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Need to Manage Management Decisions About Carbon: There Is a Dashboard for That

SUMMARY

The 193 million acres managed by the Forest Service play a significant role in the United States' mitigation of climate change by serving the dual role of removing carbon from the atmosphere and providing long-term carbon storage. In acknowledgment of the importance of these lands, the 2012 Forest Planning Rule requires forest management plans to address how management activities will affect carbon stocks. However, when the rule was adopted, there weren't baseline carbon stock estimates readily available to forest managers, nor was it fully understood how management activities or disturbances affect carbon stocks.

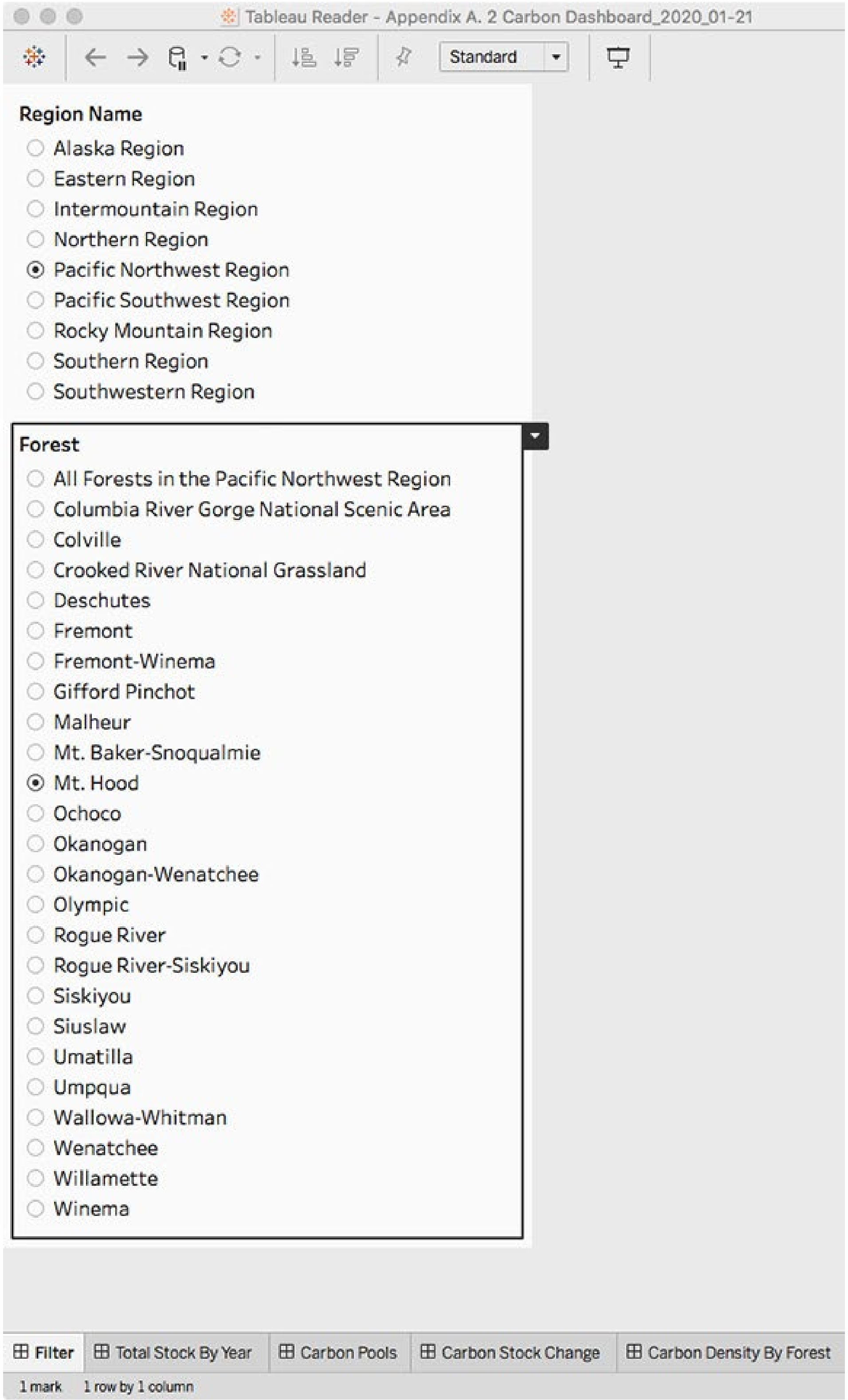
A research team with members drawn from the USFS R&D and academia sought to quantify the historical and present-day flow of carbon through the National Forest System. This required calculating a baseline assessment of carbon stocks that was combined with carbon fluxes resulting from disturbances, and the carbon still stored in forest products.

To make the carbon data easier to work with, the Office of Sustainability and Climate (OSC) created a Carbon Dashboard that provides carbon stock data for every single National Forest. As a companion to the Carbon Dashboard, OSC also created carbon templates that can be included in forest management plans and other policy-required documents. These tools will greatly aid planners and specialists as they consider effects of management activities on forest carbon and for forest- and regional-level planning.

A commonly repeated request by USDA Forest Service (USFS) line officers and district rangers is the need for data and resources to help inform management decisions or fulfill policy mandates. And that's what makes this carbon-focused initiative different from other initiatives supported by the USFS Office of Sustainability and Climate (OSC). This initiative took a holistic approach to develop the resources that the National Forest System (NFS) would need to manage for carbon—from the data on how much carbon is stored on any given National Forest to public-facing outreach materials on the carbon cycle. (Following the adoption of the 2012 Forest Planning Rule, carbon storage is an ecosystem service that must be managed along with wildlife habitat, water quality, recreation amenities, and timber.)

