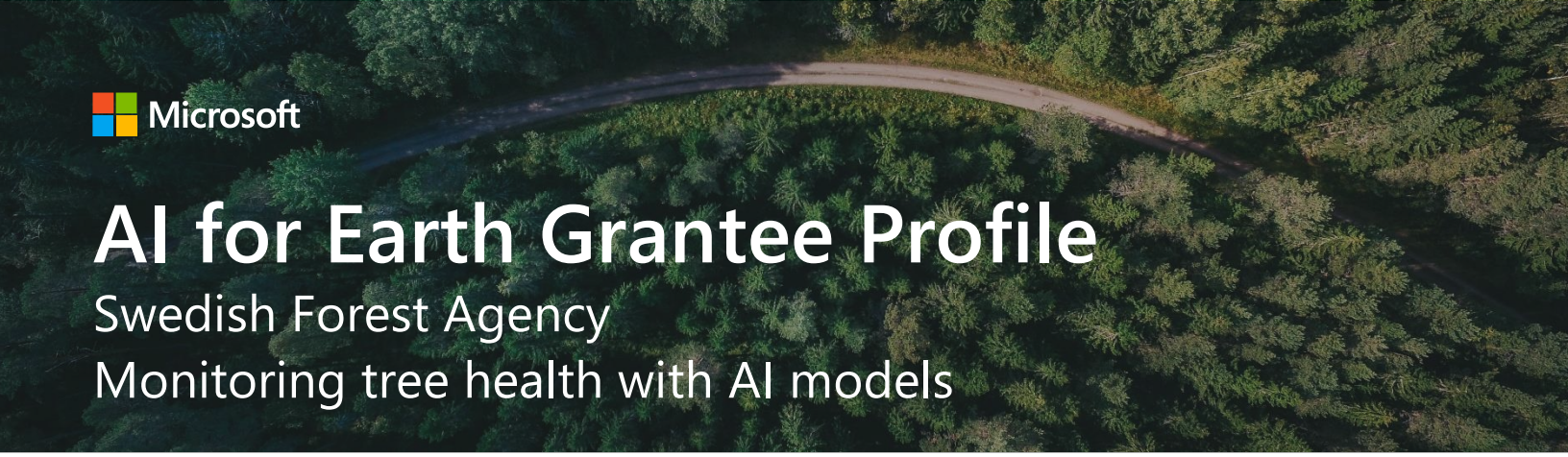


Microsoft

AI for Earth Grantee Profile

Swedish Forest Agency

Monitoring tree health with AI models

Summary

Monitoring the health of trees is a big challenge in forestry. It's important to detect signs of diseases and insect infestations in time to either provide remedies or remove affected trees before the infections spread and wipe out entire species. However, the scale, density, and difficult terrain of forests make it impractical at best to do frequent thorough surveys by humans on foot, while aerial photographic surveys can cover a lot of ground quickly but produce vast amounts of data to sort through. The Swedish Forest Agency is leading a team of partners, including Microsoft, to develop AI and machine learning models that can analyze forest photos and not only identify the trees by species but also determine their health condition and track changes over time. The Forest Agency started with the models needed for larch trees and larch casebearer moths, a relatively small problem in Sweden that served as a proof of concept that AI can do the task quickly and sufficiently accurately to be helpful. With that proof, the Forest Agency now is scaling up to bigger problems such as Dutch elm disease and spruce bark beetles which have a greater impact on forest biodiversity and the forest industry, both in Sweden and globally.

Protecting forests from infestations through AI

Like animals, trees can be subject to infection by diseases and parasites, ranging from insects to fungi to microbes (including viruses). It's very challenging to monitor trees for these health issues, because trees are typically fairly large compared to humans and cover wide areas as forests with difficult terrain. Manual surveys consequently are time-consuming and labor-intensive, limiting how much data can be collected. Modern technology offers solutions to the data-gathering problem with satellites, airplanes, and flying drones providing the capability to take thousands of high-resolution images of forests more quickly and easily. However, that then shifts the time and labor-intensive aspects over to processing all that imagery, sorting and analyzing it to identify the trees of concern, examine them for signs of damage from disease, and track the changes over time.

These issues are important to Skogsstyrelsen, the Swedish Forest Agency—Sweden's national authority in charge of forest-related issues. Sweden is a heavily forested nation, with 57 percent of the land covered by trees, and these trees are a significant natural resource not only for the economy but also for the country's ecology and for the health and wellbeing of society. Sweden has been carefully managing its forests for over

100 years, since the first Forestry Act was passed in 1903, and the Forest Agency works hard to conserve forest ecosystems and encourage forest growth while balancing the needs of the forest products industry with environmental and social interests.

