mortality, over 5,500 acres with observed defoliator damage, and nearly 11,000 acres with sap feeding insect damage was observed.

A1S - Estimated Acres of Observed Insect Damage by Land Ownership					
Insect Agent	Federal	Private	State	Tribal Lands	**Grand Total**
Bark Beetles	286,897.53	5,692.44	7,680.80	13,745.86	**314,016.63**
Defoliators	2,559.60	436.92	217.40	2,338.77	**5,552.69**
Sap Feeders	3,007.72	30.75		7,798.36	**10,836.83**
Grand Total	**292,464.85**	**6,160.12**	**7,898.20**	**23,882.98**	**330,406.15**

Table 2 – Estimated Acres with Observed Insect Damage by Land Ownership, Northern District (A1S),

In regards to the bark beetle mortality observed, there were 7 different types of bark beetles identified that caused more than 300,000 acres with mortality within the Northern District (Table 3).

Of the 7 different types of bark beetles observed causing mortality within the Northern District, the Mountain Pine beetle (*Dendroctonus ponderosae*) caused the least amount of mortality. As this damage is less than one acre, it suggests this data was collected on the ground by a forestry professional. It is worth mentioning that the Mountain Pine Beetle is not very prevalent within Arizona, and typically only occurs in very northern Arizona.

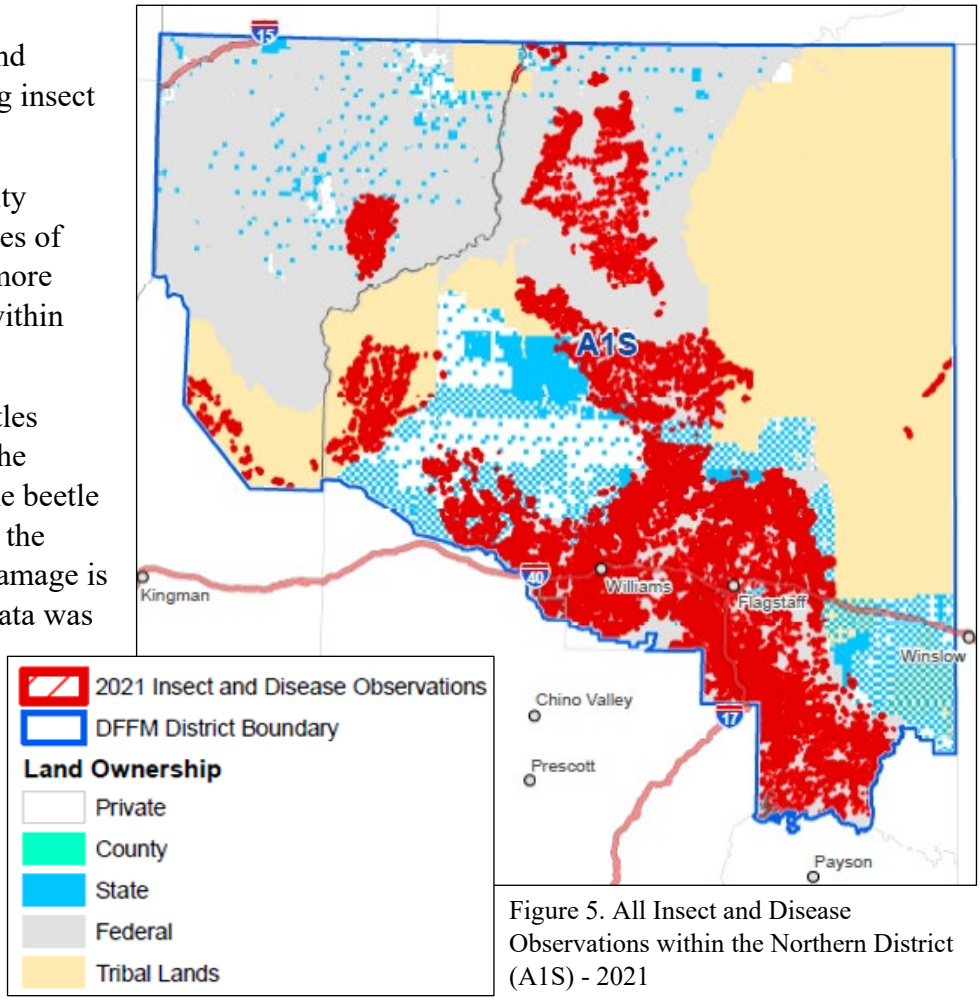


Figure 5. All Insect and Disease Observations within the Northern District (A1S) - 2021

The Douglas-fir beetle (*Dendroctonus pseudotsugae*), Fir engraver (*Scolytus ventralis*), Spruce beetle (*Dendroctonus rufipennis*), and Western Balsam bark beetle

A1S - Estimated Acres of Observed Bark Beetle Damage by Land Ownership					
Bark Beetles	Federal	Private	State	Tribal Lands	**Grand Total**
Douglas-Fir Beetle	3,138.58	2.73			**3,141.31**
Fir Engraver	4,243.46	40.32			**4,283.78**
Mountain Pine Beetle	0.75				**0.75**
Pinyon Ips	37,136.41	914.93	2,532.64	9,384.64	**49,968.63**
Spruce Beetle	360.77				**360.77**
Unknown Bark Beetle	239,356.34	4,734.47	5,148.16	4,361.22	**253,600.18**
Western Balsam Bark Beetle	2,661.22				**2,661.22**
Grand Total	**286,897.53**	**5,692.44**	**7,680.80**	**13,745.86**	**314,016.63**

Table 3 – Estimated Acres with Observed Bark Beetle Damage by Land Ownership, Northern District (A1S), 2021

(*Dryocoetes confusus*) accounted for just over 7,700 acres with bark beetle caused tree mortality (Table 3). All of this bark beetle activity occurred in high elevation, mixed conifer forests that consisted of spruce and fir species.

Pinyon ips (*Ips confusus*) caused nearly 50,000 acres with mortality (Table 3); this was mortality of pinyon pines in the lower elevation woodlands of the Northern District (A1S).

Lastly, the Unknown Bark Beetle category includes over 250,000 acres with observed mortality (Table 3). This category of unknown bark beetles includes all the bark beetles that attack ponderosa pines: *Ips pini*, *Ips lecontei, Ips calligraphus, Ips integer, Ips latidens, Ips woodi, Ips hoppingi, Ips knousi, Ips fonanseai, Dendroctonus barberi, Dentroctonus ponderosae, Dendroctonus adjunctus, Dendroctonus valens,* and *Dendroctonus approximates.* As more than one species often contributes to the decline and death of ponderosa pines, we lump all ponderosa bark beetles into this one category "Unknown Bark Beetles".

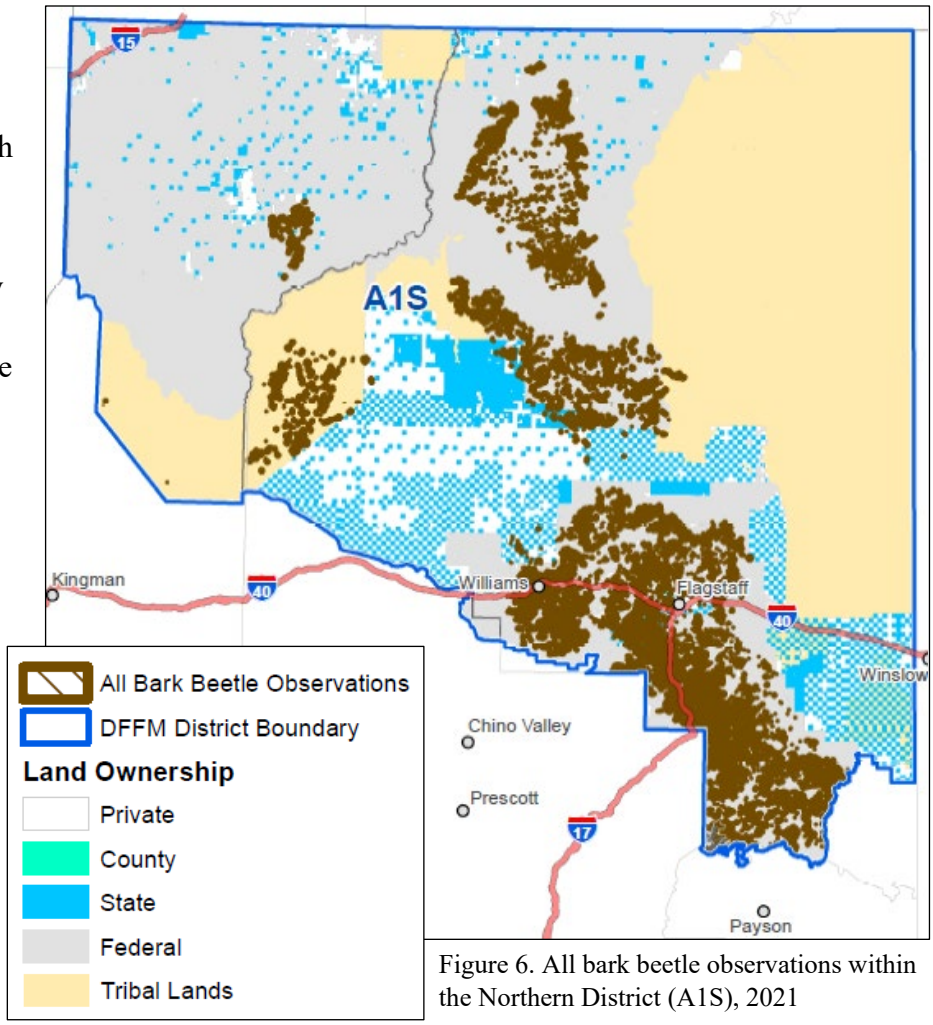


Figure 6. All bark beetle observations within the Northern District (A1S), 2021

In the Northern District, additional insect damage was observed that fell into one of two categories: sap feeders or defoliators. The majority of sap feeding or sap sucking insects fall into the orders Hemiptera and Homoptera;

Photo: Observed pine mortality from bark beetle infestation, Kaibab National Forest, 2021

they are small in size and directly injure the host tree by sucking its food and water supply, producing necrotic spots in the host tissue, and indirectly injuring the tree by introducing plant diseases into the host.

A1S - Estimated Acres of Observed Insect Damage by Land Ownership					
Other Insect Damage	Federal	Private	State	Tribal Lands	**Grand Total**
Pinyon Needle Scale	2,960.77	30.75		7,798.36	**10,789.87**
Sawflies	8.59				**8.59**
Spruce Aphid	46.95				**46.95**
Unknown Defoliator	1,254.82	93.60	143.26	748.27	**2,239.95**
Western Spruce Budworm	1,168.64				**1,168.64**
Grand Total	**5,439.77**	**124.36**	**143.26**	**8,546.62**	**14,254.01**

Table 4 – Estimated Acres with Observed Insect Damage by Land Ownership, Northern District (A1S), 2021

Photo: Pinyon needle scale instars, Sedona, AZ

Since the 1990's, spruce aphid (*Elatobium abietinum*) has been affecting high elevation spruce forests in the southwest; this insect is a sap feeder, causing early leaf/needle drop, yellowing of foliage, and reduced growth. The aerial signature for this insect is hard to see, and thus it is mostly identified on the ground by forestry professionals. This year during the aerial survey, a small area of severe infestation in the southern end of the Coconino National Forest was noticeable from the air, totaling about 47 acres with spruce aphid damage (Table 4).

Pinyon needle scale (*Matsucoccus acalyptus)* is another sap sucking insect that attacks pinyon pines. Pinyon needle scale can cause needles to yellow and drop early. Repeated attacks can cause reduced growth and stunted needles; in severe outbreaks small trees may be killed, but larger trees can become more susceptible to bark beetle attacks. This year over 10,000 acres with pinyon needle scale damage was observed in the Northern District (Table 4).

Defoliating insects damage trees by eating their leaves/needles; by removing their photosynthetic tissue, the host trees becomes increasingly susceptible to attacks from other insects and pathogens. If the defoliation is severe enough, it can lead to the death of the host tree.

Western Spruce budworm (*Choristoneura occidentalis)* attacks Douglas-fir, true firs, and spruce trees. Defoliation by the western spruce budworm can cause growth loss, with repeated heavy defoliation leading to an extreme decrease in growth and even tree deformity. Top kill can also occur in severe defoliation, which can lead to whole tree mortality. This year over 1,100 acres with western spruce budworm were observed within the Northern District of Arizona (Table 4).

There are 8 species of sawflies (*Neodiprion* spp., or *Zadiprion* spp.) that infest ponderosa and pinyon pines of the southwest. Pine sawflies in the southwest typically attack trees in open areas or locations where pines are growing at low densities. Generally, their defoliation causes slowed growth, but repeated attacks can lead to top kill and eventual tree death. This ADS season just over 8 acres with sawfly damage were observed (Table 4); this small area was identified on the ground rather than from the air.

Lastly, there is a group of defoliators identified as “Unknown Defoliator”. This is a catch-all name for defoliation we see from the air that cannot be identified as a specific insect or disease-causing agent. The majority of “Unknown Defoliator” damage occurs in aspen stands. Only some of these locations are able to be reached on the ground by forestry professionals, thus there are still locations that are not double checked and are left as “Unknown Defoliation”. This year, over 1,100 acres with observed “Unknown Defoliator” damage were mapped within the Northern District (Table 4).

Status of Invasive Insects

This year several locations were observed in riparian areas where severe defoliation of salt cedar from tamarisk leaf beetle had occurred. In the Northern District, just over 2,000 acres were observed having defoliation damage from the tamarisk leaf beetle (Table 5).

