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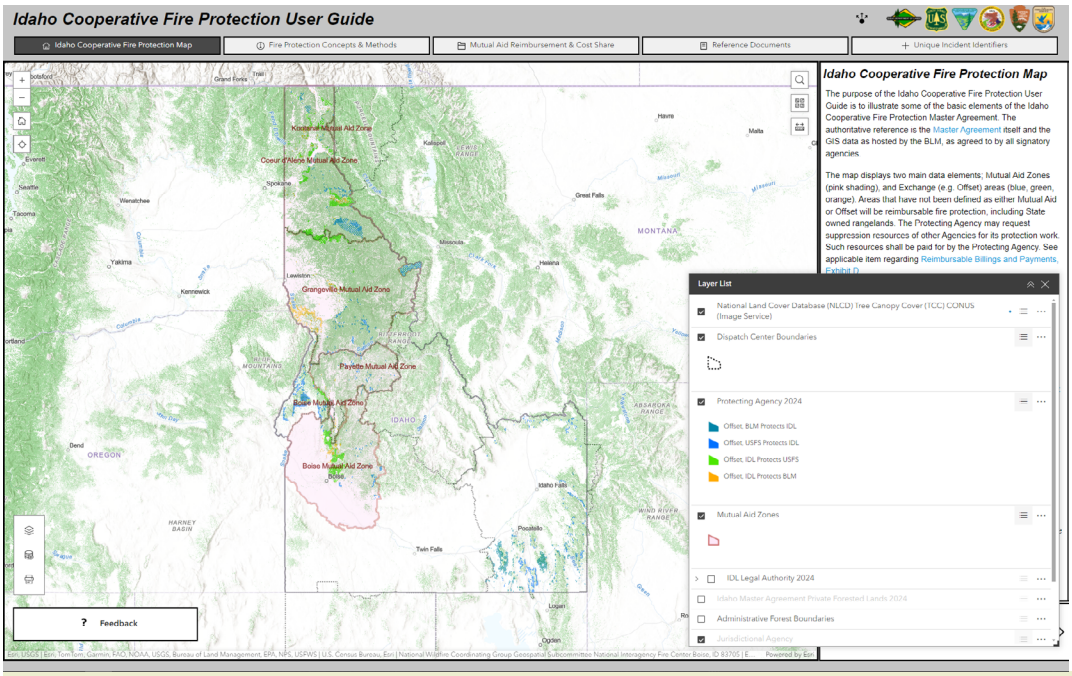
A Brief History of Trees: The National Land Cover Database Tree Canopy Cover data now available annually

How to Define "Forested Land": A case study from Idaho

Idaho has unique legislation declaring that the state pay for wildfire suppression on state lands and forested private lands. Representatives of the Idaho Department of Lands, the governor's office, the U.S. Department of Agriculture Forest Service, and Department of the Interior Bureau of Land Management met repeatedly starting around 2020 to decide who would pay for wildfire suppression. The interagency working group couldn't agree on how to define "forested land."

Tonja Opperman, assistant director of fire analytics for the Forest Service Intermountain Region in Ogden, Utah, learned that the Forest Service produces the National Land Cover Database (NLCD) Tree Canopy Cover (TCC) datasets (hereafter "NLCD TCC"). Opperman presented the datasets to the Idaho group and asked if they would agree to use that data to define forested land in the state. In 2021, the group agreed and decided that, for their purposes, forested land has at least 20 percent tree canopy cover. Forest Service staff provided a map of all such lands in the state of Idaho.



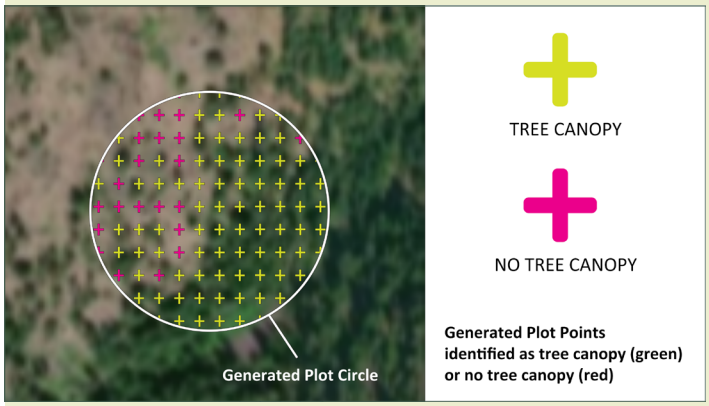
Interface of the Idaho Cooperative Fire Protection Map, which shows basic elements of the Idaho Cooperative Fire Protection Master Agreement to which the NLCD TCC layer has been added for display purposes. Web application by USDA Forest Service Northern and Intermountain Regions, Idaho BLM, and Idaho Department of Lands.