Protecting larch trees from pests

As part of its work, the Swedish Forest Agency explores new technological solutions to meeting these challenges of forest monitoring and management. Thanks in part to a Microsoft AI for Earth grant—the first awarded to an organization in Sweden—the Forest Agency conducted a project to build an AI-based system for identifying trees beset by particular pests and diseases. The test case for this project was the European larch and its nemesis *Coleophora laricella*, the western larch case-bearer moth.

> "How did we do it? We trust each other, and we share the belief that we can do AI for good."—Halil Radogoshi, Swedish Forest Agency

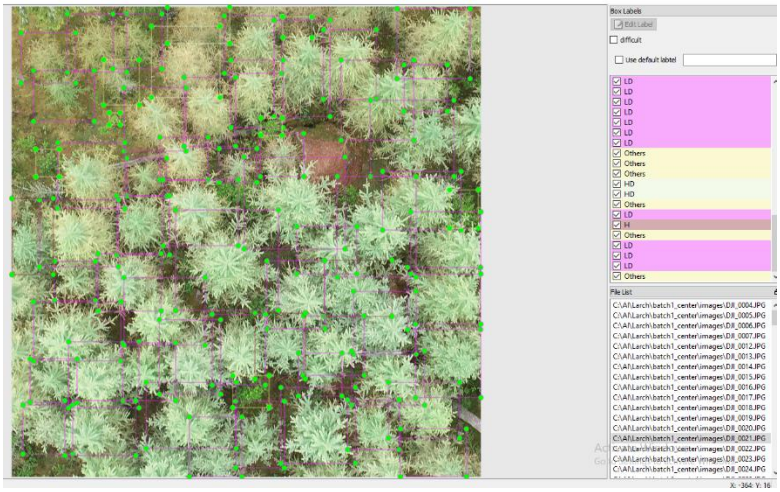
Case-bearer moths are named for their larvae's practice of creating a protective case for themselves out of the shells of the tree needles on which they feed. The larch case-bearer larvae eat through needles repeatedly in a cycle starting in July when they hatch, stay attached to the tree through the winter during which the tree drops its needles, and then resume eating and converting the fresh needles in the spring before going through the transformation into adult moths. Although this nearly continuous feeding process may take a few years to kill the larch tree, it causes a lot of harm in the meantime, limiting the tree's growth and making it vulnerable to other diseases—and this damage also limits the economic value of the infested tree.

Forest owners in Sweden have been considering the larch as an alternative to the more common spruce, which has been suffering from its own problem with insect infestation. The wood of the larch is suitable for similar uses as spruce. However, the expansion of the larch case-bearer moth threatens that opportunity. Identifying infested trees promptly would allow farmers to remove them, controlling the spread and helping keep more larch trees in good health.

Applying AI to monitor tree health

To accomplish this goal, the Swedish Forest Agency teamed up with Microsoft, consulting group B3, and the Jakova Innovation Center to develop an automated system that would use machine learning to do the heavy work of identifying the trees and their status. The Forest Agency supplied 1,600 images from five different areas of Sweden as source data to teach the AI models. The Forest Agency also planned out the systems and

support for growth and scaling. Combining the images into orthomosaics—photographic maps from overlapping the images—proved more challenging than expected, doubling the number of annotations needed to 80,000; the Jakova Innovation Center ably handled the annotation process. B3 provided model development, cloud planning, and technical support, while Microsoft supervised the technical process in addition to providing funding through AI for Earth for the data annotation and Microsoft Azure cloud computing resources.



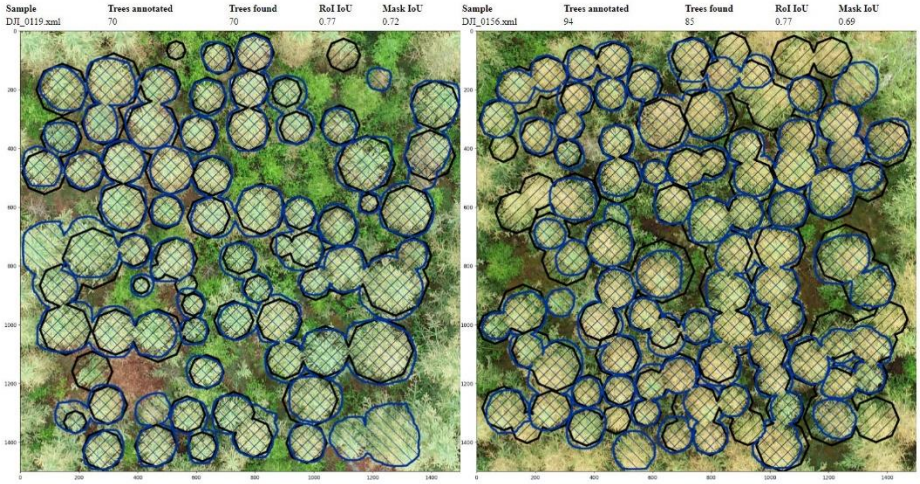
The Jakova Innovation Center made over 80,000 annotations on the images used to train the AI models. (Image courtesy of Swedish Forest Agency.)

