Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Coronado National Forest, View from Mt. Lemmon, 2023

ARIZONA FOREST HEALTH CONDITIONS **2023**

Over 14 million acres surveyed by air

17,111 acres identified with bark beetle caused tree mortality

27,783 acres identified with tree damage from sap-feeding insects

16,603 acres identified with tree damage from defoliating insects

5,328 acres identified with drought related damage

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

Assembled by Mitchell Lannan, with support from Aly McAlexander and Viridiana Quinonez. Data analysis done by Sepideh Dadashi with support from Wolfgang Grunberg.

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Major funding for this project is provided by the Arizona Department of Forestry and Fire Management's Forest Health Program and USDA Forest Service. In accordance with Federal law and U.S. Department of Agriculture policy, this institution is prohibited from discriminating on the basis of race, color, national origin, sex, age, or disability. (Not all prohibited bases apply to all programs.)

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

Published: February 23, 2024

Introduction

Despite Arizona having all four of the major North American deserts (Sonoran, Chihuahuan, Mojave, and the Great Basin), there are still many forests found throughout the state. These forests range significantly in elevation and dominant tree species. Forests cover approximately 27% of Arizona, at over 19 million acres of land and are comprised of over 40 species of coniferous and hardwood trees (Appendix I). The majority of forestland in Arizona is located in the northern part of the state, above the Mogollon Rim. Forests in the southern part of the state are often referred to as the "Sky Islands", as they are completely surrounded by lowland deserts, providing habitat for species found at higher elevations unable to survive the harsh desert climate.

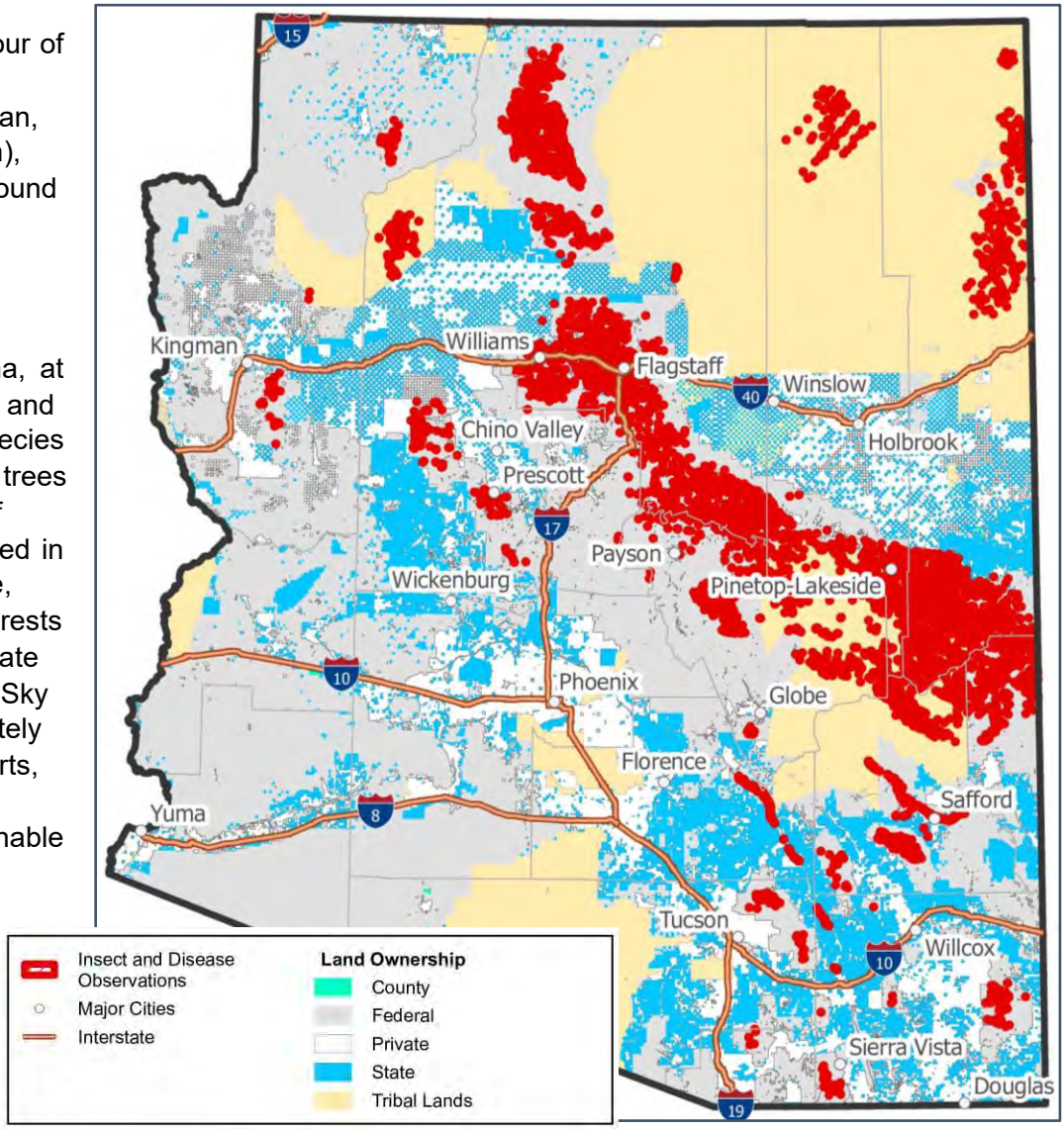

Figure 1 – All ADS Insect and Disease Observations in the State of Arizona - 2023

Juniper (*Juniperus* spp.) and pinyon-juniper (*Pinus edulis-Juniperus* spp.) woodlands are the most abundant forest types in Arizona, occupying approximately 14.8 million acres, or 20.3% of the state. The rarest forest type, and most significant in ecological terms, are the riparian forests, which occupy less than 0.5% of Arizona's land.

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

Arizona's tree and landscape diversity creates a large diversity in the insects and diseases that attack them. This report includes information on the insects and diseases having significant impacts on Arizona's forested landscapes.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Prescott National Forest, view from Mt. Union, 2023

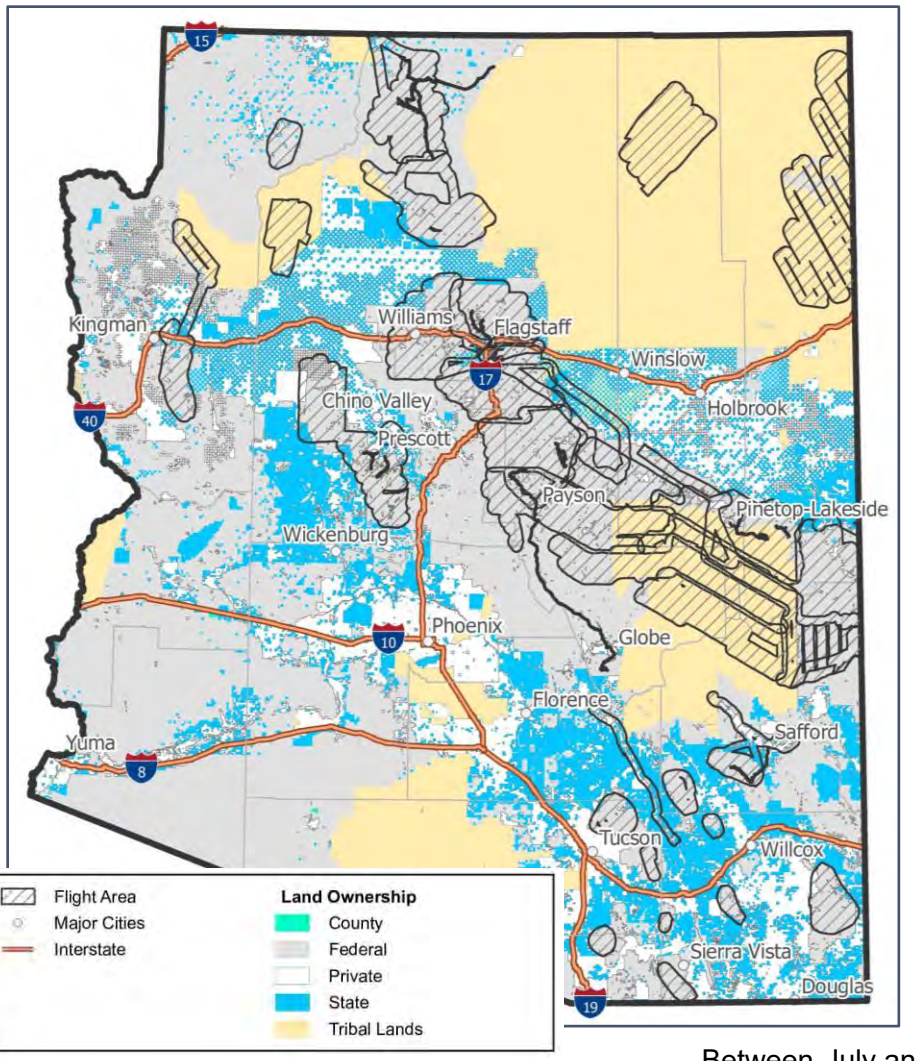

Figure 2 – All ADS Surveyed Areas in the State of Arizona - 2023

Arizona 2023 - Approximate Surveyed Area in Acres by Land Ownership		
Land Ownership*	**GIS Area (Acres)**	**%**
County	2,520.81	0%
Federal	8,004,743.72	57%
Private	936,158.31	7%
State	577,449.48	4%
Tribal Lands	4,567,175.44	32%
Grand Total	**14,088,047.77**	**100%**
* 2023 BLM Surface Management Agency data		

Table 1. Surveyed Area in Acres by Land Ownership for the State of Arizona - 2023

Arizona Department of Forestry and Fire Management

The Forest Health Program in the Arizona Department of Forestry and Fire Management (DFFM) is a cooperative forestry program, partially funded by the USDA Forest Service, via State and Private forestry, to assist forest and woodland landowners with forest health concerns.

Aerial Surveys

Annually, AZ DFFM collaborates with the USDA Forest Service- Forest Health Protection (FHP) Team, to survey millions of acres of forests and woodlands from the air. Referred to as Aerial Detection Survey (ADS), the data collected provides land managers and the public with a recent analysis of the state's forest and woodland health. This report summarizes the 2023 ADS program and discusses current forest and woodland health issues in Arizona.

Between July and September of 2023, over 14,000,000 acres were surveyed to record dead, dying, and declining trees (Figure 2). The aerial surveys primarily cover federal lands, which are 57% of the total area surveyed. Federal lands include National Forests, National Parks, and Bureau of Land Management lands. Other areas surveyed include tribal lands (32% of the area surveyed), private lands (7% of the area surveyed), state lands (4% of the area surveyed), and county lands (less than 1% of the area surveyed). Table 1 provides an overview of the number of acres per land type.

Throughout the ADS season, as well as after, the USDA Forest Service and AZ DFFM forestry professionals verify the ADS data by conducting ground surveys and providing landowners and businesses with technical assistance.

Climactic Overview

Relevance

Drought is a key factor in the health of Arizona's forests. Extreme drought has lasting effects on trees, and symptoms can persist for years after the event. In severe drought conditions, the lack of water can lead to direct drought-related tree mortality. Trees that do not perish from drought will likely be weakened. Trees weakened and stressed by drought conditions produce and collect more ethanol and terpenes in their tissues. Tree-killing insects such as bark beetles are able to detect and target these chemicals when finding new trees to attack. In the years following major drought events, lingering effects on the trees can cause them to remain in a weakened and stressed state, making them more susceptible to insects and diseases.

Weather patterns in Arizona are highly affected by La Niña and El Niño climate patterns. Here in Arizona, La Niña and El Niño conditions are driven by changing temperatures in the Pacific Ocean, with warming water creating El Niño (also known as the El Nino Southern Oscillation or ENS) conditions every 2-7 years, and colder waters creating La Niña conditions. In Arizona, these events are often more prominent in winter months. El Niño years in Arizona often (but not always) lead to a wetter winter in the southwest, whereas La Niña years often bring a drier winter.

Review of Arizona's Long-term Drought Conditions

The winter of 2022-2023 was exceptionally wet, leading to significantly improved short and long term drought conditions by March of 2023. Small areas in Yuma and La Paz counties were still experiencing Exceptional Drought Levels (D4), which is the highest and most severe level of drought according to the U.S. Drought Monitor. Extreme Drought Levels (D3) and Severe Drought Levels (D2) were still present in Yuma, La Paz, Mohave, Coconino, and Maricopa counties. La Niña conditions ended without indicating whether the monsoon season would be wet or dry. At that point there was a 60% chance of El Niño developing in the fall and winter of 2023.

Between April and June of 2023, Exceptional (D4) Drought Level conditions continued in the southernmost portion of La Paz County. Extreme Drought Levels (D3) remained in small areas of Maricopa, Mohave, La Paz, Coconino, and Yuma counties. Severe (D2) and Moderate (D1) Drought Level conditions persisted in parts of these counties as well. Southern and Eastern Arizona documented little to no long term drought conditions. El Niño conditions have since developed over the Pacific Ocean, suggesting a drier monsoon season in Arizona for 2024.

Through the summer, from July to September, areas in western Arizona received above-average rainfall. In contrast, areas in the northern, central, and southern parts of the state received less-than-average rainfall. Maricopa County and much of the southeast recorded higher average temperatures than usual, with Phoenix seeing 31 straight days at or above 110 ° Fahrenheit. The hottest temperature of the year was 118 ° Fahrenheit in Phoenix. Exceptional (D4) Drought Levels remained in La Paz County and returned to parts of Maricopa and Santa Cruz Counties. Extreme Drought Levels (D3) advanced in regions of Maricopa, Mohave, La Paz, Coconino, and Yuma counties. El Niño conditions continued, with conditions favoring a wetter winter.

Between October and December, Arizona recorded warmer than average conditions. Exceptional (D4) Drought Levels expanded in Maricopa and Coconino counties, and continued in areas of Pima and La Paz Counties. Extreme (D3) Drought Levels advanced in regions of Coconino, Yavapai, Pinal, and Pima Counties, and Severe (D2) Drought Levels advanced in regions of Mohave, La Paz, Pinal, Pima, and Coconino Counties. El Niño conditions are continuing with expected wetter conditions to come through the beginning of 2024.

Overall, Arizona had a year of extremes and fluctuations in terms of temperature, precipitation, and drought status. Increases in short- and long-term drought were documented in some parts of Arizona, while others saw decreases. These changes in drought status will be consequential in the health of our forests and ecosystems, with drought causing ever-changing conditions.

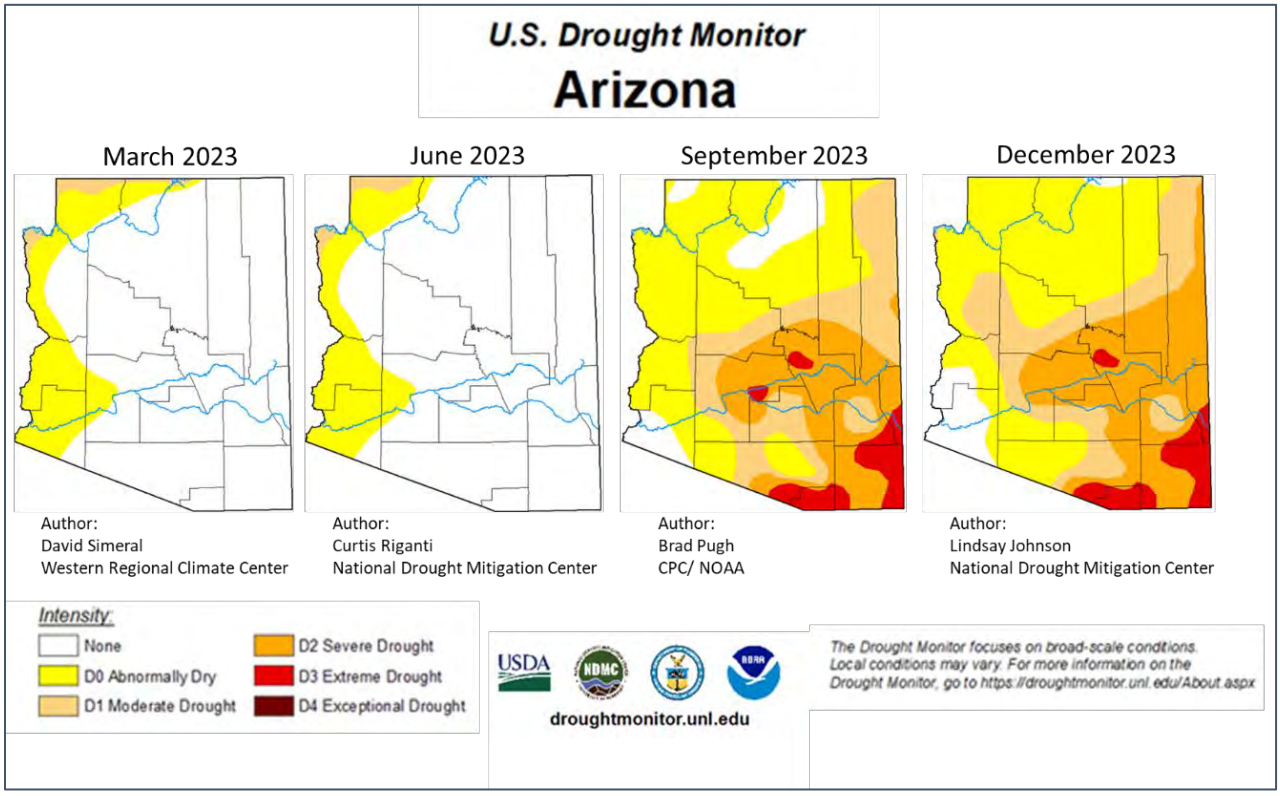

Figure 3 – U.S. Drought Monitor Maps of Arizona in March, June, September, and December, 2023; Obtained from droughtmonitor.unl.edu

Pest Overview

Review of Arizona's Insect Tree Pests

A large variety of insect pests attack and kill trees here in Arizona. Each year, thousands of acres of forests are lost as a result of these pests, along with many homeowners loosing trees on their property. Insect pests to trees are often split into five categories: Bark Beetles, Woodborers, Bud and Shoot Insects, Defoliators, and Sap-feeding Insects.

