USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Research & Development — Fire & Aviation Management | January 2026

Leveraging AI to Support Wildfire Response With Research and Innovation

Forest Service researchers, working in close partnership with Forest Service Fire and Aviation Management leadership, are leveraging artificial intelligence (AI) capabilities to advance knowledge and tools that improve operations before, during, and after wildfires. Forest Service scientists partner with Microsoft, Google, the Department of Defense and many other technology providers to develop new innovations that are freely available and rapidly applied to today's firefighting response—upholding a model that is less costly, more efficient, and more innovative than what the private sector alone, often looking to repackage and resell government data, may offer.

Broadly defined, AI is any computer system or tool that can make predictions, recommendations, or decisions based on rules and goals set by humans. Many forms of AI can decipher patterns from vast datasets, allowing predictions of wildfire occurrence and spread. Our scientists are augmenting ground-truthed fire behavior and modeling expertise with neural networks, machine learning, and other new AI technologies that yield computer simulation efficiencies, rapid sensemaking of large datasets and more—with impressive results. In many cases, AI can help make decision support tools more efficient, while leaving the decisions for action to fire managers. Importantly, Forest Service scientists work hand in hand with fire leadership and fire managers to balance powerful AI potential with its responsible use, proceeding cautiously with the integration of AI and related technologies in support of fire management, given wildfire's critical consequences for life and property.

On a Fire Near You: Tools and Applications Strengthened by AI

Fire managers and the public are already using AI-augmented tools developed by Forest Service Research and Development in their day-to-day operations. These tools combine decades of agency-produced data with the newest technologies to help managers assess strategies, adapt to changing conditions, and give the public up-to-the-minute fire information.

National Interagency Fire Center photo by Bureau of Indian Affairs, Colville Agency.

The brains behind Smokey's fire danger rating sign, the National Fire Danger Rating System, has been in use since 1972 and uses weather, fuels, and fire occurrence data to calculate fire danger for a given area. Our scientists and managers are continually modernizing the National Fire Danger Rating System to reflect the latest science. For example, generalized linear models and generalized additive models are currently being used to predict locations of human- and naturally-caused wildfires.

The Risk Management Assistance Dashboard is a set of science-based tools regularly used by wildfire incident managers, including some powered, at least in part, by AI. These include the Potential Control Location Suitability model, which uses boosted regression tree machine learning to process 20 years of past fire containment data to point managers to the safest, most effective places to contain fire. The Snag Hazard Map, based on TreeMap, uses a random forest machine learning algorithm to predict where downed and weakened trees might trap or injure firefighters.

FireCon uses neural network inference and machine learning to predict daily fire weather, fuels, and resource deployments that enable fire responders to adapt to changing conditions. The WindNinja computer program delivers high-resolution wind predictions at small scales within seconds for firefighters making on-the-ground decisions. Developers of WindNinja are currently testing prototypes of generative AI approaches for improving predictions, specifically to develop parameters for regions of air flow separation and flow recirculation on the lee side of terrain features. The Wildland Fire Decision Support System, the official system of record for Federal wildland fire incident decisions, uses a machine-learning method for information technology operations to keep its software operations running smoothly.

The AirFire Research Team developed the AirNow app to provide the public with real-time air quality and smoke information. AirNow uses an AI large language model to help increase coding efficiency and translate certain public communication outputs into Spanish to ensure information is accessible across communities. The rapidfire model uses a random forest regression—a machine learning approach—to fuse multiple data sets and produce near-real-time gridded, fine particulate matter data of wildland fire smoke conditions. The data are of sufficient quality for use in human epidemiological impact analyses and time-critical planning that is often limited by the lack of high-quality data.

AI-Augmented Technologies for Fuels Treatment Planning

Developed by Forest Service Scientists in collaboration with fuels managers, applications that leverage AI are regularly used in fuel treatment planning. TreeMap uses Random Forest models to assign detailed forest plot information seamlessly across the forested extent of the continental United States to produce tree-level maps. Researchers and managers use these maps to estimate forest biomass, emissions, fuel treatment effects, and more. FastFuels maps fuels nationwide with high-resolution 3D data. It leverages statistical matching and machine learning to improve fuel mapping connections to remotely-sensed data and to refine fuels attributes.

USDA Forest Service photo by Susan Knight-Ashley.