This initiative drew upon the expertise of disciplines and research units across the Forest Service. A supporting research team led by Sean Healey, a research ecologist with the Rocky Mountain Research Station (RMRS), and Richard Birdsey, a recently retired program manager for the Northern Research Station's (NRS) Global Change Research Program, conducted carbon baseline assessments that would enable NFS planning units to assess how management activities, disturbance, and the environment affect carbon storage.

OSC staff Duncan McKinley, a natural resource management specialist, and Alexa Dugan, formerly a carbon science specialist, transformed these carbon data into a visual framework, the Carbon Dashboard, to make it more easily useable by planning and NEPA specialists. They also collaborated with several regions to create carbon templates for use in project planning and forest management plans. Additionally, they created educational materials on the carbon cycle and the role of the Forest Service in sequestering and storing carbon.



Within the Carbon Dashboard, you can filter by region and National Forest.

"We're delivering a complete package, including science and communication products, so we can help our folks not only use the information in their day-to-day job for NEPA and planning, but to help them create a constructive dialogue with the public," explains McKinley.

In the year since the release of these resources, these carbon resources are being used by 50 National Forests and counting. Not only are staff reporting saving time when it comes to answering questions related to carbon, but there is an invaluable consistency across the NFS when it comes to understanding and communicating the Forest Service's role in the carbon cycle.

What follows is an overview of these carbon resources.

An Overview of the Carbon Dashboard and Carbon Templates

The Carbon Dashboard includes two sets of data across the NFS: carbon baseline assessment data from 1990 to 2013 and disturbance data from 1991 to 2011. Carbon baseline assessment is how carbon stocks changed from year to year, while the disturbance assessments consider how carbon stocks were affected by various types of disturbances, both natural and human.

Although these data are detailed in General Technical Reports, McKinley and Dugan realized that displaying data in Excel spreadsheets or requiring managers to find the data themselves wasn't feasible. Feedback from managers included some confusion about how to integrate the data into their work.

"The attendees asked, 'How do I put this into my environmental impact statement [EIS]?'" Dugan says. "Or 'how do I write an environmental assessment using this?' At that point we started framing the data differently. What do our policies say we need to include in the documents, such as EISs or forest management plans, and how can our carbon data fit into that?"

Through word of mouth, they learned about Tableau, software that is designed to tell a story visually with data. Dugan worked with Nathan Walker, a web GIS specialist to import the carbon baseline assessment data into Tableau and create what later became known as the Carbon Dashboard for the NFS.

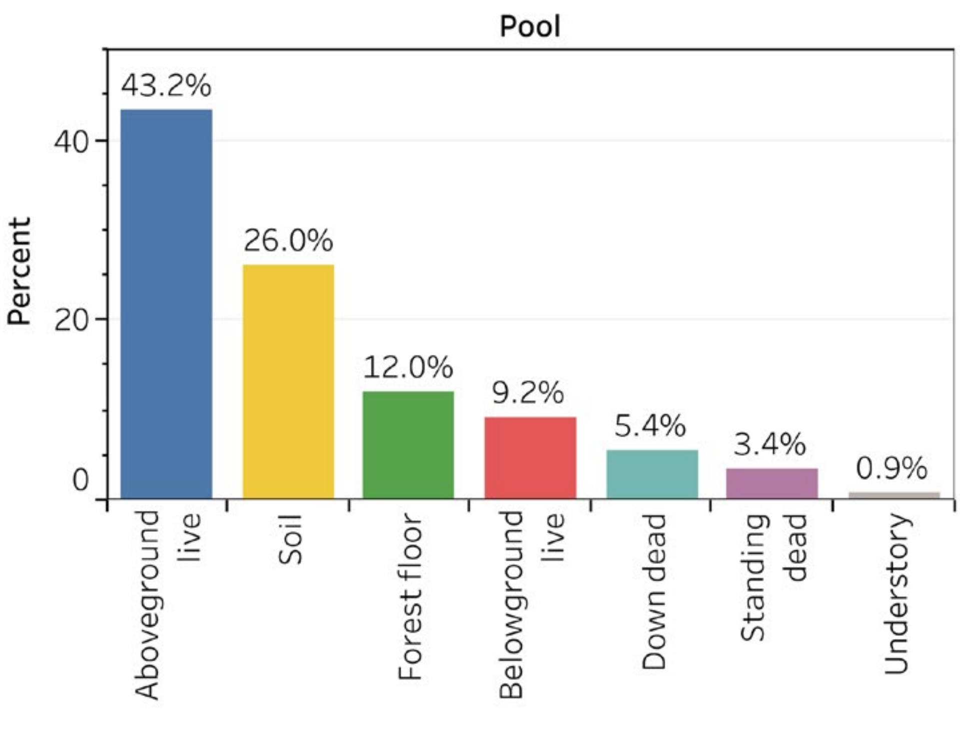
To view the Carbon Dashboard, you need to:

- Download Tableau reader, which is free and available at https://www.tableau.com/en-gb/products/reader.
- Download the Carbon Dashboard, which is available at https://usdagcc.sharepoint.com/sites/fs-nfs-osc/Pages/Carbon.aspx.