In fall 2023, all the parties signed the Idaho Cooperative Fire Protection Master Agreement, which allows for annual renegotiation and updating. Using NLCD TCC data allowed this critical decision to be based on the best available science.

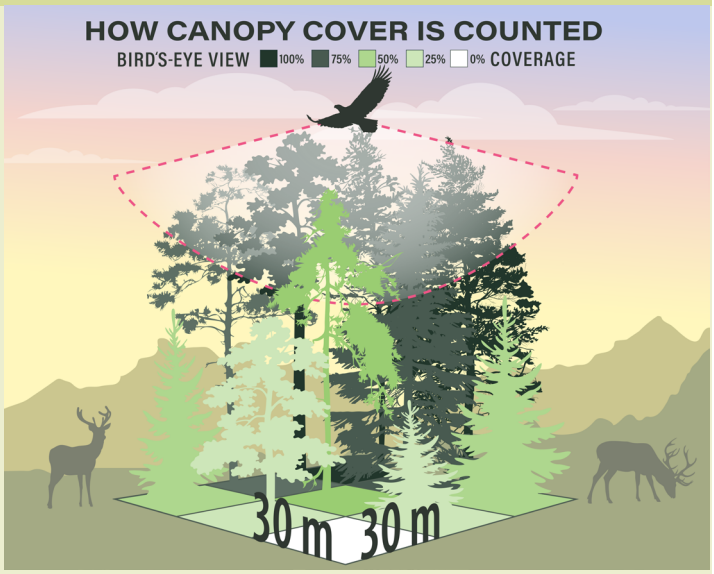
Building the Model

What do we mean by tree canopy cover? Imagine drawing a circle around the outermost perimeter of the natural spread of a tree's trunk, branches, and leaves (or needles). That defines the tree's canopy. Now imagine a bird's-eye view in which some of that area is covered by tree canopies. The percentage of the area covered by tree canopy is the tree canopy cover (TCC) percentage. Forest Service TCC maps illustrate canopy cover values as a percentage ranging from 0 to 100 for each 30-meter-square area of the United States.

For more than 80 years, the USDA Forest Service Forest Inventory and Analysis (FIA) program has been collecting, processing, analyzing, and reporting on data necessary to assess the extent and condition of U.S. forest resources. It includes data from more than 350,000 permanent plots, both public and private, nationwide.



Depiction of the FIA Canopy Cover tool used to develop tree canopy cover reference data. USDA Forest Service, GTAC



Schematic of how tree canopy cover is represented with a bird's-eye view from above. Figure courtesy of Daniel E. Ryerson.

To develop the Forest Service TCC model, FIA personnel photo-interpreted a subset of roughly 60,000 FIA plots for tree canopy using 2008–2011 high-resolution imagery from the National Agricultural Imagery Program. These photo-interpreted data went into a statistical machine learning model to build relationships among the interpreted canopy cover observed on FIA plots and satellite and other geospatial data to produce the 2011 model.

Now that those relationships are modeled and the time series of satellite data is very stable, the models can be applied to predict TCC for any year in which similar predictors are available. The model for 2011 was used to develop maps for 2008–2021.

What Is NLCD TCC and Why Is It Important?

The Forest Service produces the NLCD TCC datasets using Landsat and Sentinel-2 satellite remote sensing data collected during the growing season along with Forest Inventory and Analysis (FIA) data to produce TCC[1] maps with a spatial resolution of 30 meters, about the size of a baseball diamond. The Federal Geographic Data Committee recognizes the NLCD TCC data as a trusted geospatial asset and information source for the nation.