Boosting Accuracy and Efficiency with the Help of AI

- Prior to the development of the Potential Control Location Suitability map, fire managers who engaged a wildfire had a containment successes about 30 percent. Use of the Potential Control Location Suitability map has doubled this to nearly 60 percent. Using FireCon, fire managers can increase their success rate to 75–80 percent.
- FuelVision is a new system developed by Forest Service researchers and university collaborators to enhance wildfire preparedness. Using generative adversarial networks machine learning, FuelVision uses satellite imagery to rapidly and accurately identify wildfire fuel sources. In validation tests of the Dixie and Caldor Fires of 2021, FuelVision predictions achieved 77 percent mapping accuracy of fuel sources without the use of time consuming ground surveys.
- Raster Tools, developed by Research and Development scientists to model detailed fuel treatments and show cost implications of specific treatments, is a free Python library that uses far less processing time, power, and computer storage space than other geospatial applications and can run locally on laptops or in the cloud. We estimate this approach reduces processing time by 65 percent and requisite storage by 85 percent.

Our scientists are using a machine learning approach to predict how well treatments are at reducing wildfire risk to highly valued resources and assets. StockSmart looks simple on your phone or tablet, but it processes vast amounts of remotely-sensed data to help ranchers and range managers identify locations for targeted grazing and other treatments that benefit rural communities. As winners of a Microsoft 2025 AI for Good award, StockSmart developers will be tapping into Microsoft's machine learning and AI expertise to help guide targeted grazing for fuels reduction.

Forest Service Research and Development is using a machine-learning-based cutpoint algorithm to determine optimal prescribed burn windows and map them using real-time forecasts. Machine learning methods such as regression and denoising modeling are used to understand fire effects from aerial and terrestrial LiDAR scanning measurements that use pre- and postburn scans. This work is being done in collaboration with many State and Federal agencies and external partners.

Coming Soon: Fire Spread Models, Ember Detection, Uncrewed Aircraft Systems, and More

Forest Service researchers continue to work closely with fire leadership to innovate new and existing AI-augmented tools for fire managers. They improve upon current technologies, update fire spread models, automate operations, and develop early warning systems. This ongoing work reflects the Forest Service's commitment to supporting cutting-edge wildfire management that improves outcomes on wildfires, increases public and firefighter safety, and makes efficient use of resources.

Our public-private sector partnerships enhance these efforts by bringing the latest technologies and extensive computing power to a long legacy of fire knowledge, tools, and applications from Forest Service Research and Development. For example, researchers are combining decades of fire research and fire behavior modelling expertise using Google Research's massive computing infrastructure to develop a new and vastly improved fire-spread model. This will more accurately predict how far and fast fires can move—even under extreme conditions.

Licensed photo by Adobe Stock Image/Fidel.

Agency scientists, working with fire managers, are using AI and similar approaches to develop new tools for managing and fighting wildfires:

- Agency scientists are creating AI algorithms to show relationships between temperature changes and wind turbulence, which, in turn, affect how fuels cause fires to spread. They also found that soil moisture is an excellent predictor of fire growth and have trained machine learning models to estimate daily fire growth.
- A deep learning approach will help managers better target fire retardant and water drops from aircraft.
- AI-enabled, uncrewed aircraft systems may soon aid managers before, during, and after fires in detecting new wildfire starts, aiding firefighters on the fireline and more.
- A model based on mathematical and linear programming will help managers target treatments that connect fuel breaks over large landscapes.
- An AI-based early warning system will forecast wildfires sooner than existing systems can. It will also forecast areas that are likely to burn, an ability that may improve outcomes for fires like the 2025 fires in southern California.
- Automated methods to detect burning embers will combine infrared video with novel neural networks, helping managers track windblown embers that often start fires ahead of walls of flame.
- By pulling information from field reports and after-action reviews, AI-driven pattern recognition, machine learning technologies, and natural language processing algorithms are helping managers pinpoint factors driving wildfire outcomes.

Fire managers will soon be able to improve their decision-support systems with rapidly generated, high-resolution fuels maps. These maps incorporate ground-truthed data from agency researchers with generative AI, deep learning neural networks, decision trees, and gradient boosting tools from university partners and Amazon Science.

Forest Service researchers understand how much is at stake when wildfires burn. Our scientists are deeply committed to partnering with fire managers and serving the American public. Using state-of-the-art technologies combined with a century's worth of wildfire knowledge and applied tools, Forest Service Research & Development, together with Fire and Aviation Management, is leveraging the strengths of the private sector and leading the effort to address current and future wildfire challenges.

About Forest Service Research and Development

Forest Service Research and Development works at the forefront of science to improve the health and use of our Nation's forests and grasslands. Research has been part of the Forest Service mission since its inception in 1905. Forest Service research enhances the rigor and impact of the entire Agency. Our work directly informs management actions taken by the Forest Service, States, Tribes, and other land managers to sustain the health, diversity, and productivity of the Nation's forests and grasslands. Research and Development conducts research across the United States and beyond. Learn more at: https://research.fs.usda.gov/about.

USDA Forest Service photo by Ian Grob.