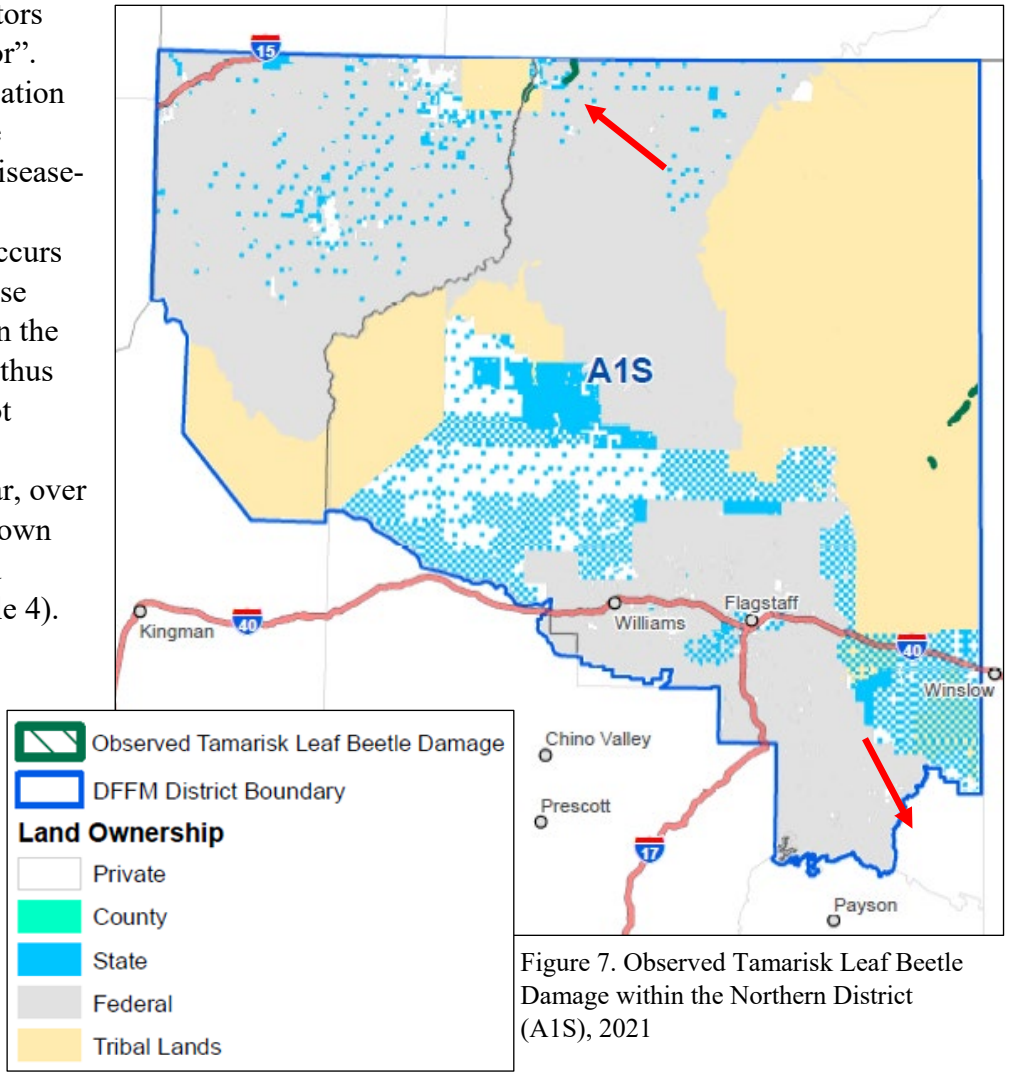


Figure 7. Observed Tamarisk Leaf Beetle Damage within the Northern District (A1S), 2021

A1S - Estimated Acres of Observed Invasive Insect Damage by Land Ownership					
Invasive Insect Damage	Federal	Private	State	Tribal Lands	**Grand Total**
Tamarisk Leaf Beetles	127.55	343.32	74.14	1,590.50	**2,135.51**

Table 5 – Estimated Acres of Observed Tamarisk Leaf Beetle Damage by Land Ownership, Northern District (A1S), 2021

The majority of this damage was observed on tribal lands (Figure 7); with over 1,500 acres of tamarisk defoliation observed on reservation lands (Table 5). The remaining several hundred acres with observed damage occurred on federal and private lands, with less than a hundred acres with damage on state lands (Table 5).

Status of Diseases

A1S - Estimated Acres of Observed Disease Damage by Land Ownership		
Disease Causal Agent	Federal	**Grand Total**
Foliage and Shoot Diseases	31.55	**31.55**

Table 6 – Estimated Acres of Observed Disease Damage by Land Ownership, Northern District (A1S), 2021

This year, within the Northern District, 31.5 acres with foliar disease damage were identified on federal lands (Table 6). This foliar disease was identified as White Pine Needle Cast (*Lophodermella arcuata*), a fungus that infects only the current year’s growth. A single season of attack typically results in only partial

defoliation of the host tree, which are Southwestern white pines (*Pinus strobiformis*). This is the only known needle cast disease of white pines in the Southwest.

Status of Noninfectious Disorders

This year almost 270,000 acres with observed drought damage were identified (Table 7). The majority of acres with drought damage were on federal lands and within pinyon-juniper woodlands spread throughout the Northern District (Figure 8).

There were 250 acres with observed salt damage, all of which were along roadways and mostly on federal lands (Table 7).

Of the nearly 11,000 acres with unknown damage (Table 7), 4,500 acres were forested lands with unknown branch flagging, 5,500 acres with unknown defoliation, and 1,000 acres with mortality and dieback. These acres were not able to be visited to confirm the damage causal agent, and were therefore left as unknown

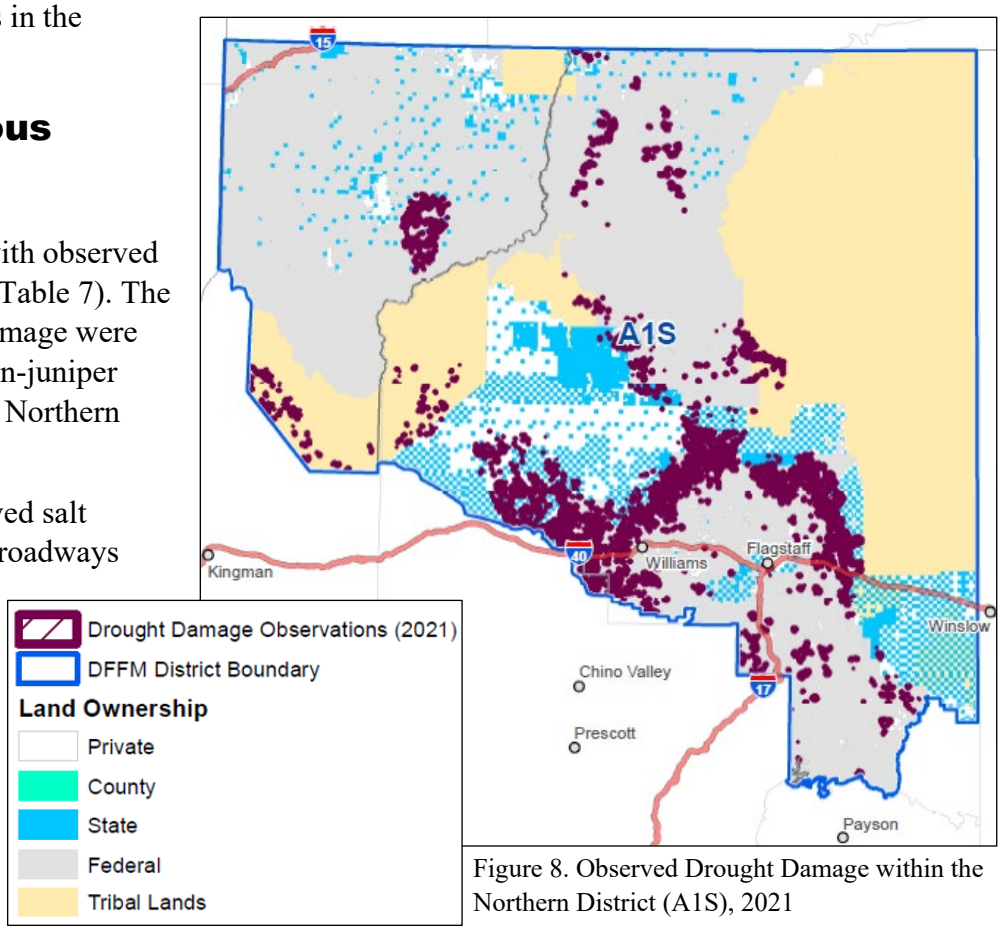


Figure 8. Observed Drought Damage within the Northern District (A1S), 2021

A1S - Abiotic and Unknown Damage by Land Ownership					
Damage Causal Agent	Federal	Private	State	Tribal Lands	**Grand Total**
Drought	175,181.94	48,706.93	33,365.13	12,207.96	**269,461.97**
Human Activities	214.23	36.15	3.36		**253.74**
Unknown	8,642.37	207.03	25.10	2,086.60	**10,961.10**
Grand Total	**184,038.54**	**48,950.11**	**33,393.59**	**14,294.56**	**280,676.80**

Table 7 – Estimated Acres of Abiotic and Unknown Damage by Land Ownership for the Northern District (A1S), 2021

Photo: Landscape of Juniper dieback due to drought, near Sunset Crater National Monument, 2021

Northeast District (A2S) Update – 2021

Status of Insects

The Northeast District is composed of Navajo, Apache, Fort Apache, and Hopi reservation lands, as well as the Apache-Sitgreaves National Forest; these lands are all surround by scattered county and state lands (Appendix I).

Figure 9 is a map showing all insect and disease observations within the Northeast District. The majority of insect observations occurred on Tribal lands (Table 8). In total, more than 101,000 acres with bark beetle mortality were observed, nearly 8,000 acres with observed defoliator damage, and over 5,000 acres with sap feeding insect damage were observed throughout Arizona's Northeast District (A2S)

There were 8 different types of bark beetles identified that caused more than 114,000 acres with mortality within the Northeast District (Table 9).

Of the 8 different types of bark beetles observed causing mortality within the Northeast District, the Mountain Pine Beetle (*Dendroctonus ponderosae*) caused a half acre of damage. This small area was identified on the ground in the northern part of the District by a forestry professional. As previously mentioned, the Mountain Pine Beetle is not very prevalent within Arizona.

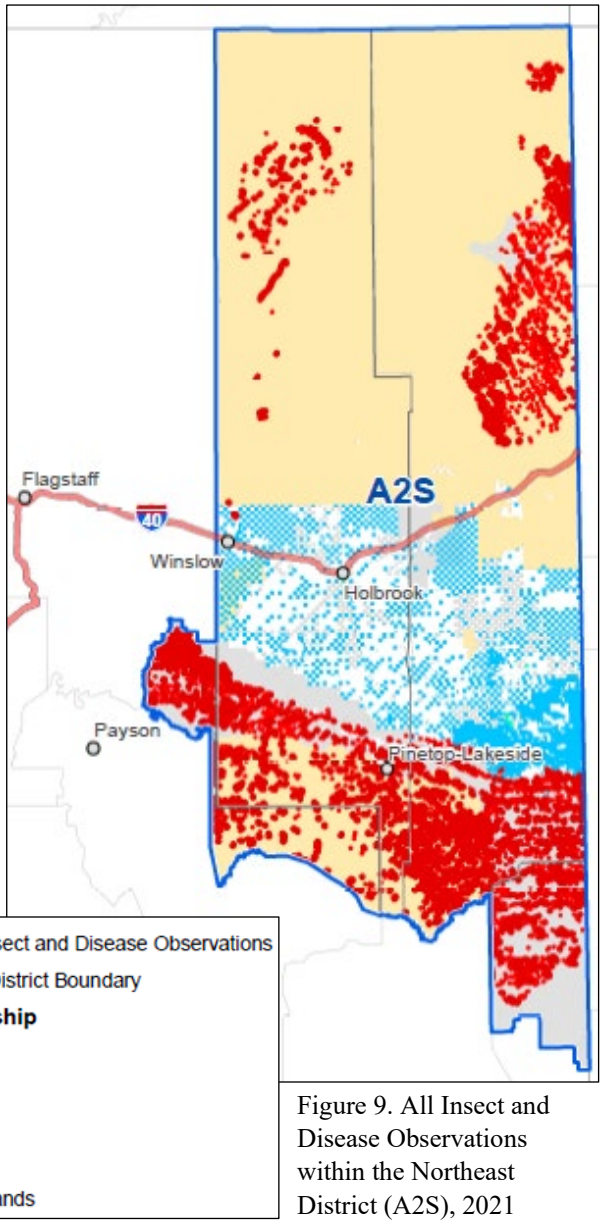


Figure 9. All Insect and Disease Observations within the Northeast District (A2S), 2021

The Douglas-fir beetle (*Dendroctonus pseudotsugae*), Fir engraver (*Scolytus ventralis*), Spruce beetle (*Dendroctonus rufipennis*), Blue spruce engraver (*Ips* spp.), and Western Balsam bark beetle (*Dryocoetes confusus*) accounted for just over 9,200 acres with bark beetle caused tree mortality (Table 9). All of this bark beetle activity occurred in high elevation, mixed conifer forests that consisted of spruce and fir species.

A2S - Estimated Acres of Observed Insect Damage by Land Ownership					
Damage Causal Agent	Federal	Private	State	Tribal Lands	**Grand Total**
Bark Beetles	44,887.65	765.43	173.21	55,593.47	**101,419.76**
Defoliators	986.59	169.48	63.08	6,728.25	**7,947.40**
Sap Feeders	432.28	8.20	58.37	4,862.96	**5,361.82**
Grand Total	**46,306.53**	**943.11**	**294.66**	**67,184.68**	**114,728.98**

Table 8 – Estimated Acres with Observed Insect Damage by Land Ownership for the Northeast District (A2S), 2021

Photo: Observed Fir engraver mortality near Chevelon lake, on the Apache-Sitgreaves National Forest, 2021

Pinyon ips (*Ips confusus*) mortality was observed on over 14,000 acres; this damage occurred on pinyon pines in the lower elevation woodlands, mostly on reservation and federal lands (Table 9).

The Unknown Bark Beetle category included over 77,000 acres with observed mortality (Table 9). As previously mentioned, this category includes all the bark beetles that attack ponderosa pines. As more than one species often contributes to the decline and death of ponderosa pines, we lump all ponderosa bark beetles into this one category "Unknown Bark Beetles".

Additional insect damage observed in the Northeast District falls into one of two categories: sap feeders or defoliators.

Figure 10. All bark beetle observations within the Northeast District (A2S), 2021

A2S - Estimated Acres of Observed Bark Beetle Damage by Land Ownership					
Bark Beetles	Federal	Private	State	Tribal Lands	**Grand Total**
Blue Spruce Engraver	12.73			2.50	**15.23**
Douglas-Fir Beetle	34.24			1,381.96	**1,416.20**
Fir Engraver	690.64	2.31	15.14	4,686.38	**5,394.47**
Mountain Pine Beetle				0.50	**0.50**
Pinyon Ips	7,211.30	197.86	150.73	7,250.12	**14,810.02**
Spruce Beetle	86.21	13.10		68.78	**168.09**
Unknown Bark Beetle	36,657.86	552.16	7.33	40,147.67	**77,365.03**
Western Balsam Bark Beetle	194.67			2,055.55	**2,250.23**
Grand Total	**44,887.65**	**765.43**	**173.21**	**55,593.47**	**101,419.76**

Table 9 – Estimated Acres with Observed Bark Beetle Damage by Land Ownership for the Northeast District (A2S), 2021

A2S - Estimated Acres of Observed Insect Damage by Land Ownership					
Other Insect Damage	Federal	Private	State	Tribal Lands	**Grand Total**
Pinyon Needle Scale	257.08	8.20	58.37	3,436.04	**3,759.69**
Prescott Scale	47.18			1,296.60	**1,343.79**
Spruce Aphid	128.02			130.32	**258.34**
Unknown Defoliator	308.64			249.87	**558.51**
Western Spruce Budworm	676.06			2,688.96	**3,365.02**
Grand Total	**1,416.99**	**8.20**	**58.37**	**7,801.79**	**9,285.35**

Table 10 – Estimated Acres with Observed Insect Damage by Land Ownership for the Northeast District (A2S), 2021

Spruce aphid (*Elatobium abietinum*), a sap feeding insect, has been affecting high elevation spruce forests in the region for several decades; this insect is a sap feeder, causing early leaf/needle drop, yellowing of foliage, and reduced growth. This year, infestation was observed on over 250 acres in the high elevation forests around the White Mountains (Table 10).

Pinyon needle scale (*Matsucoccus acalyptus)*, another sap sucking insect that attacks pinyon pines, can cause needles to yellow and drop early. Repeated attacks can cause reduced growth and stunted needles. Severe outbreaks may kill small trees while larger trees can become more susceptible to bark beetle attacks. This year over 3,700 acres with pinyon needle scale damage were observed in the lower elevation woodlands of the Northeast District (Table 10).

