YALE FOREST FORUM

SPEAKER SERIES SUMMARY

FALL 2023

YFF Review

Understanding Climate-Smart Forestry in Practice

September 2023 – November 2023

New Haven, Connecticut, USA

Yale SCHOOL OF THE ENVIRONMENT
The Forest School

Yale Forest Forum
The Forest School at the Yale School of the Environment
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Front cover photo: Ian Christmann.
Left photo: Lynn Robb.

YALE FOREST FORUM AND *YFF REVIEW*

The Yale Forest Forum (YFF) is the convening hub of The Forest School at the Yale School of the Environment. YFF offers weekly webinar Speaker Series during the academic year to provide opportunities to hear from leaders in forest management, conservation, academia, and policy. Each YFF Speaker Series is organized around a key theme or challenge facing forests, forestry, and people. Guest speakers represent a wide range of perspectives and organizations, including government, NGOs, and businesses, and across scales from local to international. The *YFF Review* is a publicly available output of the series, summarizing key learnings and examples from the YFF Speaker Series.

Redwoods marked for post-wildfire recovery and regeneration near Santa Cruz, California. Photo: Lynn Robb.

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Contents

Redwood trees near Santa Cruz, California. Photo: Lynn Robb.

Foresters survey the aftermath of a prescribed ground fire in a southern pine plantation in Raeford, North Carolina. Photo: Isaac Merson.

Introduction

By: Katie Michels

The Yale Forest Forum has been engaging people on cutting-edge issues in forestry through lecture series since 1994. In the fall of 2023, the Yale Forest Forum brought together 2,860 registered attendees from around the world to hear insights from experts and leaders on climate-smart forestry.

Climate-smart forestry has recently become a buzzword across the forestry sector and beyond. Nature-based solutions to climate change are gaining increasing prominence as cost-effective forms of carbon sequestration. In this webinar series, practitioners and researchers described how forests can be managed to enhance their carbon storage capabilities while also increasing their resilience to the impacts of a changing climate. The webinar series explored questions such as:

- How can forests be managed to be resistant to fires, storms, pests, and other acute risks that are exacerbated by climate change?
- What are the tradeoffs between managing forests for climate adaptation, climate mitigation, and other goals?
- How can incorporation of Indigenous knowledge and community connections to land improve outcomes for forests in a time of changing climate?

The series primarily focused on forest management practices in the United States. Speakers represented public-sector organizations, nonprofits, research, and academia from across the country, as well as on-the-ground practitioners. The speakers from this YFF series

shared a range of perspectives on climate-smart forestry and its potential to support both climate adaptation and mitigation goals.

Some speakers laid scientific and historical foundations for the concept of climate-smart forestry. **Steve McNulty** (USDA Southeast Climate Hub), one of the four seminar instructors, introduced the series with a broad overview of the concept of "climate-smart forestry" and how its focus on climate adaptation and mitigation distinguish it from conservation forestry. **Sara Kuebbing** (Yale Applied Science Synthesis Program) described why "carbon forestry" is a topic of increasing interest, offered an overview of how forests cycle carbon, and shared metrics about the carbon sequestration and storage potential of climate-smart forestry.

A few speakers described climate-smart silvicultural practices. **Maria Janowiak** (USDA Northern Forests Climate Hub and Northern Institute of Applied Climate Science) described insights from the Adaptive Silviculture for Climate Change (ASCC) project, which is a series of experimental silvicultural trials from multiple forest ecosystem types in the continental U.S. and Canada. **Scott Stephens** (University of California Berkeley) described silvicultural techniques for managing fire-adapted ecosystems and talked about a project he has been working on in partnership with the Amah Mutsun Tribal Band to reintroduce cultural burning in northern California. **Kyle Burdick** (Baskahegan Company) spoke about how the Baskahegan Company, a commercial timberland owner in northern Maine, decided to sell carbon credits on their commercial forestland and how that sale has both influenced management of their existing lands and enabled them to purchase new forestland.

Speakers described efforts to support adoption of climate-smart forestry practices by private landowners. **Sam Cook** (North Carolina State University) works primarily with African American landowners in the southeastern United States to help them implement forest management activities. Cook spoke about

Longleaf pine regenerates in multiple stages in North Carolina.
Photo: Brandon Wilson Radcliffe.

how climate change will especially impact vulnerable populations, including Black and Indigenous farmers, ranchers, and forest landowners. He also summarized how programs in the Farm Bill carry great potential to contribute positively to climate change mitigation by empowering historically disenfranchised smallholders and landowners and providing them financial and technical assistance. **Stephanie Chizmar** (USDA Forest Service) outlined federal programs and incentives for forest landowners and communities to implement climate-smart forestry practices in the U.S. She described how the 2022 Inflation Reduction Act creates new sources of federal funding for climate-smart forestry practices and incentivizes technical assistance to underserved landowners. **Andrea Colnes** (New England Forestry Foundation) spoke about NEFF's efforts to support climate-smart forestry on privately owned lands. Supported by a USDA Climate-Smart Commodities grant, NEFF is working with different types of landowners in New England to understand barriers to adoption of climate-smart forestry practices. They are also exploring how technical and financial assistance can help landowners manage their forests in ways that contribute to regional carbon sequestration and ecological goals.

Clara Pregitzer (Natural Areas Conservancy) and **Kristen King** (NYC Parks) described their collaborative efforts to manage forests in New York City. The Natural Areas Conservancy and New York City Parks have collaborated to build up technical expertise and decision matrices to ensure that urban forests remain healthy and resilient. This provides important carbon sequestration and human health benefits, such as urban cooling and access to green space.

Mike Dockry (Citizen Potawatomi Nation; University of Minnesota) discussed how Indigenous nations have sustainably managed forests while adapting their forest management to climate, ecosystem, and societal changes for many generations. He underscored that forests have consistently been novel ecosystems, changing in response to human and natural influences, and emphasized the importance of listening to and learning from tribal perspectives in climate adaptation and natural resource planning.

Whether discussing different goals of climate-smart forest management or specific silvicultural techniques, each presentation illustrated how to implement ideas about climate-smart forestry on the ground. Many speakers also touched on programs, policies, and ways of thinking about climate-smart forestry that center the needs of Indigenous and underserved landowners.

“Climate-Smart Forestry in Practice” was facilitated by Mark Ashton (The Forest School at YSE), Gary Dunning (The Forest School at YSE), Lindsey Rustad (USDA Northeast Climate Hub), and Steve McNulty (USDA Southeast Climate Hub). The series was jointly hosted by The Forest School at the Yale School of the Environment, the USDA Northeast Climate Hub, and the USDA Southeast Climate Hub, and co-sponsored by the Yale Center for Natural Carbon Capture.

All materials referenced in this document including bios for speakers, readings, and webinar recordings, can be found on the Yale Forest Forum website.

A longleaf pine stand regenerates after harvest in North Carolina. Photo: Amelia Napper.

What Is Climate-Smart Forestry?

WATCH SESSION RECORDING

Presented: September 11, 2023

STEVEN MCNULTY, PhD, *Senior Research Ecologist, USDA Forest Service; Director, USDA Southeast Climate Hub*

Summary by: Mary Katherine DeWane and Katie Michels

Steven McNulty

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Steven McNulty, director of the USDA Southeast Climate Hub and senior research ecologist for the USDA Forest Service, kicked off the Yale Forest Forum fall 2023 speaker series "Understanding Climate-Smart Forestry in Practice." In addition to introducing the lecture series, McNulty was also one of the facilitators for this YFF speaker series.

McNulty's talk gave an overview of the history of forestry, a general introduction to climate science, and a broad definition of climate-smart forestry. McNulty defines climate-smart forestry as sustainable forest management practices designed to adapt to and help mitigate the effects of climate change.

Sustainable forestry, as it is defined in the Western hemisphere, traces its roots to Germany around 1700, when mining engineer Hans Carl von Carlowitz was concerned about having a sufficient timber supply for sub-surface mining operations. In 1713, von Carlowitz developed the *Sylvicultura Oeconomica* — the first comprehensive guide to forest management. Following the colonization of the United States, massive deforestation led to a similar worry about wood supply, especially in the era of industrialization and war. In response, the U.S. Forest Service held public meetings to discuss sustainable forestry and developed robust forest conservation programs and forest management handbooks.

McNulty noted that existing forest management guidance was very useful until human-induced climate change began to significantly influence forest structure and function. In addition to increased temperatures, climate change also increases overall variability and will contribute to stronger storms, prolonged and more extreme drought, and other catastrophic events.

In a changing climate, forests are under increasing threats from drought, fire, pests, and pathogens. Climate change also impacts forest regeneration and previously sustainable successional regimes.

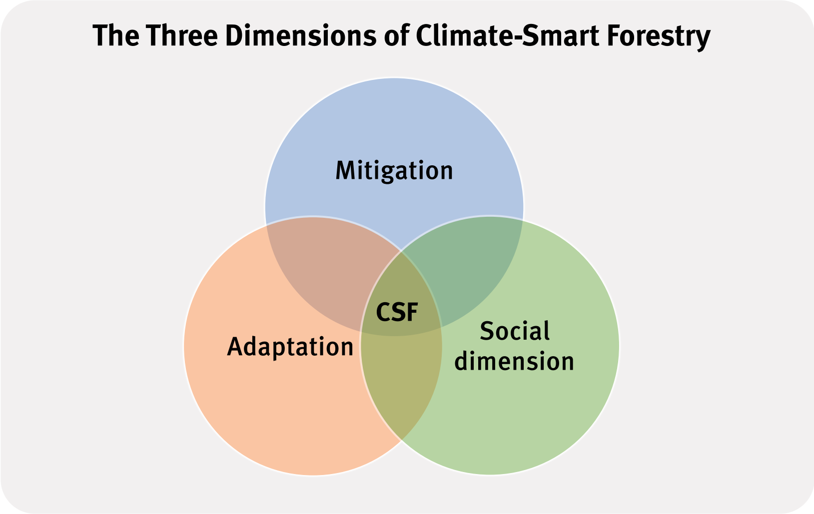

Illustration of the three dimensions of climate-smart forestry: adaptation to a warming future; mitigation of climate change's effects; and consideration of social dimensions of forestry. Figure courtesy of Steve McNulty.