Together this partnership produced three AI models capable of identifying the larch trees, their relative condition—healthy, lightly damaged, or heavily damaged—and through comparing orthomosaics over time, monitoring the changing status of the trees and forest overall. The project results include not only these models but also the original data used for developing them and technical documentation of the models and overall project. That openness will allow other organizations to reproduce and further develop the models, and even allow businesses to create products from it. (Swedish law prohibits the Forest Agency from competing with commercial businesses.) Halil Radogoshi, a systems developer with the Swedish Forest Agency and the project manager, says that "Users from different countries will be able to use the model to see if it works in their environment, maybe even improve the model. In this way, we will have a global understanding of the larch problem."

> "We chose a small project that's feasible—so if we needed more data, we could easily get it."
> —Radogoshi

This project was carried out under the auspices of the National Forest Data Lab, a collaboration between the Swedish Forest Agency and the Swedish University of Agricultural Sciences. Supported by Vinnova, the Swedish Innovation Agency, the National Forest Data Lab works to promote innovations based on forest data, such as using AI-based analysis to more efficiently find damage to forests. "We now use the knowledge from this project to develop methods where AI is used to find several types of forest damage," says Radogoshi. "This is just the beginning of a development where we use images from drones, satellites, and aircraft together with AI technology to better understand how the condition of our forests changes over time."

Scaling to larger challenges



The AI model's results in identifying trees of interest are compared to the annotations to validate how well the model is functioning. (Image courtesy of Swedish Forest Agency.)

With the success of the larch project, the Swedish Forest Agency is now prepared to scale its work up to take on bigger problems. For instance, Dutch elm disease is a fungal infection that has already devastated the elm population in Sweden, reducing the presence of elm trees mostly to the island of Gotland where they are carefully monitored. Radogoshi points out the benefit of the AI modeling process for this monitoring: "Imagine trying to do an inventory of the entire island—and Gotland is a big island, they do an inventory of the entire island and identify the trees which have been damaged, manually. Now we can train an AI model that can do this, because an AI model doesn't get tired, and then you can just do it overnight."

Similarly, one of the biggest problems for forests not just in Sweden but across the Northern Hemisphere is the spruce bark beetle. (In fact, it is a reason the Swedish forest owners have been turning to larch as a substitute.) Radogoshi attributes one success factor in the AI for larch project to the Swedish Forest Agency's decision to *not* attempt the spruce beetle problem right away. "We hadn't tested the technology yet, we didn't know," says Radogoshi, "so we chose a small project that's feasible—so if we needed more data, we could easily get it."

> "Now we can train an AI model that can do this, because an AI model doesn't get tired, and then you can just do it overnight."—Radogoshi

With that proof of concept achieved, the Forest Agency is now moving forward with developing new models to inventory the spruce trees and assess them for damage from the bark beetles. Taking advantage of the partnership with Microsoft, the Forest Agency can use Microsoft Azure for the AI infrastructure, machine learning interface, data storage, and on-demand computing, all of which enables the models and workflow to scale up to the massive processing needs for the spruce beetle project.

Radogoshi cites several factors in the success of the project to date. Having a balance of technical and conceptual experts in the team. Starting with a smaller focused project that was clearly feasible and tangible, with potential to be scalable and replicable. Having broad support to mobilize resources among all the project partners, because people recognized it was a deliverable project. And finally one more: "You know, we never met each other in person," says Radogoshi. "So how did we do it? We have the shared belief. We trust each other, and we share the belief that we can do AI for good."

About the Swedish Forest Agency

The Swedish Forest Agency (Skogsstyrelsen) is the national authority in charge of forest-related issues. Its main function is to promote the kind of management of Sweden's forests that enables the objectives of forest policy to be attained. The forest policy places equal emphasis on two main objectives: production goals and environmental goals. As the administrative body in charge of implementing the forest policy, the Forest Agency cooperates with representatives from the forest industries and environmental sector towards the goals of economically and ecologically sustainable forestry. The agency is placed under the Ministry of Enterprise and Innovation. Each year it receives direction from the government with goals and the financial framework for the organization. The Forest Agency has offices in approximately 80 places in the country, with the head office in Jönköping.

Resources

Websites

Swedish Forest Agency website (in English)

Press

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