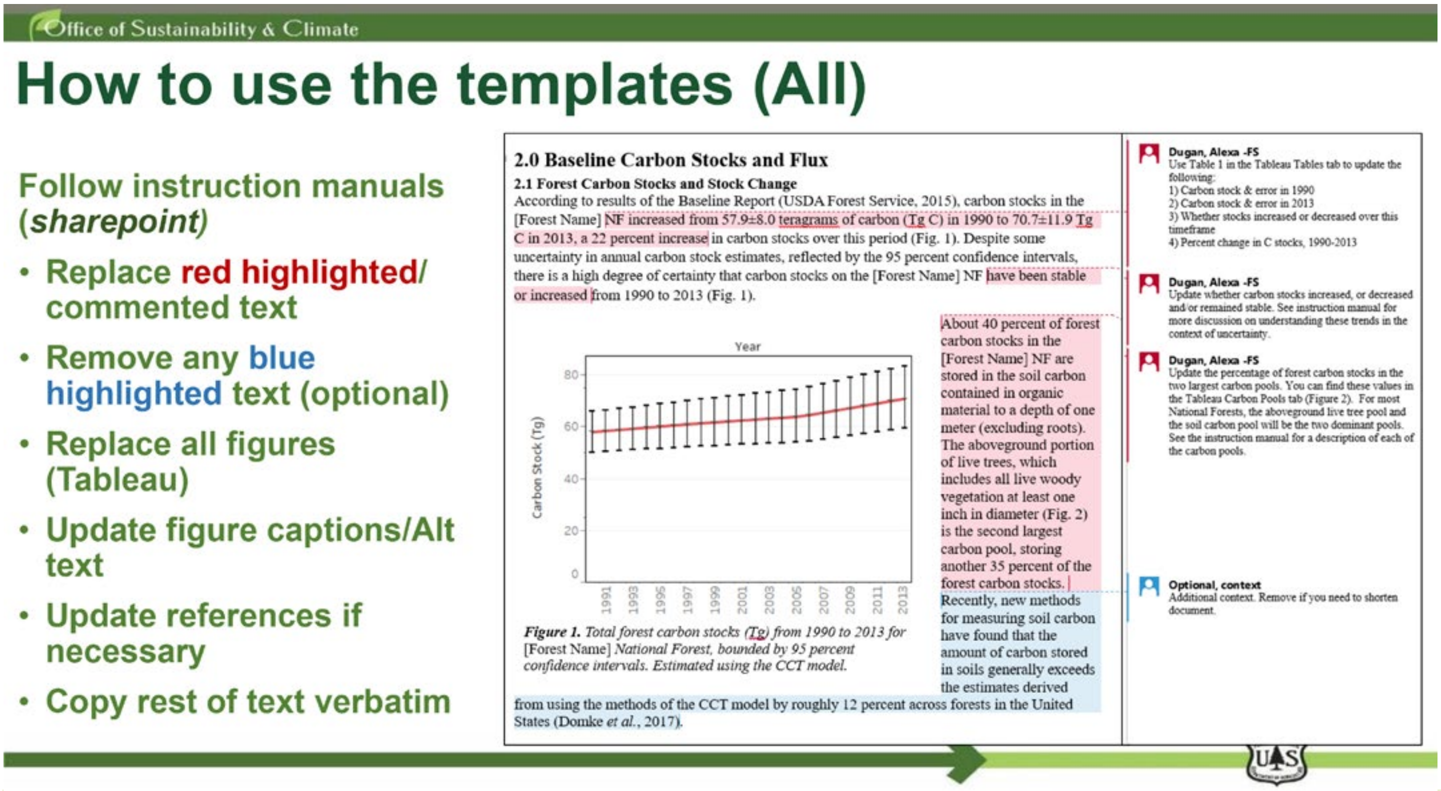
Concurrent with the development of the Carbon Dashboard was the creation of carbon templates. McKinley credits a National Forest in Region 1, which included a chapter on carbon for one of their EISs, as the initial inspiration for creating these carbon templates. In the summer of 2018, McKinley and Dugan gave a customized carbon presentation to Region 9 because one of their Forests was revising their Forest Plan. Among the slides was a mention of the new carbon template. McKinley recalled the audience members asking, "You have all we need; can you just write it for us?"

"Normally we don't get involved with this type of field planning, but we said sure," McKinley explains. "This is a learning experience for us, a new way of working with the field—the Washington Office (WO) rolling up their sleeves and getting into the shoes of people in the field."

McKinley and Dugan worked with Regions 8 and 9 to polish the template and eventually created templates for plan assessments, EISs, and project-level NEPA. These carbon templates are easy-to-



For each National Forest, the data are broken down into 12 categories, which include carbon pools, disturbances by year and type, and carbon accumulation by year. Clicking on a category reveals a graph of the data. Because all the colors are standardized, it is easy to compare variables across different National Forests. As an example, this graph shows the percentage of carbon stocks in 2013 in each of the forest carbon pools for Mt. Hood National Forest. Estimates were made using the Carbon Calculation Tool.



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Outreach Materials and Technical Resources

When it comes to discussing carbon, in his experience, McKinley has found that "it's the biggest source of conflict we have with the public because they view the forest system one way and science views it another way and how do you reconcile that?"

To help staff communicate the science of carbon to the public, OSC has produced a number of outreach materials, including graphics, pamphlets, and videos. "We spent a lot of effort developing communication products," says McKinley. "One of the things we did was took key conceptional work and converted them into relatable graphics that people can use."

The Science Behind the Carbon Dashboard

To calculate the carbon baseline assessment and disturbance assessment, Healey and Birdsey identified the data needed by the NFS planning units to fill out a performance scorecard for their respective National Forest. Specifically, they wanted to calculate a breakdown of the different carbon pools on the landscape and the impact of different disturbance processes, such as management or harvest, as well as fire and insects and other disturbances, on carbon storage for an individual National Forest. "Our goal was to cover the whole range of factors that affect carbon stocks on National Forests," Birdsey explains.