One of the main questions arising from this lecture was how "climate-smart forestry" differs from sustainable forest management practices or "conservation forestry." At one point, McNulty made the point that climate-smart forestry is not that different from "forestry!" McNulty shared a definition which states that climate-smart forestry (CSF): "is a collection of strategies and management actions that increase the carbon storage benefits from forests and the forest sector, in a way that also supports ecosystem services and cultural values.

CSF 1) reduces and removes carbon emissions, 2) increases forest resilience to climate change, and 3) supports forest economies by increasing forest productivity and incomes." Said another way, "CSF enables forests and society to transform, adapt to, and mitigate climate-induced changes." In short, climate-smart forestry is focused on adaption, mitigation, and the social dimensions of forest management, whereas conservation forestry is primarily focused on adaptation and social dimensions.

"Climate-Smart Forestry enables forests and society to transform, adapt to, and mitigate climate-induced changes."

To illustrate climate smart forestry, McNulty shared a case study about pine grown in the southeastern United States. Longleaf pine (*Pinus palustris*) was once widespread across the southeast. Loblolly pine (*Pinus taeda*) was originally found mostly in wetter areas or bottomlands. Due to loblolly's faster growth rate in its early years, it became the tree of choice for industrial forestry. However, longleaf is more resilient to hurricane level winds, drought, beetle outbreaks, and fire. Longleaf restoration has additional benefits, such as creating habitat for the endangered red cockaded woodpecker (*Leuconotopicus borealis*), increasing carbon sequestration rates, and producing forest products, such as timber and pine straw. McNulty ended the presentation with a call to action, expressing the urgency to both mitigate and adapt to climate change impacts if we are to have healthy forests in the future.

WATCH SESSION RECORDING

Carbon and Climate-Smart Forestry: Forest Protection and Management Options for Climate Mitigation

Presented: September 18, 2023

Sara Kuebbing

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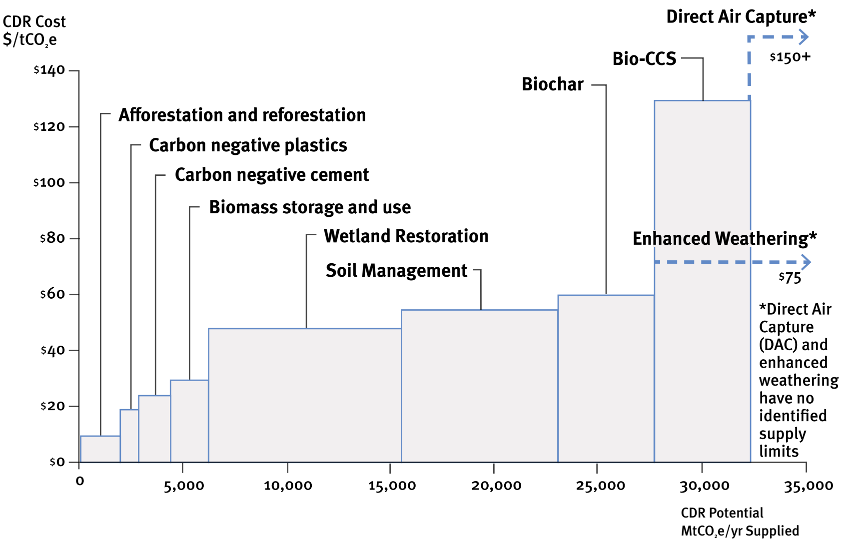
SARA KUEBBING, PhD, *Director of Research, Yale Applied Science Synthesis Program; Research Scientist, Yale Center for Natural Carbon Capture*

Summary by: Will Gardner

Sara Kuebbing, director of research for the Yale Applied Science Synthesis Program, spoke about how climate-smart forestry relates to carbon sequestration and storage. She built on the prior week's introduction to position the role of forests and forestry in the broader carbon discussion. In her opening, Kuebbing argued that carbon should not be the sole management focus for a forest, given the plethora of other benefits that forests provide. Kuebbing's talk covered the following three areas: why "carbon forestry" is being discussed, an overview of forest carbon cycling, and quantifying the carbon sequestration and storage potential of climate-smart forestry.

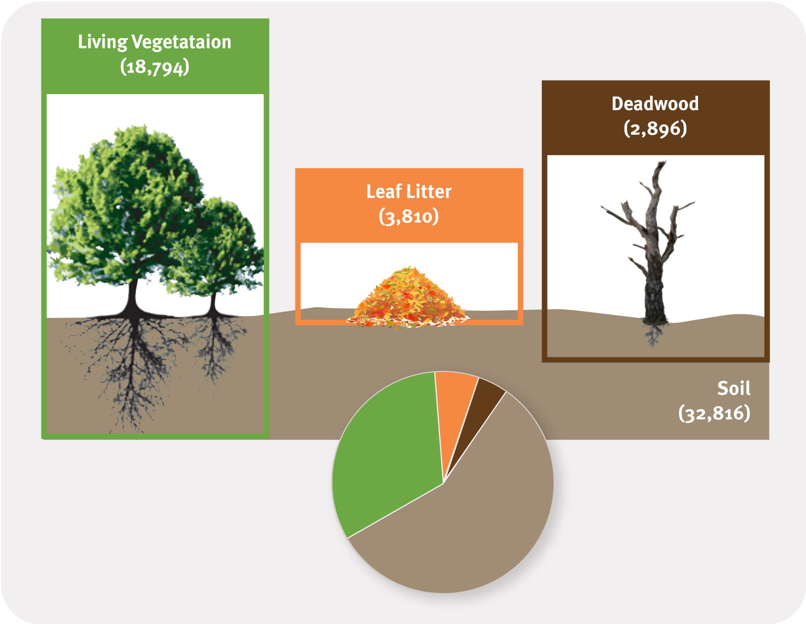
To illustrate why carbon forestry is such a hot topic, Kuebbing introduced the history of anthropogenic climate change. Humans transfer carbon from the earth's crust into the atmosphere largely through the burning of fossil fuels, which has increased dramatically since the Industrial Revolution. As the impacts from climate change are becoming more visible, discussions around climate mitigation and carbon removal are becoming more urgent. In 2021, the Intergovernmental Panel on Climate Change (IPCC) flagged that in addition to drastic emission reductions, significant atmospheric carbon removal is needed to keep global warming under 1.5 degrees Celsius. As forests grow, trees sequester carbon from the atmosphere and store it in a variety of pools, including live wood, soil, woody debris on the forest floor, and even long-lived harvested wood products. Kuebbing shared a mitigation curve, showing that forest carbon mitigation is cheap and available but limited.



A mitigation curve shows the low cost of afforestation and reforestation compared to other removal technologies. Figure: Deich, 2014.

However, there is currently a heated debate about the role of forests in climate mitigation. As Kuebbing put it, if the only reason to manage and protect forests is for carbon, and their appropriateness for carbon sequestration and storage is questioned, the appropriateness for managing and protecting forests at all is also questioned.

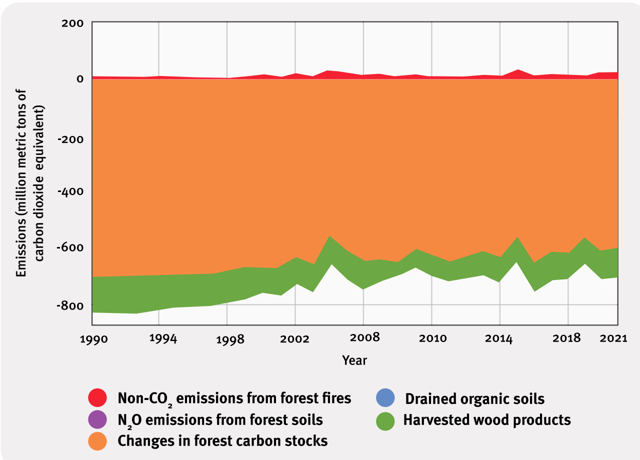
Kuebbing then gave an overview of the forest carbon cycle, introducing forests as "highly evolved, sophisticated 'direct air capture' facilities." Forests remove carbon dioxide using 100% renewable solar energy, a feat that technical direct air capture (DAC) facilities are still working to achieve. Kuebbing highlighted that U.S. forests store over 58 billion tons of carbon in living vegetation, downed woody debris, and soils, and they sequester net 593 MMT CO_2e (carbon dioxide equivalent) each year.



A breakdown of forest carbon storage pools across the U.S. shows that most carbon is stored in soil, followed by living vegetation, leaf litter, and deadwood. Figure: https://roads2removal.org/.

Forests are also dynamic, sometimes acting as sinks and sometimes as sources of carbon. Forests will continue to be a major part of the carbon budget whether they are managed for carbon removal or not. Kuebbing showed that the main cause of forests' carbon emissions is disturbance. These disturbances can be planned, as in the case of timber harvest or land conversion for agriculture or development. Disturbances can also be unplanned, such as in the case of wildfires, hurricanes, and forest pests. Wildfires have caused some western U.S. ecosystems to become net carbon sources, while tree mortality from hurricanes and forest pests is also on the rise. However, even after these disturbances, on average, all combined U.S. forests continue to act as a carbon sink.

U.S. Greenhouse Gas Emission and Sinks from Forest Land Remaining Forest Land, by Subcategory, 1990-2021



Percent change: 1990–2021

Non-CO_2 emissions from forest fires
Emissions ▲ 341.4%

Drained organic soils
No change

N_2O emissions from forest soils
Emissions ▲ 455.1%

Harvested wood products
Sink ▼ 16.9%

Changes in forest carbon stocks
Sink ▼ 15.1%

Net total:
Sink ▼ 17.8%

Despite an increase in forest fire emissions, U.S. forests continue to serve as a strong carbon sink. Figure: U.S. EPA, 2021, Greenhouse Gas Reporting Program.