Photo: Branch flagging from Prescott needle scale, Fort Apache Reservation, 2021

Prescott needle scale (*Matsucoccus vexillorum*) attacks ponderosa pines. Branch flagging is the most common symptom associated with this insect. It typically occurs in younger trees, and can be hard to identify in dense stands. For us to notice this damage from the air means the damage was fairly severe, with over 1,300 acres with observed damage (Table 10).

Defoliating insects damage trees by eating their leaves/needles; by removing their photosynthetic tissue, the host tree becomes increasingly susceptible to attacks from other insects and pathogens. If the defoliation is severe enough, it can lead to the death of the host tree.

Photo: Pinyon pine mortality and discoloration, combination of drought, pinyon ips bark beetle, and heavy pitch moth activity, Apache-Sitgreaves National Forest, 2021

Western Spruce budworm (*Choristoneura occidentalis)* attacks Douglas-fir, true firs, and spruce trees. Defoliation by the western spruce budworm can cause growth loss, with repeated heavy defoliation leading to an extreme decrease in

growth and even tree deformity. Top kill can also occur in severe defoliation, which can lead to whole tree mortality. This year over 3,300 acres with western spruce budworm defoliation was observed within the Northeast District of Arizona (Table 10).

The final group of defoliators is categorized as "Unknown Defoliator." This is a catch-all name for defoliation that is seen from the air but cannot be identified as a specific insect or disease causing agent. The majority of "Unknown Defoliator" damage occurs in aspen stands. This year, over 500 acres with observed "Unknown Defoliator" damage was mapped within the Northeast District; all this damage was observed on tribal and federal lands (Table 10).

Status of Invasive Insects

A2S - Estimated Acres of Observed Invasive Insect Damage by Land Ownership					
Invasive Insect Damage	Federal	Private	State	Tribal Lands	**Grand Total**
Tamarisk Leaf Beetles	1.89	169.48	63.08	3,789.42	**4,023.87**

Table 11 – Estimated Acres of Observed Tamarisk Leaf Beetle Damage by Land Ownership for the Northeast District (A2S), 2021

This year multiple locations were observed in riparian areas where severe defoliation of salt cedar from tamarisk leaf beetle had occurred. In the Northeast District (A2S), over 4,000 acres were observed having defoliation damage from the tamarisk leaf beetle (Table 11).

The observed damage spread from the northwest to the southwest of the District (Figure 11). The majority of the observed tamarisk leaf beetle defoliation was observed on reservation lands, with a few acres with observed damage on federal, private and state lands (Table 11).

Status of Diseases

This year, within the Northeast District, only 2.25 acres with rust disease damage were identified on tribal lands (Table 12), caused by White Pine Blister Rust (*Cronartium ribicola*). In Arizona this fungal disease has only been found on Southwestern white pines, although limber pines and bristlecone pines are also susceptible. This nonnative disease is most common in wetter, mixed conifer sites that are higher in elevation.

A2S - Estimated Acres of Observed Disease Damage by Land Ownership		
Damage Causal Agent	Tribal Lands	**Grand Total**
Rusts	2.25	**2.25**

Table 12 – Estimated Acres of Observed Disease Damage by Land Ownership for the Northeast District (A2S), 2021

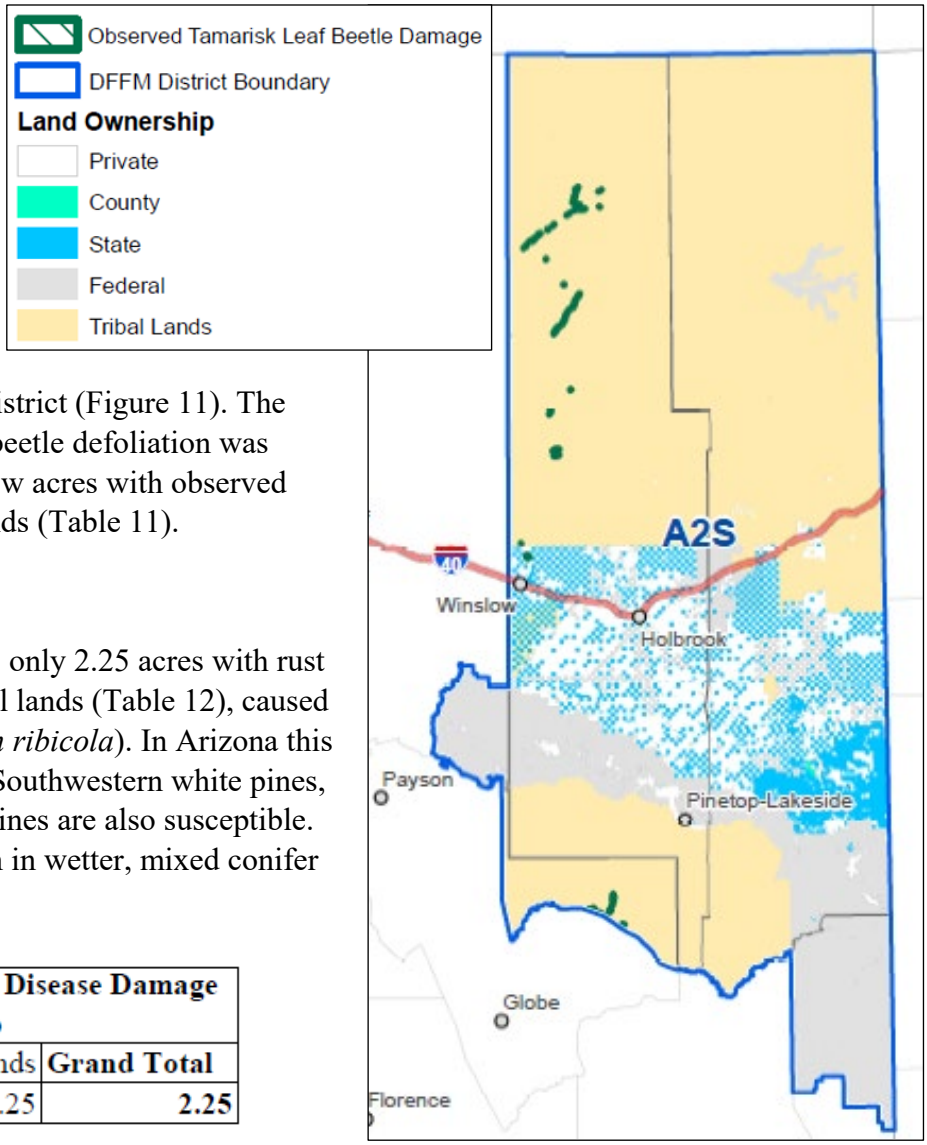


Figure 11. Observed Tamarisk Leaf Beetle Damage within the Northeast District (A2S), 2021

Status of Noninfectious Disorders

A2S - Abiotic and Unknown Damage by Land Ownership					
Damage Causal Agent	Federal	Private	State	Tribal Lands	**Grand Total**
Drought	19,281.57	337.08	91.38	24,905.89	**44,615.91**
Unknown	1,689.69	235.59	0.25	7,356.40	**9,281.92**
Grand Total	**20,971.26**	**572.66**	**91.63**	**32,262.28**	**53,897.83**

Table 13 – Estimated Acres of Observed Abiotic Damage by Land Ownership for the Northeast District (A2S), 2021

This year nearly 45,000 acres with observed drought damage were identified throughout the Northeast District. The majority of these acres were on tribal and federal lands (Table 13), and within pinyon-juniper woodlands spread throughout the District (Figure 12).

The remaining 9,200 acres (Table 13) with unknown damage were attributed to 4,600 acres of unknown branch flagging which was mostly found on tribal and federal lands. There were 900 acres with unknown defoliation, mostly on federal and tribal lands. There were 3,700 acres with unknown dieback, discoloration, mortality, and top kill.

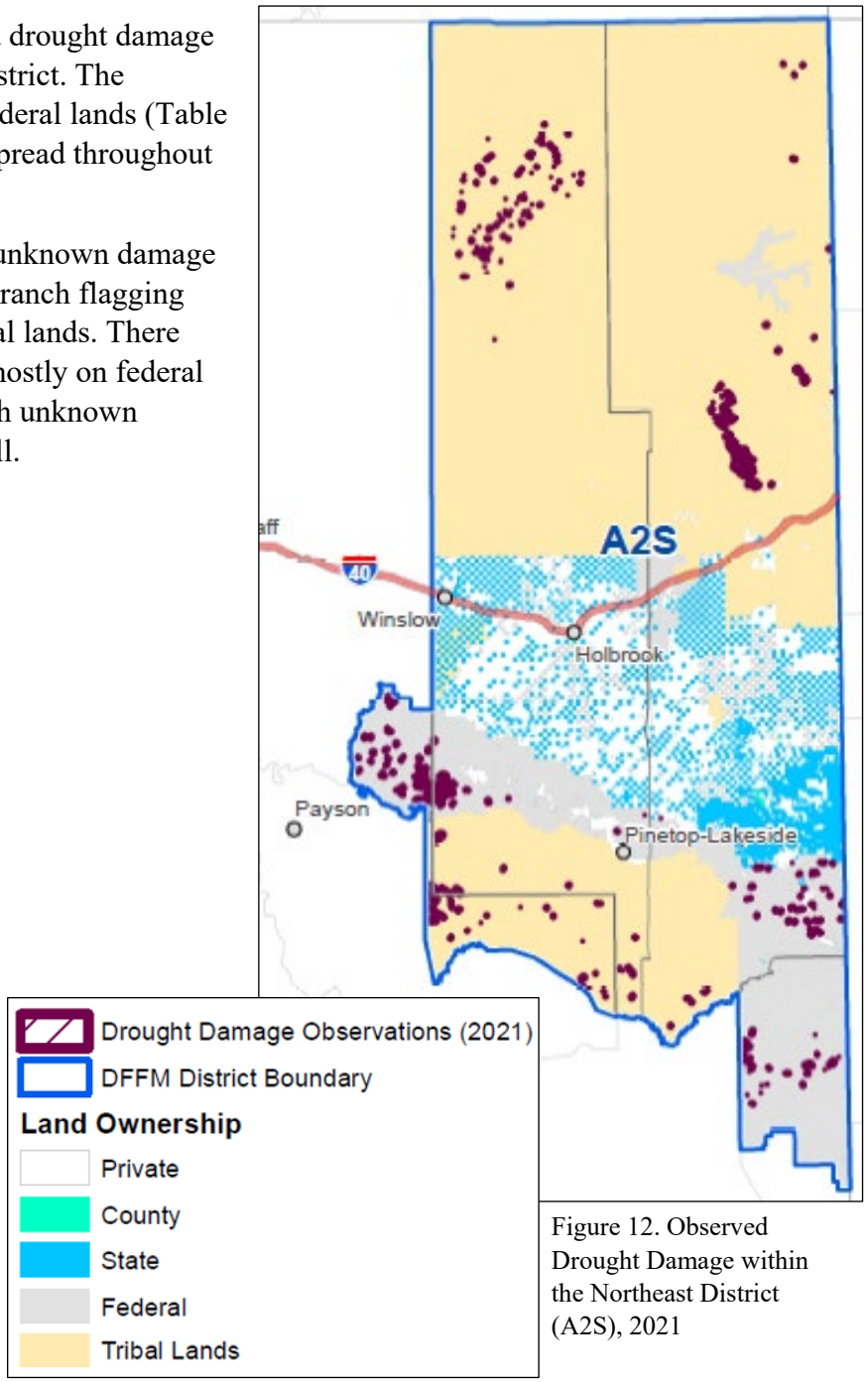


Figure 12. Observed Drought Damage within the Northeast District (A2S), 2021

Southeast District (A3S) Update – 2021

Status of Insects

The Southeast District is composed of the Ak-Chin, Tohono O' Odham, and San Xavier reservation lands, as well as the Coronado National Forest Sky Islands, the Cabeza Prieta National Wildlife Refuge, Organ Pipe Cactus National Monument, Saguaro National Park, and Chiricahua National Monument. These areas are all surrounded by scattered county and state lands, with some military reservation lands as well (Appendix I).

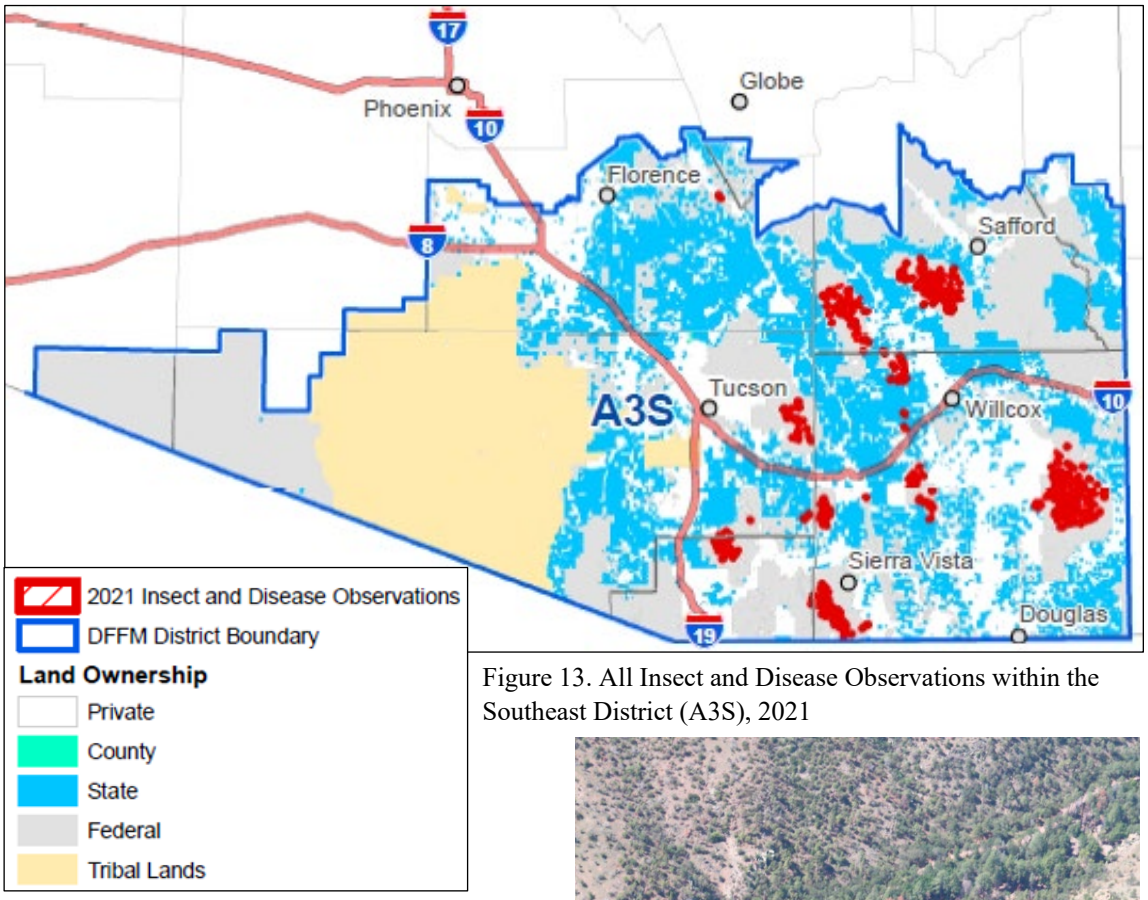


Figure 13. All Insect and Disease Observations within the Southeast District (A3S), 2021

Figure 13 is a map showing all insect and disease observations within the Southeast District. The majority of insect observations occurred on federal lands. Just over 11,000 acres were observed with bark beetle mortality, and nearly 3,000 acres with observed wood borer damage throughout Arizona's Southeast District (Table 14).