The NLCD TCC dataset is continuous, meaning that its values for percent cover are provided continuously from 0 to 100 percent, that it's an annual time-step of maps, and that it's available for the entire country across all federal, state, tribal, and private lands. Forest definitions can vary, so continuous values allow users to select a canopy cover percent definition for forests that is best suited to their application. The data are useful across larger spatial extents and management boundaries. Users can easily explore trends through time and don't have to stitch together maps made with different methods.

"Trees are some of the biggest organisms in our environment," says Karen Schleeweis, a supervisory biological scientist with the Inventory and Monitoring program and science lead of the Forest Service TCC project, "so they have a large impact in transfer of

[1] *"TCC" alone indicates the common concept of the tree canopy cover or data.*

energy, cycling of nutrients, hydrology—the basic systems of the planet. Knowing where they are, and in what density, is critical."

These data can help us understand the history and current extent of our forests and inform our big science problems such as climate change, wildfire, habitat management, and riparian health.

NLCD and Science TCC Products Serve Different Users

Different maps meet different user needs. The Forest Service TCC project is committed to serving a wide user base. In addition to the NLCD TCC data, the Forest Service releases Science TCC data that support advanced users and geospatial research with raw model outputs enhanced with information on model error and uncertainty. The NCLD TCC products, derived from the Science TCC, have been cleaned and filtered, for example, to reduce small fluctuations in temporal trends and set TCC values to 0 over water.

Meeting Service-wide Needs

Because the Forest Service TCC datasets cover all lands, multiple mission areas of the Forest Service contributed funding to support the work: National Forest System; State, Private, and Tribal Forestry; and Research and Development. The Forest Service TCC project is a great example of how the mission areas, working together, with open dialogues and partnership, have provided a solution for multiple Forest Service needs.

Schleeweis interacts with other Forest Service and university researchers on projects that advance the methods, accuracy, and utility of the Forest Service TCC datasets and ensures that projects are anchored in the needs of the Forest Service and broader science

The USDA Forest Service builds and maintains the NLCD Tree Canopy Cover datasets for the conterminous United States, coastal Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands. Water is shown as water, not trees. USDA Forest Service, GTAC

community. Schleeweis, as science lead, interacts with other Forest Service and university researchers on projects that advance the methods, accuracy, and utility of the Forest Service TCC datasets and ensures that projects are anchored in the needs of the Forest Service R&D and the broader science community. Dan Ryerson oversees the production team at RedCastle Resources, Inc., whom move R&D to operations and meet quality assurance needs. Kevin Megown, Geospatial Technology and Applications Center (GTAC) Resource Mapping, Inventory, and Monitoring program lead, interacts with the science, production, and management teams to continue to meet service-wide needs.

Major Advances

In 2023, the Forest Service TCC project released a major update, including:

- new TCC data for the continental United States, including Southeast coastal Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands;
- a longer time series of data, with annual time steps: 2008–2021 for the science products and 2011–2021 for the NLCD products; and
- map accuracy statistics and model uncertainty and performance released along with the map products themselves.

If you looked at these datasets years ago, Schleeweis suggests, you should look at them again, because they are now much more powerful. The new time series data provide more complete and smoother characterization of tree canopy cover through time. The last data release (in 2019) included maps only for the years 2011 and 2016.

After the data release in 2023, monthly total NLCD TCC downloads from the MRLC Viewer were up an average of 300 percent in the last three months of 2023 compared to the same period in 2022.

The Multi-Resolution Land Characteristics (MRLC) Consortium is a group of federal agencies that coordinates and generates consistent and relevant land cover information at the national scale. For decades, the MRLC has distributed all the NCLD data layers (thematic land cover, continuous impervious, and TCC) and partner data. The Forest Service has been a contributing member to the MRLC since 2011, when they began producing the NLCD TCC data.

For the first time the data release includes model uncertainty and performance (standard error). Together these data allow users to factor confidence intervals into their analyses.

Where You Can Get/Use TCC Data?