Kuebbing then highlighted the potential for climate-smart forestry to mitigate some planned disturbance impacts. Kuebbing defined CSF as forestry that builds on sustainable forest management with three objectives: reducing or removing carbon dioxide; building forest resilience to climate change; and sustainably increasing forest productivity and incomes. Kuebbing focused on the first objective and proposed three ways for carbon dioxide removal and reduction to be achieved: increasing the total amount of forestland, increasing forest carbon dioxide removal efficiency, and increasing the durability of forest carbon storage.

Increasing the total amount of forestland means reducing deforestation and planting more trees in areas that were once forested. In the DAC metaphor, this corresponds to building new DAC plants and not decommissioning old ones. Kuebbing shared a variety of studies that show that planting trees is highly likely to increase forestland carbon storage. Kuebbing also highlighted a study claiming that avoiding forest conversion could avert the emission of ~39 MMT CO_2e per year.

Increasing carbon removal efficiency means increasing the number of trees within existing forestlands (i.e. increasing the number of fans at existing DAC plants) and implementing "Improved Forest Management" practices to improve forest health (akin to maintenance of fans at existing DAC plants). Kuebbing shared that both are options for U.S. forests, where understocked forestlands sequester 20% less CO_2 than fully stocked ones and extended rotations could increase stocking levels up to 267 MMT CO_2 per year.

Kuebbing then addressed the primary critique of forests as climate change mitigation solutions: durability of the carbon stored. She acknowledged that, whether forests are managed for carbon or not, they face unplanned disturbance risks. Kuebbing highlighted that forests can be managed to improve their resilience, and that this is a current key area of study. She shared a study by The Nature Conservancy that highlights the role of thinning in mitigating wildfire damage. She also reminded the audience that all climate mitigation facilities, including technical ones, face climate risk from hurricanes and wildfires. Kuebbing also flagged some of the ways that technical carbon storage facilities can leak and be "non-durable."

Kuebbing concluded by again noting the potential for wood products to contribute to an even more permanent store of carbon. These wood products can have a strong positive climate effect, especially when they replace more carbon intensive products. Kuebbing reminded the audience that whether forest managers and policy makers choose to act on CSF as a climate change mitigation tool or not, forest carbon will continue to be an important part of the global carbon budget.

Apprentice foresters survey Yale-Myers Forest in Eastford, Connecticut, to create a management prescription that favors future forest regeneration. Photo: Ian Christmann.

What Does Adaptive Silviculture Look Like?

WATCH SESSION RECORDING

Presented: September 25, 2023

MARIA JANOWIAK, *Director, Northern Forests Climate Hub; Acting Director, Northern Institute of Applied Climate Science, USDA Forest Service*

Maria Janowiak

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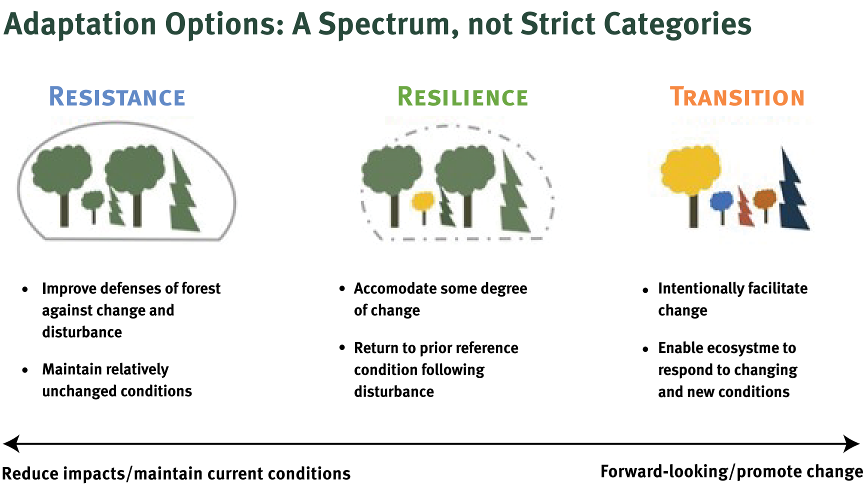
Summary by: Brittaney Key

Maria Janowiak, director at the USDA Northern Forests Climate Hub, joined the Yale Forest Forum to discuss silviculture in the context of climate change. Janowiak shared the design, goals, and case studies from Adaptive Silviculture for Climate Change (ASCC), a network of experimental management trials in multiple forest ecosystem types in the continental U.S. and Canada. This presentation brought the series' overall discussion of climate-smart forestry to a more granular level, discussing specific silvicultural techniques that can be applied to make forests better able to adapt to changing climate conditions.

Janowiak began by explaining that silviculture means managing forested areas for various ecosystem benefits depending on the needs and values of their stakeholders. Silviculture utilizes active and passive management tools to achieve these objectives, and Janowiak noted that in the context of climate change, these tools remain useful and need to be applied in new or creative ways. Adaptation is the primary climate objective of adaptive silviculture. Climate change threatens forests in multiple ways, in turn threatening the sustainability of forest carbon stocks. Managing forests for a wide range of future conditions is important to ensuring their long-term viability and to protecting their ability to sequester and store carbon.

A FRAMEWORK FOR CLIMATE ADAPTATION

At the USDA Forest Service-led Northern Institute of Applied Climate Science (NIACS), the guiding objective is to determine what actions can be taken to improve a forested ecosystem's ability to adapt while still meeting the management and use goals for that system. NIACS released an Adaptation Workbook to help forest managers understand how climate change may impact their objectives and make more informed management decisions. To make climate change less overwhelming, the workbook breaks down climate considerations and the steps of the adaptive management process to give forest managers an approachable starting point. NIACS also uses the "resistance, resilience, transition" framework to organize adaptation tools and strategies. Resistance strategies help forests resist change and disturbance; resilience strategies allow forests to absorb change while returning to their prior state; and transition strategies help forests move into new states and conditions.



The resistance, resilience, transition framework guides managers through different forest adaptation approaches depending on their objectives for their forestland. Figure courtesy of Maria Janowiak.

ADAPTIVE SILVICULTURE FOR CLIMATE CHANGE EXPERIMENTAL DESIGN

The Adaptive Silviculture for Climate Change network of 14 sites builds on the framework and resources described above. ASCC focuses strongly on collaboration and co-creation between silvicultural managers and scientists, and its goal is to develop operational examples of incorporating adaptation into silviculture. Each ecosystem and management context needs a tailored approach to adaptation, but all ASCC sites have the same minimum study design elements, metrics, and categories of treatment options — resistance, resilience, transition, and a no-action experimental "control" — to ensure comparisons and trends can be identified across time and space. To start the process, ASCC network leaders facilitate a workshop with scientists and managers to determine the desired future condition and management objectives for each treatment option and identify the silvicultural practices that can be used to achieve those outcomes. The treatments are then applied at the experimental plots using the practices identified in the workshop. In general, resistance treatments maintain existing species diversity ratios, resilience treatments look to increase diversity with native plants, and transition treatments may include range expansion of native species and/or assisted migration of novel species.

As an example, Janowiak explained the process at the oldest ASCC site, Cutfoot Experimental Forest in Chippewa, Minnesota. The Cutfoot Experimental Forest is a red pine-dominated forest with increased climate risks of drought stress, wildfire, and insect and disease outbreaks. For the resistance treatment, uniform forest thinning was applied to maintain the current mix of species diversity. For resilience, variable density thinning was applied to keep red pine dominant but support greater diversity of native future-adapted species to give the forest more response options to future disturbances. For the transition treatment, an irregular shelterwood was created with more gaps, heterogeneity of species

Apprentice foresters survey Yale-Myers Forest in Eastford, Connecticut, to create a management prescription that favors future forest regeneration. Photo: Ian Christmann.

diversity, and both native and non-native assisted migration species. Janowiak briefly shared recent monitoring results of seedling survival rates and 3-year growth rates from the trial. Native species seedlings tended to have higher survival rates and growth rates than novel species — apart from the introduced ponderosa pine species which, despite having lower seedling survival rates, had faster growth rates compared to native species. Details about each ASCC site's treatments, prescriptions, and more can be found on the ASCC website.

Janowiak listed some of the management and research questions that the ASCC network hopes to answer, and she noted that ASCC and NIACS plan to incorporate findings from these experiments into adaptation training and silvicultural training. She reminded attendees that responding to climate change is location-dependent, and oftentimes it will be the local practitioners who will know what adaptation practices will be the best fit for a given ecosystem

"Science and management really do inform each other. When we talk about management uncertainty related to climate change, being able to bring management and scientists much closer together in terms of that feedback loop is really important."

and local values. Finally, Janowiak concluded by stressing the importance of scientists and managers working together: "Science and management really do inform each other. When we talk about management uncertainty related to climate change, being able to bring management and scientists much closer together in terms of that feedback loop is really important. [...] We need scientists to make management available more readily at local scales, and conceptually downscale it so that people can make it usable, but then that place-based experience and expertise really needs to inform the action."