Following discussions with Dave Cleaves, the climate change advisor to former Forest Service Chief Tom Tidwell, Healey and Birdsey agreed that Forest Inventory and Analysis

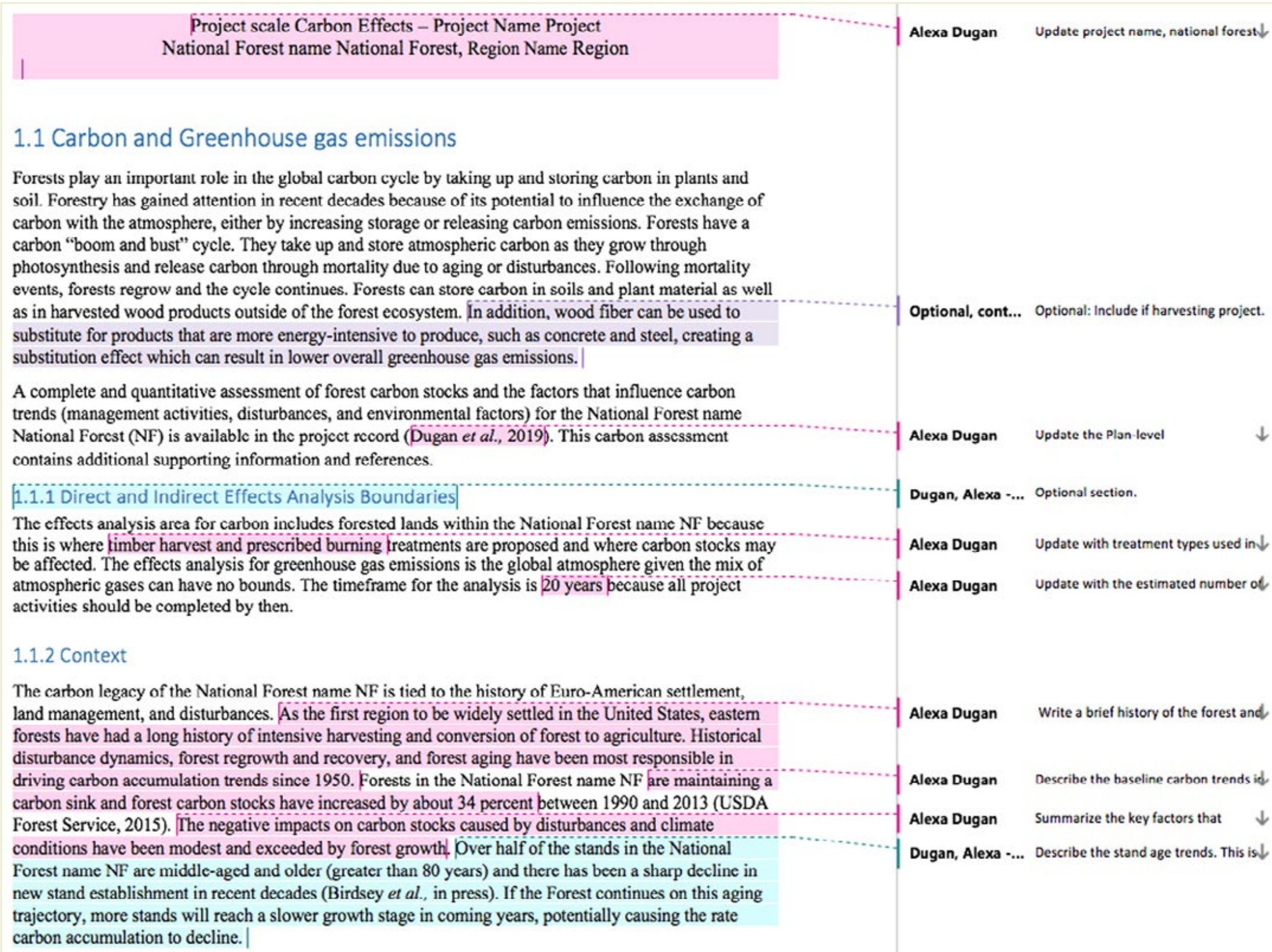
The resources are available at: https://usdagcc.sharepoint.com/sites/fs-nfs-osc/Pages/Carbon.aspx

(FIA) data would form the basis of their calculations. "FIA data are on-the-ground measurements that are taken at a pretty high density locally," explains Healey. "FIA data are also the basis for a lot of other ecosystem services the National Forest System tracks and makes decisions on, such as timber and wildlife habitat."

Birdsey would focus on quantifying how environment variables, including climate change, could affect the carbon stocks on the National Forests. Land management actions, such as fuel treatments, restoration projects, or timber sales, can impact carbon stocks, as can natural disturbances like insect epidemics or droughts. "By teasing these factors apart," Birdsey adds, "this really helps determine whether a manager's actions are affecting carbon stocks or if it is wildfire or drought."

To quantify these environmental variables, he tapped the expertise of Jing Chen, a professor at the University of Toronto. In 1998, Chen and his team released the Integrated Ecosystem Carbon Model or InTEC, which was designed to estimate the carbon budget of Canada's forests in response to a changing climate. "This model is able to simulate ecosystem processes, like photosynthesis and respiration and transpiration, and the transfer of carbon between pools," says Birdsey.

Although developed for Canada's boreal forests, the model was applicable to the United States' forests because the underlying science of physiological and ecosystem processes built into the formulas are comparable. However, there was a bit of calibration required so the FIA data could be used to run the model. In addition, local climatic data were used to determine how changing temperature and precipitation may affect tree growth and, by extension, carbon storage.



