WINTER 2023 • VOLUME 39 • NO. 1

Northwest Woodlands

A Publication of the Oregon Small Woodlands, Washington Farm Forestry, Idaho Forest Owners & Montana Forest Owners Associations

FOREST HEALTH AND PESTS

Is Forest Health in the Eye of the Beholder?

Monitoring Forest Health: The Eye in the Sky

Larch: Is a Key Species for Building Healthy Forests, Getting Sick?

What Scientists Know About Free-roaming Dogs and Cats

An Introduction to Root Disease Management in the Pacific Northwest

Insect Outbreaks After a Fire, What's the Risk?

Northwest Woodlands
P.O. Box 1010
Chehalis, WA 98532

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Thinning for the Health of Your Forest

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Table of Contents

Winter 2023

FEATURES

DEPARTMENTS

ON THE COVER:

Whitebark pine forest affected by white pine blister rust and mountain pine beetle.
Photo credit: Michelle Agne

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Northwest Woodlands is published quarterly by the Washington Farm Forestry Association for members of the Idaho Forest Owners Association, Montana Forest Owners Association, Oregon Small Woodlands Association and Washington Farm Forestry Association.

Monitoring Forest Health: The Eye in the Sky

By DANIEL DePINTE

There are approximately 86 million acres of forested land across Oregon, Washington, Idaho, and Montana. One may wonder, how in the world does the Forest Service monitor such a vast amount of forested terrain and diagnose all the different causes of forest damage each year? The USFS has been developing and evolving a system of monitoring and diagnosing forest health conditions for over 100 years.

The U.S. Forest Service's Forest Health Protection (FHP) program and its state partners collaborate annually to monitor the health of all forested lands across Oregon, Washington, Idaho, and Montana. If significant forest damage occurs, especially from insect and disease activity, FHP is typically one of the groups to know. Forest Health Protection then shares its observations of forest damage with the appropriate land managers for any given area. Collectively, FHP works with all federal, state, and private landowners to assist with their forest health concerns.

It all starts with forest health specialists who are typically trained in the fields of forest entomology and forest pathology. Over time, these specialists have observed and recorded insect and disease patterns affecting different tree species. They closely monitor how the infected trees succumb to their demise and note the subtle differences, or signatures, between the different insects and how the tree reacts. Specialists can differentiate what is happening across the forested landscape. This knowledge has been passed down for generations, through training and demonstration, creating an extremely solid foundation upon which we can build.

As the science of monitoring continues to develop and new technologies emerge, FHP evaluates them for usefulness and when appropriate, adopts new tools to increase the quality of the data, the safety of the crew, and the efficacy of the survey and monitoring program. Currently, we use a hybrid approach to surveying and monitoring which uses a mix of operational remote sensing tools including Unmanned Aviation Systems (UAS), staffed aircraft, and satellite imagery.

PHOTO COURTESY: VISION AERIAL

American-made tri-copter SwitchBlade-Elite from Vision Aerial.

Forest Health Protection understands the potential of flying UAS ("drones") to support a host of natural resource management activities regarding forest health concerns. The Forest Service takes a deliberate approach to all new technologies, such as UAS, to ensure they are adopted in an appropriate, safe, and cost-effective manner. They want to ensure the right asset is utilized to support the agency in accomplishing its mission while staying aligned with FAA regulations.

The Forest Service has a fleet of drones that can be equipped with various sensors tailored to a diversity of forest health survey missions. For example, if we need to diagnose the cause of a defoliation event in a mixed conifer forest up on a mountainside, we could use our DJI Mavic Pro with its high-definition camera sensors to see more clearly what is happening in the canopy. Other forest health missions may need more specialized sensors like the Micasense RedEdge-P which can go beyond what the human eye can see into the non-visible light spectrum. For these types of missions, we use the American-made tri-copter Switch Blade from Vision Aerial which can be mounted with a variety of mid-weight sensors. We also have larger drones such as the DJI Matrice M600 Pro which can be furnished with heavier equipment such as the GeoCue True View 515 LiDAR sensor. The main advantage of LiDAR sensors coupled with data interpretation tools is the ability to capture tree and shrub cover information and then remove it to obtain ground elevations even in dense forest canopies and the ability to accurately create canopy height models. Currently, UAS missions are only suitable for relatively small project sites of no more than a couple thousand acres. Beyond that, staffed aerial surveys are more appropriate.

Staffed aerial surveys provide an annual snapshot of forest health conditions over large areas and most of the annual monitoring is accomplished using this technique. Aerial surveys are more efficient, reliable, timely, and economical than other operational remote sensing methods to date. In the US, forest health surveys started in the 1920s and have been consistently con-

—Continued on next page —

ducted in the Pacific Northwest since 1947. Each year, since those early days, the aerial detection survey improves upon the last by modifying aircraft, passing along knowledge, and developing customized tools to assist in the monitoring of America's forests.