Forest Fires in California's New Climate Reality: There is Hope

WATCH SESSION RECORDING

Presented: October 2, 2023

SCOTT STEPHENS, PhD, *Professor of Fire Science, University of California, Berkeley*

Summary by: Jonathan Rak

Scott Stephens

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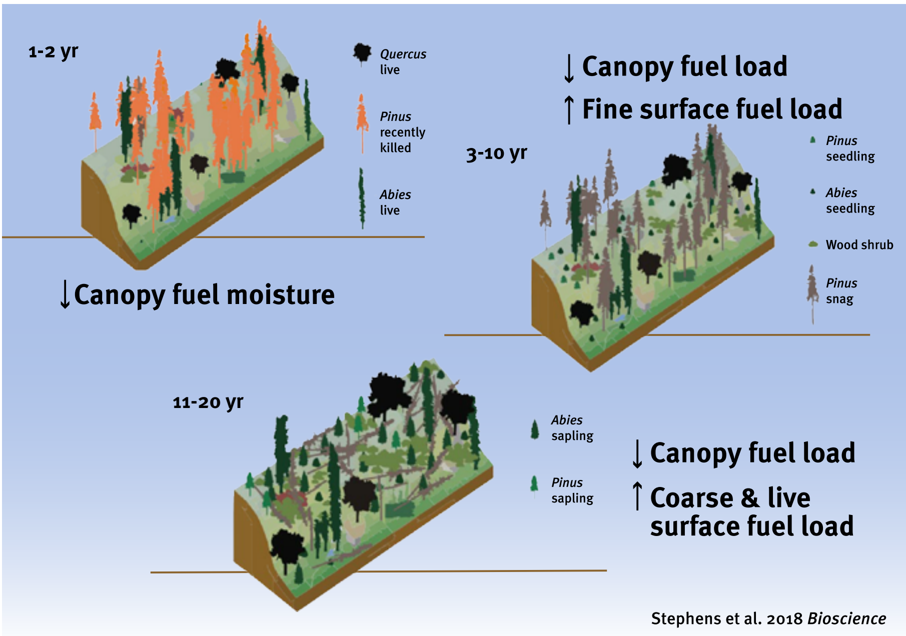
Scott Stephens, professor of fire science at the University of California Berkeley, joined the Yale Forest Forum to discuss fire in the context of climate-smart forestry. His research focuses on how prehistoric fires once interacted with ecosystems, how current wildland fires are affecting ecosystems, and how future fires and management will influence people and ecosystems. His research has become increasingly relevant as climate change models predict that fires will become more frequent and more intense. Overstocking of frequent-fire adapted forest stands contributed to a higher risk of catastrophic fires over the last century. Stephens' research is informed and influenced by his experience working with Indigenous people and learning about traditional fire management.

> "Overstocking of frequent-fire adapted forest stands contributed to a higher risk of catastrophic fires over the last century."

Stephens provided a case study demonstrating the need for climate-smart forestry in response to climate-driven fire risk. He described how the 2012-2015 California drought caused widespread tree mortality and fundamentally changed the southern Sierra Nevada.

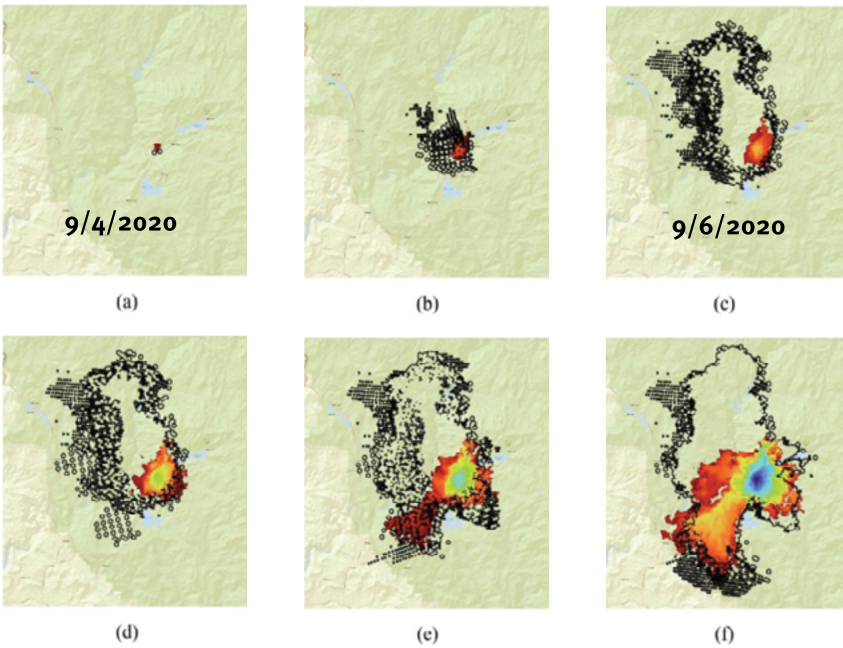
Vegetation and Fuel Dynamics Following Severe Pine Mortality (Theoretical)



Drought-related pine death increases fuel loads and the potential for higher severity fires. Figure: Stephens et al., 2018.

The Creek Fire serves as an example that demonstrates how drought impacts fire behavior. Normally the highest heat energy in a fire occurs on the perimeter, but empirical data from the Creek Fire shows surprising latent heat in the center of the fire. As drought raised tree deaths, downed trees increased fuel loads and magnified latent heat. Simultaneous combustion of fuel loads caused a mass fire. A mass fire is an instance in which an area of several square kilometers simultaneously burns at high intensity and with high flame lengths. These events create their own weather systems with powerful winds moving inward toward the fire. Stephens explained that scientists can't successfully model this type of fire with operational models. This inability to predict fire behavior is a serious issue affecting public safety.

Creek Fire Actual vs. Modeled First Spread



Stephens et al. 2022, *Forest Ecol. Manage.*

Fire spread models (the colored areas) are unable to accurately predict the real world spread (black perimeter) of the Creek Fire, due to the challenges of modelling mass fire and the impacts of drought-related tree mortality. Figure: Stephens et al., 2022.

Stephens described the forest management implications of his observations on fire behavior. Policies that promoted fire suppression and high-density stands have led to greater vulnerability of forests to catastrophic wildfire. Increased temperatures and drought resulting from climate change exacerbate this vulnerability. Stephens has observed a feedback loop of high-severity fire facilitating more high-severity fire. Addressing this vulnerability requires large-scale forest restoration. Restoration methods include prescribed burning, Indigenous burning, and restoration thinning to reduce ladder fuels (the vegetation that enables a fire to spread from the forest floor up

to the tree canopy). This suite of approaches reduces overall fuel loads and a forest's susceptibility to drought and insect outbreaks. Stephens noted that silvicultural techniques to reduce fire should concentrate on the trees that managers desire to keep in the forest, not those they wish to remove.

Stephens proceeded to discuss the lessons for forest restoration he has learned from Indigenous peoples in California working in mixed evergreen forests in the Santa Cruz Mountains. Val Lopez, chairman of the Amah Mutsun Tribal Band, taught him that "fire is a gift from the Creator for the stewardship of the land." Working with Lopez, Stephens developed three experimental treatments consisting of:

1. An underburn and removal of dead understory trees (completed by a wildfire before a prescribed burn could occur),
2. A shaded fuel break removing ladder and surface fuels,
3. Full restoration of the oak-dominated coastal forest by harvesting the competing conifers to bring back the cultural landscape.

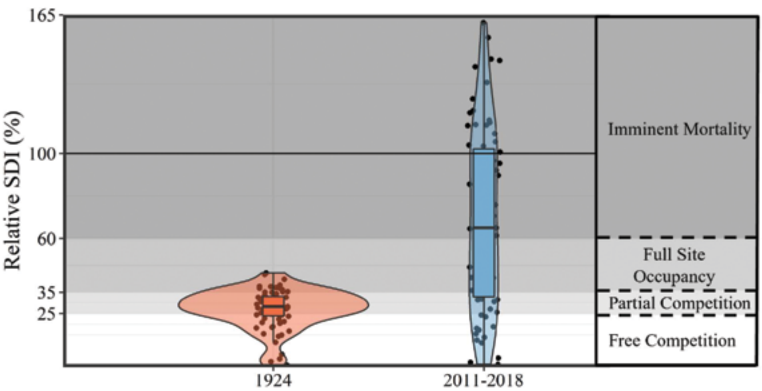
Stephens believes cultural management of forests by Indigenous peoples offers great opportunities for restoration. These restoration goals include shifting away from conifer dominance to more fire-adapted species, such as oaks. These treatments are expensive and may not be replicable in all places but deserve support, according to Stephens.

Stephens then turned to evidence that forest management practices, which increased stand density from historical levels, facilitated the extensive tree mortality in the 2012-2015 drought. Stephens described archeological evidence and physical evidence from burned stumps that shows how Indigenous management created frequent, low-intensity fires during pre-colonial periods in the northern Sierra Nevada.

Apprentice foresters mark redwoods for post-wildfire recovery and regeneration, near Santa Cruz, California. Photo: Lynn Robb.

This fire regime supported mixed conifer forests with low tree densities allowing California black oak to thrive. These practices offer guidance on the active stewardship needed to restore drought-affected forests.

Historical Relative Density and FIA Plots around Indigenous Study Areas



- **Average Relative SDI for contemporary forests is 159% higher (~70% of maxium SDI) than what existed historically (~27% of maximum SDI)**
- **Massive change in forests in the last 100 years also found in the southern Cascades, central Sierra Nevada, southern Sierra Nevada (Collins et al. 2017, Stephens et al. 2015, 2018)**

An assessment of stand density at Indigenous study areas shows low density and low mortality rates in historic management, while management over the last century has resulted in high density and high rates of mortality from competition. Figure courtesy of Scott Stephens.

Stephens concluded with a message of hope. He believes we have much to learn from Indigenous management regimes about how to make our future forests more resilient. Emerging partnerships with Indigenous people and increased investment in forest restoration are strategies for reducing tree mortality as a source for catastrophic fires. This offers a promising path forward to mitigate the problem of forest fires in California’s new climate reality.