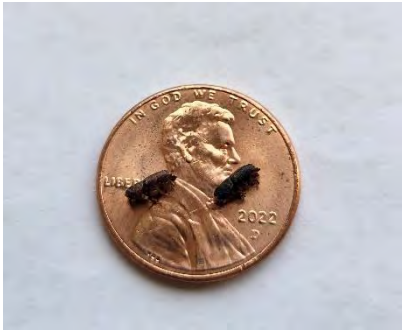

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Bark Beetles in Phoenix, 2023

Bark Beetles are small insects, typically about the size of a grain of rice, and the most damaging insect to forests at a large-scale. These beetles feed by tunneling between the bark and wood of a tree (phloem tissues), primarily in conifer trees here in Arizona. A tree that has succumbed to bark beetles will have straw, tan, or reddish-orange colored foliage (needles). Localized populations of bark beetles typically prefer weakened or stressed trees;

however, under epidemic conditions they will attack healthy trees. Common bark beetle species here in Arizona include *Ips* spp. (pine engraver beetles) and *Dendroctonus* spp. (Douglas-fir, mountain, red turpentine, roundheaded, southern, spruce, and western pine beetles). Cedar, cypress and juniper beetles (*Phloeosinus* spp.) are also common.

Woodboring beetles are insects that bore into the wood of freshly cut host trees, or those that are injured, dying, or recently dead. They are mainly a secondary pest and help to recycle the woody material within our forests. Prominent wood-borers in Arizona include the ambrosia, jewel, and longhorned beetles.

Bud and shoot-boring insects are typically beetles or moths, and injury may be caused by directly feeding on the buds and shoots of host trees, boring directly into the twig or branch, or boring into the bark producing excess resin. Common species here in Arizona include bark and pitch moths, pine tip moths, twig beetles, and juniper and oak pruners.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Oystershell Scale on Aspen in Potato Patch, 2023

Defoliating insects feed on the leaves and needles of suitable hosts. The loss of these tissues impacts the health of the plant, and the severity depends on a variety of factors, including host species tolerance, timing of defoliation, and the relative destructiveness of a particular insect. A tree attacked by defoliators may be minimally to completely defoliated. Repeated defoliation may cause branch and/or crown dieback, even tree mortality. Additionally, defoliation can lead to poor tree health, slowed growth, deformation, and subsequent increased susceptibility to other insects or diseases.

Sap-feeding insects are small insects that pierce the foliage or stem of host trees to feed on their nutrient and water supply. This injury to the plant can cause discoloration of the host tissue and occasionally introduce plant diseases. A tree that has been attacked by sap-feeding insects will have discolored, deformed, or no previous year's needles or foliage, but mortality is uncommon. Notable sap-feeding insects in Arizona include aphids, Cooley spruce gall adelgids, and pinyon needle scale.

Review of Arizona's Tree Diseases

Tree diseases are typically one of four categories (fungal, bacterial, viral, or oomycetes). Plant diseases often thrive in warm and damp conditions not commonly seen in Arizona, making diseases less of a concern within the state. Common types of tree diseases include foliage diseases, stem and trunk decay, cankers, rusts, root diseases, and dwarf mistletoe.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Needle Cast on Aleppo Pine in Phoenix, 2023

Foliage diseases are most commonly seen in Arizona on aspen, Arizona sycamore, oak, cottonwood and willow. Individual trees or whole groups can become infected when favorable, wet, conditions occur. Heavy infections can cause partial or complete defoliation of trees, reducing growth, and scattered dieback of twigs and branches. Black leaf spot, Melampsora rust, oak and sycamore anthracnose are the most common species identified. On conifers, foliage diseases are less common but may be prominent when they occur, causing infected needles to discolor and fall off. The most common conifer needle diseases include Elytroderma needle cast and Red band needle blight on

ponderosa and pinyon pine, and Rhabdocline needle cast of Douglas-fir.

Wood decay is caused by fungi that infect the living heartwood or dead wood of a tree. Decay fungi also serve a critical role in the natural recycling of nutrients back into the soil for utilization by other organisms. Most decay fungi of live trees do not cause mortality, but may structurally weaken the branch or trunk, causing wind breakage and wind-throw. This is usually correlated with the age of the tree and the extent of the decay. Hardwoods, including aspens and cottonwoods, are highly susceptible to stem and trunk decay fungi. Conifers, including Douglas-fir, white-fir and spruce, are generally more susceptible to wood decay fungi, mainly due to the wetter and cooler environments they inhabit. Conversely, pines are less susceptible due to the warmer and drier habitats in which they occur. Common decays found on hardwoods include false tinder conk on aspen, which produce conspicuous hoof-shaped conks or fruiting bodies clearly visible on the trunk. Very dramatic and large fruiting bodies of sulfur-shelf fungus can be seen on oaks and poplars. On conifers, multiple fruiting bodies or conks of red ring rot can be detected on the trunk of infected Douglas-firs and pines. Red belt fungus also produces shelf-like perennial conks which feature a red-brown band above a light-colored base on dead conifers.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Stem Decay of Honey Locust in Phoenix Parks, 2023

Localized areas of dead bark and the decaying, underlying wood on twigs, branches and trunks is caused by fungi called cankers. They are typically a response to injury and are usually found on hardwood trees. Aspen is the most common host of these diseases because of their soft bark tissue, but alders and cottonwoods also are prone to cankers. Cankers seen on aspen include Cryptosphaeria, Cytospora, Hypoxylon and sooty bark.

Rust fungi can have either a complex multispecies lifecycle or can complete their life cycle on only one host. Rusts can cause brooms, galls, flagged and swollen branches, trunk dieback, and mortality of conifers. The most notable and destructive stem rust recently identified in Arizona is the non-native white pine blister rust. Other common species include limb rust, western gall rust, fir and spruce broom rusts, and Gymnosporangium rusts on Arizona cypress and junipers.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Dwarf Mistletoe Shoots on Pinyon Pine in Grand Canyon National Park, 2023

Generally, root diseases cause decay and kill back the roots in both conifers and hardwoods. Severity varies depending on root disease species, age of the host tree, and the growing site. Principal symptoms include yellowing of the leaves or needles, shortened terminal growth, reduced needle growth, progressive thinning of foliage, fading crown, and overall reduced tree growth. Tree species in Arizona most susceptible to root disease fungi include aspen, oak, Douglas-fir, ponderosa pine, fir and spruce. Prominent root diseases include Armillaria, Annosus, and Ganoderma.

Dwarf mistletoes are parasitic flowering plants that infect conifers. Unlike the native true mistletoe which infect hardwoods, dwarf mistletoe does not photosynthesize so they completely depend on their host for nutrients and water. This causes stress in trees and predisposes them to other pests like bark beetles. Mistletoe infections cause swelling at the site of infection, overall reduced growth, and production of witches brooms.

Mistletoe spreads from tree to tree through sticky seeds; the seeds stick to a new tree, where they germinate and produce root-like structures in the tree tissue. Mistletoe then develop yellow, orange, green, or brown visible aerial shoots on its host tree. Trees may live with mistletoe for several years and mistletoe continues to form new shoots as long as the host is living.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Elk Damage to Ponderosa on Fort Apache Reservation, 2023

Review of Arizona's Vertebrate Tree Pests

Many vertebrates in Arizona can cause damage to localized trees, although rarely causing widespread damage. Elk, white-tailed deer, and mule deer feed on the leaves of young trees, and occasionally trample trees causing stem breakage or scrape trees with their antlers removing the bark.

Rodents, such as porcupines, also feed on trees, particularly ponderosa pine, pinyon pine, and aspen. These large rodents are active year round, removing and feeding on the bark from the tops of trees. Squirrels, another rodent, can also cause damage to trees by removing and feeding on bark, and clipping small twigs for their nests.

Birds can also severely damage trees. In Arizona, woodpeckers can cause a lot of damage to trees. The acorn woodpecker is notorious for creating hundreds of holes in trees to store acorns for the winter. Sapsucker woodpeckers also cause damage to trees, creating horizontal rows of holes on the trunk and branches. These holes cause injury to the tree, potentially allowing diseases to enter, and creating tree stress, which weakens the tree and allows insects such as bark beetle to better attack.

Lastly, bears can cause damage to trees. Bears will scrape at the bark of trees, typically at the base, to look for and feed on insects underneath the bark. Removing the bark like this can girdle and kill the tree.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Sapsucker Woodpecker Damage to Chinese Elm in Tempe Parks, 2023

Review of Arizona's Invasive Plants

Invasive plants are extremely detrimental to forests, causing economic and ecological harm. They are able to transform landscapes due to their aggressive nature. They reproduce quickly, grow in a variety of conditions, and are very difficult to remove once established. Invasive plants threaten the plant communities in forests by spreading over large areas and outcompeting native vegetation for resources. The loss of native plants results in decreased wildlife habitat, decreased available grazing area for herbivores, and decreased forest productivity. Invasive plants can also cause soil degradation and increase the risk of devastating wildfires.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Invasive Thistle in Flagstaff, 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Acorn Woodpecker Damage to Ponderosa Pine in Pinetop-Lakeside, 2023

Statewide Highlights

Arizona Department of Forestry and Fire Management Districts

The Arizona Department of Forestry and Fire Management divides the state into five (5) distinct districts (Appendix II). Each district shares similar forest and woodland health issues while experiencing a varying degree of tree damage from insects and diseases. In the next section, 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 reported may look inflated due to the fact that some acres are counted twice as more than one damage causal agent was found on those acres.

Insect Pest Update

In 2023, 62,743 acres with insect related tree death and decline were recorded throughout the state, with the majority of observed species being sap-feeding insects, bark beetles, and defoliators. The acres with insect related damage has significantly decreased from 2022, where 446,386 acres with insect related damage were documented.

Arizona 2023 - Estimated Area in Acres with Observed Insect Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Bark Beetles	0.25	12,014.81	46.71	36.08	5,013.63	**17,111.48**
Defoliators		2,613.41	9,431.15	474.43	4,084.66	**16,603.65**
Sap Feeders		12,669.26	757.31		14,356.77	**27,783.34**
Wood Borers					1,244.64	**1,244.64**
Grand Total	**0.25**	**27,297.48**	**10,235.18**	**510.51**	**24,699.70**	**62,743.11**

Table 2. Estimated Area in Acres with Observed Insect Damage by Land Ownership for the State of Arizona - 2023

Bark Beetle Update

When we compare the acres with bark beetle caused tree mortality throughout Arizona in 2022 and 2023, we see a large decrease in the total acres with mortality. Figure 4 shows all bark beetle mortality observations from 2023; this damage is widespread throughout the state, occurring mostly on federal and tribal lands (Table 2). In 2022, over 402,000 acres with bark beetle caused tree mortality were observed, while in 2023 that number declined to just over 17,000 acres (Table 2). This is a 183% decrease in bark beetle caused mortality statewide, likely due to the improved drought conditions throughout the state, reducing overall tree stress and susceptibility to attack. Bark beetle damage will be broken down by district, with detail provided on each bark beetle species (Table 3). One type of bark beetle mortality identified in every district is “Unknown Bark Beetle” damage, 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.

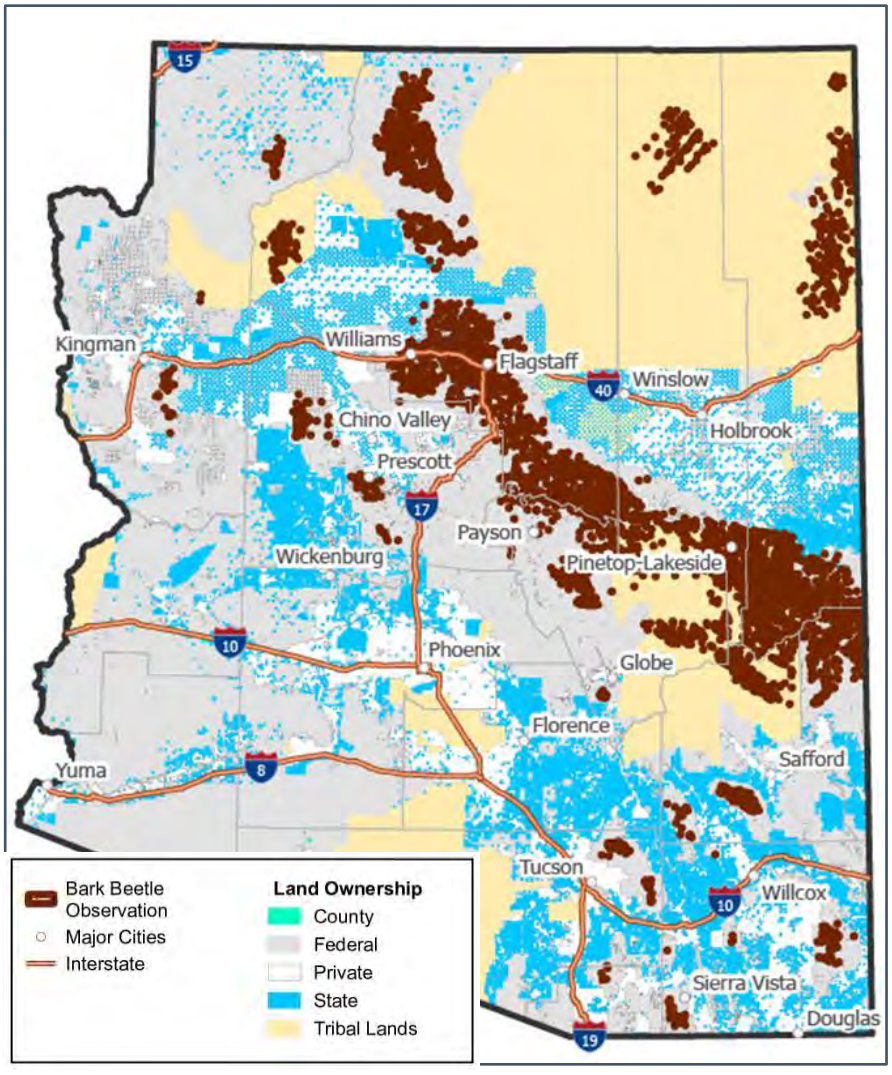

Figure 4 – All ADS Bark Beetle Observations within Arizona - 2023

In Arizona's Southeast (A3S) district this "Unknown Bark Beetle" category also includes the southern pine beetle (*Dendroctonus frontalis)* and Mexican pine beetle (*Dendroctonus mexicanus)*, because they attack Chihuahua and Apache pines that are found in this part of Arizona.

Fir engraver bark beetle (*Scolytus ventralis*.) damage was observed in several Arizona Districts in 2023. This species primarily attacks white fir and subalpine fir (including corkbark fir) trees at higher elevations. Extensive damage and mortality is often observed following drought events.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Bark Beetle Mortality of Ponderosa Pine in Prescott National Forest, 2023

Douglas-fir bark beetle (*Dendroctonus pseudotsugae*), attacking only Douglas-fir, is another species found in several Arizona districts. This bark beetle often attacks scattered trees, but can cause large-scale mortality when conditions are right.

Arizona 2023 - Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership						
Bark Beetle Damage Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Blue Spruce Engraver		2.50			5.00	**7.50**
Douglas-fir Beetle		2,127.97			313.45	**2,441.43**
Fir Engraver		3,062.21	7.61		1,369.22	**4,439.03**
Pinyon Ips		52.50	2.00	1.00	355.12	**410.62**
Spruce Beetle		16.90			163.78	**180.68**
Unknown Bark Beetle	0.25	6,375.24	37.11	35.08	2,708.85	**9,156.52**
Western Balsam Bark Beetle		377.49			98.21	**475.70**
Grand Total	**0.25**	**12,014.81**	**46.71**	**36.08**	**5,013.63**	**17,111.48**

Table 3. Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership for the State of Arizona – 2023

Tamarisk Update

Tamarisk leaf beetles (*Diorhabda* spp.*)* were introduced in the 1990's as a potential bio-control agent for the invasive tamarisk plant (*Tamarix* spp.), also known as salt cedar. Salt cedar was introduced as an ornamental in the southwest in the 1800s; thus, it had centuries to become established within Arizona. Since, it has taken over native riparian habitat throughout much of the state. Salt cedar grows rapidly and densely, outcompeting native trees and shrubs in a matter of years.