Project scale Carbon Effects – Project Name Project
National Forest name National Forest, Region Name Region

1.1 Carbon and Greenhouse gas emissions

Forests play an important role in the global carbon cycle by taking up and storing carbon in plants and soil. Forestry has gained attention in recent decades because of its potential to influence the exchange of carbon with the atmosphere, either by increasing storage or releasing carbon emissions. Forests have a carbon "boom and bust" cycle. They take up and store atmospheric carbon as they grow through photosynthesis and release carbon through mortality due to aging or disturbances. Following mortality events, forests regrow and the cycle continues. Forests can store carbon in soils and plant material as well as in harvested wood products outside of the forest ecosystem. In addition, wood fiber can be used to substitute for products that are more energy-intensive to produce, such as concrete and steel, creating a substitution effect which can result in lower overall greenhouse gas emissions.

A complete and quantitative assessment of forest carbon stocks and the factors that influence carbon trends (management activities, disturbances, and environmental factors) for the National Forest name National Forest (NF) is available in the project record (Dugan *et al.*, 2019). This carbon assessment contains additional supporting information and references.

1.1.1 Direct and Indirect Effects Analysis Boundaries

The effects analysis area for carbon includes forested lands within the National Forest name NF because this is where timber harvest and prescribed burning treatments are proposed and where carbon stocks may be affected. The effects analysis for greenhouse gas emissions is the global atmosphere given the mix of atmospheric gases can have no bounds. The timeframe for the analysis is 20 years because all project activities should be completed by then.

1.1.2 Context

The carbon legacy of the National Forest name NF is tied to the history of Euro-American settlement, land management, and disturbances. As the first region to be widely settled in the United States, eastern forests have had a long history of intensive harvesting and conversion of forest to agriculture. Historical disturbance dynamics, forest regrowth and recovery, and forest aging have been most responsible in driving carbon accumulation trends since 1950. Forests in the National Forest name NF are maintaining a carbon sink and forest carbon stocks have increased by about 34 percent between 1990 and 2013 (USDA Forest Service, 2015). The negative impacts on carbon stocks caused by disturbances and climate conditions have been modest and exceeded by forest growth. Over half of the stands in the National Forest name NF are middle-aged and older (greater than 80 years) and there has been a sharp decline in new stand establishment in recent decades (Birdsey *et al.*, in press). If the Forest continues on this aging trajectory, more stands will reach a slower growth stage in coming years, potentially causing the rate carbon accumulation to decline.

A screen capture of a carbon template open in a Microsoft Word window. Carbon templates are available for the following management scenarios.

Forests not revising their forest management plan

- *Forest-level White Paper*

Forests revising their forest management plan

- *Plan assessment*
- *EIS*
- *Project-level NEPA*

As Birdsey's team quantified how environmental processes affected carbon stores, Healey quantified how disturbances, such as wildfires, insect outbreaks, and timber harvests, affected carbon. Although the science of wildfire's and insect outbreaks' effects on carbon were well established, not so much for timber harvests.

"There was a question about the contribution of harvested wood products to the carbon cycle," Healey explains. "People cut down trees for forest products, but that wood doesn't automatically go into the atmosphere. It's turned into paper, construction materials, and other wood products that decompose over time and goes into landfills or the atmosphere."

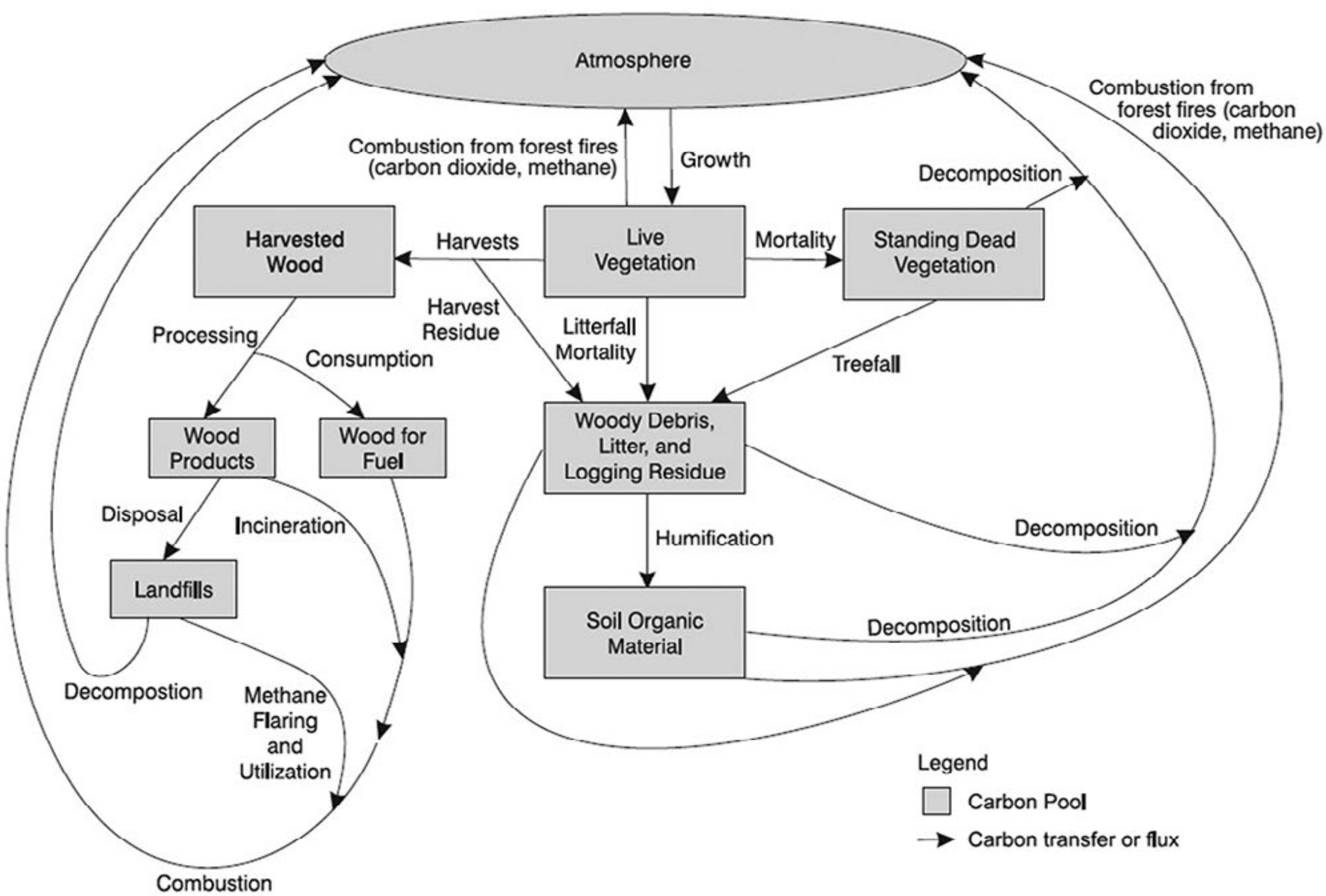
Disturbance maps, created from LandSAT images, also provided data on harvests and natural disturbances from 1990 to 2011.