WATCH SESSION RECORDING

Why the Farm Bill Could Shape Solutions for Small Landowners from All Walks of Life

Presented: October 9, 2023

SAM COOK, *Executive Director of Forest Assets, North Carolina State University College of Natural Resources*

Summary by: Tara Hoda and Nicole Israel-Meyer

Sam Cook

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Sam Cook is the executive director of forest assets at the College of Natural Resources at North Carolina State University and vice president of the Natural Resources Foundation. Cook provided the Yale Forest Forum with an overview of the impacts of climate change on vulnerable populations, including farmers, ranchers, and forest landowners. Cook also shared a summary of the Farm Bill, a package of legislation passed about once every five years in the United States that governs most U.S. farming and agricultural conservation programs, in addition to food security programs such as SNAP. Because Congress is preparing a new Farm Bill for passage in 2024, Cook urged attendees to pay attention to it because of its widespread implications for food security and its potential to contribute positively to climate change mitigation. Cook also focused on how the Farm Bill can empower historically disenfranchised smallholders and landowners.

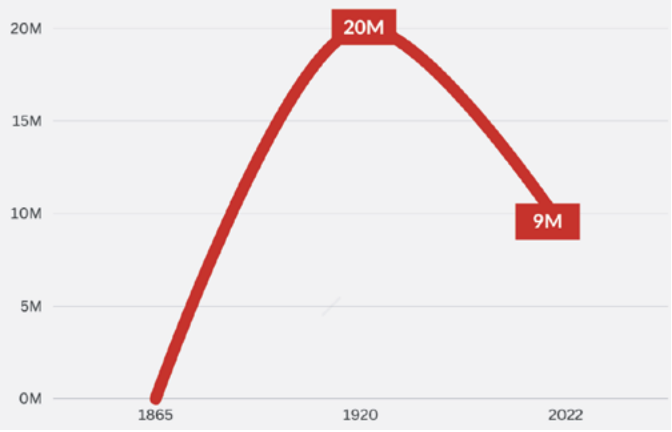
The Farm Bill contains support and incentives for practicing climate-smart agricultural methods, including agroforestry, restoration of disturbed lands, and nitrogen management. The bill would provide financial, technical, and other resources to promote forest ownership, stewardship, and sustainable agricultural practices.

About one-third of the United States is covered in forests, most privately owned in plots averaging between 85 and 90 acres. Cook compellingly argued that climate-smart forestry programs should focus not only on large public lands but also on small landowners. Administered by the USDA, the Farm Bill can target many of the most vulnerable landowners, who tend to belong to historically marginalized communities, including those who are Black, Native American, people with disabilities, refugees, and others with limited resources and historical social disadvantages.

The Farm Bill provides a suite of climate-smart agricultural and forestry solutions, including incentives for practicing agroforestry and improving soil health. Figure courtesy of Sam Cook.

Cook emphasized the importance of working with minority landowners to build family and generational wealth. Black real estate ownership has dramatically decreased since its peak in the 1920s; in 2022, Black Americans only owned about 9 million acres compared to 20 million acres in 1920. Cook described non-profit-run programs, such as the Sustainable Forestry and African American Land Retention Project, which seek to help Black landowners secure land tenure and address heirs' property issues. Technical assistance to help Black landowners navigate heirs' property rights is foundational to landowners' ability to invest in land conservation and stewardship. The 2024 Farm Bill could include new programs to help navigate property rights and legislative fixes, helping landowners without clear title to access technical assistance programs.

Cook believes working with small landowners is as important as working with large landowners or public land agencies to achieve the country's climate-smart goals. The Farm Bill provides initiatives and subsidies for landowners to partake in conservation and climate-smart programs. The bill will invest $3.1 billion in programs supporting climate solutions in historically vulnerable communities. According to Cook, agencies should focus on the most vulnerable landowners because they have great potential to implement climate-smart practices on their land.



In the wake of the U.S. Civil War, Black landownership steadily increased to a high of 20 million acres in 1920 but has since fallen to approximately nine million acres in 2022. Figure courtesy of Sam Cook.

Cook ended his talk by emphasizing that the USDA has the responsibility to use agriculture and forestry initiatives to create more opportunities for minority landowners, find ways to address conservation through the Farm Bill, address equity issues in rural communities, and educate landowners on the funding and technical opportunities available to best manage their lands and successfully profit from them. Cook emphasized that one of the most critical strategies needed to strengthen many of these initiatives is to build trust between landowners and the government through continuous boots-on-the-ground representation and support. These initiatives should also work with individuals and local organizations who have already built trust with communities. Though these programs require significant investment in staff time, they can yield long-term land stewardship and conservation outcomes.

Climate-Smart Forestry: Research on Programs and Incentives

WATCH SESSION RECORDING

Presented: October 23, 2023

STEPHANIE CHIZMAR, PhD, *Research Economist, USDA Forest Service Southern Research Station*

Stephanie Chizmar

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Summary by: Yinhao Wang

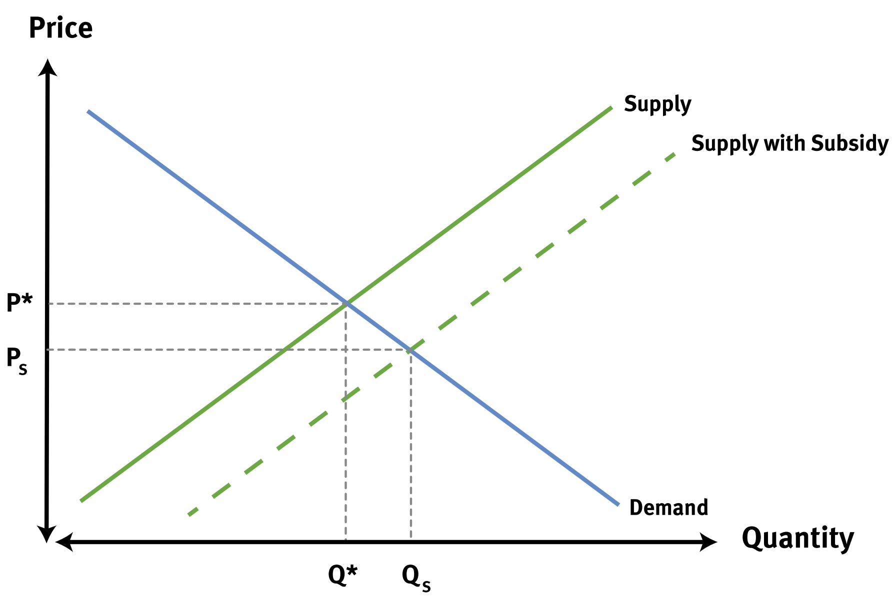
Stephanie Chizmar, research economist at the USDA Forest Service Southern Research Station, joined the Yale Forest Forum to review programs and incentives for forest landowners and communities to implement climate-smart forestry practices in the U.S.

Chizmar outlined available programs, including financial incentives, technical assistance, and market opportunities provided by public and non-public entities, that support climate-smart agriculture and forestry. She categorized landowner assistance programs into two categories: financial assistance (like tax provisions and direct payments) and technical assistance (providing knowledge, information, and connections with professionals). She described the range of providers of financial assistance programs, including public programs like the federal level Farm Bill, state level cost-share programs, and local easements. She emphasized the existence of programs provided by private organizations and NGOs, underlining their importance where public programs are either insufficient to meet landowner demand or are not available.

Chizmar delivered a brief economic description of why financial assistance motivates landowners to manage forests for a broad suite of values. For example, landowners cannot profit from simply growing and maintaining more forestland than they would harvest, even while that extra forestland contributes to valued ecosystem services like increased biodiversity or carbon sequestration. However, financial incentives like subsidies make it viable for landowners to manage their forests for values beyond timber. As a result, the market reaches a new equilibrium where landowners provide more forest services, which is better for social wellbeing.

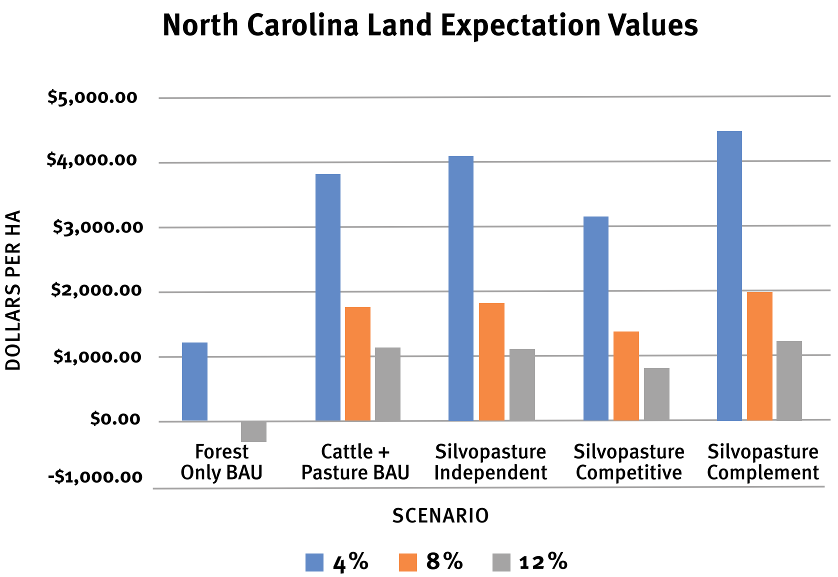
TWO BROAD CATEGORIES	
FINANCIAL ASSISTANCE	**TECHNICAL ASSISTANCE**
• **Tax provisions** (income, property, etc.) • **Direct payments** (cost-share, payments for ecosystem services, easements rental payments, etc.)	• **Knowledge exchange** • **Extension programming** • **Connect with professional forester and/or natural resources professional**

Landowner assistance programs fit into two broad categories: financial assistance and technical assistance. Figure: Stephanie Chizmar.



Financial incentives such as subsidies can increase supply, helping to reduce costs for consumers and meet increased demands on climate-smart forest products. Figure: Stephanie Chizmar.