Tamarisk leaf beetles were released in hopes that they would help slow or stop the salt cedar invasion, and allow native plants to move back into their natural habitat. However, as salt cedar became established, and native riparian habitats

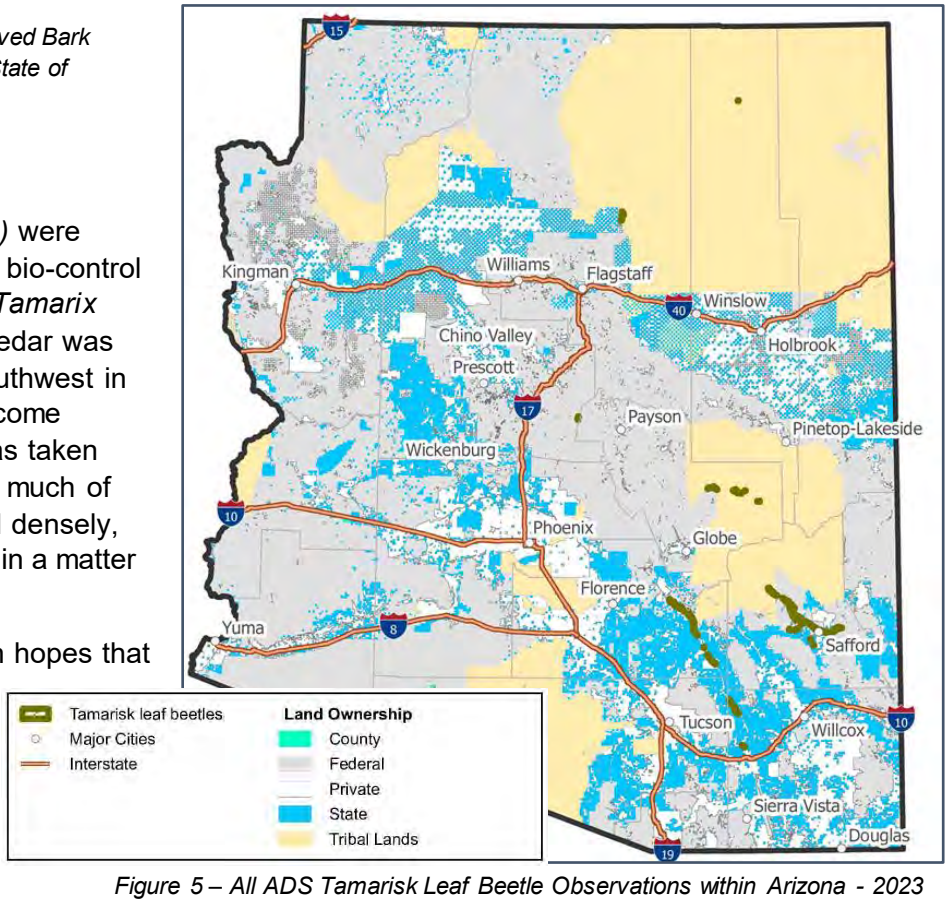

Figure 5 – All ADS Tamarisk Leaf Beetle Observations within Arizona - 2023

declined, the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*) began using salt cedar for its nesting grounds. The extent of control that the beetle will exert on salt cedar and the affect that will have on Southwestern Willow Flycatcher habitat is still 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. Areas in Arizona along the Gila, Salt, Little Colorado, San Pedro, Santa Cruz, and Verde Rivers are now known to be infested with Tamarisk leaf beetles.

Photo credit: Aly McAlexander- DFFM Forest Health Program Manager, Tamarisk Leaf Beetle Defoliation to Salt Cedar in Coronado National Forest, 2023

Several Arizona Districts have observed salt cedar defoliation from Tamarisk leaf beetle (Figure 5), and special surveys were conducted to record their range in southern Arizona. The acres observed with tamarisk leaf beetle damage are areas that are not typically flown over during ADS flights. It is reasonable to assume damage from these insects is on additional acres throughout Arizona, therefore the acres reported here are not representative of the entire state.

Non-Infectious 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 infestations. In this report, abiotic damage falls into five categories: Drought, Wind, Hail, Flooding, and Road Salts and De-icer. Drought

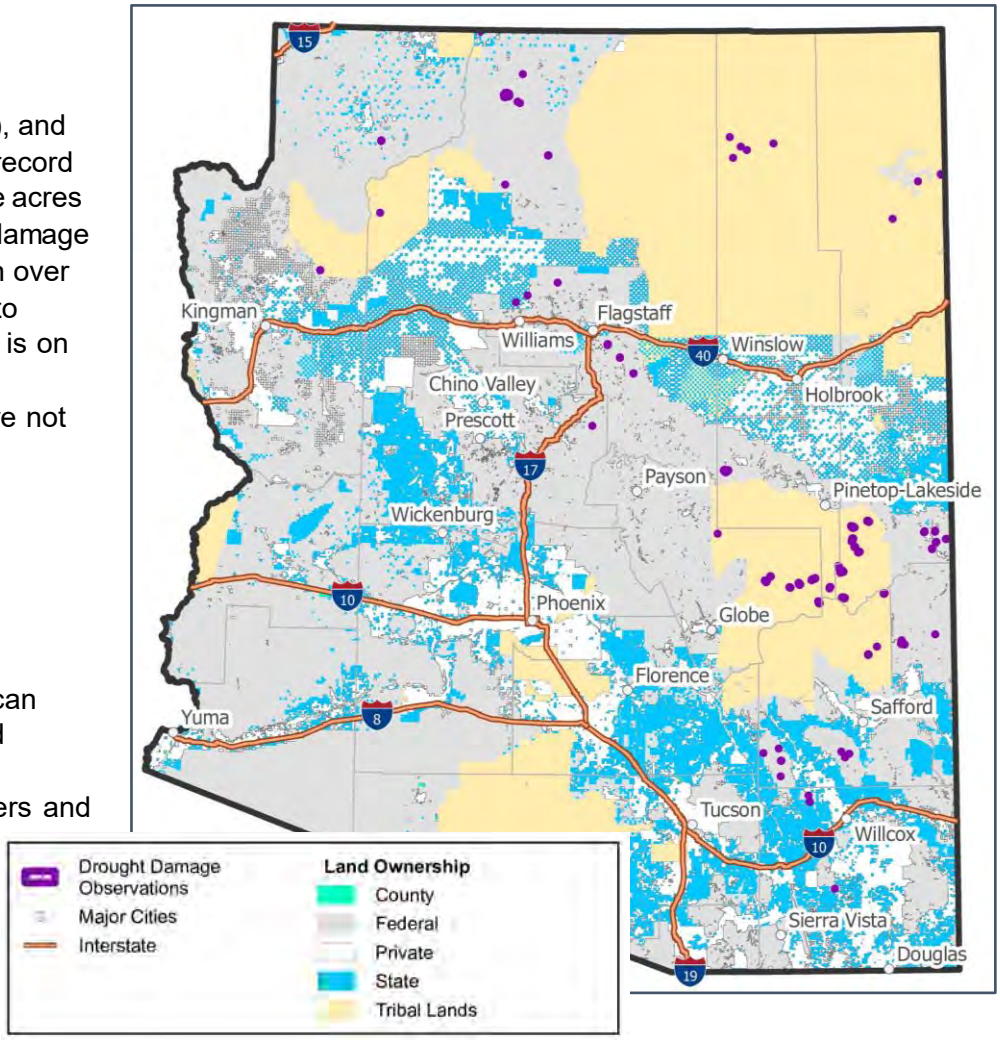

Figure 6 – All ADS Drought Damage Observations within Arizona - 2023

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 of 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 and move downward. 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.

Drought damage significantly decreased from 2022 to 2023, dropping from 195,000 acres to 5,323 acres, or a 189% decrease. Forestry professionals began noticing large areas of juniper-pinyon dieback in northern Arizona, near Flagstaff and Williams in late spring of 2022. Ground surveys confirmed the pinyon-juniper woodland dieback was due to drought. In 2023, less than 800 acres with drought were recorded in pinyon-juniper woodland, well over a 196% decrease from 2022.

Wind, hail, and flooding tend to be more random, causing damage to trees throughout the year. This damage can often be tied to specific known weather events, such as a tornado or a flash flood. These damage causal agents rarely are seen at a widespread level.

Road salt and de-icer damage is seen along roadways throughout the state. 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, and 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 are insignificant, and appear as tip burn. Mortality can often occur when magnesium chloride or calcium chloride is applied right before heavy rainstorms.

Although not recorded through ADS, the most common abiotic injury we see is human-related mechanical injury. This type of injury impacts individual trees, often in recreational areas like campgrounds and along trains, or found in yards, or along roadways. In many cases the trees are injured from heavy machinery, or the roots are damaged from compaction or construction. These types of injuries can impact the trees ability to uptake and transport water and nutrients, and create an entry point for insects and diseases.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Injury to Urban Ponderosa Pine in Show Low, 2023

Disease Identification during Aerial Detection Surveys

Many of the signs and symptoms associated with tree diseases can be difficult to identify from the air. For this reason, USDA Forest Service and Arizona DFFM forestry professionals perform ground surveys to 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.

Northern District (A1S)

Status of Insect Pests

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 lands (Appendix II).

Figure 7 is a map showing all insect and disease observations within the Northern District in 2023. The majority of insect observations occurred on federal lands. In total, more than 7,376 acres were observed with bark beetle mortality, over 1,629 acres with observed defoliator damage, and little or no sap-feeder and wood borer activity was seen (Table 4).

The bark beetle mortality that was observed (Figure 8) was caused by multiple bark beetle species (Table 5), attacking multiple species of pine, fir, and spruce.

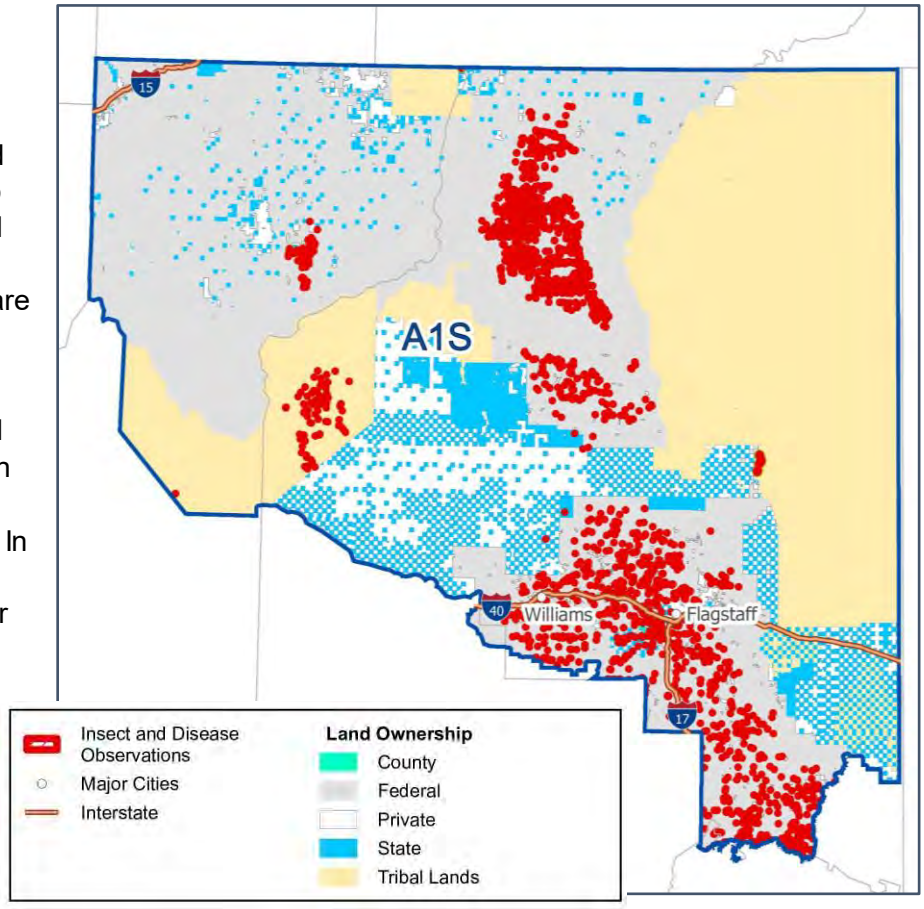

Figure 7 – All ADS Insect and Disease Observations within the Northern District (A1S) - 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Pinyon Pine and Juniper in Grand Canyon National Park, 2023

A1S 2023 - Estimated Area in Acres of Observed Insect Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Bark Beetles	0.25	7,318.06	24.75	5.99	27.49	**7,376.54**
Defoliators		1,301.97	63.78	2.03	261.52	**1,629.30**
Sap Feeders		2.18				**2.18**
Grand Total	**0.25**	**8,622.21**	**88.54**	**8.02**	**289.01**	**9,008.02**

Table 4. Estimated Area in Acres with Observed Insect Damage by Land Ownership for the Northern District (A1S) - 2023

Douglas-fir beetle (*Dendroctonus pseudotsugae*) and fir engraver (*Scolytus ventralis*) beetle each caused over 2,000 acres with observed mortality (Table 5). Compared to the previous year, Douglas-fir beetle mortality remained fairly consistent, while fir engraver beetle mortality decreased by 172% (31,228 acres in 2022).

The "Unknown Bark Beetle" category includes over 2,624 acres with observed mortality (Table 5). 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.* It is important to note this is a 191% decrease in ponderosa pine mortality from the "Unknown Bark Beetle" category from 2022; which documented 121,580 acres with bark beetle mortality to ponderosa pine.

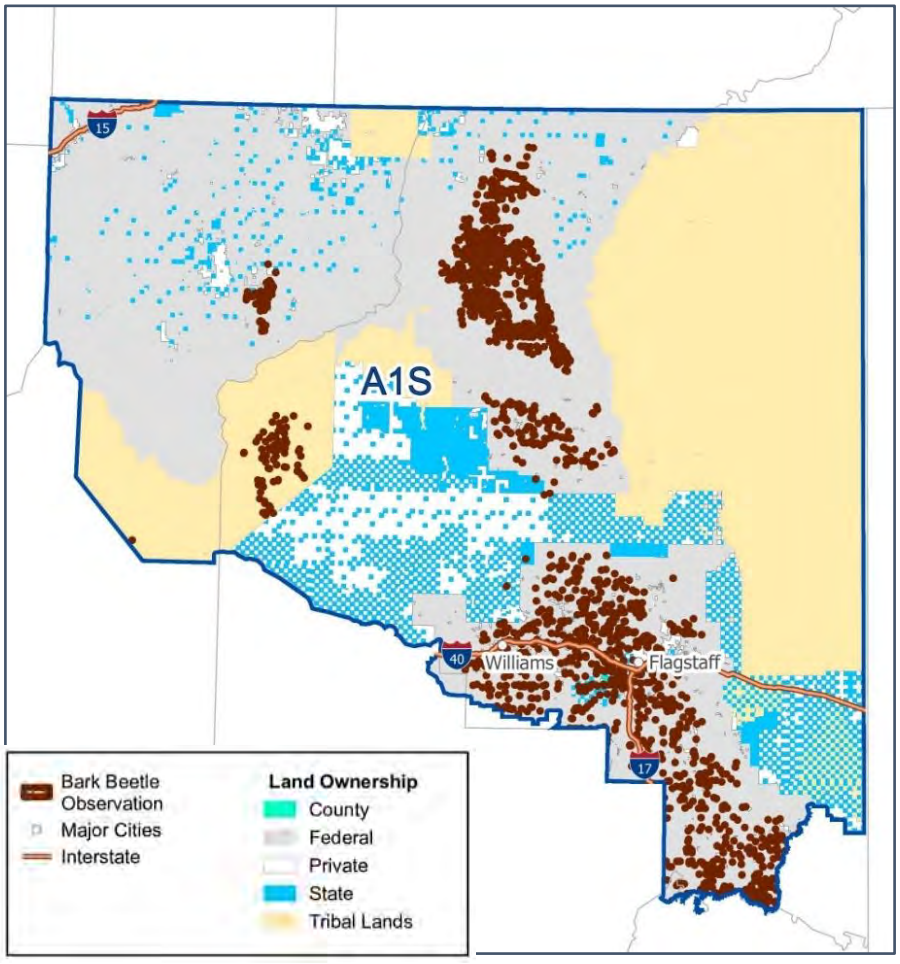

Figure 8 – All ADS Bark Beetle Observations within the Northern District (A1S) - 2023

Bark beetles seen in low numbers this year included pinyon ips, spruce beetle, and the western balsam bark beetle. Pinyon ips decreased by 199% (91,762 acres in 2022) and western balsam bark beetle by 178% (6,328 in 2022). Spruce beetle remained relatively the same between years.

A1S 2023- Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership						
Bark Beetle Damage Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Douglas-fir Beetle		2,028.67				**2,028.67**
Fir Engraver		2,343.72	0.96			**2,344.68**
Pinyon Ips		23.78	0.50	0.50	1.75	**26.53**
Spruce Beetle		0.50				**0.50**
Unknown Bark Beetle	0.25	2,569.77	23.29	5.49	25.74	**2,624.54**
Western Balsam Bark Beetle		351.62				**351.62**
Grand Total	**0.25**	**7,318.06**	**24.75**	**5.99**	**27.49**	**7,376.54**

Table 5. Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership for the Northern District (A1S) - 2023

Additional insect damage observed in the Northern District (A1S) primarily fell into the defoliator category. Defoliators were split evenly between two groups, the tamarisk leaf beetles and unknown defoliators.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Bark Beetle Mortality to Ponderosa Pine in Kaibab National Forest, 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Pinemoth Defoliator in Coconino National Forest, 2023

Over 1,200 acres were recorded with unknown defoliators, all to aspen. This is a catch-all name for defoliation seen from the air that cannot be identified as a specific insect or disease-causing agent. Only some of these locations are able to be reached on the ground by forestry professionals, thus there are still locations that are not checked and are left as "Unknown Defoliation."

Status of Tamarisk

This year a couple riparian areas were surveyed which had defoliation of salt cedar from tamarisk leaf beetle. In the Northern District, just over 358 acres were observed with defoliation damage from the tamarisk leaf beetle (Table 6).

The majority of this damage was observed on tribal lands (Figure 9) at just over 260 acres recorded with damage.