For the carbon baseline assessment, Healey sought the assistance of other Forest Service researchers working on this area of carbon. Researchers with the Forest Products Lab had data on how long carbon remains sequestered in forest products, and economist Keith Stockmann led an effort to create a harvest products life cycle for each National Forest from 1906-2010.

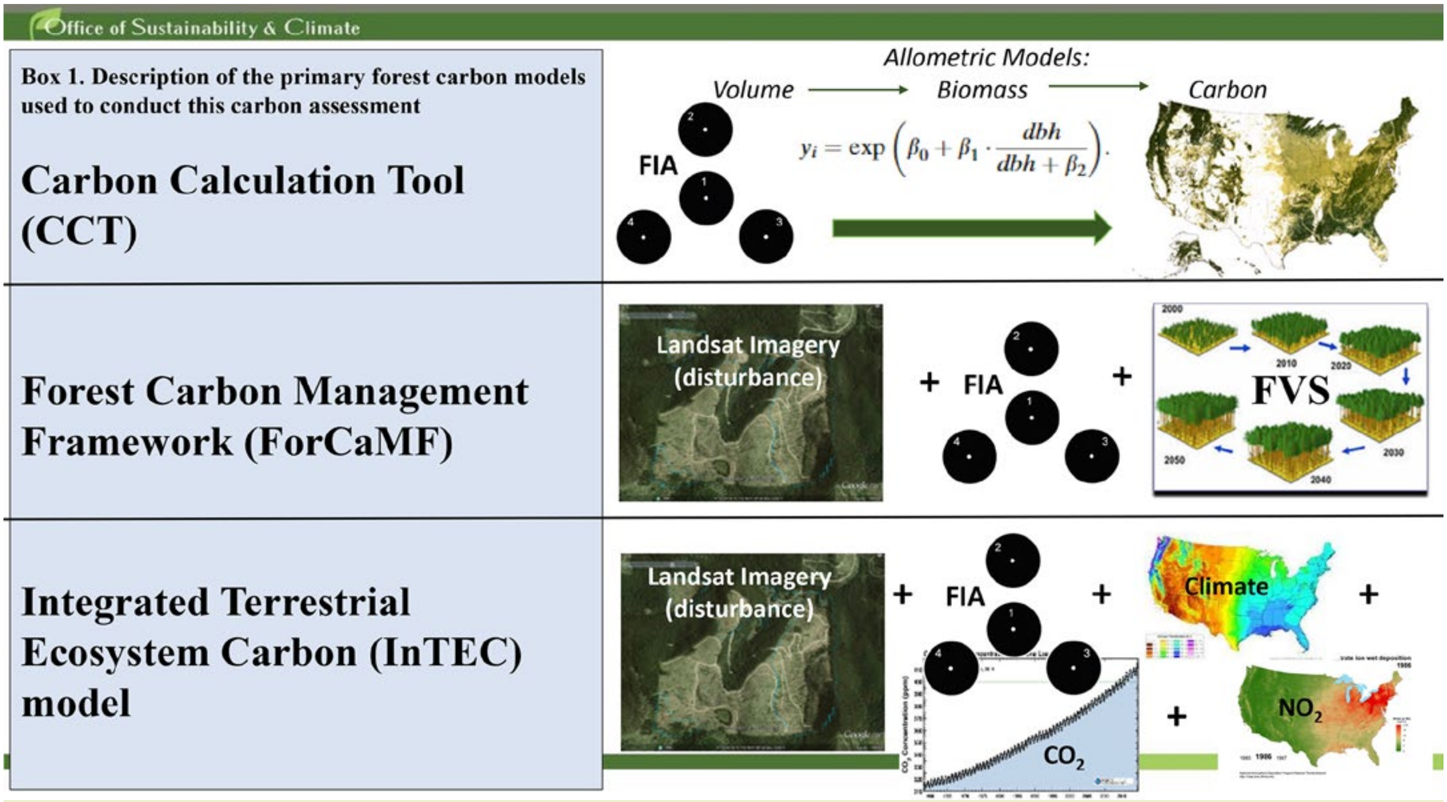
The Forest Carbon Management Framework (ForCaMF) provided data on how the impact of disturbance on the carbon stock over the past 30 years enabled the team to assess the sensitivity of landscapes to wildfire or insect outbreak disturbances, which has carbon storage implications. "If we know that carbon would be 5 percent higher now or 10 percent higher, it tells us how sensitive the area is to fire," Healey explains. "It's not a perfect predictor of what the future holds, but it's a pretty good indicator of risk."