Photo: Observed pine mortality caused from bark beetles, Coronado National Forest, 2021

The bark beetle mortality observed throughout the Southeast District was caused by 6 different types of bark beetles. These bark beetles caused more than 14,000 acres with mortality within the Southeast District (Table 15).

A3S - Estimated Acres of Observed Insect Damage by Land Ownership				
Damage Causal Agent	Federal	Private	State	**Grand Total**
Bark Beetles	10,883.03	189.96		**11,072.99**
Wood Borers	2,695.10	175.60	96.76	**2,967.45**
Grand Total	**13,578.13**	**365.56**	**96.76**	**14,040.44**

Table 14 – Estimated Acres with Observed Insect Damage by Land Ownership for the Southeast District (A3S), 2021

Of the 6 different types of bark beetles observed causing mortality, the group of "Unknown Bark Beetles" caused the most damage with over 9,500 acres with observed mortality. As previously mentioned, the category of unknown bark beetles includes all the bark beetles that attack ponderosa pines. As more than one species often contributes to the decline and death of ponderosa pines, we lump all ponderosa bark beetles into this one category "Unknown Bark Beetles". In the Southeast District (A3S) the "Unknown Bark Beetle" category also includes the Southern pine beetle (*Dendroctonus frontalis)* and Mexican Pine Beetle (*Dendroctonus mexicanus)* as they attack Chihuahua and apache pines that are found in this part of Arizona.

A3S - Estimated Acres of Observed Bark Beetle Damage by Land Ownership			
Bark Beetles	Federal	Private	**Grand Total**
Cedar & Cypress Bark Beetles	0.25		**0.25**
Douglas-fir beetle	175.09		**175.09**
Fir Engraver	1,168.14		**1,168.14**
Pinyon Ips	45.33		**45.33**
Unknown Bark Beetle	9,398.18	189.96	**9,588.14**
Western Balsam Bark Beetle	96.04		**96.04**
Grand Total	**10,883.03**	**189.96**	**11,072.99**

Table 15 – Estimated Acres with Observed Bark Beetle Damage by Land Ownership for the Southeast District (A3S), 2021

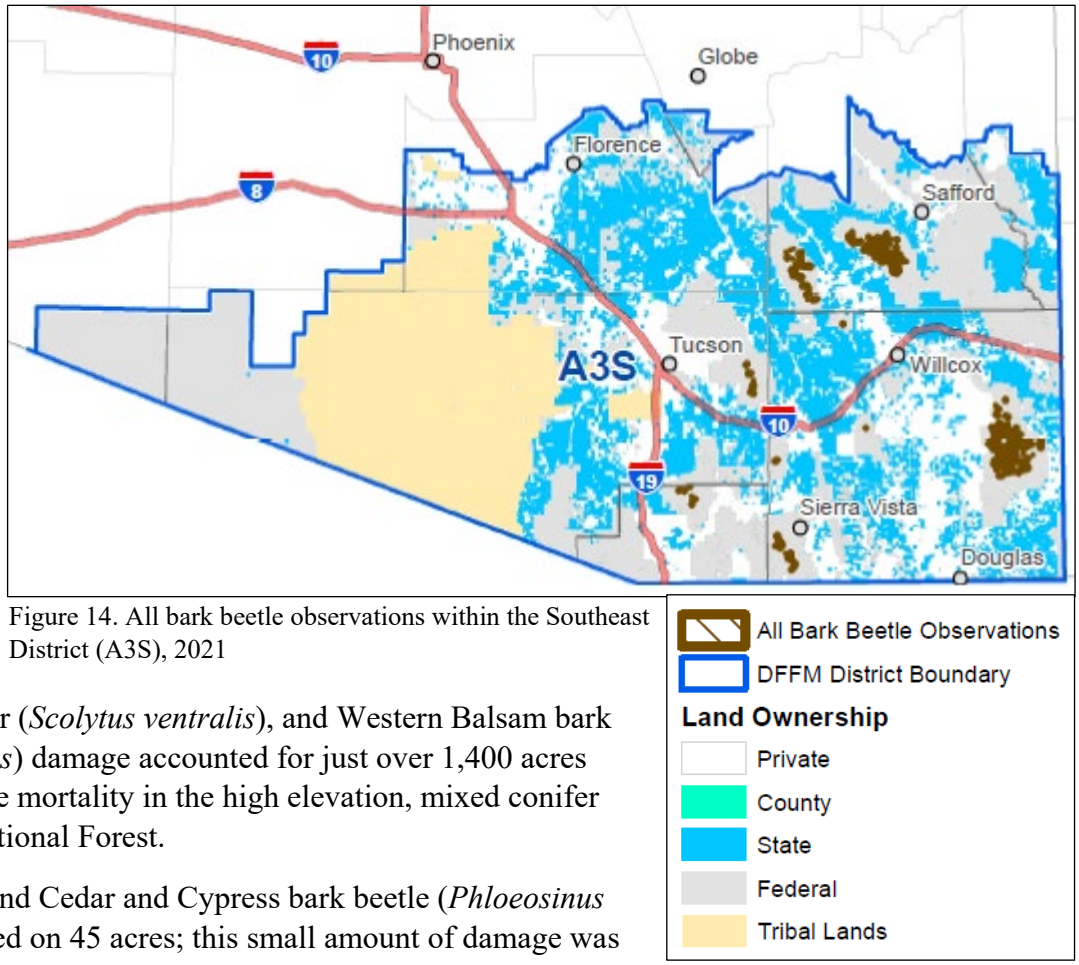


Figure 14. All bark beetle observations within the Southeast District (A3S), 2021

The Douglas-fir beetle (*Dendroctonus pseudotsugae*), Fir engraver (*Scolytus ventralis*), and Western Balsam bark beetle (*Dryocoetes confusus*) damage accounted for just over 1,400 acres with bark beetle caused tree mortality in the high elevation, mixed conifer forests of the Coconino National Forest.

Pinyon ips (*Ips confusus*) and Cedar and Cypress bark beetle (*Phloeosinus* spp.) mortality was observed on 45 acres; this small amount of damage was observed in the lower elevation woodlands on federal lands (Table 15).

Most woodborer damage observed through the 2021 ADS season was caused by nonnative species and will be discussed in more detail in the Invasive Insect Update section of this report. However, the woodborer causing damage in the Southeast District is the native Goldspotted Oak Borer (*Agrilus auroguttatus*). This year nearly 3,000 acres with Goldspotted Oak Borer (GSOB) damage was observed in the Southeast District (Table 16).

Larval feeding by GSOB causes the most extensive damage on oaks. As the larvae feed, water and nutrient uptake is disrupted, leading to the oaks eventual death.

A3S - Estimated Acres of Observed Insect Damage by Land Ownership				
Other Insect Damage	Federal	Private	State	**Grand Total**
Goldspotted Oak Borer	2,695.10	175.60	96.76	**2,967.45**

Table 16 – Estimated Acres with Observed Goldspotted oak borer mortality by Land Ownership for the Southeast District (A3S), 2021

Photo: Observed Goldspotted Oak Borer mortality near the Coronado National Forest, 2021

Status of Noninfectious Disorders

This year 17,000 acres with observed drought damage were identified in the Southeast District (Table 17). The majority of these acres were on federal lands, mostly spread throughout the eastern half of the District, within pinyon-juniper woodlands (Figure 15).

Lastly, there were just over 200 acres with unknown damage, identified as unknown defoliation and dieback during the aerial detection surveys. These areas were not able to be confirmed on the ground, thus their damage causal agent remained as unknown damage

Photo: Juniper dieback due to drought, Coronado National Forest, 2021

A3S - Abiotic and Unknown Damage by Land Ownership				
Damage Causal Agent	Federal	Private	State	**Grand Total**
Drought	15,543.16	688.08	771.59	**17,002.84**
Unknown	11.67	166.58	56.15	**234.40**
Grand Total	**15,554.84**	**854.66**	**827.74**	**17,237.24**

Table 17 – Estimated Acres of Abiotic and Unknown Damage by Land Ownership for the Southeast District (A3S), 2021

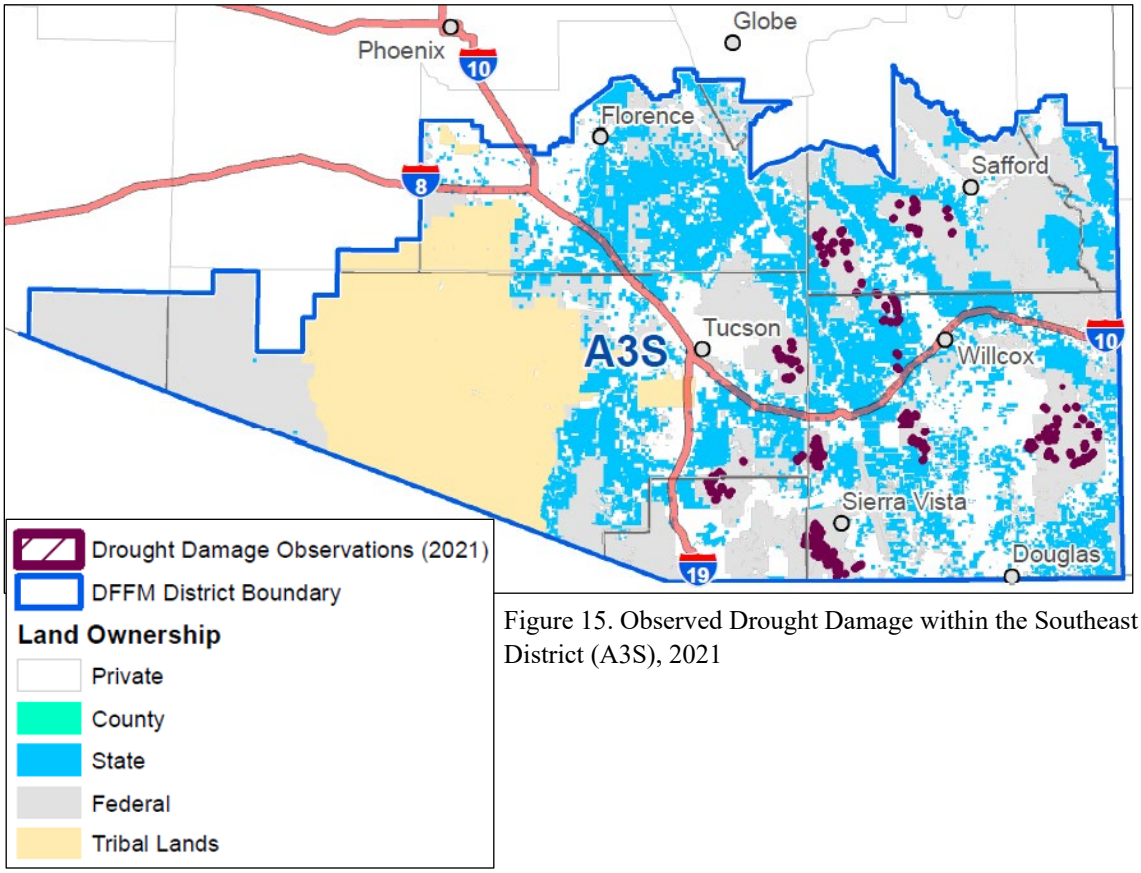


Figure 15. Observed Drought Damage within the Southeast District (A3S), 2021

Central District (A4S) Update – 2021

Status of Insects

The Central District is composed of the Tonto National Forest, San Carlos, Gila River, Salt River, and Fort Howell Reservation lands, and the Kofa National Wildlife Refuge; these areas are all surrounded by scattered county and state lands, with some military reservation lands as well (Appendix I).

Figure 16 is a map showing all insect and disease observations within the Central District. The majority of insect observations occurred on federal and tribal lands. Just over 60,000 acres with bark beetle mortality were observed, almost 1,000 acres with observed defoliator damage, and more than 10,000 acres with sap feeder damage were observed throughout Arizona's Central District (Table 18).

The bark beetle mortality observed throughout the Central District was caused by 3 different types of bark beetles. These bark beetles caused more than 60,000 acres with mortality (Table 18). The majority of this bark beetle caused mortality occurred on federal and tribal lands in the northeastern part of the District (Figure 17).

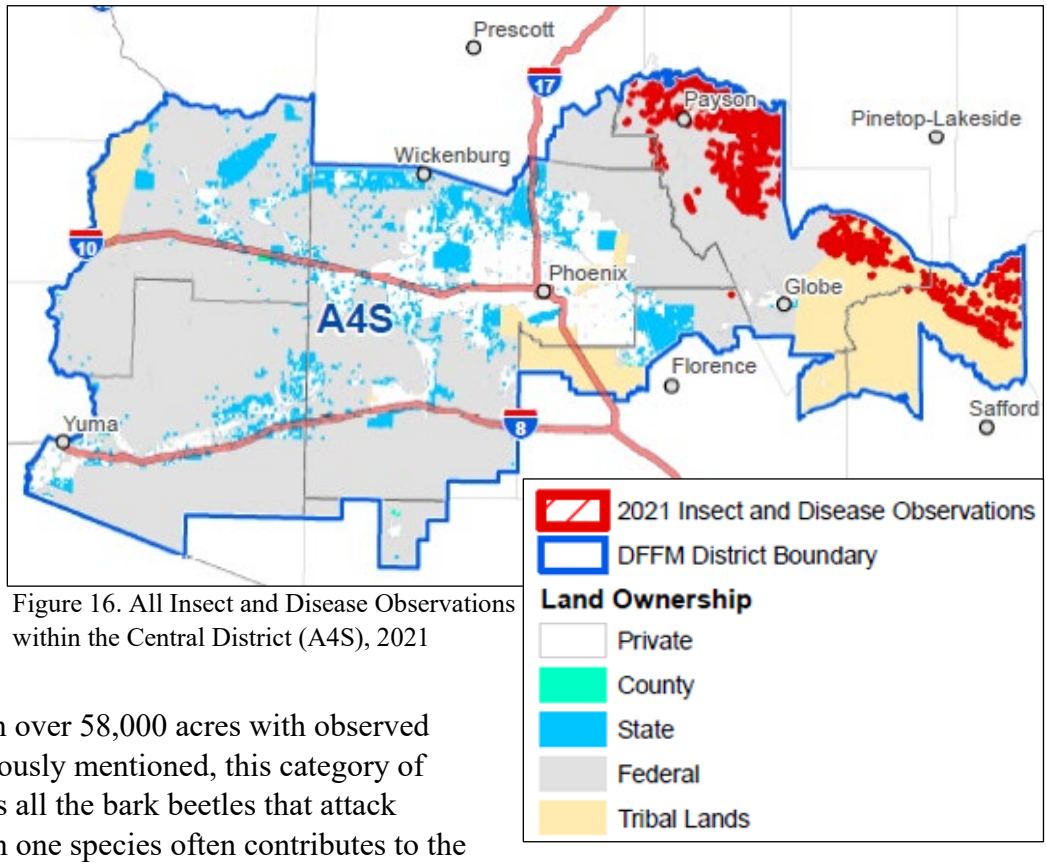


Figure 16. All Insect and Disease Observations within the Central District (A4S), 2021