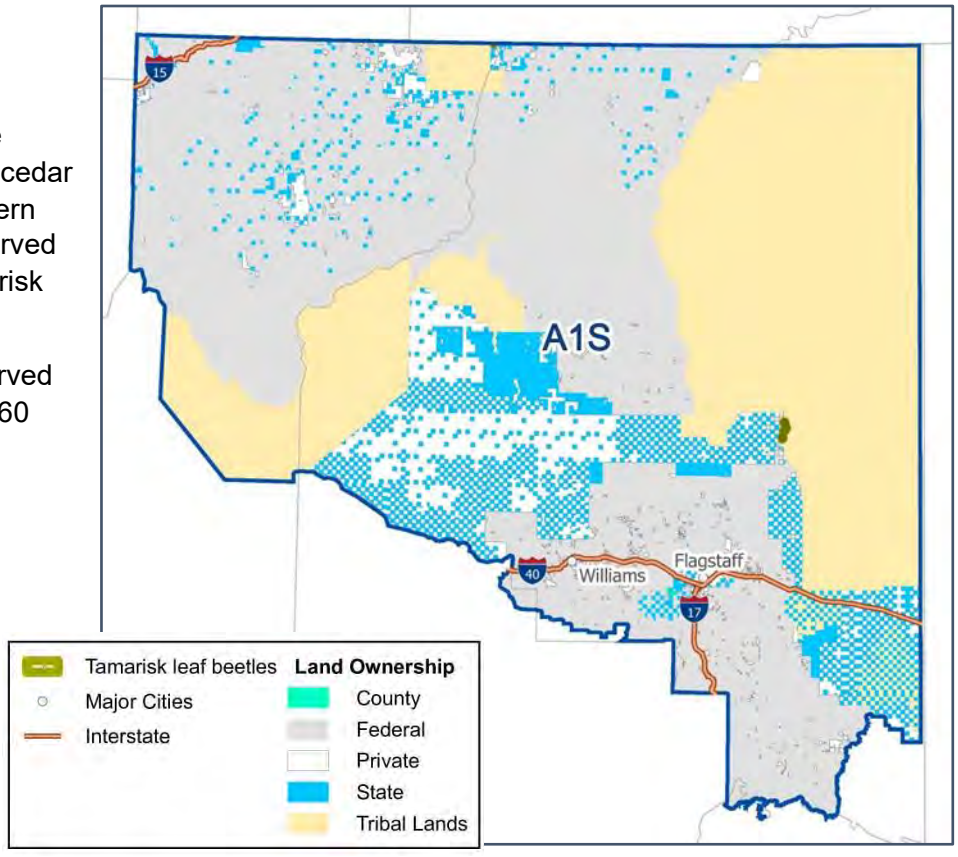

Figure 9 – All ADS Tamarisk Leaf Beetle Observations within the Northern District (A1S) – 2023

A1S 2023- Estimated Area in Acres with Tamarisk Leaf Beetle Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Tamarisk Leaf Beetles		33.21	63.78		261.52	**358.51**

Table 6. Estimated Area in Acres with Tamarisk Leaf Beetle Damage by Land Ownership for the Northern District (A1S) - 2023

Status of Unknown and Non-Infectious Disorders

This year over 2,000 acres with observed drought damage were identified (Table 7). Most of these observed acres with damage were on federal lands and within ponderosa pine or mixed conifer forests (Figure 10).

A1S 2023- Estimated Area in Acres with Abiotic and Unknown Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Drought		2,077.38	0.50	0.25	0.25	**2,078.38**
Road Salt or Deicers		140.06	86.41	4.96		**231.42**
Unknown		4,233.34	14.30	32.61	24.76	**4,305.01**
Wind-Tornado/Hurricane		128.95		0.25		**129.20**
Frost		2.70				**2.70**
Unknown Abiotic Damage		0.50				**0.50**
Flooding-High Water		23.21				**23.21**
Hail		1,974.22				**1,974.22**
Grand Total		**8,580.36**	**101.21**	**38.07**	**25.01**	**8,744.65**

Table 7. Estimated Area in Acres with Observed Abiotic and Unknown Damage by Land Ownership for the Northern District (A1S) - 2023

Over 1,974 acres were observed with hail damage in the Kaibab National Forest north of the Grand Canyon (Table 7). This hail damage caused mortality, limb dieback, and injury to trees of all species, including ponderosa pine and aspen.

Of the 4,305 acres with unknown damage (Table 8), over 3,614 acres were recorded with unknown mortality. This mortality was all to aspen, and the causal agent is unknown.

Photo credit: Mitchell Lannan- DFFM Forest Health Specialist, Fire Damage along Road in Kaibab National Forest- North Rim, 2023

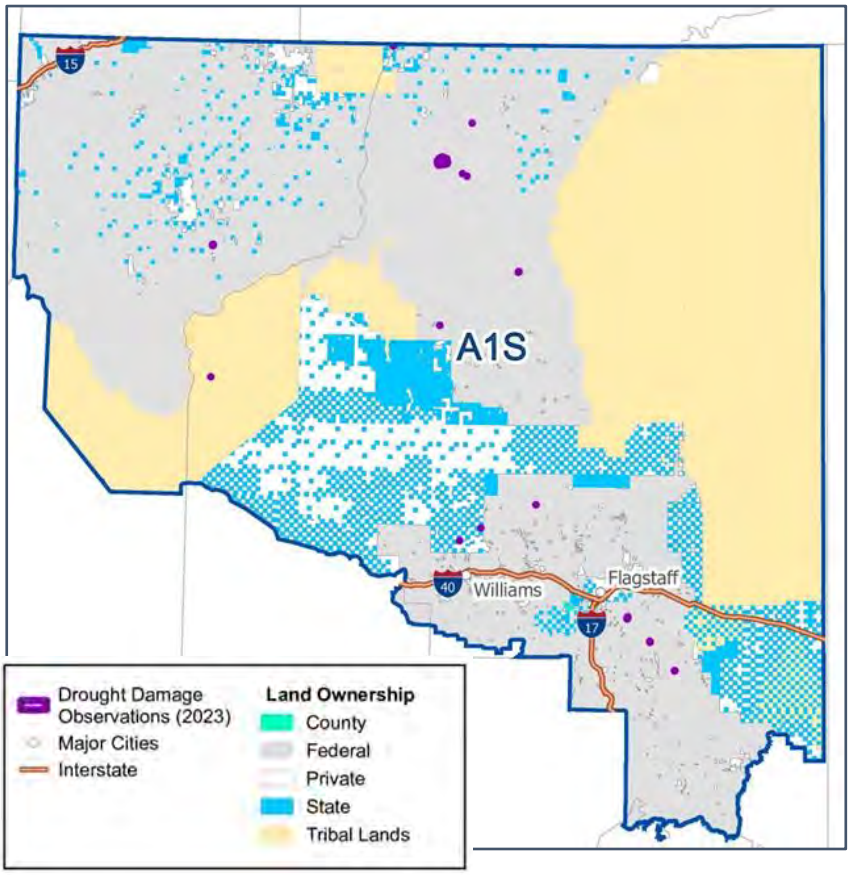

Figure 10 – All ADS Drought Observations within the Northern District (A1S) – 2023

A1S 2023 - Estimated Acres with Unknown Damage by Land Ownership						
Damage Type	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Branch flagging		38.77			0.25	**39.02**
Crown Dieback		594.73			24.51	**619.24**
Defoliation				32.61		**32.61**
Mortality		3,599.84	14.30			**3,614.13**
Grand Total		**4,233.34**	**14.30**	**32.61**	**24.76**	**4,305.01**

Table 8. Estimated Area in Acres with Unknown Damage by Land Ownership for the Northern District (A1S) - 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Hail Damage to Ponderosa Pine in Kaibab National Forest- North Rim, 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Hail Damage to Aspen in Kaibab National Forest- North Rim, 2023

Northeastern District (A2S)

Status of Insect Pests

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 surrounded by scattered county and state lands (Appendix II).

Figure 11 is a map showing all insect and disease observations within the Northeast District (A2S). The majority of insect observations occurred on federal and tribal lands. In total, more than 7,024 acres with bark beetle mortality were observed, over 3,434 acres with defoliator damage, over 18,255 acres with sap-feeding insect damage, and 1,193 acres with wood borer damage were observed (Table 9).

There were more than 7 different types of bark beetles observed causing mortality within the Northeast District (Table 10).

Of the 7 different types of bark beetles observed causing mortality within the Northeast District, the blue spruce engraver caused the least amount of damage with only 7.5 acres with observed mortality (Table 10).

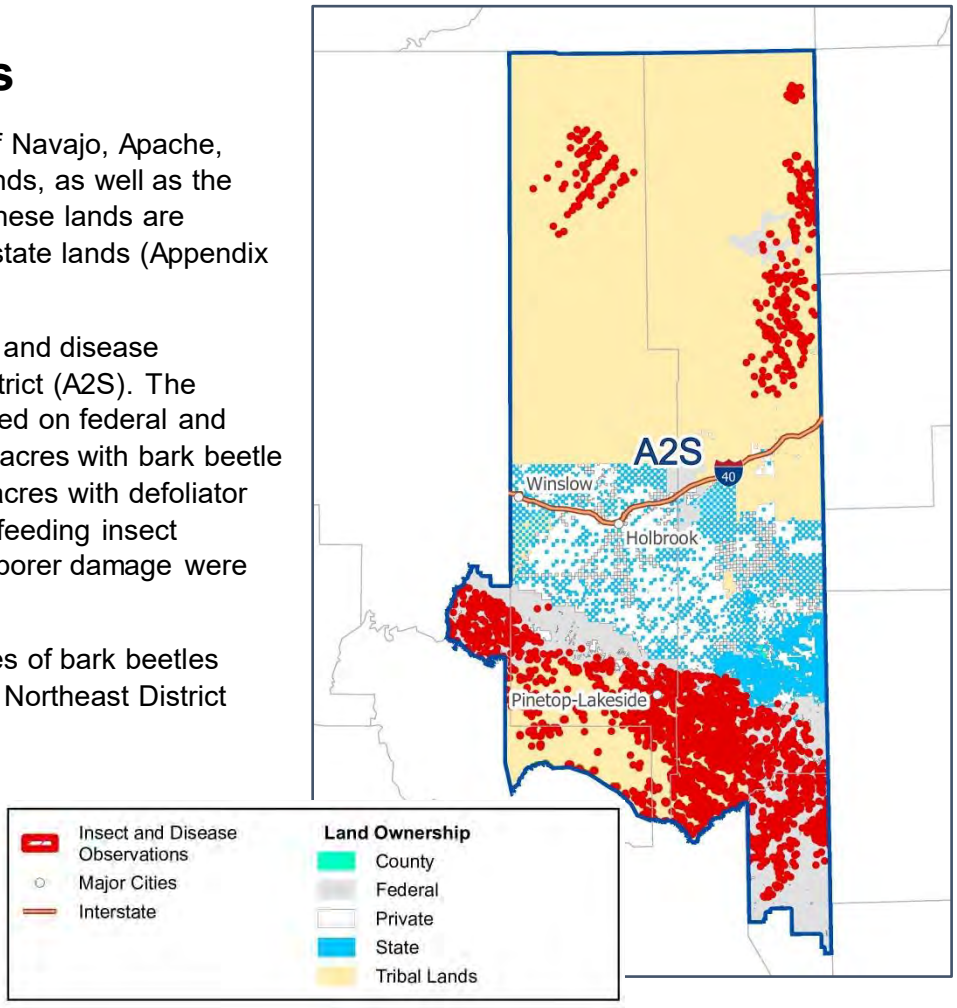

Figure 11 – All ADS Insect and Disease Observations within the Northeast District (A2S) - 2023

Douglas-fir beetle (*Dendroctonus pseudotsugae*), spruce beetle (*Dendroctonus rufipennis*), fir engraver (*Scolytus ventralis*), and western balsam bark beetles (*Dryocoetes confusus*) accounted for over 2,116 acres with bark beetle caused tree mortality (Table 10), a 133% decrease from 2022 (with 10,700 acres).

A2S 2023 - Estimated Area in Acres with Observed Insect Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Bark Beetles		3,084.35	8.30	0.75	3,931.05	**7,024.46**
Defoliators		628.28	10.20		2,796.41	**3,434.89**
Sap Feeders		11,793.39	711.25		5,750.68	**18,255.32**
Wood Borers					1,193.89	**1,193.89**
Grand Total		**15,506.02**	**729.75**	**0.75**	**13,672.03**	**29,908.56**

Table 9. Estimated Area in Acres with Observed Insect Damage by Land Ownership for the Northeast District (A2S) - 2023

A2S 2023- Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership						
Bark Beetle Damage Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Blue Spruce Engraver		2.50			5.00	**7.50**
Douglas-fir Beetle		6.50			313.45	**319.95**
Fir Engraver		147.62			1,369.22	**1,516.84**
Pinyon Ips		21.97	0.25	0.50	350.87	**373.59**
Spruce Beetle		16.40			163.78	**180.18**
Unknown Bark Beetle		2,886.11	8.05	0.25	1,630.52	**4,524.93**
Western Balsam Bark Beetle		3.25			98.21	**101.46**
Grand Total		**3,084.35**	**8.30**	**0.75**	**3,931.05**	**7,024.46**

Table 10. Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership for the Northeast District (A2S) - 2023

Pinyon ips (*Ips confusus*) mortality was observed on more than 375 acres (Table 10). A 197% decrease from 2022 (with 71,000 acres).

Lastly, the "Unknown Bark Beetle" category included over 4,500 acres with observed mortality (Table 10). 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." It is worth mentioning this is a 149% decrease in ponderosa pine mortality from the Unknown Bark Beetle category in 2022; which saw over 31,000 acres with Unknown Bark Beetle caused mortality in the Northeast District (A2S).

The Northeast District had other insect damage caused by woodboring beetles, with over 1,190 acres with damage observed (Table 9). This damage was attributed to roundheaded borers (Cerambycidae spp.), otherwise known as longhorned beetles, which primarily attack weakened, dying, or dead trees.

Additional insect damage observed in the Northeast District (A2S) fell into sap-feeding or defoliating insect categories.

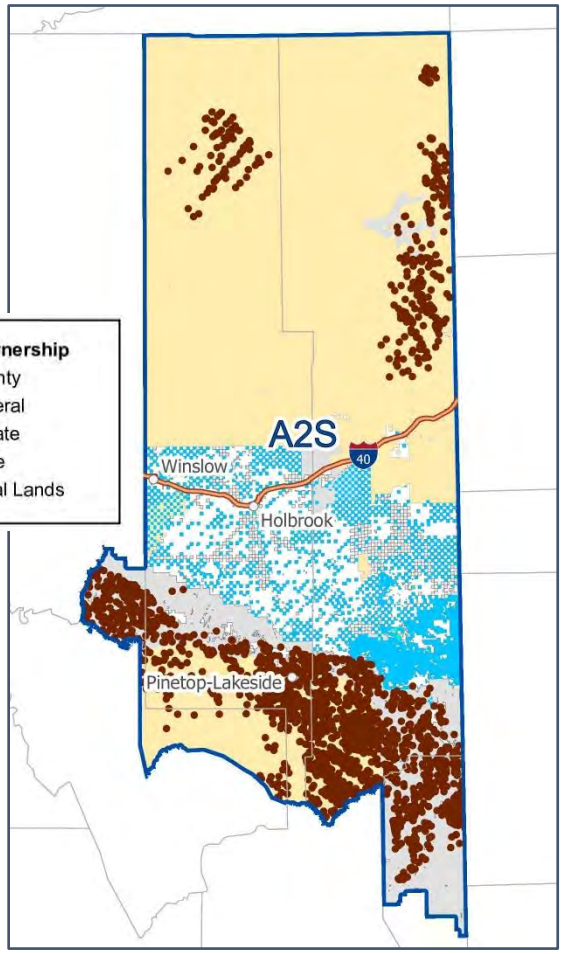

Figure 12 – All ADS Insect and Disease Observations within the Northeast District (A2S) - 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Bark Beetle Mortality to White Fir on Mt. Baldy in the Apache Sitgreaves National Forest, 2023

Pinyon needle scale (*Matsucoccus acalyptus*) is a sap-feeding insect that attacks pinyon pines and 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 14,286 acres with pinyon needle scale damage were observed in the Northeast District (Table 11); this is a 72% increase from last year's pinyon needle scale damage in the Northeast District (A2S)

when over 6,700 acres were observed with damage. It should be noted that this increase in pinyon needle scale is likely due to the lack of other damage causal agents seen by the aerial surveyor, with priority in past years focusing on more significant damage causal agents, such as bark beetles.

A2S 2023- Estimated Area in Acres with Sap Feeding and Defoliator Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Other Sap Feeder		123.93			3,785.36	**3,909.29**
Oystershell Scale					0.25	**0.25**
Pinyon Needle Scale		11,658.41	711.25		1,917.01	**14,286.67**
Spruce Aphid		11.05			48.07	**59.12**
Unknown Defoliator		617.17	10.20		2,682.91	**3,310.28**
Grand Total		**12,410.56**	**721.45**		**8,433.59**	**21,565.60**

Table 11. Estimated acres with Observed Sap-feeding and Defoliator Damage by Land Ownership for the Northeast District (A2S) - 2023

Spruce aphid (*Elatobium abietinum*) has been affecting high elevation spruce forests in the southwest for just a few decades; this insect is a sap-feeder, causing early 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, 59 acres with spruce aphid damage were observed on the Northeast District (Table 11).