These data are available in different formats to accommodate users with different needs and levels of experience in GIS:

- Users primarily concerned with viewing the data in an online viewer can access the NLCD TCC data through the MRLC Viewer.
- Users with limited to moderate technical/analytical skills or disc space who want to explore individual pixel values or TCC statistics over a specific area of interest—perhaps one national forest ranger district or administrative boundary—can clip the data to an area of interest and download only those smaller pieces through the MRLC Viewer. Downloads can be opened and used in a program such as ArcGIS.
- Experienced geospatial data users interested in downloading a single year of the national map or the entire NLCD TCC or Science TCC time series (with model error and uncertainty layers) have a variety of places to get the products: MRLC and Google Earth Engine (most recent release only), and the FSGeodata Clearinghouse and ESRI Image Server REST image services (both offer all previous releases).

The Forest Service TCC team is working to provide improved data delivery that will help to close the gap in data delivery between novice and expert user needs.

The production team has some capacity to help users with specific requests. Users can submit questions to sm.fs.tcc@usda.gov.

Some Recent Peer-Reviewed Studies That Used NLCD TCC Data

Postfire vegetation cover—A research team examined influences of postfire vegetation and fire severity on diurnal, seasonal, and multiyear variation in evapotranspiration to find impacts of wildfire on the landscape-level ecosystem water balance in the Desert Southwest. NLCD TCC datasets were used to observe postfire canopy cover. Forests in this region are critical to water provisioning, and wildfire-generated shrublands have high levels of evapotranspiration, according to study results.

Forest health—Insect and disease survey data have a wide variety of users. NLCD TCC datasets were evaluated for a new technique to improve accurate reporting of total damage across multiple regions and nationally, despite the variability in canopy density across and even within regions. The new technique allowed the researchers to adjust the data to better represent "acres of" damage rather than "acres with" damage.

Forest structure dynamics—NASA's spaceborne GEDI lidar represents a new era in space-based, consistent, global measurements of multiple forest structure characteristics, including canopy height, percent canopy cover, plant area index, and foliage height diversity. NLCD TCC datasets were used along with other data to screen GEDI observations to include only forest-related observations and remove noise. Outcomes include reliable global one-km maps of multiple forest structure characteristics that can be used to improve models that predict weather and climate and inform sustainable development and climate solutions.

Forest disturbance—An innovative study integrated many national datasets across western landscapes to investigate estimates of the area of potentially impaired forest succession, where biotic and abiotic fctors may hinder forest recovery following disturbance, leading to potentially permanent conversion of forest to different natural land cover types. This study used NLCD TCC and other data sources as stand-ins for ecological context and to determine a location's proximity to seed sources—an important determinant of recovery.

Fractional snow mapping—Maps of snow cover inform water forecasting models, which inform water management strategies, especially where snowmelt is a major portion of people's water supply. In forested landscapes, vegetation's interference with mapping snow is a limitation and source of uncertainty in map products, because it is difficult to know whether snow is under the canopy. In this study, the team found that their canopy correction methodology using the NLCD TCC datasets improved remotely sensed snow mapping accuracy in forested environments, reducing bias by 20 percent.

Snow surface temperatures—Space-based optical sensors cannot measure surface brightness or reflected light from snow or vegetation under closed tree canopy. The NLCD TCC maps were useful to this study in mapping the location and relative cover of tree canopy cover, which, when combined with thermal satellite imagery, yields a mean temperature for the portion of the canopy in sunlight during the day. This is warmer than snow surface temperatures under the canopy. These measures are important in forecasting snow melt where it makes up a significant component of drinking water supplies.

Carbon and biomass—NLCD TCC datasets were used in the assessment of greenhouse gas fluxes resulting from land use and land-use change in the U.S.

Bioenergy potential and suitability modeling—NLCD TCC datasets were used along with NLCD land cover data to represent green areas in a study of methodologies for bioenergy estimation and facility location selection.

Urban forests—This study found that tree canopy cover within a one-mile radius of public high schools in Illinois was positively related to high school academic performance but not to graduation rates.

Environment and health—This work made quantitative economic estimates on the value that tree cover provides for the U.S. urban population in heat reduction (avoided deaths, illness, and electricity consumption). Even with the acknowledged underestimate of urban area TCC associated with the NLCD TCC 2011 product, data from over 97 U.S. cities suggest an estimated $1.3–2.9 billion value for heat-reduction services by tree canopy cover. The work also extrapolated this value to the entire urban U.S. population at $5.3–12.1 billion, accounting for urban gradients from downtown out to suburbs.