Of the 6 different types of bark beetles observed causing damage, the group of "Unknown Bark Beetles" caused the most mortality with over 58,000 acres with observed mortality (Table 19). As previously mentioned, this category of unknown bark beetles includes all the bark beetles that attack ponderosa pines. As more than one species often contributes to the decline and death of ponderosa pines, we lump all ponderosa bark beetles into this one category "Unknown Bark Beetles". In the Central District (A4S) this "Unknown Bark Beetle" category also includes the Southern pine beetle (*Dendroctonus frontalis)* and Mexican Pine Beetle

A4S - Estimated Acres of Observed Insect Damage by Land Ownership				
Damage Causal Agent	Federal	Private	Tribal Lands	**Grand Total**
Bark Beetles	31,797.67	333.96	28,602.85	**60,734.48**
Defoliators	222.88		716.49	**939.37**
Sap Feeders	9,030.11	216.61	1,127.18	**10,373.90**
Grand Total	**41,050.65**	**550.57**	**30,446.52**	**72,047.74**

Table 18 – Estimated Acres with Observed Insect Damage by Land Ownership for the Central District (A4S), 2021

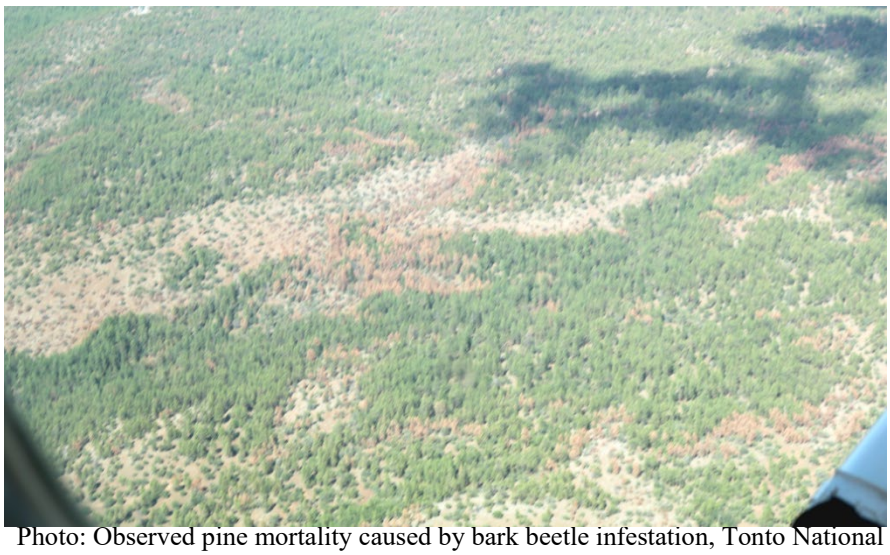


Photo: Observed pine mortality caused by bark beetle infestation, Tonto National Forest, 2021

A4S - Estimated Acres of Observed Bark Beetle Damage by Land Ownership				
Bark Beetles	Federal	Private	Tribal Lands	**Grand Total**
Fir Engraver	305.48			**305.48**
Pinyon Ips	2,098.85	72.16	55.86	**2,226.87**
Unknown Bark Beetle	29,393.34	261.79	28,546.99	**58,202.13**
Grand Total	**31,797.67**	**333.96**	**28,602.85**	**60,734.48**

Table 19 – Estimated Acres with Observed Bark Beetle Damage by Land Ownership for the Central District (A4S), 2021

(*Dendroctonus mexicanus)* as they attack Chihuahua and Apache pines that can be found in this part of Arizona.

Fir engraver (*Scolytus ventralis*) damage accounted for just over 300 acres with bark beetle caused tree mortality in the high elevation, mixed conifer forests of the Tonto National Forest and adjacent San Carlos reservation lands (Table 19).

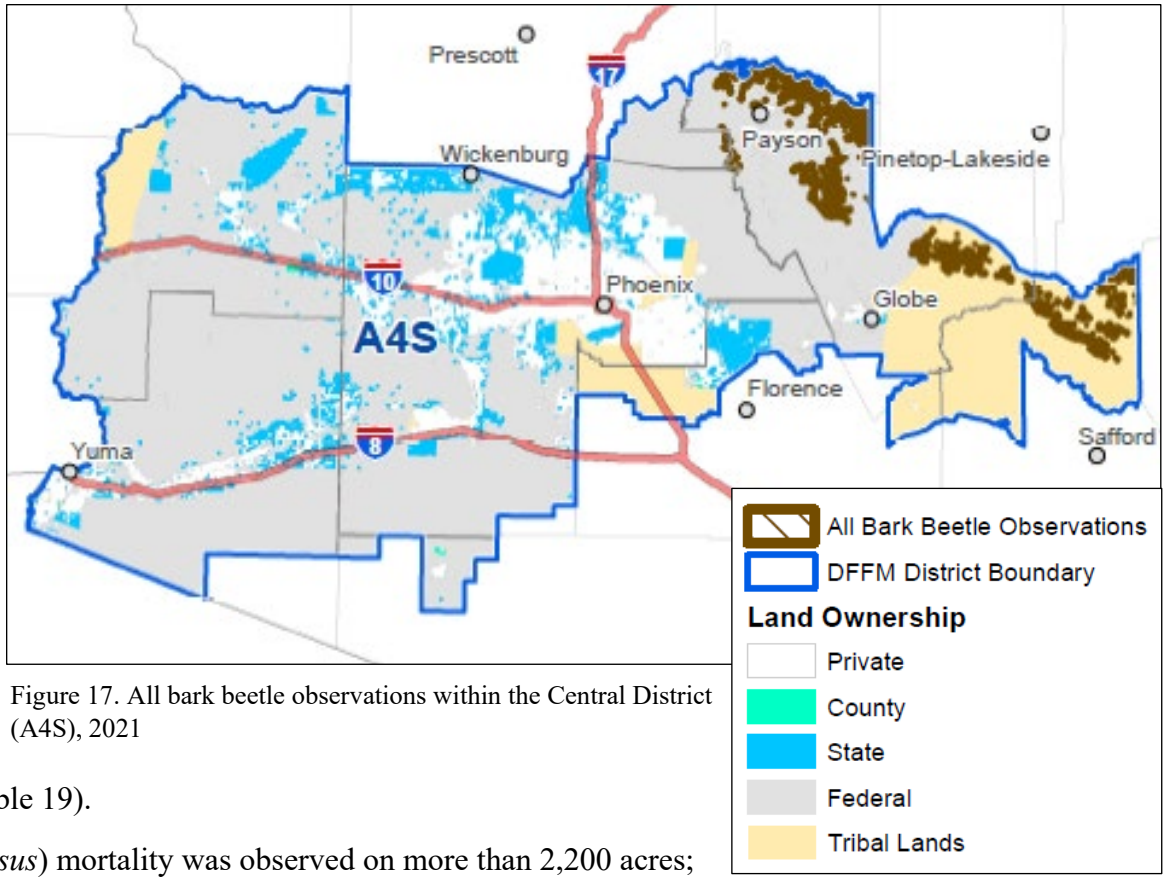


Figure 17. All bark beetle observations within the Central District (A4S), 2021

Pinyon ips (*Ips confusus*) mortality was observed on more than 2,200 acres; damage was observed in the lower elevation woodlands on federal, private, and tribal lands (Table 19).

Pinyon needle scale (*Matsucoccus acalyptus)* is a sap sucking insect that attacks pinyon pines. Pinyon needle scale can cause needles to yellow and drop early. Repeated attacks can cause reduced growth, and stunted needles. Severe outbreaks may kill small trees, while larger trees can become more susceptible to bark beetle attacks. This year over 10,000 acres with pinyon needle scale damage was observed in the Central District (Table 20).

A4S - Estimated Acres of Observed Insect Damage by Land Ownership				
Other Insect Damage	Federal	Private	Tribal Lands	**Grand Total**
Pinyon Needle Scale	9,030.11	216.61	1,127.18	**10,373.90**

Table 20 – Estimated Acres with Observed Insect Damage by Land Ownership for the Central District (A4S), 2021

Status of Invasive Insects

Less than 1,000 acres were observed with tamarisk leaf beetle damage throughout the Central District (Table 21). More than 700 acres with salt cedar defoliation were observed within tribal lands, and the remaining 200 plus acres were on federal lands (Table 21).

The damage observed within the Central District (A4S) is on the border with the Northeastern District (A2S), northeast of Globe, AZ (Figure 18).

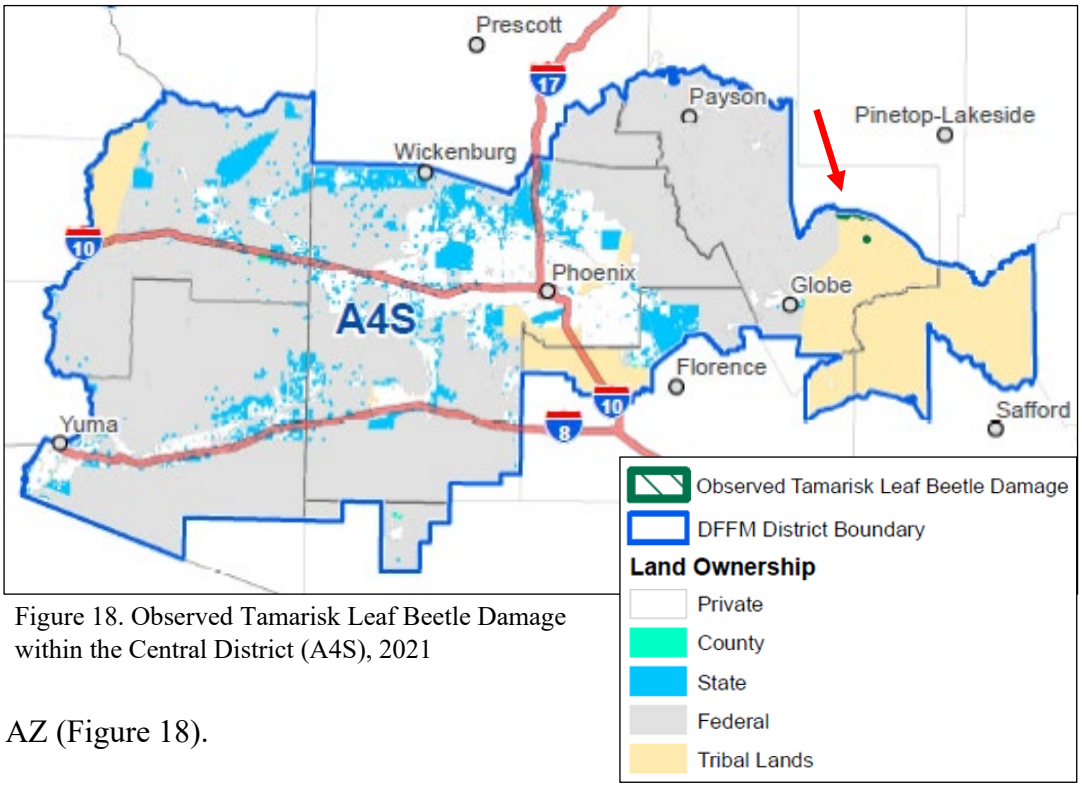


Figure 18. Observed Tamarisk Leaf Beetle Damage within the Central District (A4S), 2021

Photo: Tamarisk leaf beetle damage observed on the San Carlos Reservation, 2021

A4S - Estimated Acres of Observed Invasive Insect Damage by Land Ownership			
Invasive Insect Damage	Federal	Tribal Lands	**Grand Total**
Tamarisk Leaf Beetles	222.88	716.49	**939.37**

Table 21 – Estimated Acres of Observed Tamarisk Leaf Beetle Damage by Land Ownership, for the Central District (A4S), 2021

Status of Noninfectious Disorders

This year more than 15,000 acres were observed with drought damage in the Central District (Table 22). This damage was observed along the eastern edge of the District (Figure 19) and essentially all of these acres were on tribal and federal lands (Table 22). There were only 17 acres with observed salt damage on federal and private lands (Table 22).

Lastly, there were just over 2,100 acres with observed unknown damage (Table 22); 1,900 of these acres were observed with unknown defoliation, and the remaining 200 acres were observed with unknown branch flagging. These areas were not able to be confirmed on the ground, thus their damage causal agent remained as unknown damage.

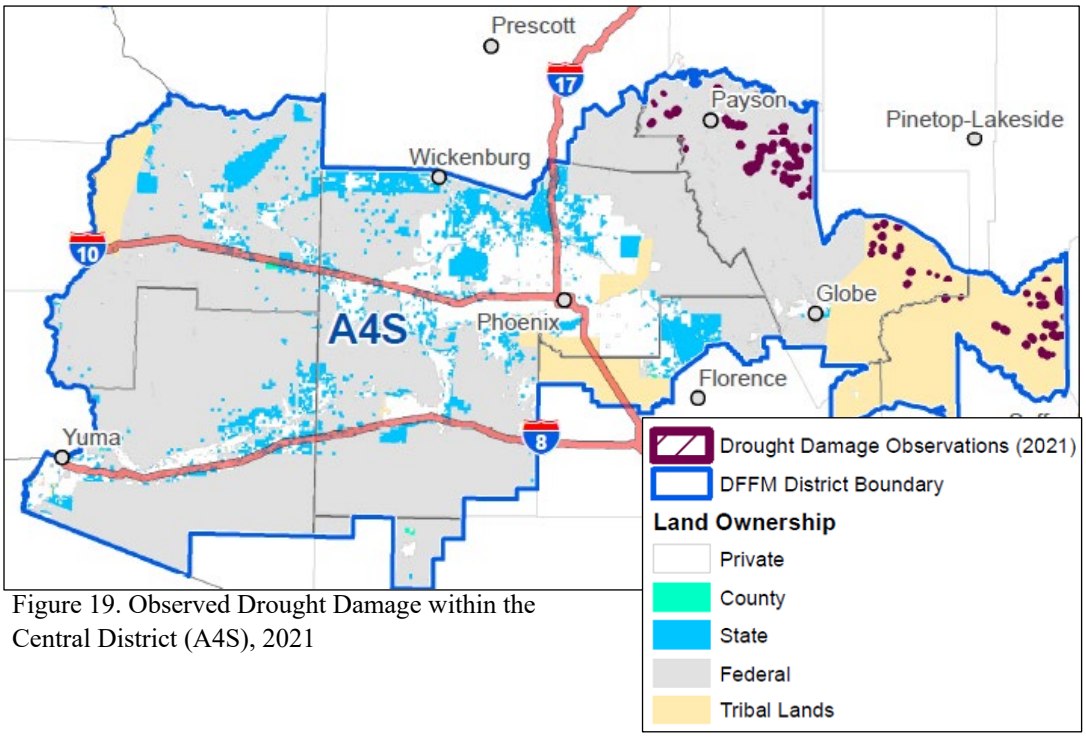


Figure 19. Observed Drought Damage within the Central District (A4S), 2021

A4S - Abiotic and Unknown Damage by Land Ownership				
Disease Causing Agent	Federal	Private	Tribal Lands	**Grand Total**
Drought	7,765.85	16.30	7,544.04	**15,326.19**
Human Activities	12.25	4.75		**17.00**
Unknown	1,769.38	360.12	12.53	**2,142.04**
Grand Total	**9,547.48**	**381.18**	**7,556.57**	**17,485.23**

Table 22 – Estimated Acres of Abiotic and Unknown Damage by Land Ownership for the Central District (A4S), 2021

Photo: Pine mortality from bark beetle infestation, surrounded by discolored, drought stressed pines, San Carlos Reservation, 2021

Northwest District (A5S) Update – 2021

Status of Insects

The Northwest District is composed of the Prescott National Forest, Lake Mead National Recreation Area, Fort Mohave Reservation, and the Havasu National Wildlife Refuge; these areas are all surrounded by scattered county and state lands, with some military reservation lands as well (Appendix I).