The final set of numbers needed for the analysis—the current carbon pools on the landscape—was generated by the Carbon Calculation Tool (CCT). The CCT is used by the United States to report the nationwide forest carbon totals to the United Nations and provides a summary of current carbon pools. A team at the Northern Research Station used CCT to create carbon estimates by carbon pool type for each National Forest.

Forest Sector Carbon Pools and Flows



The forest sector has seven distinct carbon pools, and the Carbon Dashboard provides data on how the volume of carbon has changed within these pools. Quantifying these volumes required drawing upon multiple datasets, including FIA data, life cycle analyses, and LandSAT imagery. Image taken from Assessment of the Influence of Disturbance, Management Activities, and Environmental Factors on Carbon Stocks of United States National Forests.



The foundation of the carbon baseline assessments for each national forest are its FIA data being fed into three carbon models. Slide created by Office of Climate and Sustainability.

The Carbon Dashboard and Carbon Templates in Action on National Forests

Region 8—Francis Marion and Sumter National Forests White Papers

As the forest planner for both the Francis Marion and Sumter National Forests, Mary Morrison updates the forest plans and writes the biennial monitoring reports. Since the adoption of the 2012 Forest Planning Rule, monitoring reports must now include how each Forest is managing its carbon.

For the most recent monitoring reports, Morrison simply appended the Forest Carbon Assessment white paper that her colleague Patrick Yamnik, the environmental coordinator for the Francis Marion and Sumter National Forests, wrote for each respective Forest. Yamnik didn't spend hours tracking down and compiling carbon data to write the white paper. Instead, he used data from the Carbon Dashboard and the Forest Carbon Assessment white paper template.

"We don't get a lot of questions from stakeholders and the public about carbon, but we do get some," Yamnik says. "It is helpful to have the white paper and the supporting information to respond when we do get comments."

Region 9 - Hoosier National Forest Project Level Planning

For an upcoming forest management project, Chris Thornton, the ecosystem program manager on the Hoosier National Forest, needed to address carbon stocks because he anticipated there would be public comments related to climate change since it involved harvest treatments of thinning and clearcuts.

Having heard of the Carbon Dashboard, Thornton reached out to the Office of Sustainability and Climate for assistance. After he explained his carbon reporting needs, Dugan created an environmental assessment template that Thornton edited and filled out with data from the Carbon Dashboard and included in the published project package.

Because of his previous experience as a forester, Thornton considers himself knowledgeable about climate change and the carbon cycle. “Yet to sit down and write a technical document about carbon, it would have taken me a long time to do,” he explains. “I wouldn’t have been really confident that it was the best available science because it’s not my area of expertise.”

Region 9 - Wayne National Forest Plan Assessment

Two years ago, the forest plan revision team of the Wayne National Forest began the assessment phase of the plan revision, which entailed reviewing the current plan through the lens of ecosystem services. There would be a main assessment document and 10 supplemental reports.

“Those individual supplement reports were developed because they didn’t quite line up within the context of ecosystem services but information in them was really important and I still wanted to make sure that they had their appropriate place and space to provide the information for the public,” says Lisa Kluesner, a forest ecologist who joined the assessment team earlier this year.

One of these supplemental reports was for carbon. However, lacking a carbon expert and having heard there were carbon templates available, they reached out to McKinley for assistance. McKinley in turn worked with the team to develop a new carbon template for the forest plan assessment.

The forest plan assessment was released for public review, and as it would happen, the public did have questions about climate change. “We did have quite a few comments come in specifically around climate change and carbon,” Kluesner explains. “Those two often came in together. It definitely showed us there is an opportunity to engage more with our public about how the Forest Service is assessing its carbon stocks.”

Kluesner appreciates that OSC is producing the carbon data for use by the NFS, and that the data are standardized: “It definitely helps to take the pressure off the Forest to find someone who has the time and a strong enough understanding of carbon to know what pieces to collect.”

Region 9 - Green Mountain National Forest and Public Comments

Since there is a small staff to oversee the joint administration of the Green Mountain and Finger Lakes National Forests, Jay Strand becomes involved in the environmental analysis work that’s required for projects. As the forest planner and environmental coordinator, Strand knows enough about carbon to “get myself in trouble,” he jokes, but adds, “I’m totally a novice to understanding carbon. I don’t have the expertise to know whether or not the data I’m seeing are actually right or not.”

Around 2018 is when he started seeing public comments about their carbon analysis and comments related to “ensuring we were not impacting the carbon storage capacity and exacerbating climate change issues by emitting carbon into the atmosphere as a result of our timber harvesting practices,” explains Strand. “It was initially raised as something we started to need to put a fine point on. We felt we needed to do a bit more than a cursory review or analysis than we had been doing up to that point of time on carbon emissions.”

Through his work with Maria Janowiak, the deputy director with the Northern Institute of Applied Climate Science, Strand reached out to ask about more resources regarding carbon. She connected him to McKinley and Dugan who, as it turned out, were creating the carbon assessment templates. Dugan worked with Strand to refine the project-level NEPA template for use in the Robinson Project, a timber harvest project.

A year later, when working on a subsequent timber harvest project, also for the Green Mountain National Forest, Strand noticed additional improvements to the project-level NEPA template. “The template now has a lot of

To assist units in determining how they can address carbon stewardship, the Office of Climate and Sustainability outlined a framework for identifying management activities that can be undertaken. Slides created by Office of Climate and Sustainability.

references to the exact same questions that came out of our discussions to the Robinson Project," he says. "It seems much more refined and the comment bubbles throughout it provide really good direction."