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Spruce Aphid Damage on Mt. Baldy, 2023

The "Unknown Defoliator" group is a catch-all name for defoliation as seen from the air that cannot be identified as a specific insect or disease-causing agent. The majority of "Unknown Defoliator" damage occurs in aspen or other deciduous tree stands. Only some of these locations were able to be reached on the ground by forestry professionals, thus some locations are not ground checked and are left as "Unknown Defoliation." This year, over 3,310 acres with observed "Unknown Defoliator" damage were mapped within the Northeast District (Table 11).

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Branch Flagging of Ponderosa Pine in Apache Sitgreaves National Forest, 2023

This year 3,909 acres were recorded as "Other Sap-feeder" damage. This damage was likely from a variety of pest insects, including the Prescott scale (*Matsucoccus vexillorum*). This scale insect causes branch flagging or dieback, but rarely leads to tree mortality.

Status of Tamarisk

This year several locations were observed in riparian areas where defoliation of salt cedar from tamarisk leaf beetle had occurred (Figure 13). In the Northeast District (A2S), over 120 acres were observed with defoliation damage from the tamarisk leaf beetle (Table 12).

The observed damage was split between federal and tribal lands (Table 12). This damage was mostly found along the southern edge of the district (Figure 13).

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Tamarisk Leaf Beetle on Salt Cedar, 2023

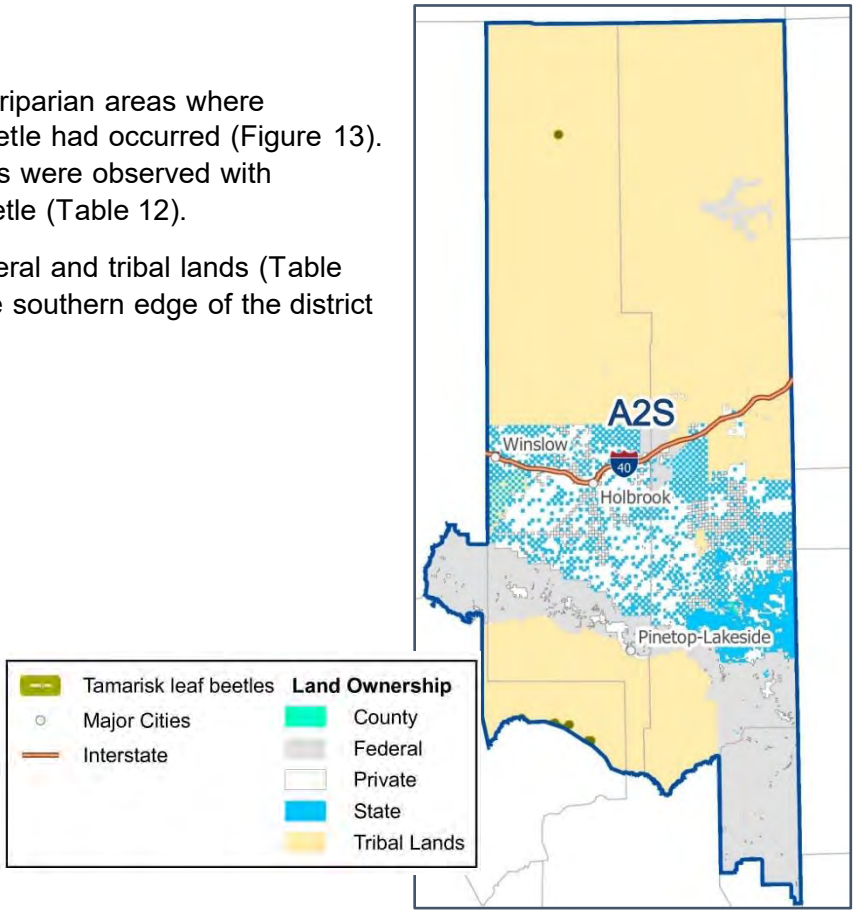

Figure 13 – All ADS Tamarisk Leaf Beetle Observations within the Northeast District (A2S) - 2023

A2S 2023- Estimated Area in Acres with Tamarisk Leaf Beetle Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Tamarisk Leaf Beetles		11.11			113.50	**124.61**

Table 12. Estimated Area in Acres with Tamarisk Leaf Beetle Damage by Land Ownership for the Northeastern District (A2S) - 2023

Status of Tree Diseases

This year, within the Northeast District (A2S), 196 acres with disease damage was identified on federal and private lands (Table 13). These diseases are difficult to identify from the air, therefore total acres are relatively low.

Sycamore anthracnose was the only disease identified in this district this year. Sycamore anthracnose is a foliar disease that infests Arizona sycamore. The symptoms include twig and stem cankers, shoot blight following cold snaps in the spring, and leaf blight from direct infection of leaves. This disease is ubiquitous with Arizona sycamore.

A2S 2023- Estimated Area in Acres with Disease Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Sycamore Anthracnose		88.874	107.21			**196.08**

Table 13. Estimated Area in Acres with Observed Disease Damage by Land Ownership for the Northeast District (A2S) - 2023

Status of Unknown and Non-Infectious Disorders

This year over 2,420 acres with observed drought damage were identified in the Northeast District (Table 14). All of these acres with observed damage were on federal and tribal lands within pinyon-juniper woodlands and ponderosa pine forests (Figure 14).

There was just over 18 acres with observed salt or de-icer damage, all of which is found along roadways mostly on federal lands (Table 14).

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Woodpecker Damage to Ponderosa Pine in Apache-Sitgreaves National Forest, 2023

Of the 905 acres with unknown damage, over 165 acres were observed with unknown defoliation damage (Table 15); this damage was either categorized as heavy defoliation (> 2/3 of foliage) or light defoliation (< 1/3 of foliage). There were 383 acres with observed unknown dieback, 165 acres with unknown branch flagging, and 191 acres with unknown mortality (Table 15). These acres were not able to be surveyed on the ground, thus they remain as an unknown damage type.

Figure 14 – All ADS Drought Observations within the Northeast District (A2S) - 2023

A2S 2023- Estimated Area in Acres with Abiotic and Unknown Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Drought		772.29			1,648.08	**2,420.37**
Road Salt or Deicers		18.38	0.25		0.25	**18.88**
Unknown		332.62	120.55		452.59	**905.77**
Wind-Tornado		161.09	0.25			**161.34**
Winter Injury			1.00			**1.00**
Grand Total		**1,284.39**	**122.05**		**2,100.92**	**3,507.36**

Table 15. Estimated Area in Acres with Unknown Damage by Land Ownership for the Northeast District (A2S) - 2023

A2S 2023 - Estimated Acres with Unknown Damage by Land Ownership						
Damage Type	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Branch flagging		0.75			164.93	**165.68**
Crown Dieback		139.73	119.58		123.94	**383.25**
Defoliation		165.29				**165.29**
Mortality		26.86	0.97		163.72	**191.55**
Grand Total		**332.62**	**120.55**		**452.59**	**905.77**

Table 14. Estimated Area in Acres with Abiotic and Unknown Damage by Land Ownership for the Northeast District (A2S) - 2023

Southeastern District (A3S)

Status of Insect Pests

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 surrounded by scattered county and state lands, with some military reservation lands as well (Appendix II).

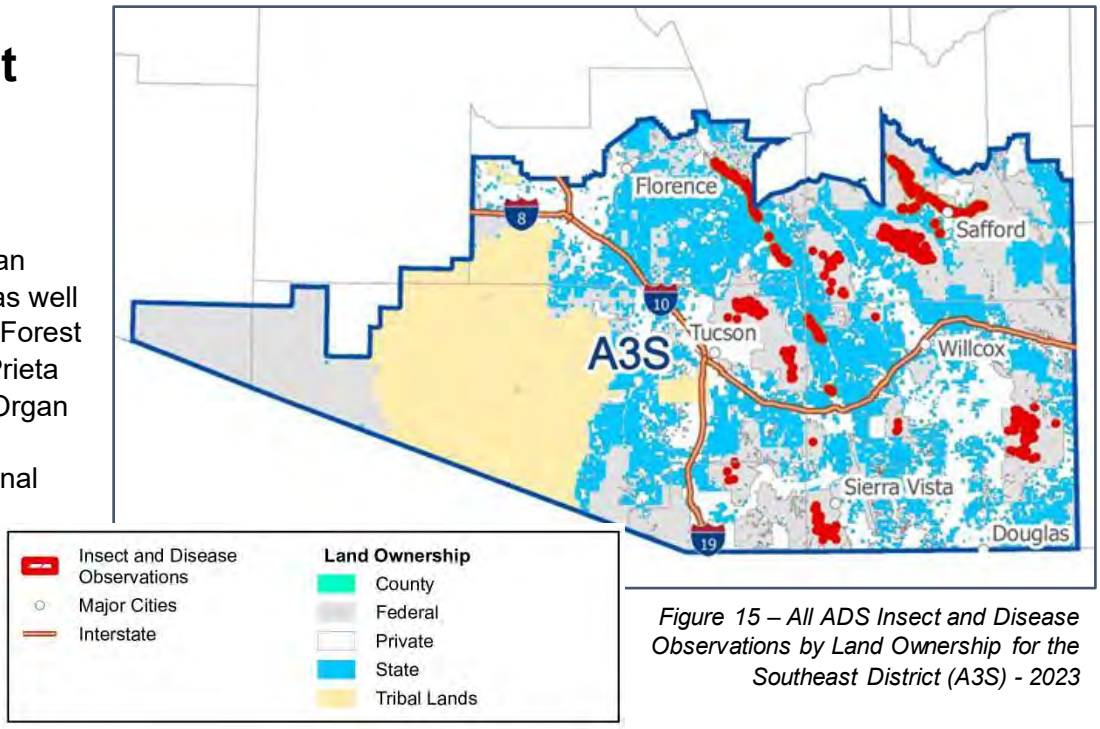

Figure 15 – All ADS Insect and Disease Observations by Land Ownership for the Southeast District (A3S) - 2023

A3S 2023 - Estimated Area in Acres with Observed Insect Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Bark Beetles		859.83	1.10			**860.93**
Defoliators		643.20	9,357.16	472.40	92.59	**10,565.35**
Grand Total		**1,503.02**	**9,358.27**	**472.40**	**92.59**	**11,426.29**

Table 16. Estimated Area in Acres with Observed Insect Damage by Land Ownership for the Southeast District (A3S) - 2023

Figure 15 is a map showing all insect and disease observations within the Southeast District (A3S). The majority of insect observations occurred on federal and private lands, due to the special Tamarisk leaf beetle surveys (Table 16).

The bark beetle mortality observed throughout the Southeast District was caused by more than 5 different types of bark beetles, resulting in more than 860 acres with observed mortality (Table 16). This is a 124% decrease from 2022 which recorded 3,668 acres with mortality.

Of the 5 different types of bark beetles observed causing mortality, the group of "Unknown Bark Beetles" caused the most damage with just over 469 acres with observed mortality (Table 17). As previously mentioned, the category of "Unknown Bark Beetles" includes all the bark beetles that attack ponderosa

Photo credit: Aly McAlexander – AZ DFFM Forest Health Program Manager, Pine Mortality from Bark Beetles in Coronado National Forest, 2023

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.

Douglas-fir beetle (*Dendroctonus pseudotsugae*), fir engraver (*Scolytus ventralis*), and western balsam bark beetle (*Dryocoetes confusus*) damage accounted for over 385 acres with bark beetle caused tree mortality in the high elevation, mixed conifer forests of the Coconino National Forest.

A3S 2023- Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership						
Bark Beetle Damage Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Douglas-fir Beetle		90.80				**90.80**
Fir Engraver		273.27				**273.27**
Pinyon Ips		3.75	0.75			**4.50**
Unknown Bark Beetle		469.39	0.35			**469.74**
Western Balsam Bark Beetle		22.62				**22.62**
Grand Total		**859.83**	**1.10**			**860.93**

Table 17. Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership for the Southeast District (A3S) - 2023

Pinyon ips (*Ips confusus*) mortality was observed on just over 4 acres. This damage was observed in the lower elevation woodlands on federal lands (Table 17).

All other insect damage recorded in this district in 2023 was from Tamarisk leaf beetles.

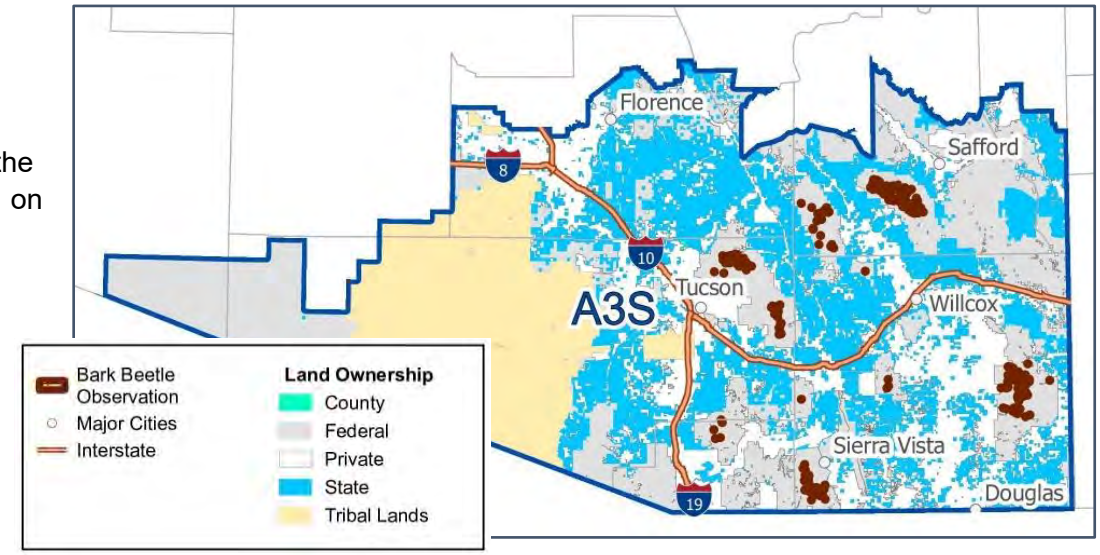

Figure 16 – All Bark Beetle Observations by Land Ownership for the Southeast District (A3S) - 2023

Photo credit: Aly McAlexander – AZ DFFM Forest Health Program Manager, Pine Mortality from Bark Beetles in Coronado National Forest, 2023

Status of Tamarisk

This year several locations along portions of the San Pedro and Gila Rivers near Safford were surveyed specifically to record the presence of Tamarisk leaf beetles. In these riparian areas, severe defoliation of salt cedar from tamarisk leaf beetle was recorded. Over 10,565 acres were observed having defoliation damage from the Tamarisk leaf beetle (Table 18).

The observed damage was on federal, private, state, and tribal lands (Table 18). This damage was observed in the northern end of the Southeast District (Figure 17).

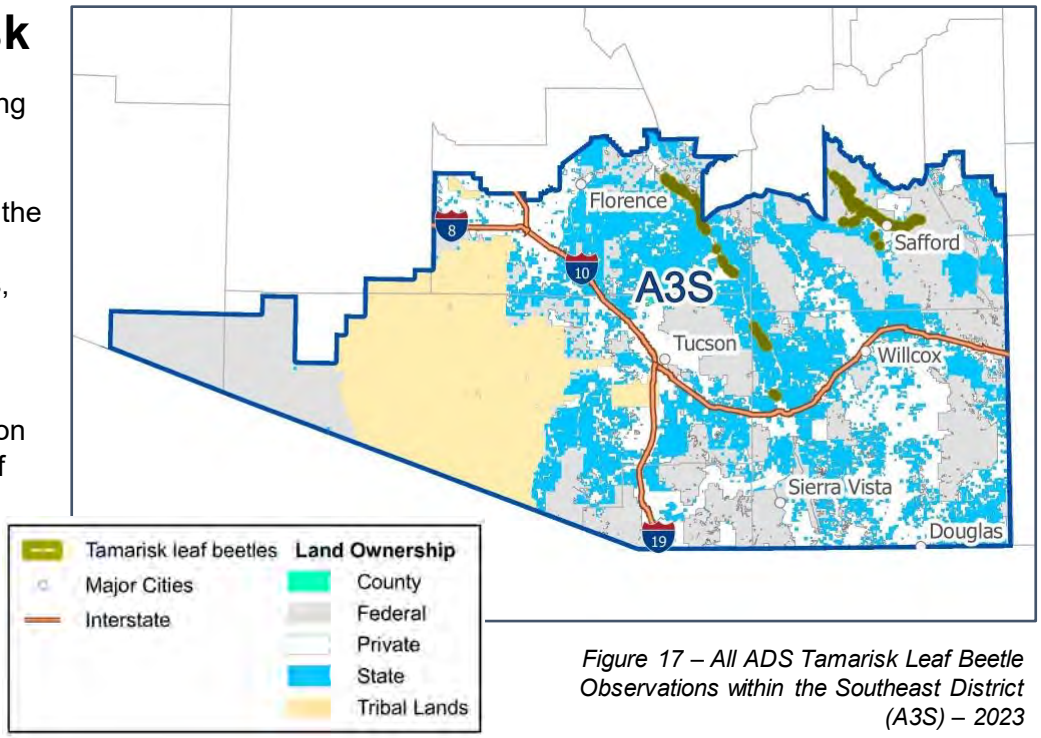

Figure 17 – All ADS Tamarisk Leaf Beetle Observations within the Southeast District (A3S) – 2023

A3S 2023- Estimated Area in Acres with Tamarisk Leaf Beetle Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Tamarisk Leaf Beetles		643.20	9,357.16	472.40	92.59	**10,565.35**

Table 18. Estimated Area in Acres with Observed Invasive Insect Damage by Land Ownership for the Southeast District (A3S) - 2023

Photo credit: Aly McAlexander – AZ DFFM Forest Health Program Manager, Salt Cedar Defoliated by Tamarisk Leaf Beetles, 2023

Status of Unknown and Non-Infectious Disorders

This year over 65 acres with observed drought damage were identified in the Southeast District (Table 19), which is a 195% decrease from 2022 (which recorded 6,000 acres). All of these acres were on federal lands, within oak woodlands and mixed conifer forests (Figure 18).