Figure 20 is a map showing all insect and disease observations within the Northwest District (A5S). The majority of insect observations occurred on federal lands, with over 40,000 acres with observed bark beetle mortality, almost 15,000 acres with observed sap feeder damage, more than 1,600 acres with wood borer activity, and only 6 acres with defoliator damage occurring throughout Arizona's Northwest District (Table 23).

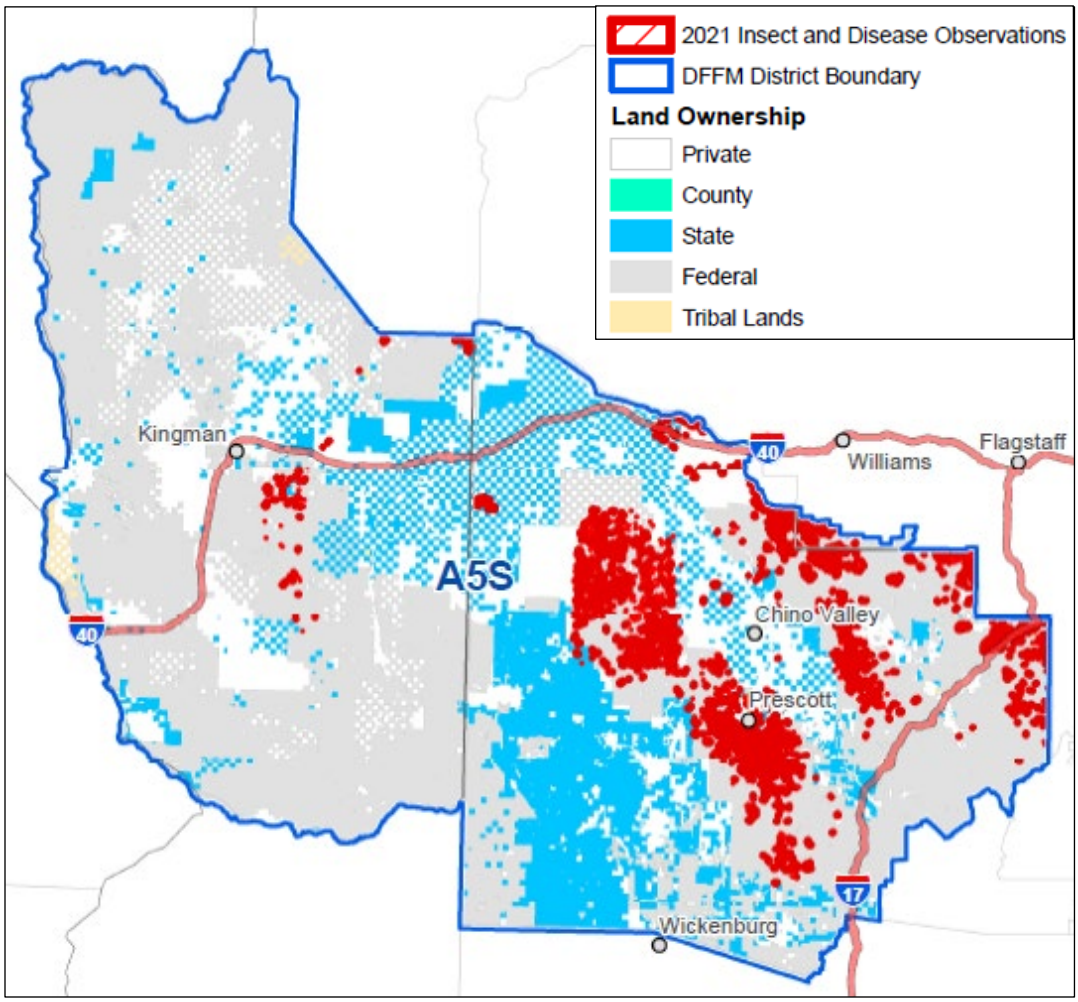


Figure 20. All Insect and Disease Observations within the Northwest District (A5S), 2021

A5S - Estimated Acres of Observed Insect Damage by Land Ownership						
Damage Causal Agent	County	Federal	Private	State	Tribal Lands	**Grand Total**
Bark Beetles		35,154.85	5,548.50	161.07		**40,864.43**
Defoliators			6.63			**6.63**
Sap Feeders	4.91	11,915.15	2,595.54	617.80	19.40	**15,152.81**
Wood Borers		1,693.43				**1,693.43**
Grand Total	**4.91**	**48,763.43**	**8,150.68**	**778.87**	**19.40**	**57,717.30**

Table 23 – Estimated Acres with Observed Insect Damage by Land Ownership for the Northwest District (A5S), 2021

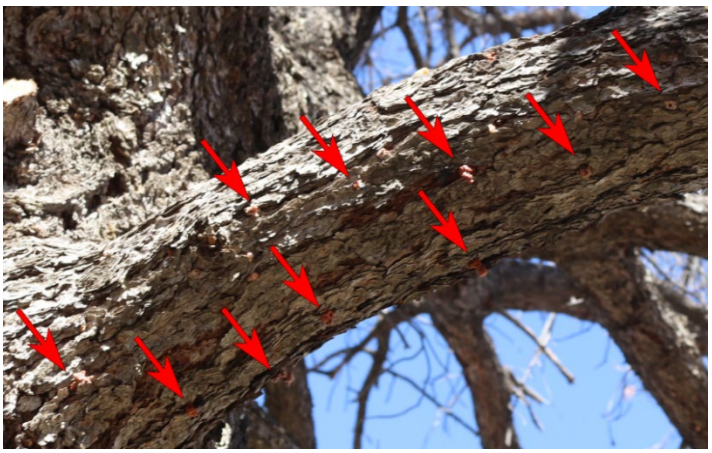
The bark beetle mortality observed throughout the Northwest District was caused by 5 different types of bark beetles that affected more than 40,000 acres with mortality (Table 24). The majority of this bark beetle caused mortality occurred on federal lands (Figure 21).

Of the 5 different types of bark beetles observed causing mortality the group of "Unknown Bark Beetles" caused the most damage with nearly 41,000 acres with observed mortality (Table 24). As previously mentioned, this category of unknown bark beetles includes all the bark beetles that attack ponderosa pines. As more than one species often contributes to the decline and death of ponderosa pines, we lump all ponderosa bark beetles into this one category "Unknown Bark Beetles".

A5S - Estimated Acres of Observed Bark Beetle Damage by Land Ownership				
Bark Beetles	Federal	Private	State	**Grand Total**
Cedar & Cypress Bark Beetles	1.25			**1.25**
Douglas-Fir Beetle	362.06			**362.06**
Fir Engraver	719.62	51.07		**770.69**
Pinyon Ips	1,540.41	257.89	93.74	**1,892.04**
Unknown Bark Beetle	32,531.53	5,239.54	67.33	**37,838.40**
Grand Total	**35,154.85**	**5,548.50**	**161.07**	**40,864.43**

Table 24 – Estimated Acres with Observed Bark Beetle Damage by Land Ownership for the Northwest District (A5S), 2021

Photo: Observed pine mortality from bark beetle infestation, Prescott National Forest, 2021



It is worth mentioning again that severe bark beetle mortality in ponderosa pines was being reported in the fall/winter of 2020 into 2021. This led to a supplemental flight occurring in February of 2021. As Figure 21 indicates, there was quite a bit of damage identified in February of 2021, but by July of 2021, the damage had significantly increased. This figure really shows how quickly bark beetles can spread and cause damage if the climatic conditions are favorable.

Douglas-fir beetle (*Dendroctonus pseudotsugae*) and Fir engraver (*Scolytus ventralis*) damage accounted for just over 1,100 acres with bark beetle caused tree mortality in the higher elevation, mixed conifer forests of the Prescott National Forest (Table 24).

Pinyon ips (*Ips confusus*) and Cedar and Cypress bark beetle (*Phloeosinus* spp.) mortality was observed on nearly 1,900 acres; this damage was observed in the lower elevation woodlands of federal, private, and state lands (Table 24).

Photo: Observed Arizona Cypress mortality from bark beetle infestation, Prescott National Forest, 2021

A5S - Estimated Acres of Observed Insect Damage by Land Ownership						
Other Insect Damage	County	Federal	Private	State	Tribal Lands	**Grand Total**
Oystershell Scale		2.78	28.42			**31.20**
Pinyon Needle Scale	4.91	11,912.37	2,567.13	617.80	19.40	**15,121.61**
Roundheaded Borer		1,693.43				**1,693.43**
Grand Total	**4.91**	**13,608.58**	**2,595.54**	**617.80**	**19.40**	**16,846.24**

Table 25 – Estimated Acres with Observed Insect Damage by Land Ownership for the Northwest District (A5S), 2021

Pinyon needle scale (*Matsucoccus acalyptus)* is a sap sucking insect that attacks pinyon pines. Pinyon needle scale can cause needles to yellow and drop early. Repeated attacks can cause reduced growth and stunted needles. Severe outbreaks may kill small trees directly, while larger trees can become more susceptible to bark beetle attacks. This year over 15,000 acres with pinyon needle scale damage was observed in the lower elevation woodlands of the Northwest District (Table 25).

Photo: Pinyon needle scale egg masses, observed outside of Prescott, AZ, 2021

Pitch moth (*Synanthedon* spp.) is another sap sucking insect whose damage is not typically noticeable from the air. However, this year, upon further investigation on the ground, pitch moth caused noticeable, wide spread damage in Peeples Valley, AZ. Pitch moth damage appears as large, unsightly masses of pitch that form at the wound site. Pitch moth larvae feed on pitch the tree produces in response to larvae tunneling/feeding. These insects do not typically cause tree mortality, but can increase the host's susceptibility to additional insect and disease infestation.

Photo: Pitch moth activity on pinyon pine, Peeples Valley, AZ, 2021

Photo: Cytospora canker on an oyster shell scale infested aspen tree. Notice the healthy uninfested aspen to the right and in the background. Potato Patch, AZ, 2021

Another sap sucking insect observed in the Northwest District is Oystershell scale (*Lepidosaphes ulmi*). Oystershell scale is an armored scale insect that feeds primarily on aspen, but can survive and reproduce on other thin-barked shrubs/trees. The scales damage the plant by sucking out nutrients and water from the host tree. If their infestation is severe enough, it will lead to decreased photosynthesis, thus increasing the host's susceptibility to infestation from other insects and diseases (Appendix II). Just over 30 acres with Oystershell scale were observed on the ground near Walker, AZ, and within and around the Potato Patch community (Table 25).

Roundheaded borer damage was visible as branch flagging from the air. This year, almost 1,700 acres with branch flagging caused by the Juniper twig pruner (*Styloxus bicolor*) was observed in the Prescott National Forest (Table 25). The Juniper twig pruner is a bud and shoot insect that causes twig dieback on junipers and cypress trees growing throughout the southwest.

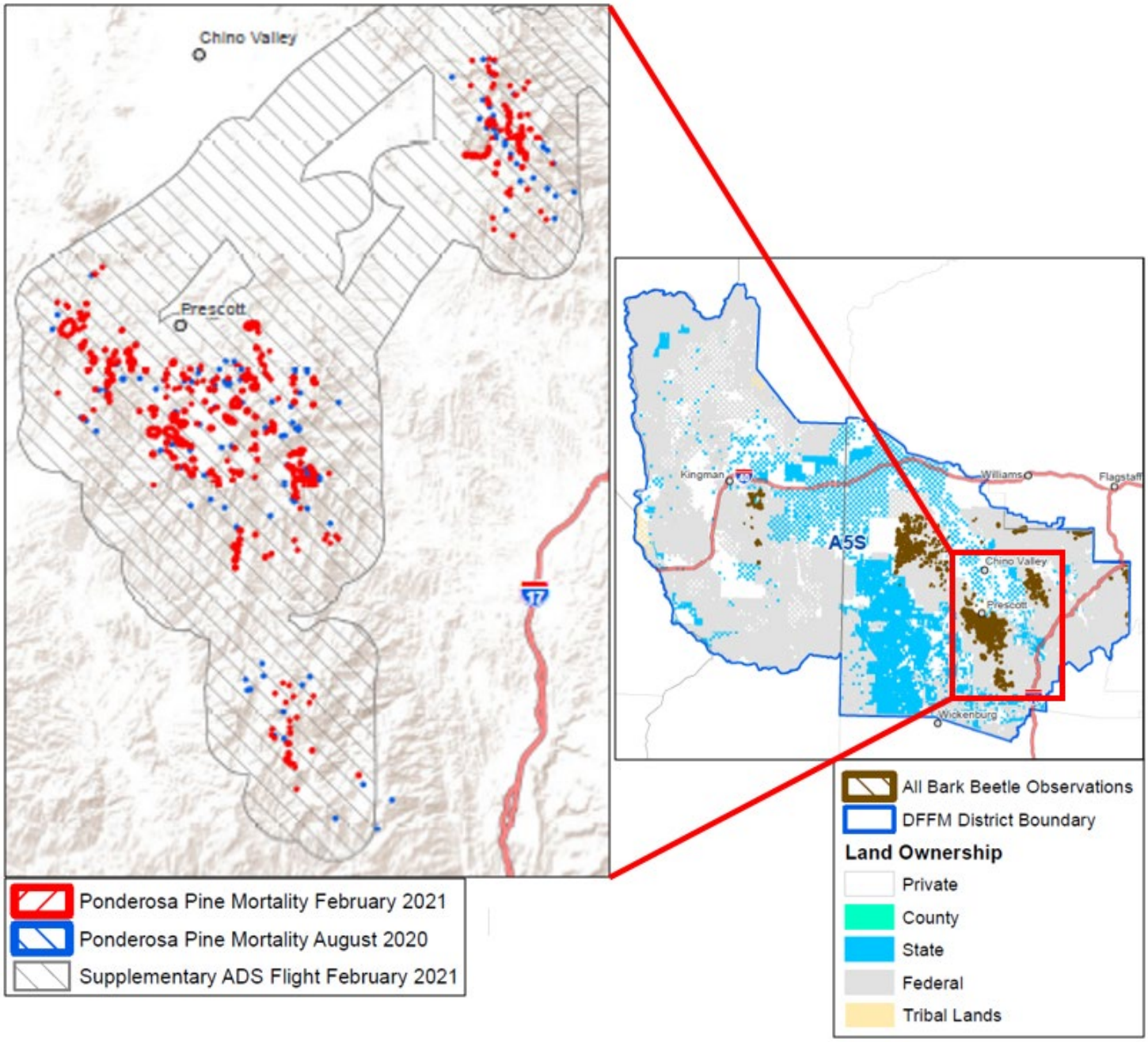


Figure 21. The map on the right shows all bark beetle observations from the 2021 ADS season for the Northwest District (A5S); the insert map on the left shows a close up area of bark beetle damage identified during the supplementary flight in February 2021 and the additional acres observed during the ADS season from July-August, 2021.