Next, Chizmar introduced some of her past research. In 2019, she conducted an economic assessment of North Carolina silvopasture systems, which are considered climate-smart agricultural practices. She discovered that at various discount rates, the silvopasture system yields less revenue than a traditional cattle pasture system. This means that financial incentives may help encourage landowners to consider silvopasture. Chizmar also conducted a literature review in 2021, in which she found five different studies that indicate state cost-share programs are positively related to environmental and non-market outcomes. Though many of the programs came before the term climate-smart forestry was widely used, the benefits of these current programs largely align with CSF concepts. Currently, Chizmar is working on a review of forest management incentives and landowner behavior. She is finding that while participation in programs remains low, compensation increases participation in certain cases. Also, each incentive may have a different impact on landowner behavior.



In North Carolina, a transition from traditional cattle pastures to silvopastures increases land expectation values. Figure: Stephanie Chizmar.

Chizmar then discussed new initiatives to incentivize climate-smart forestry. The Inflation Reduction Act (IRA) provides almost $20 billion over five years to the USDA. These funds focus on quality incentives, stewardship, and other various fields. To tap into IRA funding for climate-smart forestry, legislation stipulates that contracts for Natural Resource Conservation Service (Farm Bill) programs need to include at least one core climate-smart agriculture and forestry conservation practice, which could include forest farming, forest stand improvement, tree/shrub establishment, windbreak/shelterbelt establishment and renovation, riparian forest buffers, or silvopasture.

The IRA provides the U.S. Forest Service $450 million for competitive grant programs to financially incentivize forest-based carbon reduction pathways for small or underserved landowners. It's worth noting that these support programs do not provide funds directly to the landowners but establish a framework for compensation. Furthermore, Chizmar described the recent Partnerships for Climate-Smart Commodities grant awards, which provide $3.1 billion for 141 projects that last one to five years, aimed at supporting the production and marketing of climate-smart forest and agricultural commodities.

Beyond the IRA, Chizmar discussed additional initiatives for climate-smart forestry. Forest carbon offset markets can compensate landowners for forest management activities that increase carbon sequestration and storage. Activities supported by the carbon market include improved forest management, avoided conversion of forestland to non-forestland, and afforestation or reforestation. There are also voluntary projects like forest certification.

Chizmar identified several challenges in these new grant programs. Not all landowners are profit-motivated, and many may not want to work with technical assistance providers. High upfront capital needs and varying levels of climate change awareness are among other barriers. Capacity is another issue, as demand for funds is greater than availability, and there are a limited number of field foresters who are able to provide necessary technical support in-person.

Great Mountain Forest, in Canaan, Connecticut, is stewarded under a conservation easement. Photo: Joe Dwyer.

Climate-Smart Forest Management in the Urban Context

WATCH SESSION RECORDING

Presented: October 11, 2023

CLARA PREGITZER, PhD, *Deputy Director of Conservation Science, Natural Areas Conservancy*

KRISTEN KING, *Chief of Environment and Planning, NYC Parks*

Summary by: Youyi Xu

Clara Pregitzer

Kristen King

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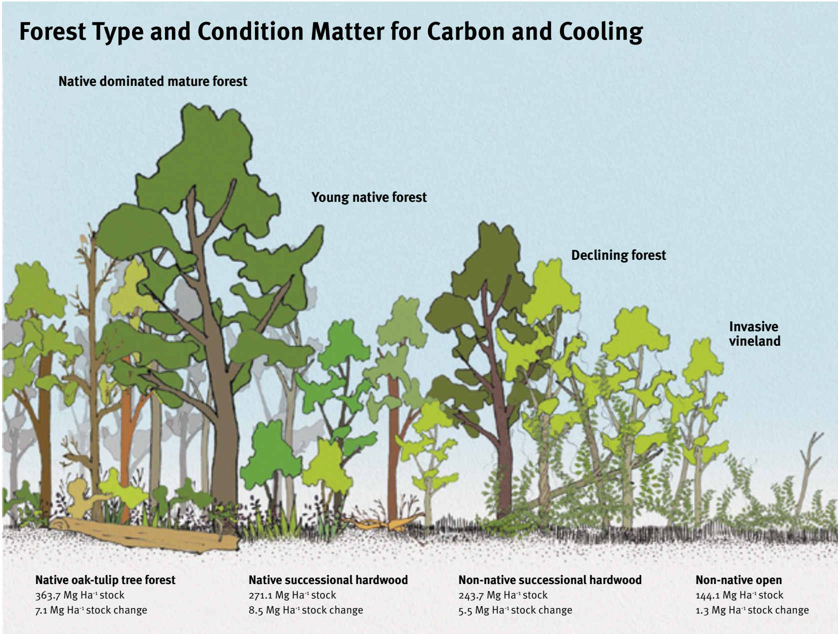
Clara Pregitzer, deputy director of conservation science at the Natural Areas Conservancy, and Kristen King, chief of natural resources for New York City Parks, joined YFF to speak about what climate-smart forestry means in the urban context of New York City. Forested areas within cities provide benefits, such as carbon storage, cooling, and social benefits, and serve as potential mitigators of the effects of climate change on city dwellers.

Both rapid climate change and urbanization stress urban forests. Climate change is causing more frequent and intense storms, periods of drought, and warmer temperatures. Pavement and smaller forest patch sizes amplify high temperatures and increase the "flashiness" of water availability during storm events. To cope with this dual-pressure challenge, climate-smart urban forest management is needed.

Urban forests offer many social benefits. Pregitzer emphasized how social factors influence forest management, not just in terms of preservation but also for public enjoyment. In cities like New York and Washington D.C., there is widespread public concern that historic trees, some over a century old, will be affected by extreme weather events. Adapting to these challenges requires careful consideration of existing practices and data sources. It is crucial to address these challenges from both a practical and policy perspective, factoring in political, governance, and financial challenges.



Forest types and conditions determine an urban forest's ability to sequester carbon and cool. Figure: Pregitzer et al., 2022.

The Natural Areas Conservancy and NYC Parks collaboratively built the data library and technical analysis needed to support decisions that ensure urban forests remain healthy and resilient. Kristen King described the forest condition matrix they developed to assess the health of and threats to 1,100 forest plots across New York City. Forest health is determined by factors including the size of trees, the amount of carbon stored, and threats related to forest composition and structure, such as the presence of invasive species. The matrix allowed the organizations to categorize and prioritize plots based on these factors. The analysis further helped allocate appropriate resources based on the forest's condition. The analysis illustrated that forests that are in good health but face significant threats that require management interventions. By addressing these threats, these plots can be moved into the highest quality category. Forests with high threats require costly restoration. In contrast, healthier forests can be maintained with community efforts and volunteers, making their care less expensive. With limited funding and personnel, making strategic decisions to optimize resources can lead to more successful outcomes for a greater area of forest. Increased forest health results in increased forest longevity and sustainability, so identifying the proper balance of management is essential.

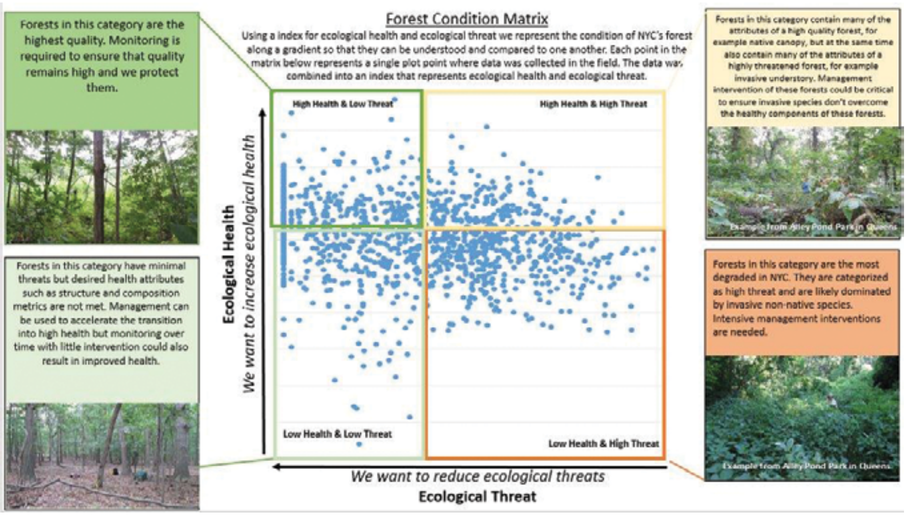
"Increased forest health results in increased forest longevity and sustainability."

There has been consistent active management in the parks of New York City for the past 40 years. On-the-ground activities, such as mechanical maintenance for invasive species control, herbicide application, and tree planting, have been implemented widely.

Clara Pregitzer served as lead author of Guidelines for Urban Forest Restoration, which contains methods to address management challenges in natural areas using mechanical, chemical, and cultural means. The document provides guidance on amending soil and planting special species. In addition to the guide, NYC Parks provides seeds and produces locally adapted plant material for restoration projects led by local organizations.

NYC Parks and the Natural Areas Conservancy also worked together to design a forest identification and restoration selection tool — the "FIRST Tool." This tool assists in identifying species suitable for planting at specific sites, which is a more proactive way to combat climate change.

The management of forests is dynamic. As one example, the speakers described a project at Van Cortlandt Park, where trees and shrubs were densely planted to quickly create shade and suppress invasive species. The goal was for trees to self-establish over time. However, the process was slower than anticipated, and dominant fast-growing trees, like tulip trees (*Liriodendron tulipifera*), became predominant. To promote biodiversity and shift toward an oak-dominated forest, managers thinned the forest as a transition strategy. This successful strategy, currently applied to just one forest, has the potential to be applied to other sites.



The forest condition matrix helps managers to prioritize different forest patches for management action, with particular care given to those that fall into the high health and high threat category. Figure: Clara Pregitzer and Kristen King.

Urban forest management faces numerous challenges. The lack of funding, political will, and data are the main hurdles to effective long-term urban forest management. On average, less than 5% of parks budgets flow into stewarding natural areas. Many U.S. cities, especially smaller ones, are losing forests to development as there is no national law to protect urban forestland from conversion. In addition, more efforts are needed to map out where urban natural areas exist and to identify the risks and climate impacts these urban natural areas face.