A3S 2023- Estimated Area in Acres with Abiotic and Unknown Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Drought		65.384				**65.384**
Unknown		0.021	117.32			**117.343**
Grand Total		**65.406**	**117.32**			**182.727**

Table 19. Estimated Area in Acres with Observed Abiotic and Unknown Damage by Land Ownership for the Southeast District (A3S) - 2023

Lastly, there were just over 117 acres with unknown damage (Table 20), identified as unknown crown dieback and discoloration, along with unknown defoliation during the surveys (Table 20). These areas were not able to be confirmed on the ground, thus their damage causal agent remains as unknown damage.

A3S 2023 - Estimated Acres with Unknown Damage by Land Ownership						
Damage Type	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Crown Dieback			41.43			**41.43**
Crown Discoloration			9.53			**9.53**
Defoliation		0.02	66.36			**66.38**
Grand Total		**0.02**	**117.32**			**117.34**

Table 20. Estimated Area in Acres with Unknown Damage by Land Ownership for the Southeast District (A3S) - 2023

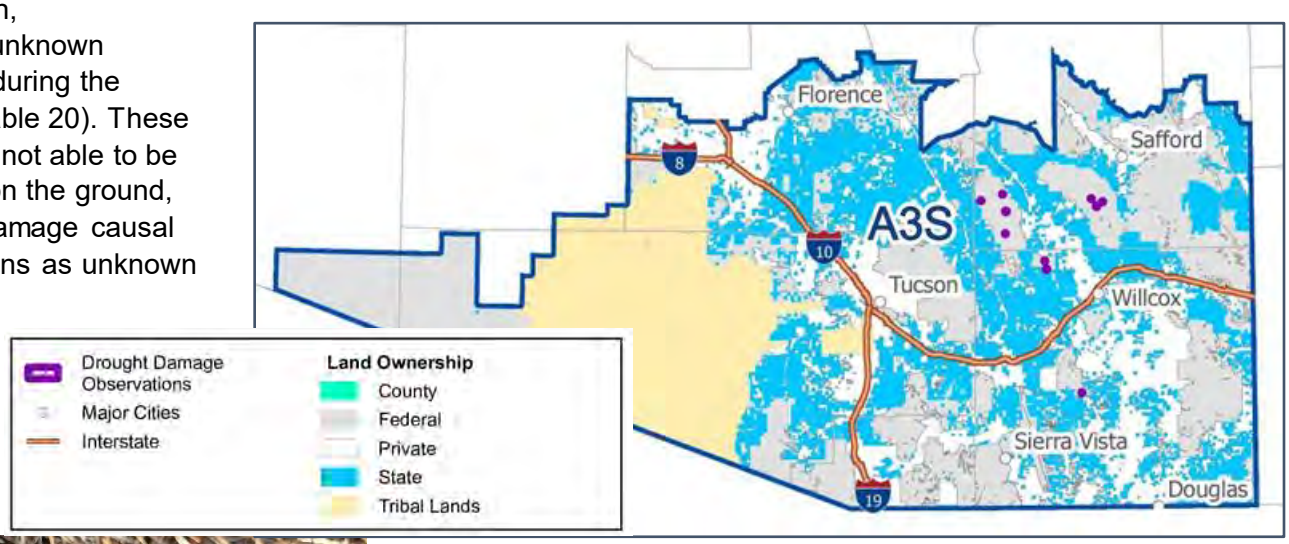

Figure 18 – All ADS Drought Observations within the Southeast District (A3S) – 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Unknown Woodborer Frass in Coronado National Forest, 2023

Central District (A4S)

Status of Insect Pests

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 surrounded by scattered county and state lands, with some military reservation lands as well (Appendix II).

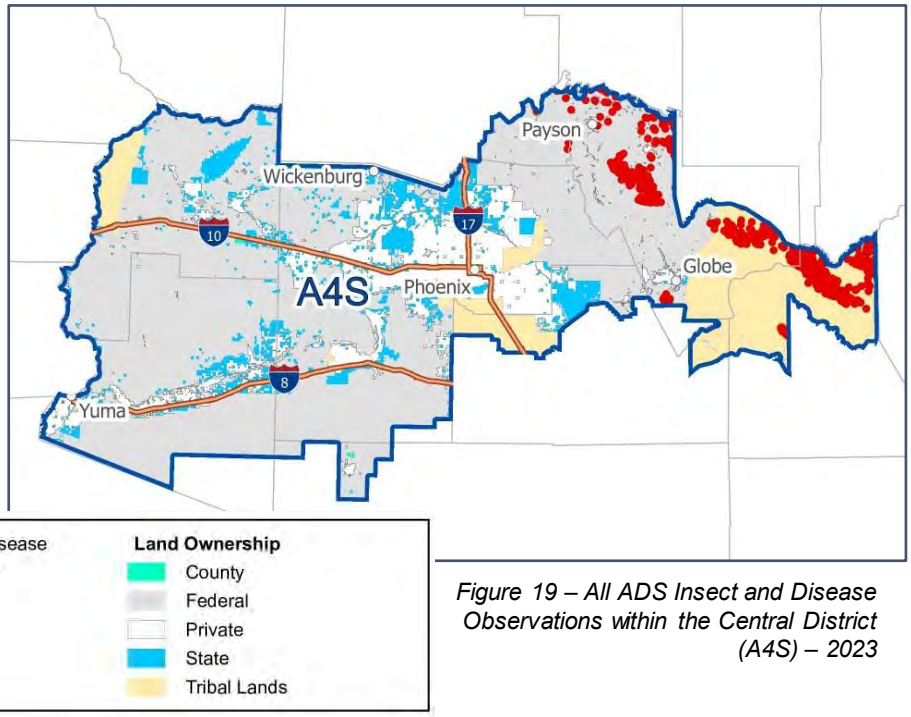

Figure 19 – All ADS Insect and Disease Observations within the Central District (A4S) – 2023

Figure 19 is a map showing all insect and disease observations within the Central District. The majority of insect observations occurred on tribal lands. Just over 1,500 acres with bark beetle mortality was observed, over 900 acres with observed defoliator damage, and more than 9,200 acres with sap-feeder damage was observed throughout Arizona's Central District (Table 21).

A4S 2023 - Estimated Area in Acres with Observed Insect Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Bark Beetles		472.92	1.75		1,055.09	**1,529.76**
Defoliators		33.67			934.14	**967.81**
Sap Feeders		609.77			8,606.09	**9,215.86**
Wood Borers					50.75	**50.75**
Grand Total		**1,116.37**	**1.75**		**10,646.07**	**11,764.19**

Table 21. Estimated acres with Observed Insect Damage by Land Ownership for the Central District (A4S) - 2023

A4S 2023- Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership						
Bark Beetle Damage Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Douglas-fir Beetle		2.00				**2.00**
Fir Engraver		250.37	0.25			**250.62**
Pinyon Ips		1.00			2.50	**3.50**
Unknown Bark Beetle		219.56	1.50		1,052.59	**1,273.64**
Grand Total		**472.92**	**1.75**		**1,055.09**	**1,529.76**

Table 22. Estimated acres with Observed Bark Beetle Damage by Land Ownership for the Central District (A4S) - 2023

The bark beetle mortality observed throughout the Central District was caused by more than 4 different types of bark beetles. There was a 172% decrease in the acres with observed bark beetle mortality compared to 2022, which had 20,000 acres. The majority of this bark beetle caused mortality occurred on federal and tribal lands in the northeastern part of the District (Figure 19).

Of the more than 4 different bark beetles observed causing mortality, the group of "Unknown Bark Beetles" caused the most mortality with over 1,200 acres with observed mortality (Table 22). 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".

Douglas-fir beetle (*Dendroctonus pseudotsugae*) and fir engraver (*Scolytus ventralis*), and pinyon ips (*Ips confusus*) accounted for just over 255 acres with bark beetle caused tree mortality (Table 22).

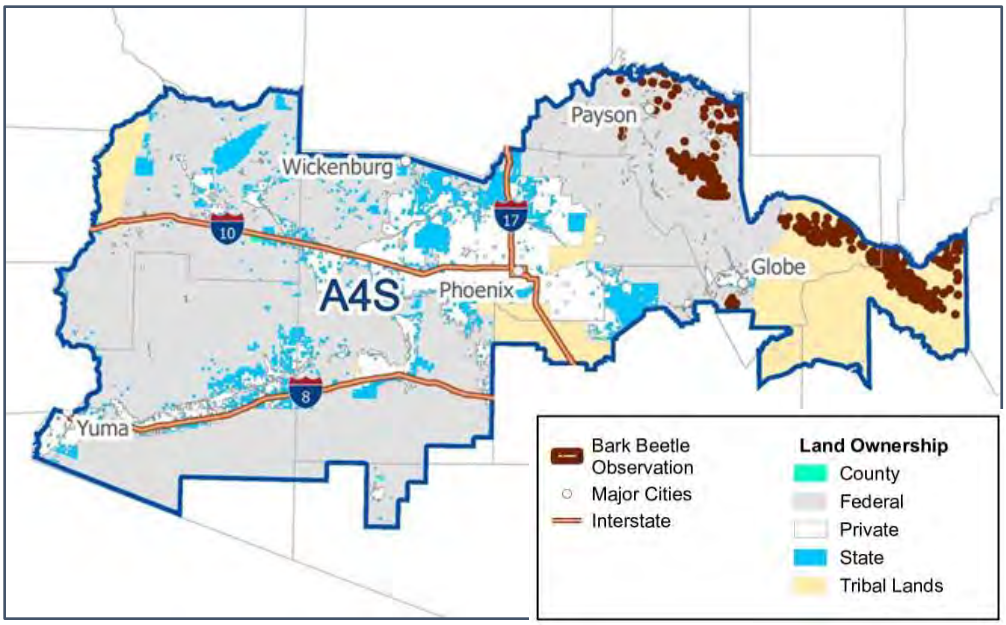

Figure 20 – All ADS Bark Beetle Observations within the Central District (A4S) – 2023

A4S 2023- Estimated Area in Acres with Sap Feeding and Defoliator Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Pinyon Needle Scale		609.768			8,606.09	**9,215.86**
Tamarisk Leaf Beetles		33.675			934.14	**967.81**
Grand Total		**643.443**			**9,540.23**	**10,183.67**

Table 23. Estimated Area in Acres with Observed Sap-feeding and Defoliator Damage by Land Ownership for the Central District (A4S) - 2023

Additional insect damage was observed in the Central District (A4S); this damage was identified as defoliator or sap-feeding insect damage, with all defoliator damage attributed to Tamarisk leaf beetle, and all sap-feeding insect damage attributed to pinyon needle scale.

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 9,200 acres with pinyon needle scale damage was observed in the Central District (Table 23). It should be noted that this increase in pinyon needle scale is likely due to the lack of other damage causal agents seen by the aerial surveyor, with priority in past years focusing on more significant damage causal agents, such as bark beetles.

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Honey Bee Feeding on Sap of Pine Recently Killed by Bark Beetles, 2023

Status of Tamarisk

Just over 960 acres were observed with tamarisk leaf beetle damage in the Central District (Table 24). More than 900 acres with salt cedar defoliation were observed within San Carlos tribal lands, in the north western edge of the reservation (Figure 21). The remaining 33 acres in the Central District (A3S) with salt cedar defoliation were on federal lands, west of Payson, AZ (Figure 21).

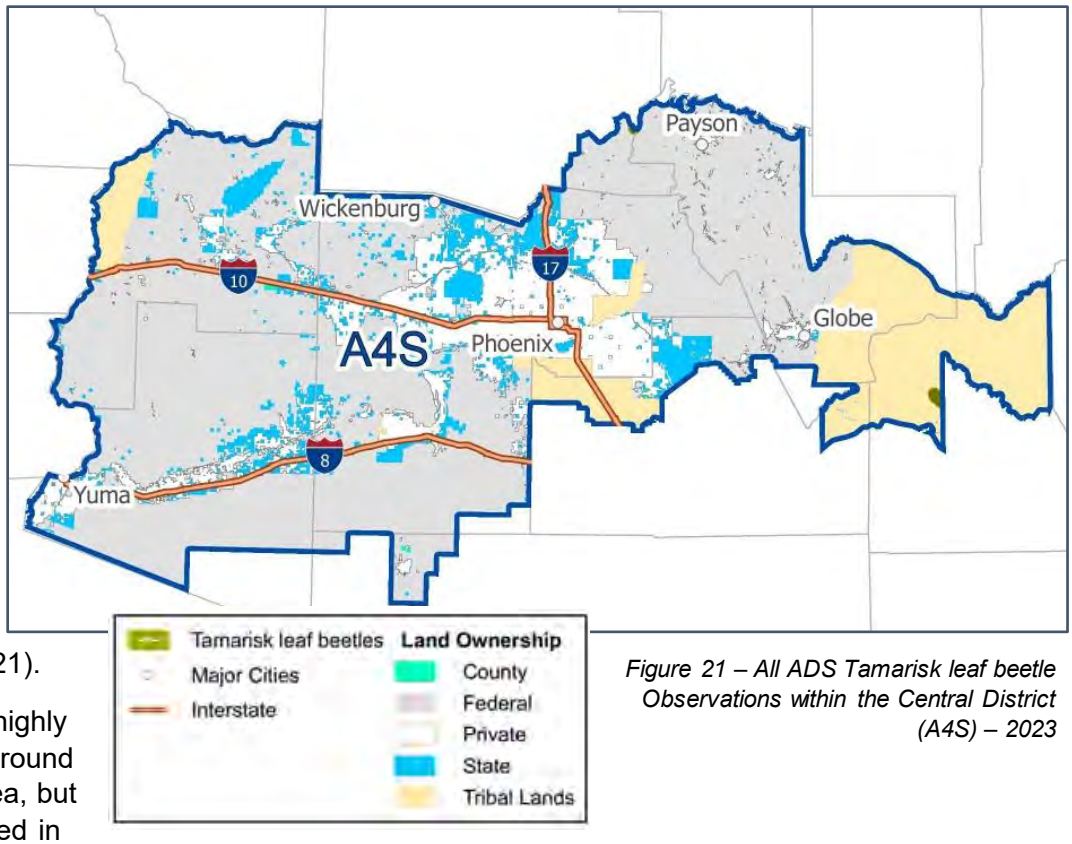

Figure 21 – All ADS Tamarisk leaf beetle Observations within the Central District (A4S) – 2023

Tamarisk leaf beetle is also highly prevalent in the waterways around the Phoenix Metropolitan area, but these areas were not surveyed in 2023.

A4S 2023- Estimated Area in Acres with Tamarisk Leaf Beetle Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Tamarisk Leaf Beetles		33.67			934.14	**967.81**

Table 24. Estimated Area in Acres with Observed Invasive Insect Damage by Land Ownership for the Central District (A4S) - 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Salt Cedar after Heavy Defoliation along the Salt River, 2023

Status of Unknown and Non-Infectious Disorders

This year more than 750 acres were observed with drought damage in the Central District (Table 35). This is a 182% decrease from 2022 which documented 16,000 acres with damage. This damage was observed along the eastern edge of the District (Figure 22), all being on tribal lands (Table 25).

Lastly, there were just over 99 acres with observed unknown damage. Of these 99 acres with unknown damage, all were recorded as unknown branch flagging to ponderosa pine. These areas were not able to be confirmed on the ground, thus their damage causal agent remains as unknown damage.

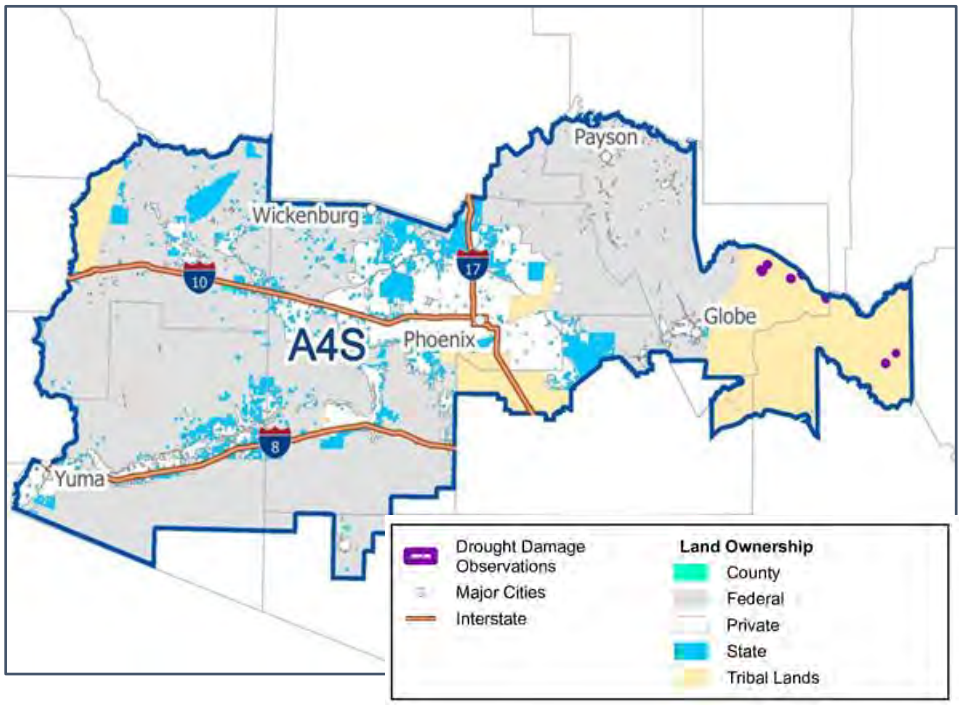

Figure 22 – All ADS Drought Observations within the Central District (A4S) – 2023

A4S 2023- Estimated Area in Acres with Abiotic and Unknown Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Drought					759.485	**759.485**
Unknown					99.212	**99.212**
Grand Total					**858.696**	**858.696**

Table 25. Estimated Area in Acres with Abiotic and Unknown Damage by Land Ownership for the Central District (A4S) - 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Tonto National Forest, 2023

Northwestern District (A5S)

Status of Insect Pests

The Northwest District (A5S) is composed of the Prescott National Forest, Lake Mead National Recreation Area, Fort Mohave Reservation, and the Havasu National Wildlife Refuge; these areas are surrounded by scattered county and state lands, with some military reservation lands as well (Appendix II).