Status of Invasive Insects

This year a small area of salt cedar defoliation was observed on private lands on the eastern edge of the Northwestern District (Figure 22). This accounted for just over 6 acres that were observed with tamarisk leaf beetle defoliation of salt cedar (Table 26).

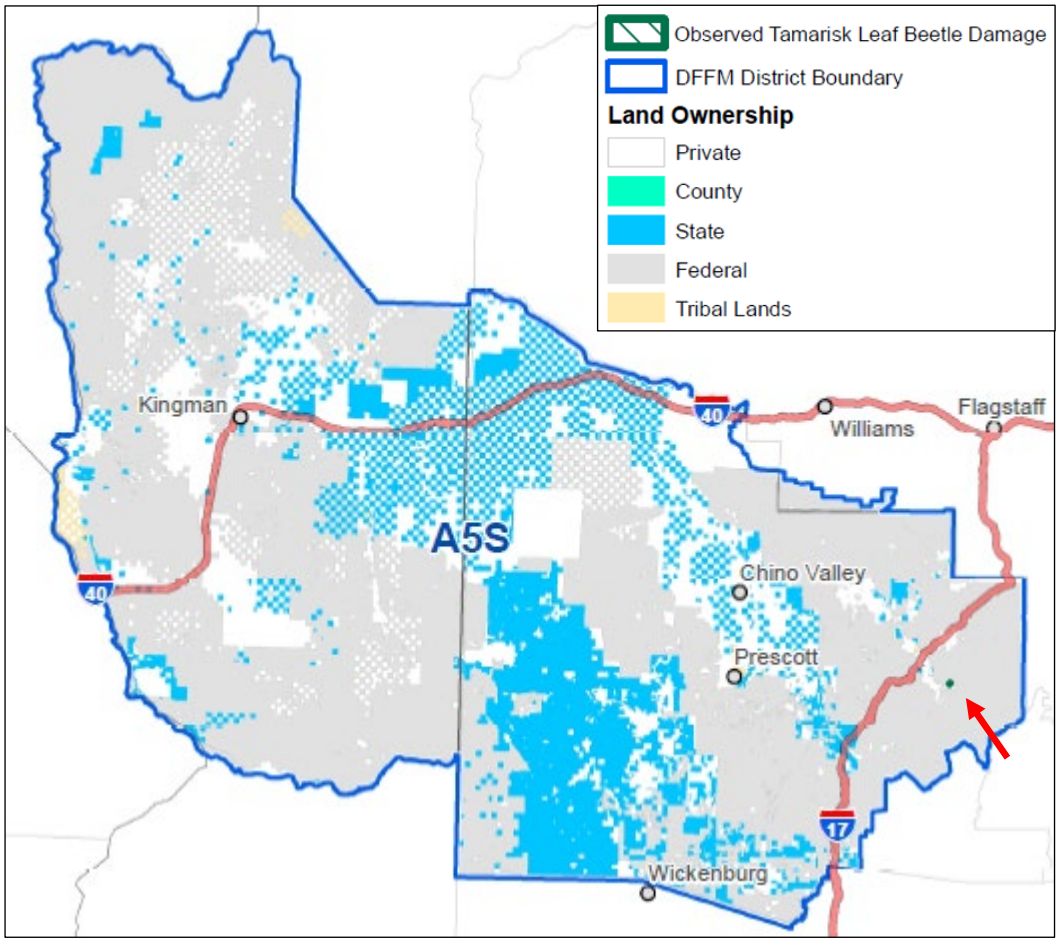


Figure 22. Observed Tamarisk Leaf Beetle Damage within the Northwest District (A5S), 2021

A5S - Estimated Acres of Observed Invasive Insect Damage by Land Ownership		
Other Insect Damage	Private	**Grand Total**
Tamarisk Leaf Beetles	6.63	**6.63**

Table 26 – Estimated Acres of Observed Tamarisk Leaf Beetle Damage by Land Ownership for the Northwest District (A5S), 2021

Status of Noninfectious Disorders

This year nearly 60,000 acres with observed drought damage were identified within the Northwest District (Figure 23). There were less than 3 acres observed with salt damage on federal and private lands (Table 27). Of the 800 remaining acres of unknown damage (Table 27), 650 acres were observed with unknown branch flagging and 150 acres of unknown defoliation and dieback. These areas were not able to be confirmed on the ground, thus their damage causal agent remained as unknown damage.

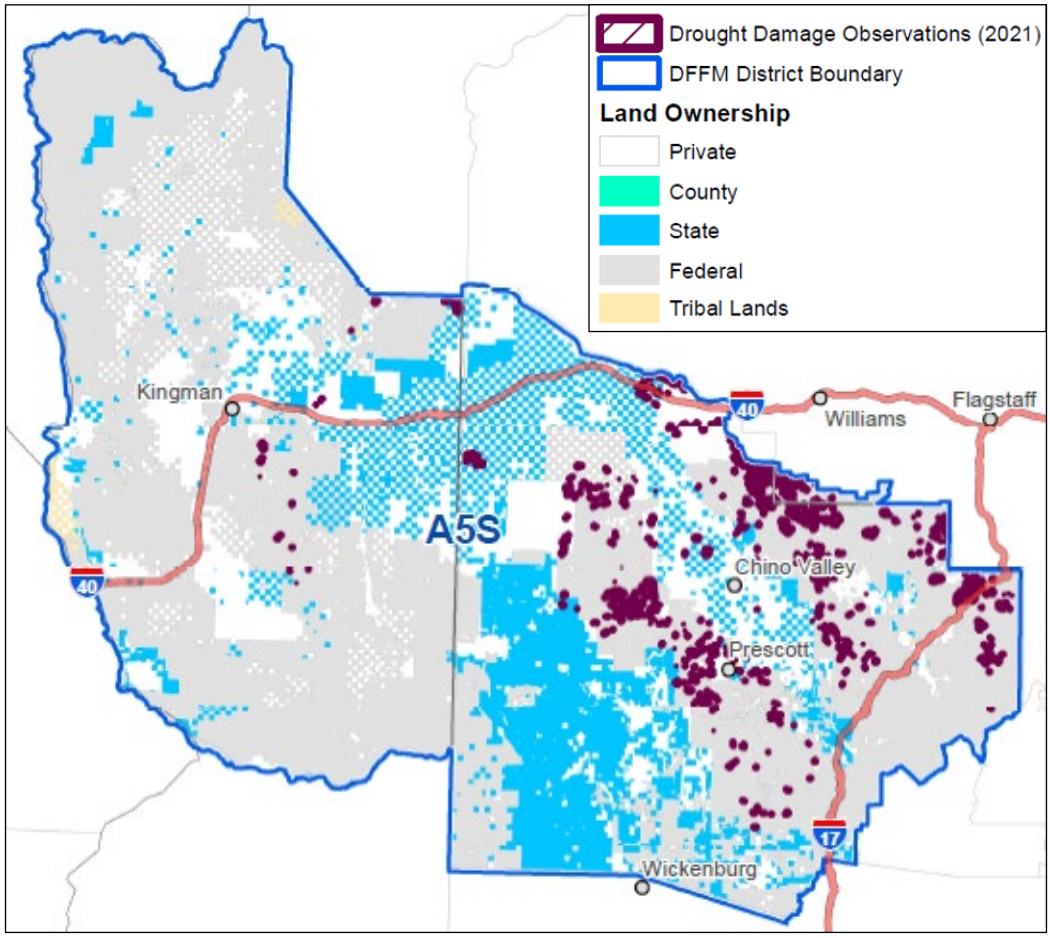


Figure 23. Observed Drought Damage within the Northwest District (A5S), 2021

A5S - Abiotic and Unknown Damage by Land Ownership						
Damage Causal Agent	County	Federal	Private	State	Tribal Lands	**Grand Total**
Drought	76.75	44,968.55	11,112.38	3,421.56	8.68	**59,587.92**
Human Activities		1.75	0.75			**2.50**
Unknown		657.81	179.39			**837.20**
Grand Total	**76.75**	**45,628.11**	**11,292.52**	**3,421.56**	**8.68**	**60,427.63**

Table 27 – Estimated Acres of Abiotic and Unknown Damage by Land Ownership for the Northwest District (A5S), 2021

Photo: Landscape of Juniper dieback due to drought, Hualapai Reservation, 2021

Mediterranean Pine Engraver

The Mediterranean pine engraver (*Orthotomicus erosus*), or MPE, was first discovered in the Central Valley of California in 2004. Since its introduction, this non-native bark beetle has steadily spread to Nevada, Arizona, and Texas. In 2018, the DFFM began monitoring for the presence of MPE, to determine if it had become established in the Phoenix Metro area. MPE traps were established throughout the Phoenix metropolitan area. When the program began, 16 traps were placed around the Phoenix Metro area for a period of 20 weeks in the summer. In 2020 a total of 30 traps were placed throughout the Phoenix Metro area and monitored for 20 weeks throughout the summer. In 2021, 30 traps were placed in the Phoenix Metro, and an additional 10 traps were placed in Tucson, AZ. These 40 traps in the Phoenix metro and city of Tucson were left out for 24 weeks, from April to September. In order to determine if the beetles' lifecycle is different in Arizona's warm climate (i.e. if the beetles are actively flying and reproducing during the relatively mild fall and winter), 5 of the 30 traps in Phoenix were left in place after the summer trapping season ended. Trap samples were collected every week, frozen, and later processed and counted. Since monitoring began in 2018, over 168,000 MPE beetles have been collected from the Phoenix Metropolitan area (Figure 24). Significantly, MPE was confirmed in the Tucson region for the first time as well (Appendix III).

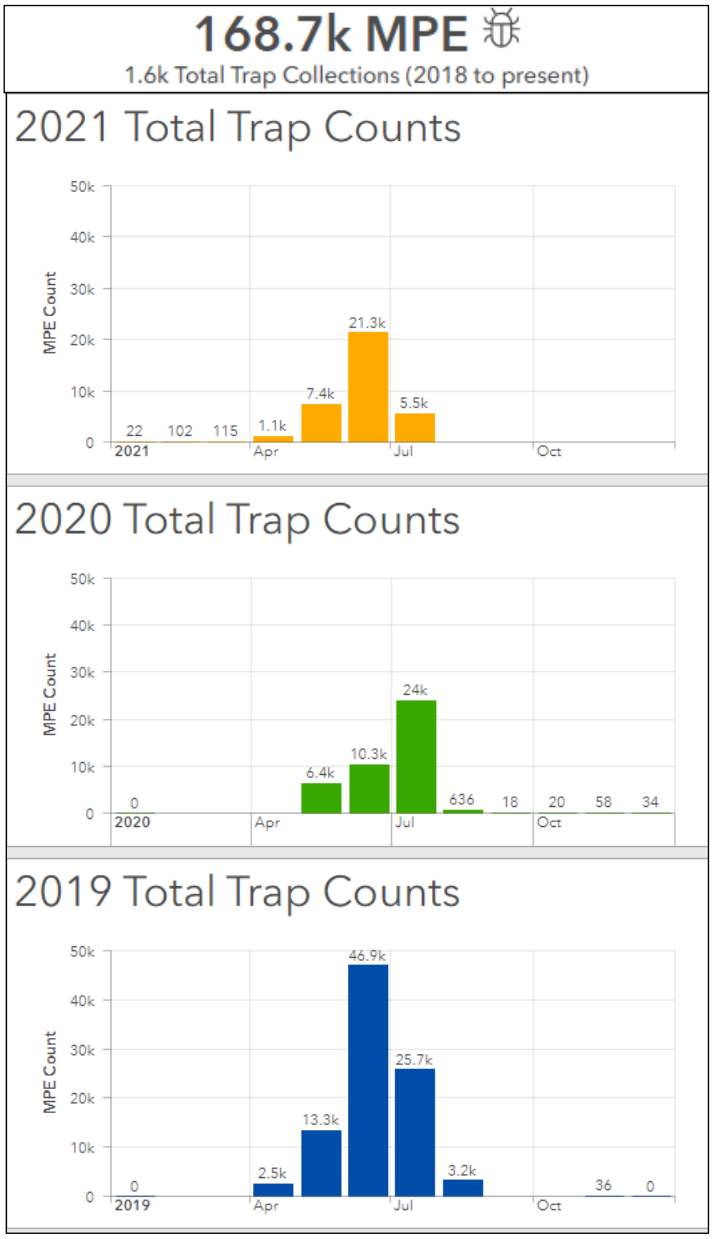


Figure 24. Total Trap Counts of Phoenix Metro Mediterranean Pine Engraver Traps

It is important to mention that this beetle is known to have a large host range, in both urban and wildland forest types. At this point, MPE has only been found in urban forests. But due to its large host range, this invasive insect poses the risk of infesting wildland forests, underscoring the importance of continued monitoring and research regarding management options.

Photo: Credit, Chris Baptista, Entomology Program Manager, Environmental and Plant Services Division, AZDA

The Arizona Department of Forestry and Fire Management's public facing dashboard on the Mediterranean Pine Engraver in the Phoenix metro can be found at the following link: https://dffm.maps.arcgis.com/apps/MapSeries/index.html?appid=4cb0e4f828d44b158aa37006880d664e

General Contact Information

The DFFM Forest Health Program is a statewide program that is based in Phoenix, AZ.

Office of the State Forester
1110 West Washington St., Suite 500
Phoenix, Arizona 85007

602-771-1400

Website: dffm.az.gov

Forest Health Website: dffm.az.gov/forestry-community-forestry/forest-health

The Forest Health Team

Assistant State Forester for Forestry Programs: John Richardson, jrichardson@dffm.az.gov, 602-771-1420

Forest Health Program Manager: Cori Dolan, cdolan@dffm.az.gov, 520-262-5519

GIS Coordinator: Wolfgang Grunberg, wgrunberg@dffm.az.gov, 602-399-1886

Forest Health Specialist: Aly McAlexander, amcalexander@dffm.az.gov, 602-290-9644

Urban Forestry Specialist: LoriAnne Barnett-Warren, lbarnett@dffm.az.gov, 602-399-9447

Invasive Plant Program Manager: William Sommers, wsommers@dffm.az.gov, 602-771-1405

Photo Credits

All aerial photos of observed insect, diesease, and noninfectious disorders were taken by Aly McAlexander; any additional photos without credit were either taken by Aly McAlexander or other Department of Forestry and Fire Management employees.

The State of Arizona Forest Health Program is made possible with assistance from the USDA Forest Service.