However, there is hope for urban forest management, and many opportunities exist to connect urban dwellers with urban forests. Promisingly, forests in urban areas can be agents of change, by serving as sites where people can make investments to mitigate climate change. Urban areas offer a unique chance to engage the public, increasing awareness about the environment and the impacts of climate change.

Indigenous Perspectives on Novel Forests and Ecosystem Change

WATCH SESSION RECORDING

Presented: November 6, 2023

MIKE DOCKRY, PhD, (**Citizen Potawatomi Nation**), *Assistant Professor of Tribal Natural Resource Management, Department of Forest Resources, University of Minnesota*

Mike Dockry

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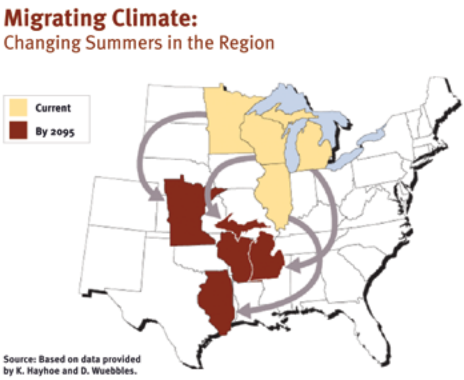
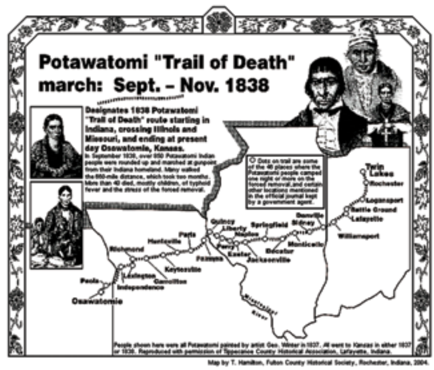
Summary by: Hayden Stebbins

Mike Dockry is an assistant professor of tribal natural resource management at the Department of Forest Resources at the University of Minnesota. He is also a member of the Citizen Potawatomi Nation. In his lecture for the Yale Forest Forum, he described forests in the temperate Great Lakes region of the United States as novel ecosystems and discussed how Indigenous populations have been one of the main drivers of these forests' composition and management. Dockry spoke of this relationship in four different time periods: the deep past; the recent past's sustainable management of forests; the present's movement of species for climate adaptation; and the future of sustainability as informed by the past.

Dockry observed that Indigenous populations in the Great Lakes region of North America have been dealing with climate change for centuries. Indigenous populations have moved themselves and culturally important plants along glacial gradients and waterways since time immemorial, but the forced displacement of Indigenous populations accelerated the imperative to adapt to novel climates. From September to November of 1853, the Potawatomi were forced from northern Indiana to western Kansas, a drastic shift in climate and ecoregion in a very short amount of time. They quickly learned how to live in and be in relationship with this new ecosystem. Dockry drew similarities between forced displacement and climate change, as historically southern climates migrate north in a short amount of time, forcing forest management to adapt. Tribes are continually adapting their forest management to climate and ecosystem changes.





While climate change now forces states to deal with climates historically associated with more southern regions, Indigenous populations such as the Potawatomi have dealt with climate changes through forced displacement since the arrival of Europeans. Left figure courtesy of Mike Dockry, adapted from Confronting Climate Change in the Great Lakes Region. Right figure: Hamilton, 1995.

Reid's Paradox of Plant Migration, an explanation for rapid migration and an interpretation of the paleoecological records, observes that mast species established in the Northern Midwest much sooner after the Pleistocene glacier retreated than ecological models predict. According to Dockry, evidence of the Menominee people's presence at glacial margins, in tandem with Reid's Paradox, suggests that Indigenous peoples moved masting and culturally important trees as glaciers receded. The Menominee call themselves Mamaceqtawak, which means "Ancient Ones" or "The Movers." Their ancestral lands stretch over a rough triangle from near modern-day Escanaba, Wisconsin, west toward Eau Claire, Wisconsin, and south to modern day Milwaukee, including the peninsula northeast of Green Bay. The current Menominee Reservation covers a small portion of this former expanse in the northern portion of their historic territory. Stories of Indigenous peoples as seed movers are ubiquitous and include stories like Diane Wilson's account of the Dakota people sewing seeds into their clothing during forced displacement in her book *The Seed Keepers*. Dockry said plant movement is a part of certain Indigenous people's relationship and obligation to the land. This is consistent with the idea of forests as novel ecosystems because it illustrates the ways that humans have constantly interacted with and shaped their landscapes through time.

Cultural connections with tree species beyond timber, such as weaving with black ash bark, gives Indigenous peoples insights into ecological dynamics often overlooked by academia. Left image: Newberry Library. Right image: Mike Dockry.

The Menominee have been practicing sustainable silviculture even under the modern reservation system. Chief Oshkosh, a Menominee leader during the formation of their reservation, instructed the Menominee to manage their forests: "start with the rising sun and work toward the setting sun, but take only the mature trees, the sick trees, and the trees that have fallen. When you reach the end of the reservation, turn and cut from the setting sun to the rising sun and the trees will last forever." Since 1854, the quality and volume of Menominee harvests has increased. While maintaining constant harvest rates, the Menominee have maintained a 95% closed canopy in forested areas. This is a testament to the prescience of this instruction. Since 1890, the Menominee have limited their annual timber harvest to 20 million board feet, helping to ensure sustainable forestry.

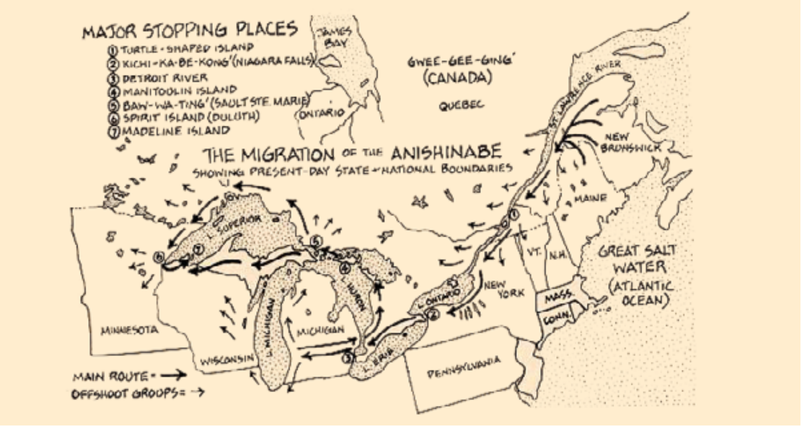
The Menominee Reservation — the dark green area in the center of the satellite imagery — maintains a 95% closed canopy despite continuous harvests since 1854. Figures courtesy of Mike Dockry.

The integration of Indigenous cultures with non-timber forest species has proved invaluable in dealing with the unforeseen impacts of climate change and "non-local beings" — a phrase used by Dockry and others to describe non-native invasive species. The Akwesasne Task Force on the Environment of the Mohawk Community of Akwesasne in New York has been collecting seeds, producing seedlings, and planting black ash for over 30 years to bring trees closer to tribal members' homes for weaving ash baskets. When emerald ash borer (*Agrilus planipennis*) arrived, the Akwesasne were already experts on ash cultivation and production. This coincidence of cultural expertise and a threatening non-local species has spurred collaborations between tribes, federal organizations, and universities. To ensure the continuation of ash weaving culture in the face of emerald ash borer, basket weaving has been documented in videos and more youth are being trained in weaving.

Indigenous groups are experimenting with novel climate-adapted ecosystems, integrating new species together to test how ecosystems persist and adapt. The Fond du Lac Band of Lake Superior Chippewa initiated a common garden experiment in 2015, utilizing 40 species planted in six areas to experiment with combinations of species to keep ash-dominated ecosystems intact as climate change moves emerald ash borer north. Meanwhile, the Menominee are planting a variety of species and separating grafted oak roots in oak wilt-affected areas to prevent the spread of oak wilt fungus. These experiments exemplify the ecological and sustainable spirit in which Indigenous cultures view forests as novel ecosystems. The Tribal Climate Adaptation Menu provides guidance on integrating Indigenous knowledge and culture into climate adaptation. Maria Janowiak, acting director of the Northern Forests Climate Hub and the Northern Institute of Applied Climate Science (NIACS) with the USDA, mentioned this document during her talk earlier in the series, which should serve as a model for collaborative climate adaptation silvicultural projects.

Dockry ended with a call to involve tribal voices in climate adaptation and to learn from their expertise. He reminded attendees that there is no one tribal voice, meaning not all tribal cultures and peoples can be treated the same. Each culture has their own perspective that they bring to discussions about climate change, and their inclusion in climate adaptation is indispensable. He said — and emphasized — about Native peoples: “We have been here before. We are still here. We will be here in the future.” Considering the magnitude of the challenges we face with forest management during climate change and the depth of knowledge and experience held within Indigenous cultures and people, forest managers would do well to collaborate with and listen to Indigenous peoples.

“We have been here before. We are still here. We will be here in the future.”



Indigenous peoples such as the Anishinabe have migrated and adapted their cultures to different climates over millennia and hold cultural knowledge on how to adapt to climate change. Figures: Low (Pokagon Band Potawatomi), 2015.

WATCH SESSION RECORDING

How Carbon Credits Influence Commercial Forest Management

Presented: November 13, 2023

KYLE BURDICK, *Vice President, Baskahegan Company*

Summary by: Baboucarr Joof

Kyle Burdick

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Kyle Burdick is the vice president of the Baskahegan Company, a commercial timberland owner in northern Maine. The Baskahegan Company is a family-owned company that has been in operation since 1920. Baskahegan is dedicated to long-term, sustainable timber harvesting. Through the company's management choices, their land's stocking rates have increased from two cords per acre in the 1940s to twenty-two cords per acre today. The amount of carbon stored on Baskahegan's land has increased commensurately. In 2012, the company owned about 102,000 acres of land and cut about 31,000 cords. In 2013, they acquired an additional 18,000 acres of liquidated land in the town of Bancroft, Maine; the purchase of this additional land brought their allowable annual cut (AAC) to 38,000 cords of wood per year.