Environmental justice—The RAND Corporation used NLCD TCC and other datasets to develop a tool to compare current environmental indicators to the history of discriminatory redlining policies in housing in the U.S., which created neighborhoods where disproportionate environmental burdens persist.

Urban heat islands—TCC datasets were used in a study of urban heat vulnerability and urban cooling interventions in Yonkers, New York. Neighborhoods identified by the project results can support equitable distribution of cooling infrastructure. The analyses will serve as a heat literacy tool to educate residents and officials about how investment in tree canopy cover improves the city's environment and helps reduce extreme heat.

Topographic maps—NLCD TCC datasets are used to map woodlands as one of the data layers in the Forest Service Base Maps products, which are produced for a variety of scales and cover all Forest Service lands.

Updated Workflow in 2023

The team revamped their workflow for efficiency and sustainability. They now use Google Earth Engine (GEE), which provides access to large amounts of hosted image data and massive computing and storage capacity. The GEE-based workflow drastically streamlines image management and processing, the creation of national composites of satellite images, and the application of LandTrendr—a process that removes noise from the image time series. The GEE environment empowered the team with easier data exploration and testing and allowed for more robust quality control. Outcomes of this new workflow include improved quality controls and maps; a more consistent data record—a critical characteristic for environmental monitoring data; and lower latency—the ability to make new data available to users more quickly.

FIA data are still processed and used only on powerful local GTAC machines, to maintain FIA security protocols and standards.

"Earth Engine allows us to ask questions that we never could," says Ian Housman, lead technical consultant with RedCastle Resources.

Annual Data Allow More Uses

Jody Vogeler, research scientist at the Natural Resources Ecology Laboratory at Colorado State University and Forest Service TCC science team collaborator, notes that as the time series of these data becomes longer, there will be more uses for it, because of more ecologically relevant time scales.

"Now that we have TCC in annual time steps," says Vogeler, "it opens up a lot of opportunities for matching the timing of other datasets." For instance, collecting wildlife data is time- and labor-intensive. In studying habitat, Vogeler notes the importance of having vegetation data that match the timing of when the wildlife data were collected. Scientists often use wildlife datasets to ask new questions for years after the data were collected. Having the annual TCC maps allows scientists to use updated vegetation data and continue to extract value out of wildlife datasets.

Canopy cover is a critical variable in almost all wildlife habitat suitability models. Separate from her research for the Forest Service TCC science team, Vogeler is researching habitat for the Canada lynx, which is listed as threatened under the Endangered Species Act. The Forest Service is mandated to protect and conserve their habitat.

The 2021 Bipartisan Infrastructure Law includes funds for managing fuels in the wildland-urban interface in the West. The goal is to achieve fuel management to reduce wildfire risk without negatively affecting habitat for species of concern, such as Canada lynx. TCC data can help to clarify that delicate balance.

The Google Earth Engine environment enables the production team to streamline workflows, data exploration, and quality control/testing. For example, the team developed applications with the geeViz data viewer to quickly evaluate the effects of testing different modeling and input parameters. The top viewer screen shows test model results that yielded missing data pixels. The team adjusted the inputs, remodeled, and used geeViz to interactively verify that the changes had positive effects on the model output without having to wait until much later in the modeling process or download large amounts of data. USDA Forest Service, GTAC

Time series data allow for analyses of disturbances, which are often unpredictable. These annual data can be evaluated for changes to TCC pre- and post-disturbance and allows researchers to pose questions about how patterns of canopy patches in the postdisturbance landscape potenitally affect wildlife or connectivity of habitat.

"If we can represent their habitat using these spatial products, we might be able to better help managers pinpoint where they can protect certain forest patches, or direct them in planning their forest management activities." —Dr. Jody Vogeler

Nuanced Trends

The annual time steps in the latest release of data allow users to account for both gross (sum of all losses and gains) and net change (the difference between TCC losses and gains for the period of choice from 2008 to 2021). This accounting provides a more precise depiction, because net change can underestimate total change on the landscape.

The goal of the new annual Forest Service TCC data is not to identify forest disturbance events, says Schleeweis. It is to look at consistent trends through time. Monitoring allows users to identify the direction (increase or decrease) and magnitude (percent of vegetation affected) of changes—to determine if there are departures from baseline and if an area is on the brink of larger change.