To conduct the aerial detection survey (ADS), forest health specialists board small aircraft armed with a digital aerial sketch-mapping system that incorporates tablets, geographic information system (GIS), and global positioning system (GPS) technology into a single app called Digital Mobile Sketch Mapper (DMSM). The forest health crew then flies over the forests anywhere from 500 to 2000 feet above the canopy in either a grid or contour pattern depending on the terrain below. Traveling around 100 mph the surveyors looking out about two miles can survey around 15-30 acres per second, diagnosing forest damage, mapping its extent, and rating the severity of that damage for any given location for less than a penny per acre. In real-time, forest health specialists can distinguish between the different tree species and the variety of damage causal agents which could be impacting each tree species.

For example, let's imagine a large ponderosa pine forest. As we fly over this forest, specialists are looking out the windows for different forest characteristics such as the color and quality of the canopy to determine if the trees are healthy, defoliated, dying, or recently dead. As a ponderosa pine dies, typically the foliage will transition from a green to a specific chlorotic yellow-straw color, then to an orange-reddish color. The arrangement of the dying or recently dead ponderosa pines can further tell us more about the possible cause of this forest damage. If the pines are all the same color of red and recently dead along one side of a highway and those dead trees only extend about 100 yards from the highway while the rest of the forest is healthy and green, then salt or herbicide damage from road management are most likely the cause. Now imagine that we fly further and observe clusters of dead ponderosa pines in a variety of fading canopy colors scattered throughout the forest. Bark beetles are most likely the cause of such patchy mortality. The same goes for defoliation events in ponderosa pines and, based on the topographic position of the trees and which needles (interior older foliage only, exterior youngest foliage only, top-down, bottom-up) specialists can make an educated guess from the plane whether it is most likely pandora moths, pine butterflies, sawflies, foliage pathogens, or fire damaging those ponderosa pine needles. This process of distinguishing the subtle differences repeats for each tree species and location as we fly along recording our observations on the DMSM app which keeps track of the plane's location on a customizable scrolling map. Using a variety of imagery as a background for this map, surveyors can easily correlate the damage they are observing out the window and locate where the damage would be on the app's map.

PHOTO COURTESY: DANIEL DePINTE

To conduct an aerial survey, forest health specialists use small aircraft armed with a digital aerial sketch-mapping system.

The aerial survey data is collected over the summer and into the fall to capture the best forest damage signatures possible, then processed in the fall and finished by November 15th. The raw or 'draft' aerial detection survey data, which is not processed, is shared publicly online on our website, typically the same week that area is flown. During the survey season, we periodically check areas of damage on the ground for verification, especially prioritizing "unknown" damage that's been observed and following up to review areas of high value such as timber management project areas, campgrounds, or areas that may have damage from a new invasive insect or pathogen such as emerald ash borer or sudden oak death. No algorithm, artificial intelligence, or sensor to date has been able to replace the ability of an educated forest health specialist to diagnose and map hundreds of millions of forested acres and share those findings at the speed and cost that is currently happening with aerial surveys. But that won't always be the case.

Using imagery from satellites has shown some promising results for the future of monitoring forest health across large landscapes and is currently being used in conjunction with aerial surveys from aircraft, when applicable, to increase the quality or the extent of the data produced by FHP and their State Partners. The USFS has access to the MAXAR satellite fleet from the National Geospatial-Intelligence Agency which provides high-resolution imagery. This imagery can then be analyzed in a variety of ways to map damage or detect changes across the landscape over time. In 2021, when the heat dome event slowly crossed Washington and Oregon, brutally scorching trees across hundreds of thousands of acres, FHP used imagery from Worldview-3 in conjunction with aerial survey data to map the extent and severity of the foliar damage. This mapping was accomplished with what is called heads-up digitizing, where a human draws the lines around the visible damage on the provided imagery. Other remote sensing techniques develop algorithms that detect the change by comparing satellite images of the current forest to how that forest looked in the past.

In the Pacific Northwest, FHP, Washington Department of Natural Resources (WADNR), and Oregon State University's College of Earth, Ocean, and Atmospheric Sciences are collaborating to develop and fine-tune those algorithms and digital tools, such as LandTrendr, to assist with forest health change detection. We also collaborate with other federal and private groups such as the Geospatial Technology and Applications Center (GTAC) and Redcastle Resources, which share the same goal of change detection and forest health monitoring but take different approaches. Each approach may use a different set of satellite imagery with varying resolution or focus on a different component of the landscape such as a change in greenness or infrared spectrum imagery. Collectively we are moving forward with new technology and providing the best available monitoring possible.

As the forests change over time, so will the tools we use to detect and monitor those changes. The importance of monitoring forest health has always been vital. With the impacts of climate change being felt across the landscape now, more than ever, we need to remain vigilant in our monitoring of forest health. The interconnected nature of climate, insects, diseases, wildfires, and forests is complex, and scientists will continue to better understand those relationships. With that understanding, hopefully, we can mitigate some of the damage and plan for future forests with greater success. For more information on forest health, or to see the current state of the aerial detection survey in Oregon and Washington, please visit our website at https://www.fs.usda.gov/main/r6/forest-grasslandhealth. ■

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