Figure 23 is a map showing all insect and disease observations within the Northwest District. The majority of insect observations occurred on federal lands, with over 300 acres with observed bark beetle mortality, roughly 6 acres with observed defoliator damage, and over 300 acres with observed sap-feeding insect damage, occurring throughout Arizona's Northwest District (Table 26).

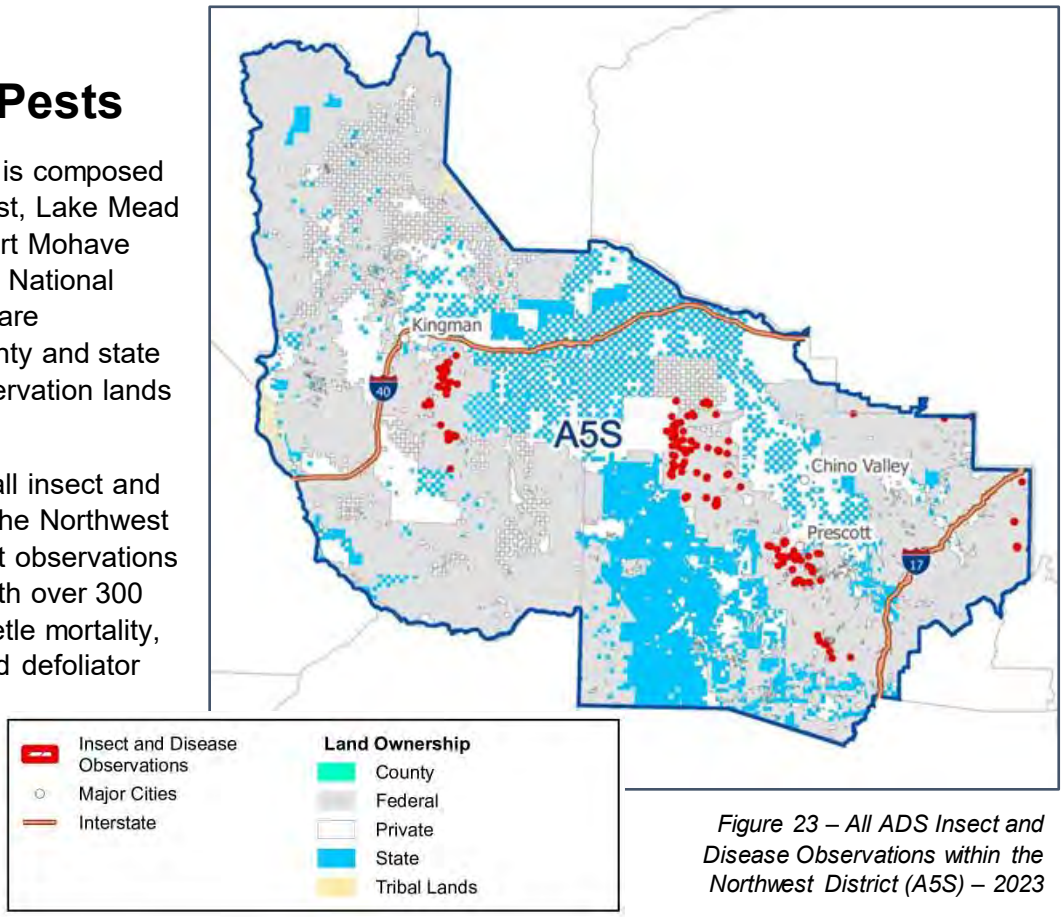

Figure 23 – All ADS Insect and Disease Observations within the Northwest District (A5S) – 2023

The bark beetle mortality observed throughout the Northwest District was caused by more than 3 different types of bark beetles. The majority of this bark beetle caused mortality occurred on federal lands (Figure 23). This mortality was a 187% decrease from 2022, when over 10,000 acres were observed with bark beetle caused mortality.

Of the more than 3 different types of bark beetles observed causing mortality the group of "Unknown Bark Beetles" caused the most damage with over 263 acres with observed mortality (Table 27). 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 2023 - Estimated Area in Acres with Observed Insect Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Bark Beetles		279.64	10.80	29.34		**319.79**
Defoliators		6.30				**6.30**
Sap Feeders		263.92	46.06			**309.98**
Grand Total		**549.85**	**56.87**	**29.34**		**636.06**

Table 26. Estimated Area in Acres with Observed Insect Damage by Land Ownership for the Northwest District (A5S) - 2023

Fir engraver (*Scolytus ventralis*) damage accounted for over 50 acres with bark beetle caused tree mortality in the higher elevation, mixed conifer forests of the Prescott National Forest (Table 27).

Pinyon ips (*Ips confusus*) mortality was also observed on nearly 3 acres; this damage was observed in the lower elevation woodlands of federal, private, and state lands (Table 27).

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Pinyon Ips Mortality on Pinyon Pine in Prescott National Forest, 2023

A5S 2023- Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership						
Bark Beetle Damage Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Fir Engraver		47.23	6.40			**53.62**
Pinyon Ips		2.00	0.50			**2.50**
Unknown Bark Beetle		230.41	3.91	29.34		**263.66**
Grand Total		**279.64**	**10.80**	**29.34**		**319.79**

Table 27. Estimated Area in Acres with Observed Bark Beetle Damage by Land Ownership for the Northwest District (A5S) - 2023

Additional insect damage was observed in the Northwest District (A5S); this damage was identified as sap-feeding and defoliator insect damage (Table 26), with all defoliator damage attributed to Tamarisk leaf beetle, and all sap-feeding insect damage attributed to pinyon needle scale.

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 309 acres with pinyon needle scale damage was observed in the Northwestern (Table 28).

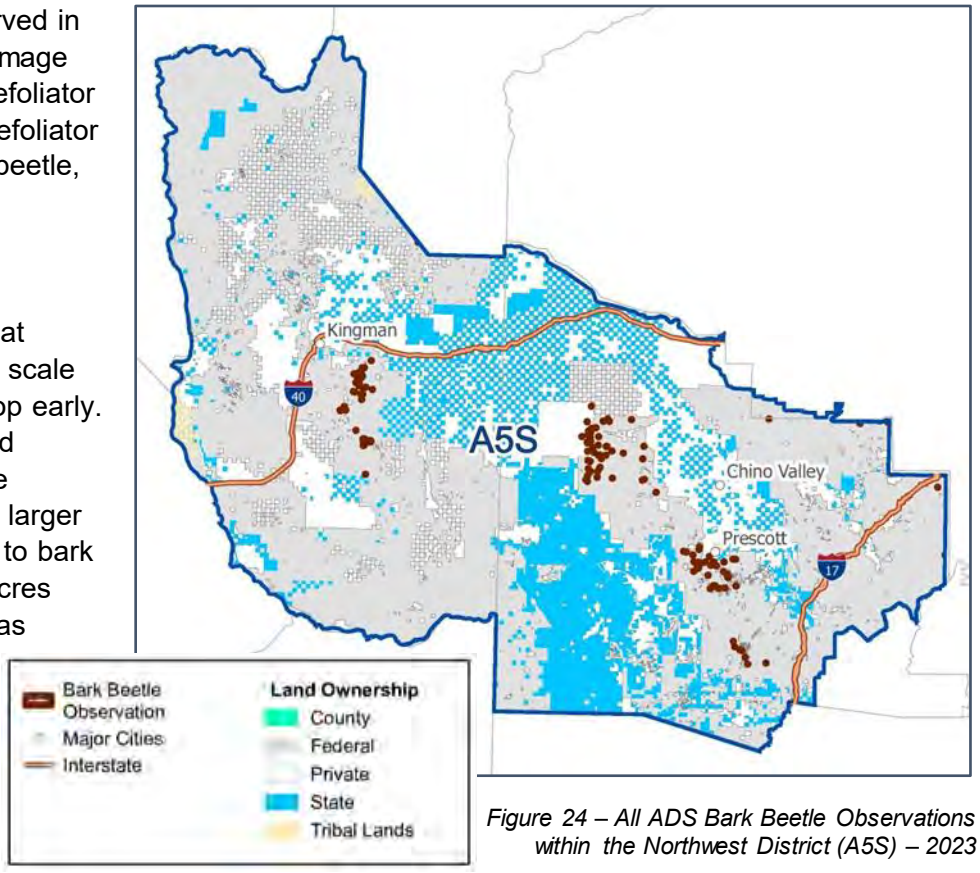

Figure 24 – All ADS Bark Beetle Observations within the Northwest District (A5S) – 2023

A5S 2023- Estimated Area in Acres with Sap Feeding and Defoliator Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Pinyon Needle Scale		263.916	46.06			**309.98**
Tamarisk Leaf Beetles		6.295				**6.30**
Grand Total		**270.212**	**46.06**			**316.27**

Table 28. Estimated Area in Acres with Observed Insect Damage by Land Ownership for the Northwest District (A5S) - 2023

Status of Tamarisk

This year a small area of salt cedar defoliation was observed on federal and private lands. This accounted for over 6 acres that were observed with tamarisk leaf beetle defoliation of salt cedar (Table 29).

A5S 2023- Estimated Area in Acres with Tamarisk Leaf Beetle Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Tamarisk Leaf Beetles		6.30				6.30

Table 29. Estimated Area in Acres with Observed Invasive Insect Damage by Land Ownership for the Northwest District (A5S) - 2023

Status of Unknown and Non-Infectious Disorders

This year less than one acres with observed drought damage was identified within the Northwest District (Table 30); all on federal lands (Figure 25). Over 100 acres were observed with unknown damage (Table 30). Of these 100 acres with unknown damage, just over 70 acres were observed with crown dieback of oak. The other 30 acres were reported as crown dieback of Fremont cottonwood. These areas were not able to be confirmed on the ground, thus their damage causal agent remains as unknown damage.

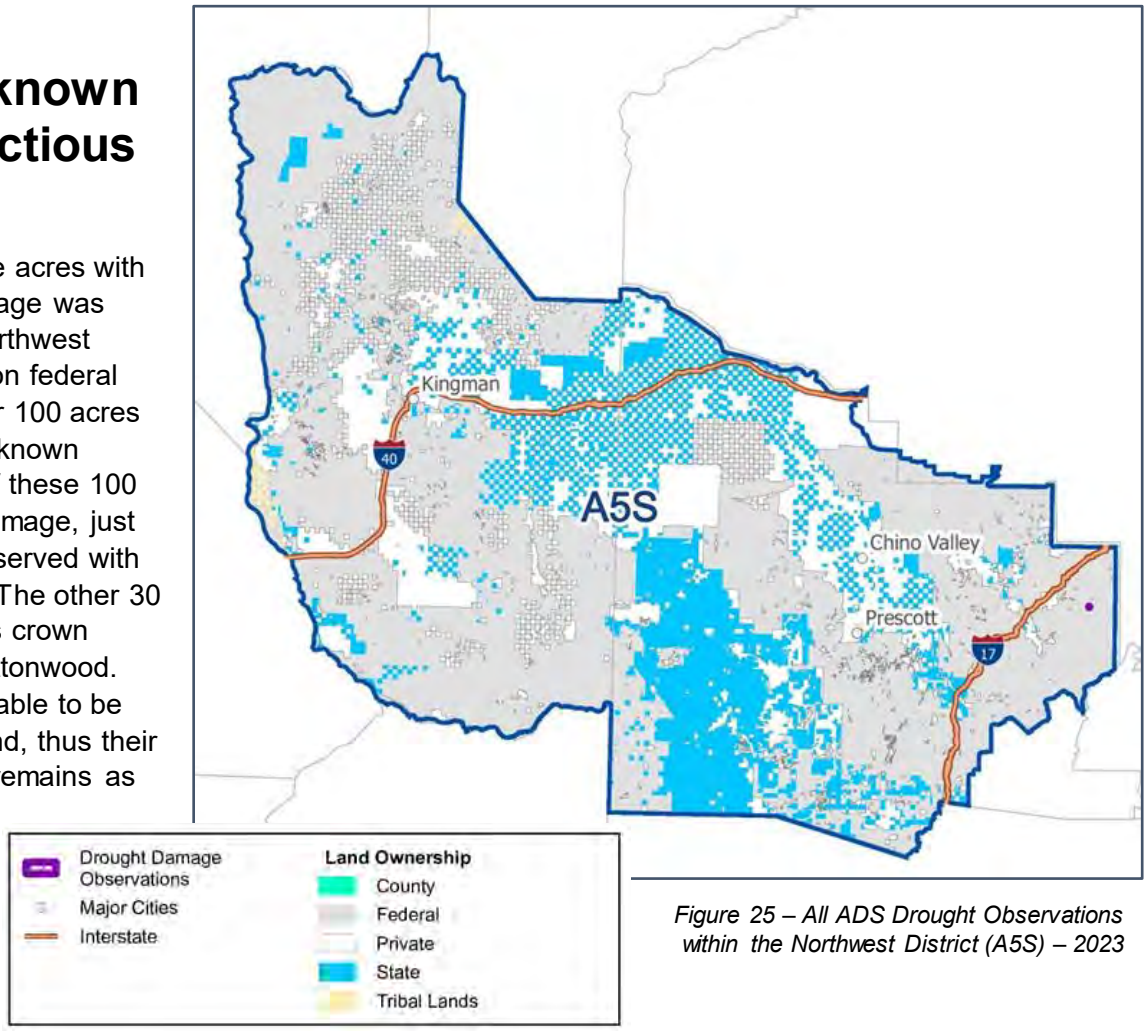

Figure 25 – All ADS Drought Observations within the Northwest District (A5S) – 2023

A5S 2023- Estimated Area in Acres with Abiotic and Unknown Damage by Land Ownership						
Disease Causal Agent	**County**	**Federal**	**Private**	**State**	**Tribal Lands**	**Grand Total**
Drought		0.250				0.250
Unknown		70.806	28.757	5.271		104.833
Grand Total		**71.056**	**28.757**	**5.271**		**105.083**

Table 30. Estimated Area in Acres with Observed Abiotic and Unknown Damage by Land Ownership for the Northwest District (A5S) - 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Stick Insect in Prescott National Forest, 2023

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, Juniper in Prescott National Forest, 2023

Mediterranean Pine Engraver

Photo credit: Chris Baptista – AZDA Entomology Program Manager, Adult Mediterranean Pine Engraver

The non-native, invasive, Mediterranean pine engraver (*Orthotomicus erosus*), or MPE, has been steadily spreading across Arizona. MPE was first found in Arizona in 2018, and in 2019 a monitoring program was created to determine its establishment. Trapping efforts have confirmed over 350,000 beetles from 2018 to 2023 in the Phoenix Metro area alone. In 2021, an expanded trapping program found MPE in Tucson. These findings confirmed the need for additional monitoring. With funding from the USDA Forest Service, an Early Detection Rapid Response (EDRR) monitoring program was initiated to determine the presence of MPE, along with other non-native bark, ambrosia, and woodboring beetles across Arizona. Through these trapping efforts, MPE was found in the Arizona cities of Phoenix, Tucson, Kingman, Topock, Pinetop-Lakeside, Superior, and Nogales in the spring of 2023. Please see our Forest Health Alert for more details on these findings (Appendix III)

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 forest, underscoring the importance of continued monitoring and research regarding management options. 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

In order to better understand this pest, the Arizona Department of Forestry and Fire Management is working on multiple projects that will give insight into the biology, behavior, and best management practices for this pest. Projects and their descriptions are as follows:

Invasive Insect Monitoring: This project will carry on with trapping efforts across the state in 2024 for the detection of non-native insect pests of trees. We will expand this monitoring program to several Arizona cities that have not yet been monitored, including Green Valley, Show Low, Summerhaven, Casa Grande, Buckeye, and Anthem. This will help determine the spread and severity of MPE, along with other invasive insects, in each city.

Push-pull Assessment: This project is occurring in parks around Phoenix with the intention of reducing MPE populations in these localized areas. This strategy will test the ability of verbenone, a known bark beetle deterrent (anti-aggregation), to "push" MPE out of an area. Nearby, traps with lures will be placed to "pull" the MPE into that area. This project will help assess if verbenone has an effect on MPE behavoir.

Host Tree Assessment: This project involves working with local tree care contractors and tree care professionals in urban areas around the state to collect bark beetles from recently cut conifer trees. This assessment will help us to determine which bark beetle species, including MPE, are attacking Arizona's ornamental conifers (Appendix IV).

Bolt Assessment: Similar to the Host Tree Assessment, this project will be looking to see which native tree species are susceptible to an MPE attack. We will bait logs (bolts) with MPE lures to see if the beetles are able to bore into and reproduce in these trees. Knowing which native species are susceptible to MPE will help us predict their spread throughout the state.