Summary

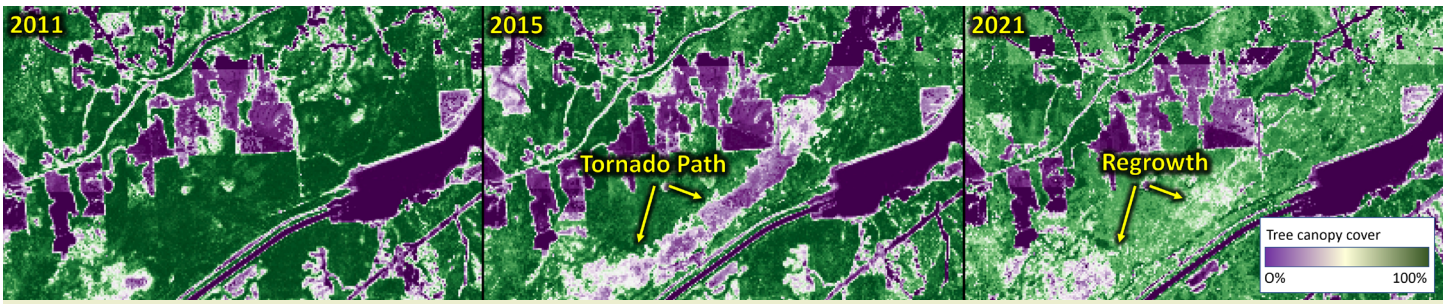
Tree canopy cover (TCC) is a proxy for forest structure and function. The USDA Forest Service National Land Cover Database (NLCD) TCC datasets were created to improve understanding of tree cover nationally and to inform forest, watershed, and wildlife policy, among other applications. The NLCD TCC datasets have been used in investigations related to land cover projections, postfire vegetation cover, wildlife habitat modeling, bioenergy, snow cover modeling, forest health reporting, environment and health, and urban heat islands, among other uses.

In 2023, the Forest Service TCC project released data that included a new collection of annual NLCD TCC maps (2011–2021) supplemented with annual Science TCC data for 2008–2021, standard error, and model uncertainty to better meet the needs of project stakeholders and multiple user communities.

For the same reason, the team updated their workflow in 2023 to use Google Earth Engine, which makes map production and release faster, more automated, and more accurate.

The NLCD TCC maps long have supported spatial analyses. Now, with longer coherent time series, these datasets can support observations and investigations of the patterns and processes that affect, and are affected by, tree canopy dynamics (stability, loss, and gain) through time.

"Tree canopy cover data, together with FIA data, can tell the story of how things are changing on the landscape, where some of those changes are occurring, and even why." — Kevin Megown



A tornado with winds up to 150 mph tore through Tupelo, Mississippi, in spring 2014. The annual NLCD TCC time series captured the shifts in canopy cover, here truncated to three time steps: persistent pre-tornado conditions in 2011, the loss in 2014, and the growth that had occurred by 2021. USDA Forest Service, GTAC

Supporting Community and Urban Forests

Thirty-meter resolution data are not best suited for analysis of tree cover in urban areas, but NLCD TCC is still a good proxy for social inequality.

The datasets are useful to a tree canopy assessment tool that is geared specifically for community and urban areas—i-Tree Landscape. This tool allows users to explore urban tree canopy, land cover, and demographic information; view tree canopy benefits in terms of carbon dioxide, air pollution, and stormwater impacts; and identify priority tree planting and protection areas for climate and social justice efforts. Where communities do not have their own high-resolution canopy cover data, i-Tree uses the most recent NLCD TCC data.

Ongoing Research

Over the last five years, the Forest Service TCC science team has included researchers from four of the Forest Service research stations and five universities. They have investigated new techniques related to accuracy standards and protocols, potential to augment the FIA reference data, the stability of the models over time, and the sensitivity of the time-series record to disturbance and regrowth. Most of these projects will culminate in refereed journal articles or related manuscripts, including an in-depth manuscript on the new methods.