In addition to having the templates available, Strand also cites the availability of McKinley to provide much-needed carbon expertise as invaluable. "It's absolutely essential [to have access to Duncan]," Strand explains. "We don't have the expertise on Forests to be able to make a lot of these determinations about carbon."

Region 4—Forest Carbon White Papers

In January 2020, Natalie Little, Region 4 regional sustainability and climate coordinator, hosted McKinley and other speakers on a 1-day webinar on carbon principles and how to develop a forest carbon white paper.

Forests expect to use the information in NEPA and forest plan revision processes, according to Little. "The forest carbon white papers are going to help with communicating and understanding more technical information around carbon," explains Little. "Forest specialists will be able to simply reference the regional carbon white paper in NEPA, Forest Plan Revision, and other efforts providing a consistent best available science approach across the region."

The design of the Carbon Dashboard allows for easy navigation of the carbon data. "It's a big time-saver that specialists are able to easily point and click, selecting the data they need to use in the papers," she says.

A huge benefit of the Carbon Dashboard and carbon templates, Little explains, is "they improve quality of information given to land managers and offer consistency across the region and across the agency, helping us communicate carbon principles with our partners and the general public as well."

The Future of the Carbon Dashboard

Since its formal release last year, the Carbon Dashboard and carbon templates are gradually being adopted across the NFS. "Nearly all of Region 4 and all of Region 6 have their Forests on board, with drafts in progress or nearly finished," says McKinley. "The dashboard has been used to provide the technical background in a white paper for 50 forests, which is huge." Region 9 will likely be next to have white papers written for all its forests, and McKinley has shared his carbon presentation to nearly all the regions.

The Carbon Dashboard will also be a valuable resource when units fill out the new Sustainability scorecard since one of the elements is carbon stewardship. "In order for regions and units to be successful in making progress toward carbon stewardship, this resource allows them a clear and doable pathway to get there," McKinley explains.

For most National Forests, this pathway will begin with writing a white paper and then using the carbon templates as part of their NEPA or EIS process. Other activities include public outreach and engagement once unit employees become more comfortable talking about carbon, and the data in the Carbon Dashboard will be useful when telling the carbon story at the local level.

Expect Updates

What further sets the Carbon Dashboard apart from other projects is that future updates are already planned. Last year, the OSC provided resources to update the baseline carbon data and the harvested wood products section in the dashboard. "Right now, the harvested wood products data are only at the regional scale so there was no Forest-level information," McKinley explains. "It will be updated and improved to include forest-level dynamics."

Healey's team will update the ForCaMF model to include inventory and disturbance data to the most current year since the model data ended in 2011. "There's a lot happening in our forests right now, such as the wildfires and insect outbreaks," says Healey. "Obviously the most recent slice of time is the most important for land managers."

One new resource that Healey's team will use is the Landscape Change Monitoring System. This tool turns Landsat images into high-resolution maps of forest disturbance history for the conterminous United States and Coastal Alaska. "The Landscape Change Monitoring System will save us a lot of time in detecting disturbance than the disturbance maps we used previously," Healey explains.

While approximately a third of the lands managed by the Forest Service are rangelands, there is a critical gap in the Carbon Dashboard to support planning and management in these ecosystems. Nationally, rangelands contain nearly 10–30 percent of soil organic carbon; however, most of these landscapes do not have carbon estimates available.

Matt Reeves, a research ecologist with the RMRS, conducted a carbon stock assessment for the Intermountain Region for shrubs and soil organic carbon. This work was championed by the Region 4 planning group and the brief report is available here: https://www.fs.usda.gov/treesearch/pubs/60860.

> *"The dashboard has been used to provide the technical background in a white paper for 50 forests, which is huge."*
>
> —Duncan McKinley
> *Research Ecologist with the Office of Sustainability and Climate*

Given the success of this inaugural effort, OSC is working with Reeves and Grant Domke, a research forester with NRS, to expand this rangeland cover mapping effort in the lower 48 states.

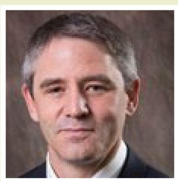
The datasets that Reeves and Domke will create are spatially explicit estimates of standing carbon in shrubs and in the soil; this work will be accomplished using a combination of satellite remote sensing, inventory data, and advanced statistical modelling.

These new data are expected to be included in the Carbon Dashboard by 2022.

SCIENTIST AND MANAGER PROFILES

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

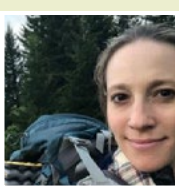
SEAN HEALEY is a Research Ecologist with the Rocky Mountain Research Station. His primary research focuses are assessment of the role of disturbance and management on carbon storage at management-relevant scales, and creating meaningful spatial data products by combining remote sensing and inventory data. Healey earned an undergraduate degree in biology from the New College of Florida, a master's degree in science education from Columbia, and a doctorate in silviculture and forest protection from the University of Washington.



MATT REEVES is a Research Ecologist at the Rocky Mountain Research Station. He specializes in the use of remote sensing and GIS to facilitate evaluation of contemporary issues facing U.S. rangelands. Reeves is the Forest Service liaison to the Northern Plains Regional Climate Hub and serves on the Sustainable Rangelands Roundtable, along with being a member of the Resources Planning Act scientist cadre.

RICHARD BIRDSEY is a Senior Scientist at the Woodwell Climate Research Center. He spent four decades with the USDA Forest Service, studying the role that U.S. forests play in absorbing and storing carbon. He is a specialist in quantitative methods for large-scale forest inventories and has pioneered the estimation of national carbon budgets for forest lands.

DUNCAN McKINLEY is a Research Ecologist with the Office of Sustainability and Climate in the Washington Office.



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About the
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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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