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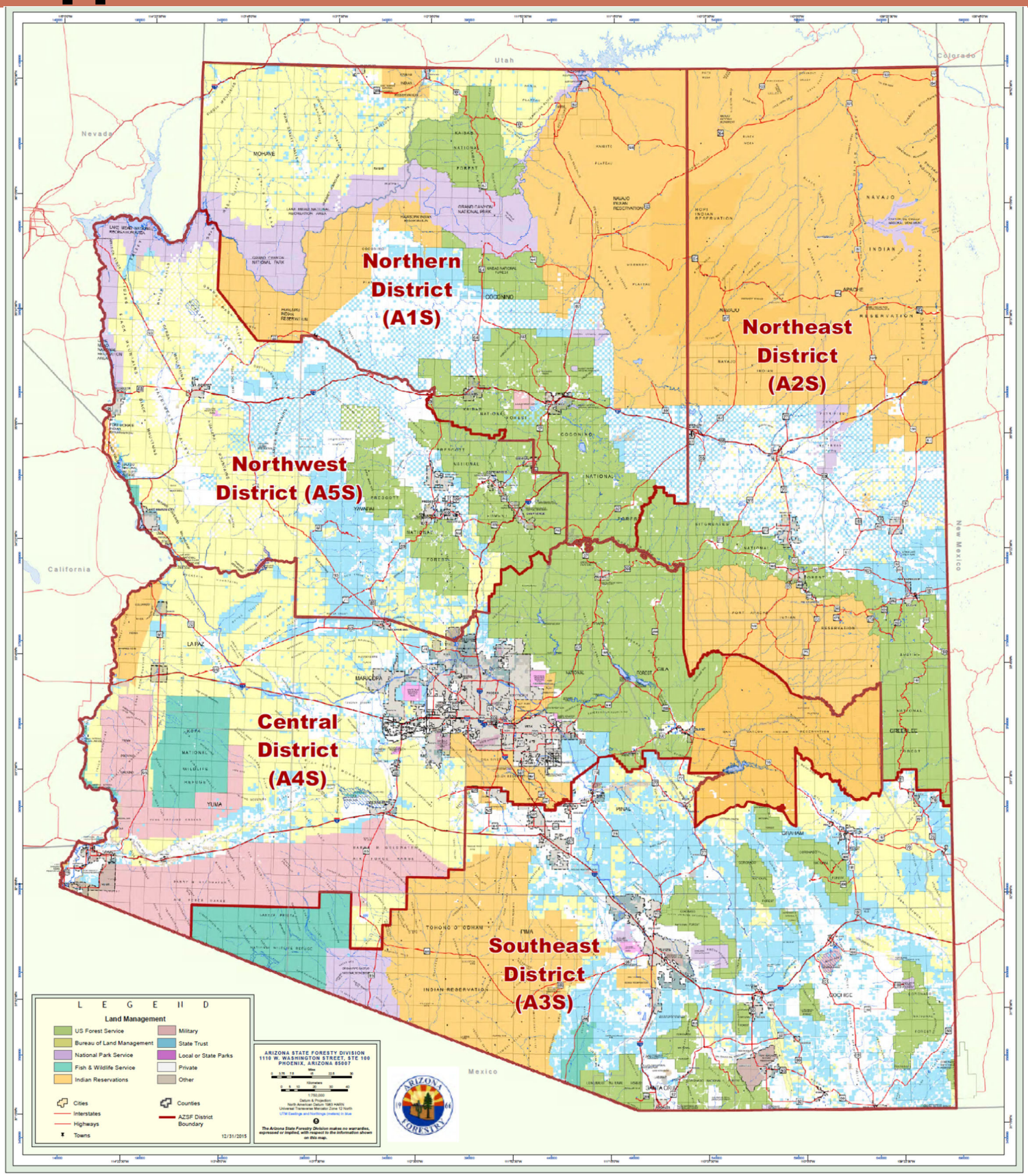
Photo: Lobster Mushroom (*Hyphomycetes lactiflourum*), Coconino National Forest, 2021

Published: January 14, 2022

Appendix I: AZ DFFM Districts



Arizona Forest Health Alert

Oyster Shell Scale Crawlers Emerging in Northern and Central Arizona

May 2021

Adult OSS. Photo by Colorado State University Extension

Oystershell scale crawlers will hatch in early June in northern and central Arizona. This is the time for homeowners with infested trees to most efficiently treat the pest.

The Arizona Department of Forestry and Fire Management and USDA Forest Service, Forest Health Protection in Flagstaff are reporting that the crawler stage of the oystershell scale (OSS) (*Lepidosaphes ulmi)* will emerge on aspen in early-June. Begin monitoring for crawler emergence by Memorial Day weekend. Most crawlers will emerge over a brief 2-3 week period. The crawler stage of OSS is the period of development when they are most vulnerable to treatments that can reduce their population and impacts.

Why do we care?

Populations of OSS have increased across northern and central Arizona, leading to greater impacts in both urban and wildland settings (Figure 1). Oystershell scales damage host trees by inserting their piercing sucking mouthparts into the bark to suck fluids from the tree. This can lead to branch mortality or whole tree death if the infestation is severe. OSS damage may also weaken hosts plants which may become more susceptible to pathogens. Although aspen appears to be the preferred host of OSS, this insect may also affect poplars, willow, ash, lilac, and other tree and shrub species with thin bark. This is a persistent insect that will continue to infest the same hosts, and potentially nearby hosts, year after year.

Signs of activity

Up close, the scale resembles the shell of an oyster. From a distance, large groups of scales may appear as dark or gray patches against the white trunk of an aspen (Figures 1, 2). Newly emerged OSS crawlers can be difficult to identify. They look like tiny yellow-orange specks on the tree trunk and branch surfaces (Figure 3). Using a high-powered hand lens can help with crawler identification. As crawlers hatch and emerge from beneath the old mother scale they will crawl up the tree trunk in search of a new feeding spot or can be wind-blown to a nearby host.

What To Look For

Photos by the USDA Forest Service

Fig. 1 OSS infestation on a small aspen. Note dark patch on white aspen trunk caused by severe scale infestaion.

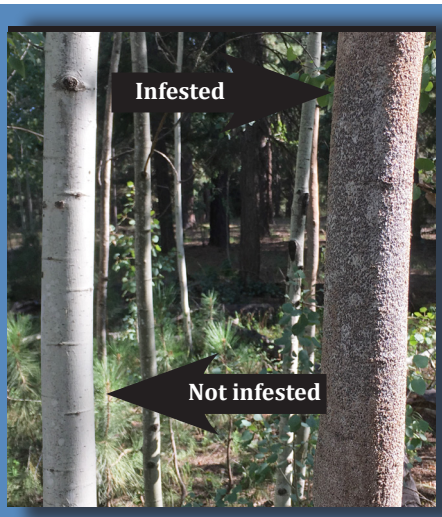


Fig. 2 Severely infested aspen (right) next to an unaffected aspen (left).

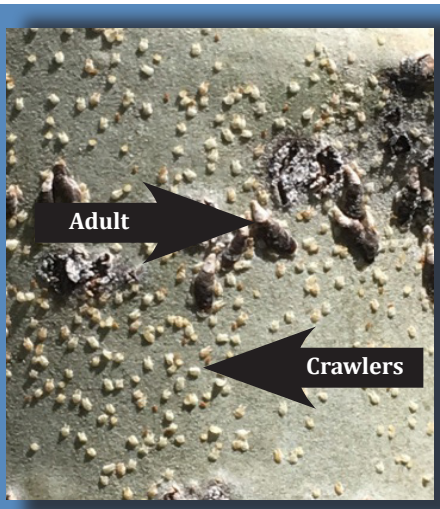


Fig. 3 Close up of adult scales among many tiny yellowish-white crawlers.

Once they settle and begin to feed, the armored scale or shell begins to harden. After the outer shell hardens the scale is protected and less susceptible to treatments including the use of contact pesticides.

What else could it be?

There are other scales that occur on aspen, but none that will look similar to OSS. However, there are non-insect agents that cause damage which resembles OSS damage, namely cankers. A variety of fungal pathogens cause canker formation on aspen. From a distance, cankers may appear as darkened patches that may be confused with oystershell scale. Cankers generally colonize stressed or injured trees through wounds or dead branch stubs. A few common aspen cankers that might be confused with OSS include: Cytospora canker (*Cytospora* spp.) (Figure 4), hypoxylon (*Entoleuca mammatum*) (Figure 5) and sooty bark canker (*Encoelia pruinosa*) (Figure 6).

Photos by the USDA Forest Service

Fig. 4 Orange fruiting bodies emerging from pimple-like structures caused by *Cytospora* spp.

Fig. 5 White and black stromata of *E. mammatum*. Note the dark, roughen bark caused by the pathogen.

Fig. 6 Alternating white and black barber pole pattern characteristic of sooty bark canker.

What can you do?

A variety of treatments are recommended for OSS mitigation. The most benign treatments include physical removal of OSS adults and crawlers (Figure 7), summer season horticultural oils, insect growth regulators (pyriproxifen), or even a strong jet of water from a garden hose may be used to displace and kill the fragile crawlers. Remember to check the entire tree trunk and branches for infested patches. Several more persistent contact pesticides and one systemic insecticide (dinotefuran) are also recommended for armored scales and may be needed to treat severe infestations. Adult scales can be removed anytime of the year; however, the crawler stage is most vulnerable and treatments during this time increase effectiveness. Old scales will remain on the bark after treatments. Remove scales from an infested area to monitor emergence the following year to determine if additional treatments are needed. For more information on treatment methods see the Colorado State University Extension, Oystershell Scale Fact Sheet No. 5.513 (https://extension.colostate.edu/topic-areas/insects/oystershell-scale-5-513/).

Fig. 7 Physical removal of scales. Photo courtesy of Colorado State University Extension.

For further information about this insect or other forest health concerns, contact Aly McAlexander, Forest Health Specialist, at (602) 771-1415 or amcalexander@dffm.az.gov.

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Funding provided by the USDA Forest Service.

Arizona Forest Health Alert

Mediterranean Pine Engraver Found In Tucson

July 2021

Louis-Michel Nageleisen, Département de la Santé des Forêts, Bugwood.org

Urban forestry specialists in Arizona have been monitoring a non-native bark beetle that has made its way to Arizona. The **Mediterranean pine engraver beetle** (MPE) (*Orthotomicus erosus*) was found in Phoenix in 2018. An expanded trapping program recently discovered MPE in Tucson in May of 2021. MPE are native to Europe, the Middle East, northern Africa, and China. They likely got to the United States by hitching a ride in solid wood packing materials. MPE are tiny, only about 3-3.5mm long, and reddish-brown in color. To date, MPE have only been found on eldarica pines (*Pinus eldarica*) in the Phoenix metro area.

Why do we care?

MPE beetles generally attack distressed trees by boring holes in the bark and chewing on the layer just under the bark, called the phloem, where a tree transports sugars and water. Tunnels created by the beetles block the tree's ability to transport water and nutrients, effectively killing the tree.

Healthy pines have a natural defense against bark beetles - they ooze out a thick resin when beetles try to gain entry, pushing the beetles out and trapping them in sticky pitch. Stressed trees, however, produce little or no resin and become susceptible to MPE beetle attack. In addition, even apparently healthy trees may not be able to fend off MPE if beetle populations are abnormally high.

Signs of activity

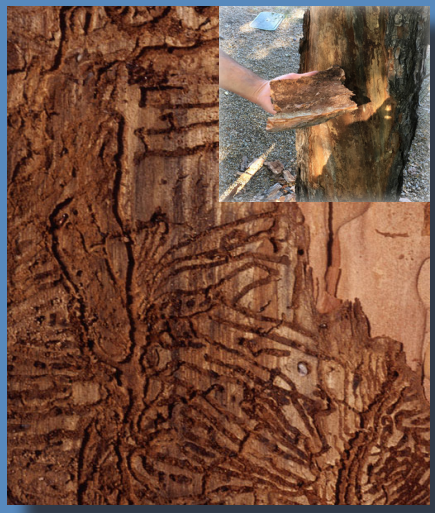
The two most common external signs that an urban tree may have been attacked by MPE are yellowing needles, especially at the top of the tree, and the presence of red boring dust on the bark. Less common signs in an urban setting include pin-sized holes in the bark and resin oozing out of holes in the bark.

What To Look For

Discolored Needles

Red Boring Dust

Galleries Under Bark



Right to left: Discolored needles on eldarica pine; Steve McKelvey, Department of Forestry and Fire Management. Red boring dust on bark, Bob Celaya, Department of Forestry and Fire Management. Galleries under bark, William Ciesla, Forest Health Management International, Bugwood.org

The telltale internal sign of an MPE infestation is the presence of galleries under the bark. Galleries are tunnels carved by the beetles as they reproduce and feed. An arborist or tree care professional will be able to remove a small section of bark to determine if galleries are present.

What else could it be?

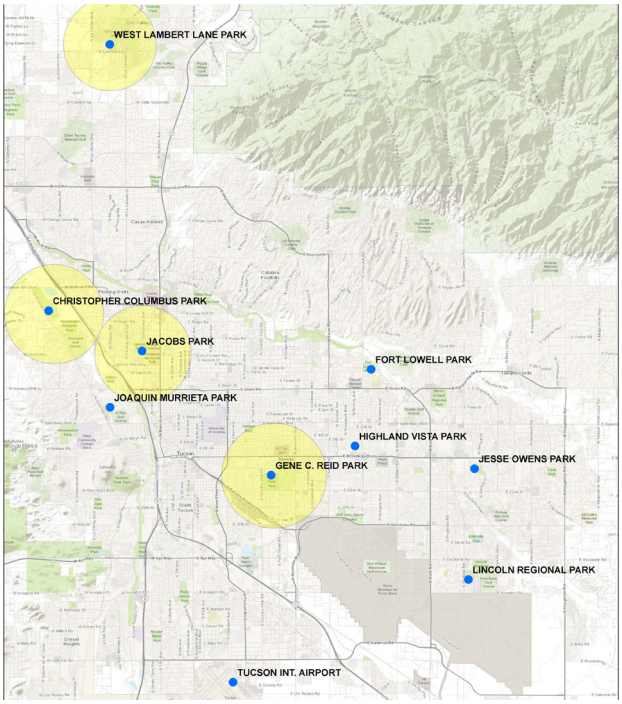
If you don't see the majority of signs listed above, then your tree might be suffering from another look-alike ailment. Yellowing or orange-brown needles alone could be a sign that the tree needs more water.

Other insects can also make holes in the bark of pine trees. The main difference is that non-MPE wood boring beetles are generally found on trees that are already dead. In addition, the holes they make are much bigger and are usually flat on one side rather than perfectly round, like those of MPE.

Flathead borers make large holes with flat tops. Fabio Stergulc, Università di Udine, Bugwood.org

Woodpeckers and other sapsuckers also make holes in bark, but they will be fairly large and likely in rows or columns. MPE holes are pinhead-sized and spread randomly over the bark.

MPE Traps in Tucson



Ten traps were placed around Tucson in April 2021 (blue dots) and will be monitored through September 2022. MPE have been detected in four of those traps (blue dots with yellow highlight) as of the writing of this alert.

Large woodpecker holes are usually found in rows or columns. Top: Terry Spivey, USDA Forest Service, Bugwood.org. Bottom: Pompilid, Wikimedia Commons

What can you do?

If you suspect that a pine may be infested with MPE beetles, contact a certified arborist for an assessment. To find certified tree care professionals in your area, you can use the **Find An Arborist** tool on the International Society of Arboriculture's website: **www.treesaregood.org**.

The best method to stop the infestation from spreading may be to have the infested tree removed. This will remove beetles from the area before they spread to other trees. All infested green material should be removed from the site, chipped, buried or burned. A certified tree care professional will be able to help you determine the best course of action.

Please contact the Department of Forestry and Fire Management with specific tree location details to help us monitor where MPE is spreading. This information is invaluable in helping us stay ahead of the problem. Information or questions can be emailed to **foresthealth@dffm.az.gov.**

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