Management Implications

- The new time series of Forest Service TCC maps and data are available for the continental United States, coastal Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands.
- The new 2011–2021 NLCD TCC datasets are designed to reflect canopy cover changes greater than 10 percent loss or gain. The temporally coherent maps can inform not only the direction of change, but also the magnitude. Due to the high temporal resolution, they can also be used to better report gross and net change categories through time.
- The NLCD TCC has been used to improve the precision of nationwide forest inventory estimates; in broad-scale assessments of wildlife habitat; in studies of environmental justice, urban heat, and energy consumption; and to inform snow mapping and snow surface temperatures critical for water supply forecasting in the dry West, among other uses.

Vogeler and her lab group are consistent contributors to Forest Service TCC project research:

- About one project, Vogeler explains that while we often train models on one or a few periods of time from a set of training data, we then want to apply those models across longer time periods. This project seeks to validate those models across that longer timeline and determine how stable they are through time.
- Another project tests both the impact of different training data sources on the resulting maps and their impacts on FIA estimation, which uses NLCD TCC to improve the precision of forest characteristics. The project has traditionally used interpretations from high-resolution aerial imagery as training data for canopy cover modeling, but that is time- and cost-intensive data to collect. The team wants to know if there are other data or combinations of data that might also serve as training data. Vogeler's lab is looking at airborne and spaceborne lidar, such as NASA's Global Ecosystem Dynamics Investigation (GEDI)—high-resolution laser ranging of Earth's forests and topography from the International Space Station—and different types of TCC measurements from FIA field plots in Colorado. Because accuracy can vary with forest type and spatial arrangement, these are factors in data suitability that warrant exploration.
- A third project is quantifying TCC sensitivities across different disturbance histories. Vogeler's lab has created a suite of different continuous "GEDI fusion structure products"—30-meter resolution, Landsat-based, and trained on GEDI data—across six western states. The lab is comparing the GEDI products, airborne lidar, and the 2023-released Forest Service TCC time series for their performance in characterizing post-disturbance tree canopy structures and to identify paths for improvements.

"As new data become available," Vogeler says, "it's important to continue to test how new technologies might improve our ability to minimize error."

Key Findings

- The NLCD TCC products support multiple Forest Service business needs; the USDA Forest Service Resources Planning Act Assessment, FIA estimation for state and national reporting, i-Tree Landscape, the Multi-Resolution Land Characteristics (MRLC) Consortium, and the Greenhouse Gas Inventory and Assessment program.
- The newly redesigned workflow in Google Earth Engine allows for quicker release of new annual maps in the time series.
- In the last five years, the project's science team and researchers from four Forest Service research stations and five universities have engaged in studies to inform the next generation of Forest Service TCC mapping.

Error and Accuracy

"With any mapping product based on a model," says Vogeler, "there are going to be errors associated. It's important for end users to understand what those errors are and how that might impact how they interpret results for their own applications." If users are looking at change in TCC data between years and the percentage change is about the same as the percent error in the map, they should have low confidence in whether there was actually a change.

Schleeweis cautions users that pixel counting (summing up pixels in an area of interest) is not guaranteed to provide unbiased area estimates on any map. Map performance in one 10-acre area may or may not be representative of other areas of the same size, if landscape characteristics differ among the areas.

As noted above, the project team is always looking for ways to reduce error. Users should know that the NLCD TCC has been filtered through time to smooth out any changes that do not amount to an increase or decrease of at least 10 percent TCC. Users also should understand that appropriate scales for applications using the data are much larger than a single pixel and vary by location and specific use. The Forest Service TCC project provides abbreviated methods and accuracy reports in a technical report, while the full methods paper is in progress.

Next Steps

Schleeweis believes that the Forest Service TCC data are "on the cusp of being able to feed a whole new range of users and applications." Besides initiatives noted above, the project team is working on:

- ensuring the data are used by and useful to a wide range of users, and evaluating the ability of the new Forest Service TCC time-series data to inform specific resource and management applications;
- enhanced methods of data delivery and communication and developing reporting capabilities that are more accessible to people without geographic information systems (GIS) skills;
- hindcasting Forest Service TCC data back to 1985 across the conterminous United States to allow deeper trend analysis over almost 40 years;
- improved accuracy reporting and enabling users to make informed decisions about acceptable accuracy; and
- investigating synergies between the Forest Service TCC and the Landscape Change Monitoring System (LCMS), a Forest Service product that provides maps of land cover and land use classes separately. Used together, the two products may be able to provide users unique information about the landscape.