BBRCS Program: Our Bark Beetle Reduction Cost Share (BBRCS) Program helps landowners respond to bark beetle infestations by paying for 50% of the tree removal cost of actively infested trees. This program aims to help private landowners reduce the spread of localized bark beetle populations to their own trees, and the surrounding natural areas. When beetle populations get large enough, they will start attacking healthy trees. Removing actively infested bark beetle trees has proven to reduce bark beetle spread in otherwise healthy forests. This program is open statewide. (Appendix V).

Emerald Ash Borer

Emerald Ash Borer (EAB, *Agrilus planipennis*) is a non-native, invasive insect spreading through the US. This insect attacks and kills ash trees of all size and species, and has recently been found to attack and kill olive species as well. Many ash species are native to Arizona, along with many planted olive species, making this pest especially concerning. EAB is a woodboring beetle that feeds on the tissue underneath the bark of the tree, girdling the tree.

This insect has not been detected in AZ, but continues to spread westward, now in Oregon and Colorado. The Arizona Department of Forestry and Fire Management will begin monitoring for this pest in spring of 2024. DFFM has begun outreach efforts for EAB and other westward spreading invasive insects to help increase public awareness (Appendix VI)

Photo credit: Mitchell Lannan – AZ DFFM Forest Health Specialist, AZ DFFM
Performing Invasive Insect Outreach at a Middle School, 2023

Department of Forestry and Fire Management

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

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Appendix I: Native Trees of Arizona's Forests

The list below includes Arizona's native trees found in our forests, wildlands, and riparian areas. Many of these trees are mentioned throughout the Forest Health Conditions Report.

Common Name	Scientific Name
Alligator Juniper	*Juniperus deppeana*
Apache Pine	*Pinus engelmannii*
Arizona Alder	*Alnus oblongifolia*
Arizona Ash	*Fraxinus veluntina*
Arizona Black Walnut	*Juglans major*
Arizona Cypress	*Cupressus arizonica*
Arizona Pine	*Pinus ponderosa var. arizonica*
Arizona Sycamore	*Platanus wrightii*
Arizona White Oak	*Quercus arizonica*
Bigtooth Maple	*Acer grandidentatum*
Blue Spruce	*Picea pungens*
Border Pinyon	*Pinus discolor*
Boxelder	*Acer negundo*
California Juniper	*Juniperus californica*
Canyon Live Oak	*Quercus chrysolepis*
Chihuahua pine	*Pinus leiophylla var. chihuahuana*
Colorado Pinyon	*Pinus edulis*
Common Juniper	*Juniperus communis*
Corkbark Fir	*Abies lasiocarpa var. Arizonica*
Douglas-fir	*Pseudotsuga menziesii*
Emory Oak	*Quercus emoryi*
Engelmann Spruce	*Picea engelmannii*
Fremont Cottonwood	*Populus fremontii*
Gambel Oak	*Quercus gambelii*
Gray Alder	*Alnus incana*
Limber Pine	*Pinus flexilis*
Mahogany spp.	*Swietenia spp.*
Mexican Pinyon Pine	*Pinus cembroides*
Netleaf Hackberry	*Celtis reticulata*
New Mexico Locust	*Robinia neomexicana*
One-seed Juniper	*Juniperus monosperma*
Ponderosa Pine	*Pinus ponderosa*
Redberry Juniper	*Juniperus pinchotii*
Rocky Mountain Bristlecone Pine	*Pinus aristata*
Rocky Mountain Juniper	*Juniperus scopulorum*
Singleleaf Pinyon	*Pinus monophylla*
Smooth Arizona Cypress	*Cupressus arizonica*
Southwestern White Pine	*Pinus strobiformis*
Subalpine Fir	*Abies lasiocarpa*
Quaking Aspen	*Populus tremuloides*
Utah Juniper	*Juniperus osteosperma*
White Fir	*Abies concolor*

Appendix VI: AZ DFFM Invasive Insect Posters

Mediterranean Pine Engraver Spreading in Arizona

Forest Health Alert
September 2023

AZ Department of Forestry and Fire Management

Why Do We Care?

The non-native Mediterranean pine engraver beetle (MPE) (*Orthotomicus erosus*) (Figure 1) made its way to Arizona in 2018, likely through the movement of wood packing products from neighboring states. MPE are native to Europe, the Middle East, northern Africa, and China. Since being introduced into the US, they have spread quickly through warmer climate states.

Figure 1: MPE are small, about 3mm in length, as shown in relation to a penny.

MPE are tiny beetles, ranging from 3-3.5mm long, and are reddish-brown in color. MPE beetles generally attack distressed pine 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. The tunneling created by the beetles' chewing blocks the tree's ability to transport water and nutrients, effectively killing the tree.

Healthy pines have a natural defense against bark beetles; they secrete thick resin when beetles try to gain entry, pushing the beetles out and trapping them in sticky resin. However, stressed trees produce little to no resin and can become susceptible to MPE and other bark beetle attacks. In addition, even healthy trees may not be able to fend off MPE if beetle populations are abnormally high.

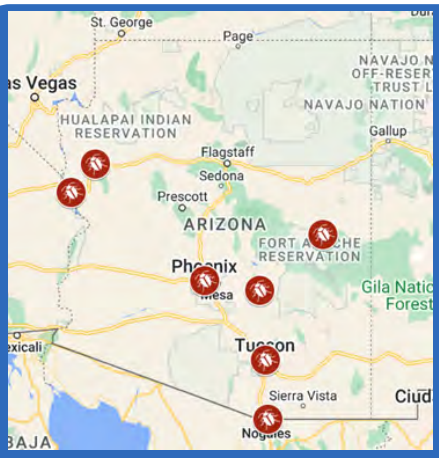


Figure 2: Map showing MPE monitoring locations across the state.

Arizona Monitoring Locations

The Arizona Department of Forestry and Fire Management, in collaboration with the USDA, has monitored for this insect pest with various trapping efforts and management projects. MPE was discovered in Tucson in May of 2021 through an expanded trapping program, and an Early Detection Rapid Response monitoring program identified the presence of MPE in Kingman, Topock, Pinetop-Lakeside, Superior, and Nogales in spring of 2023 (Figure 2).

Signs of Activity - What to Look For

The two most common external signs that an urban tree may be infested with MPE are yellowing or browning needles, especially at the top of the tree, and the presence of red boring dust on the bark or accumulated at the base of the tree. Less common signs in an urban setting can include pin-sized exit holes in the bark and resin oozing out of the holes in the bark; if water availability is minimal, the tree may not ooze resin.

Figure 3: Eldarica pine showing yellow needles at the top of the crown.

Figure 4: Pitch tubes and exit holes made by MPE in Aleppo pine.

Figure 5: Red boring dust as seen on pine bark.

What Else Could it Be?

Various other insects can cause trees to have similar signs and symptoms to an MPE infestation. 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. Woodpeckers and other sapsuckers also make holes in bark, but they will be fairly large, roughly 1 cm in diameter or larger, and likely in rows or columns. MPE holes are pinhead-sized and spread randomly over the bark in a shot-hole-like appearance.

Figure 6: Non-MPE wood boring beetle holes, significantly larger and deeper than MPE. Photo Credit: Stanislaw Kinelski, bugwood.org

Figure 7: Woodpecker holes in tree bark showing a horizontal pattern. Photo Credit: Joy Viola, Northeastern University, Bugwood.org

What We're Doing

The Arizona Department of Forestry and Fire Management is working to better understand MPE and the best management practices for dealing with this pest through three ongoing projects:

Push-pull Assessment: This project is occurring in parks around Phoenix with the intention of reducing MPE populations in these localized areas. This strategy will test the ability of verbenone, a known bark beetle deterrent, to "push" MPE out of an area. Nearby, traps with lures will be placed to "pull" the MPE into that area. This project will help assess if verbenone has an effect on MPE. Future projects will look at other known deterrents, such as conophthorin and Ips dienol.

Figure 8: Photo of verbenone pouches placed on an Aleppo pine in hopes of deterring MPE

Host Tree Assessment: This project involves working with local contractors in Phoenix and Tucson to collect bark beetles from recently cut conifer trees. This assessment will help us to determine which bark beetle species, including MPE, are attacking Arizona's ornamental conifers.

Bolt Assessment: Similar to the Host Tree Assessment, this project will be looking to see which native tree species are susceptible to an MPE attack. We will bait logs (bolts) with MPE lures to see if the beetles are able to bore into and reproduce in these trees. Knowing which native species are susceptible to MPE will help us predict their spread throughout the state.

What Can You Do?

Preventing an MPE infestation from starting is the best option.
Prevention involves keeping trees unstressed and healthy, so they are able to fight off the attack themselves. Water trees appropriately, plant trees in the correct location, and remove dead and dying trees.

Once an infestation has started, the best method to stop the infestation from spreading may be to have the tree removed.
This will remove beetles from the area before they spread to nearby 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.

If you suspect that a pine may be infested with MPE beetles, 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. We may also be able to cover a portion of the cost of removing the tree. Information or questions can be emailed to foresthealth@dffm.az.gov.

Bark Beetle Host Tree Assessment

The Arizona Department of Forestry and Fire Management (DFFM) has been monitoring the **Mediterranean pine engraver beetle (MPE)** (*Orthotomicus erosus*), a non-native bark beetle first found in Arizona in 2018. MPE, like most bark beetles, targets stressed and weakened trees by boring holes into the bark of a tree. As the beetles chew and feed underneath the bark, they create a network of tunnels that prevent the tree from transporting water and nutrients, effectively killing the tree.

With MPE spreading through Arizona, DFFM is conducting a **Bark Beetle Host Tree Assessment** to determine whether MPE is attacking all mediterranean pines, and/or our native pine trees as well. This assessment will improve our knowledge of MPE and allow for a more strategic IPM approach to help reduce the spread of this pest.

How You Can Help:

If you suspect a tree was killed by bark beetles, or is dying from bark beetles, and you will be removing the tree or trees for a customer/ homeowner, please reach out prior to your scheduled removal date using the contact information below, because we would like to meet you and collect bark beetle samples.

Homeowners interested in helping in this assessment, or who would like more information, should contact foresthealth@dffm.az.gov

Bark Beetle Reduction Cost Share Program

What's Bugging AZ Trees?

Bark beetles are very small insects that feed on phloem, or the "sugary" tissue that lies between the bark and the wood of a tree. As they feed, they create tunnels that, when severe enough, may cause the tree to die. Bark beetles typically prefer to attack weakened, stressed trees. When bark beetles find forested areas that contain weak, stressed trees, they produce an aggregate pheromone that attracts more beetles to the area.

Figure 1: Two bark beetles on a penny

How Do I Know if My Trees Are Infested?

Bark beetle infestations are most often seen in evergreen trees. The most common signs and symptoms of an active bark beetle infestation are the yellowing of needles, especially those at the top of the tree (Fig. 2), and the presence of pin-sized holes in the bark (Fig. 3). You may also see accumulations of frass (sawdust like material) at the base of the tree (Fig. 4), or tree sap leaking from small holes in the tree (Fig. 5).

Figure 2: Top-down die back of crown

Figure 3: Exit holes in bark

Figure 4: Accumulated frass in cracks of bark

Figure 5: Sap production

What Can You Do?

Schedule a Site Assessment, Remove Infested Trees

When beetle populations get large enough, they will start attacking healthy trees. Removing bark beetle infested trees has proven to reduce bark beetle spread in otherwise healthy forests. To assist in maintaining healthy forests and reduce bark beetle infestations, the Bark Beetle Reduction Cost Share Program gives landowners financial assistance to remove infested trees.

The Bark Beetle Reduction Cost Share Program helps landowners respond to bark beetle infestations by paying 50% of the cost of tree removal. This program aims to help private landowners reduce the spread of bark beetles to their own trees, and to the surrounding natural areas.

Figure 5: Rust colored needles and tree mortality caused by Bark beetles shown at the landscape scale

How Do I Sign Up?

STEP 1: If you suspect bark beetle infestation on your property or are unsure, simply call or email us to let us know you're interested in the Cost Share Program.
Call [602]-771-1400
Email foresthealth@dffm.az.gov
Tell us your name, contact info, and location.

STEP 2: A DFFM forestry professional will perform an onsite assessment of your property and identify all actively infested trees with flagging and a paint mark.

STEP 3: After the assessment, you will obtain quotes from contractors to remove the marked and flagged trees, including the removal of all debris. You will send your quotes to DFFM, specifically Mitchell Lannan. Based on the quotes, you pick which company you'd like to work with and pay half the total amount directly to the contractor.

STEP 4: Once the tree removal is conducted, you will be contacted by the DFFM to confirm the work was completed on your property, and all debris was removed as well. The Arizona Department of Forestry and Fire Management will then pay the remaining 50% of the total cost directly to the contractor.

Have Questions?

Mitchell Lannan
Forest Health Specialist
AZ Dept. of Forestry and Fire Mgt.
mlannan@dffm.az.gov

This program supports the mission of the Arizona Department of Forestry and Fire Management by:

» Protecting Healthy Forests
» Supporting Communities
» Reducing Wildfire Risk

Funding for the Bark Beetle Reduction Cost Share Program is provided by the AZ Dept. of Forestry and Fire Management and USDA Forest Service. These institutions are equal opportunity providers.

Help Protect Arizona's Ash Trees

Emerald Ash Borer (EAB, *Agrilus planipennis*) is a non-native insect spreading through the US. This insect attacks and kills ash trees of all size and species. EAB is a wood boring beetle that feeds on the tissue underneath the bark.

EAB are about ½ **inch long** with a **metallic green flat body** and leave **D-shaped exit holes** on the bark of trees.

This insect has **NOT** been detected in AZ but has been found in the neighboring state of Colorado.

EAB can easily spread through the transportation of firewood and other wood products. **Buy it where you burn it!**

Do Not Transport Firewood

If you have questions or suspect you have seen this insect, please report to DFFM at **foresthealth@dffm.az.gov** or call **602.376.0056**

Have You Seen This Invasive Insect?

The **Spotted Lanternfly** (SLF, *Lycorma delicatula*) is a non-native insect spreading westward through the US. This insect attacks and weakens plants, including tree of heaven, grape, apple, stone fruit, maple, poplar, walnut, and willow. SLF are sap feeders, primarily found on the branches and stems of plants.

SLF have different life stages, with both nymphs and adults having spotting on their back. This species often spreads through the transport of its flat, grayish egg masses in winter.

This insect has **NOT** been detected in AZ, but is prominent on the east coast. Keep an eye out for SLF egg masses on firewood, landscaping materials, vehicles, and nursery plants being transported from outside of the state.

Do Not Transport SLF

If you have questions or suspect you have seen this insect, please report to DFFM at **foresthealth@dffm.az.gov** or call **602.376.0056**

Have You Seen This Invasive Insect?

Spongy moth (*Lymantria dispar*) is a non-native moth whose caterpillars feed on over 300 species of trees and shrubs. These host species include oak, maple, linden, blue spruce, aspen, and fruit trees. Caterpillars can completely defoliate trees. This moth is found in the northeastern US and has **NOT** been found in western states.

Adult pair

Caterpillar

Female moths are larger than males, with a two-inch wingspan. They are nearly all white with brown saw-toothed patterns on their wings. Male moths are brown with a darker brown pattern on their wings. This species is often identified by their caterpillars, which get up to 2.5 inches in length with blue and red spots, or by the orangey-gray egg masses they lay on trees in autumn.

Egg mass

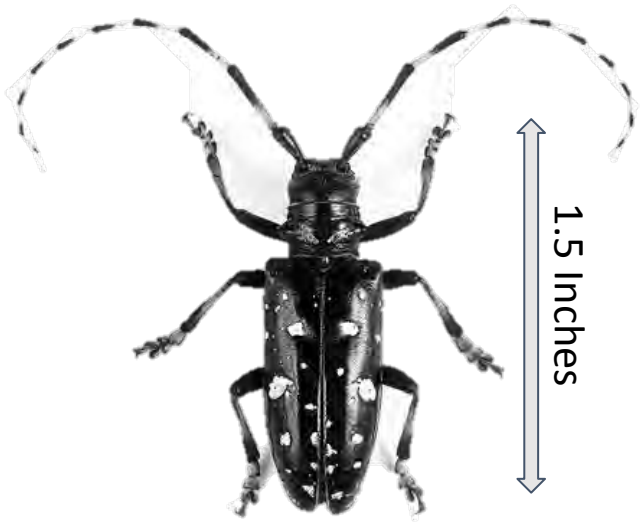
This insect unintentionally spreads by laying egg masses on nursery stock, vehicles, tents, boats, etc.

Check For Egg Masses

If you have questions or suspect you have seen this insect, please report to DFFM at **foresthealth@dffm.az.gov** or call **602.376.0056**

Help Protect Arizona's Hardwood Trees

Asian Longhorned Beetle (ALB, *Anoplophora glabripennis*) is a non-native wood boring beetle spreading through the eastern US. Larvae of ALB feed on the tissues underneath the bark, killing the tree. This beetle attacks maple, birch, elm, ash, poplar, and willow. This insect has **NOT** been found in any western states, however all states are considered at risk.



ALB adults are **shiny and black** with irregular **white spots**. At 1.5 inches in length, this species has distinct **bluish-white legs** with long black and white **striped antennae**. Look for exit holes large enough to fit a pencil on the trunk and branches of host trees.

Round, half inch exit hole

ALB can spread through the transportation of wood products including firewood. **Buy it where you burn it!**

Do Not Transport Firewood

If you have questions or suspect you have seen this insect, please report to DFFM at **foresthealth@dffm.az.gov** or call **602.376.0056**