"Trees are some of the biggest organisms in our environment, so they have a large impact in transfer of energy, cycling of nutrients, hydrology—the basic systems of the planet. Knowing where they are, and in what density, is critical."

— Dr. Karen Schleeweis

Further Reading

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Dedication

This bulletin is dedicated to Dr. Jarlath O'Neil-Dunne (University of Vermont and USDA Forest Service–Northern Research Station), who passed away in early 2024. Dr. O'Neil-Dunne and his team at the Spatial Analysis Lab, through Forest Service TCC science team collaboration, contributed immensely to the future of the project, both in spirit and in practice. The lab continues to collaborate on delivery of high-quality and high-volume production of tree structure measurements with robust QA/QC from airborne lidar at a national extent.

Scientist and Collaborator Profiles

The following individuals were instrumental in the creation of this Bulletin:

Kevin Megown is the program lead for the Resource Mapping, Inventory, and Monitoring program at the Forest Service–Field Services Innovation Center. His focus is on applying geospatial sciences and tools for development of products and services supporting Forest Service business needs.

Dr. Bonnie Ruefenacht is a senior specialist with RedCastle Resources, Inc. Her work involves modeling and analysis of various types of remote sensing and geospatial data.

Dan Ryerson is a geospatial specialist with the Geospatial Technology and Applications Center (GTAC). His work involves coordinating and facilitating several vegetation mapping projects through the center. Prior to joining GTAC, he worked for the Forest Service Southwestern Region, primarily with Forest Health Protection, monitoring and assessing forest conditions.

Dr. Karen Schleeweis, the current Forest Service TCC project science team lead, is a supervisory biological scientist and the FIA program's Techniques Research team lead in the Rocky Mountain Research Station. Her work focuses on developing and applying geospatial techniques to guide natural resources-related land management decisions and integrating geospatial and remote sensing technologies into inventory and monitoring processes. She earned a Ph.D. in geographical sciences from the University of Maryland, College Park.

Dr. Jody Vogeler is a research scientist at the Natural Resources Ecology Laboratory at Colorado State University. Her research program integrates remote sensing data sets with field surveys and other reference data focusing on the intersection of wildlife habitat ecology, carbon dynamics, and human-environmental interactions within changing forest and woodland systems. She earned a Ph.D. in forest science from Oregon State University.

Scientist and Collaborator Profiles

The following individuals have been/are current collaborators on the US Forest Service Tree Canopy Cover project's Science Team:

USDA Forest Service Research and Development, Forest Inventory and Analysis Program: Dr. Karen Schleeweis, Dr. Demetrios Gatziolis, Dr. Greg Liknes, Dr. Andy Lister, Dr. Mark Nelson, Dr. Todd Schroeder

USDA Forest Service Research and Development: Jim Ellenwood (WO), Dr. Andy Hudak (RMRS), Dr. Bob McGaughey (PNWRS)

USDA Forest Service National Forest System, Geospatial Technology and Applications Center (GTAC): Stacie Bender, Michael "Seth" Bogle, Wendy Goetz, Josh Heyer, Ian Houseman, Dr. Bonnie Ruefenacht, Dan Ryerson, Vicki Smith

Colorado State University: Patrick Fekety, Steven Filippelli

Virginia Tech: Dr. Jill Derwin, Ben Miller, Dr. Susmita Sen, Dr. Valerie Thomas, Dr. Randy Wynne

University of Vermont: Terry Barrett, Dr. Jarlath O'Neil-Dunne

University of Maryland: Dr. Chengquan Huang, Dr. Khaldoun Rishmawi

Oregon State University: Dr. Franscisco Mauro

Conservation Science Partners: Dr. Tony Chang (Dr. Brett Dickson)

This Science You Can Use Bulletiin was written primarily by Dr. Karen Schleeweis with co-author Joy Drohan.

Writer's Profile

Dr. Karen Schleeweis is a supervisory biological scientist and the FIA program's Techniques Research team lead in the Rocky Mountain Research Station.

Joy Drohan is a freelance science writer and editor specializing in environmental and agricultural topics.

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The purpose of SYCU is to provide scientific information to people who make and influence decisions about managing land.

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