After years of board-level deliberations, the Baskahegan Company decided to sell carbon credits on 88,000 acres of their land through the California Compliance Offset Program in 2018. The company signed up to sell conservation credits with a 100 year-long commitment. At the time, there was no distinction between carbon storage (conservation credits) and carbon sequestration (removal credits). Conservation credits pay landowners for agreeing to store carbon on their landscape by not harvesting or otherwise releasing that carbon into the atmosphere. Conversely, removal credits pay for additional carbon sequestered over an established baseline due to changed management practices. Today, these distinct types of credits are valued at different prices and have different regulatory requirements in the California marketplace.

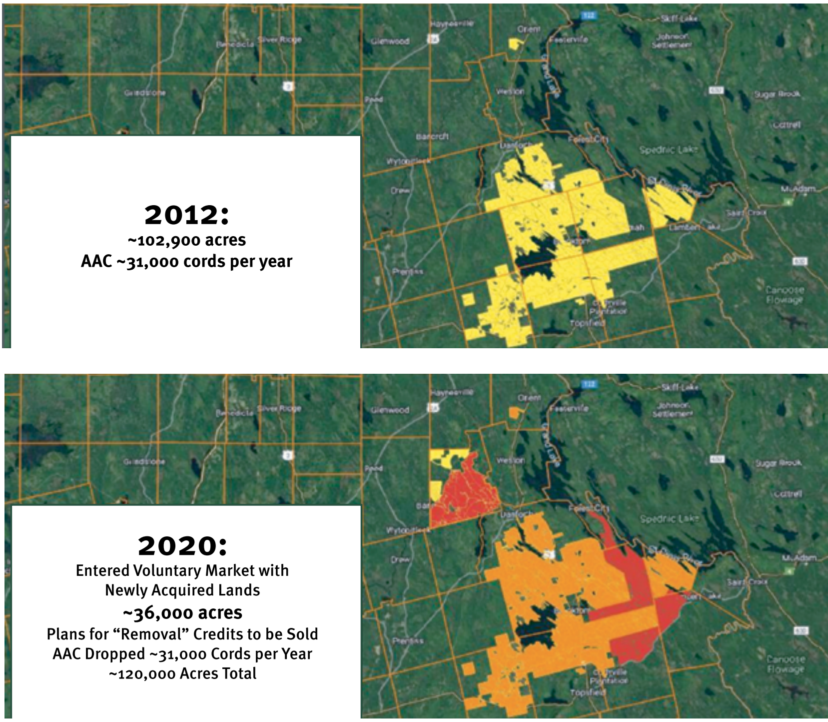
Baskahegan used proceeds from selling carbon credits to purchase a 24,400-acre plot of land. Acquiring this land came with additional costs that the company needed to cover. The company was faced with the decision to either harvest the newly acquired land in a way that was not in line with their principles or enter this land into the carbon market to secure additional revenue. They decided to enter the voluntary market and sell removal credits.

YEAR	ACRES OWNED	AAC	CARBON CREDITS?
2012	102,000	31,000	No
2013	120,000	38,000	No
2018	120,000	31,000 (after credit sale)	Conservation credits sold on 88,000 acres
2020 (land purchase)	144,400	40,000	
2020 (after additional credit sale)	144,400	31,000 (harvest restricted on newly acquired lands)	Removal credits sold on 36,000 acres

Carbon credits reduce Baskahegan's allowable annual cut even as its overall acreage has increased after its 2020 land purchase. Data courtesy of Kyle Burdick.

The sale of carbon credits did not substantially change Baskahegan's land management practices, but this was largely because they were already practicing ecologically oriented forestry that matched practices allowed under the carbon credit protocols. For instance, cutting more than 40 acres of forest at once is prohibited under their carbon credit contract, but Baskahegan already managed on a small block size and typically used shelterwoods rather than clear cuts. They were also at a projected low point in the timber inventory of their forests, which meant they did not need to substantially restrict harvest rates.

Many landowners in Maine have concerns about entering the carbon market. These concerns range from the timeframe of commitment, the uncertainty about pre-salvage, and how credit protocols restrict management, among other things. Burdick spoke about his engagement in a project led by the New England



Baskahegan's overall land holdings increase from 2012 to 2020 following acquisition of new land, but increased restrictions on the use of that land accompany carbon credit sales. Baskahegan sold conservation credits on 88,000 acres (orange parcels) in 2018 and sold removal credits on a total of 36,000 acres (red parcels) in 2020. Figure courtesy of Kyle Burdick.

Forestry Foundation and the University of Maine. The project considers how carbon credits influence commercial forest management and explores how commercial forestland owners could sequester more carbon on their lands through improved forest management practices. Industrial forestland owners shared the following concerns with the project:

- **Length of Commitment:** Signing on to long-term carbon credit agreements can affect the resale value of the land. Many family forest owners want to maintain as much value in their land as possible for future generations.

- **Pre-salvage cuts:** There was uncertainty as to how pre-salvage cuts would be handled once carbon credits were sold. If there was a disease outbreak or large acreage disturbance event like a hurricane, a landowner's carbon stocks might dip below what is allowable under their contract. Baskahegan is involved in extensive pest management and is in a good position to manage or handle any outbreak; so far this has not been an issue under their carbon credit agreements.

- **Price Uncertainty:** Some landowners are concerned about how the price of carbon credits may change over time. Many carbon projects require up-front payments to set up a project, and some landowners were concerned about not breaking even if the price for carbon credits suddenly dropped.

- **Independence:** Landowners in Maine are relatively conservative. Selling credits and therefore management decisions to an external entity can run counter to a general sense of independence and control.

- **Timber Economy:** Many landowners in Maine are generally concerned with the challenges their timber economy is facing. Many are pro-labor and believe that selling carbon credits means losing Maine jobs. However, in his lecture, Burdick made the point that the forestry industry is faced with much bigger issues right now, mostly due to global price pressures. Over the last 10 years, harvesting rates have drastically fallen and the state has lost five out of 11 paper mills. However, this concern is still real and felt in many rural parts of Maine.

- **Changes to Management Practices:** Many carbon credit protocols restrict certain forest management practices. For Baskahegan, these restrictions were in line with their existing management protocols, but for other timberland owners, they would create substantial shifts in timber management and reporting.

Foresters examine white pine regeneration after a shelterwood near Bradley, Maine. Photo: Mark Ashton.

Overall, Burdick noted that Baskahegan's carbon credit sale was the first time they had received recognition or financial compensation for their ecologically oriented forest management practices. The company still maintains its AAC, and their harvesting output has not changed substantially, though their total land ownership has grown. This is due to the historic management regime of their land and their relatively low stocking rates when they initially sold credits. Burdick also said that using carbon revenues to buy additional land seems to be a good way to ensure that further land will come under ecological management.

Burdick concluded by identifying several questions and hopes for the future of the carbon market. For example, he is frustrated that soil carbon is not included in carbon credit accounting. He also is concerned about how to best account for leakage. Overall, he saw some of his concerns from Baskahegan's initial 2018 credit sale addressed by changes in the carbon market over the past five years, and he thinks that carbon markets are evolving in a positive direction. By design, carbon offset programs have been revising their protocols since they were first launched, and Burdick sees them moving in a direction that will better sequester additional carbon on commercial lands. Burdick closed by reflecting on climate change. He claims, "forestry didn't cause climate change, you did," a tongue-in-cheek way of pointing out that capitalism and consumerism are to blame for not curtailing emissions. Real sacrifices and changes — not just offsets — are necessary to address climate change. Burdick feels confident that forestry can play an important role in being part of the solution.

Great Mountain Forest, in Canaan, Connecticut, is stewarded under a conservation easement. Photo: Joe Dwyer.

Climate-Smart Forestry on Private Lands

WATCH SESSION RECORDING

Presented: November 27, 2023

ANDREA COLNES, *Deputy Director and Climate Fellow, New England Forestry Foundation*

Summary by: Omar Al-Farisi

Andrea Colnes

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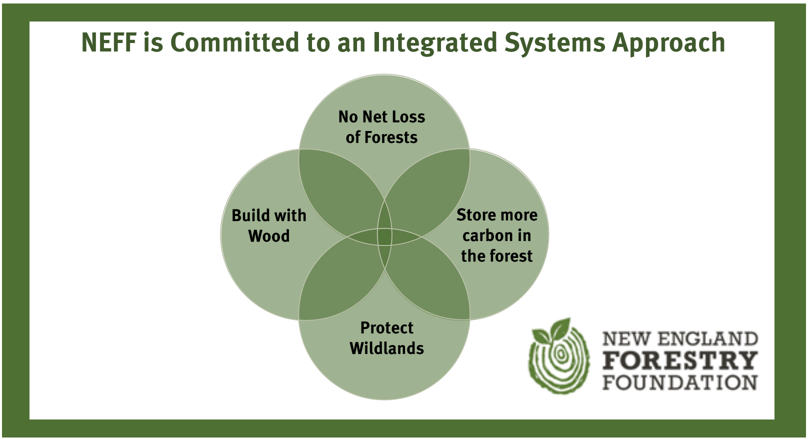
Andrea Colnes, deputy director and climate fellow at the New England Forestry Foundation (NEFF), addressed the Yale Forest Forum about implementing and scaling climate-smart forestry on private lands. Colnes spoke about how these practices can deliver nationally significant regional carbon sequestration alongside ecological outcomes like biodiversity conservation. She outlined NEFF's approach to doing so through its Exemplary Forestry standards and offered insight into the regional implementation of climate-smart forestry through NEFF's USDA Climate Smart Commodities Partnership program. Colnes also explained how climate-smart forestry can contribute to the essential shift to a bioeconomy and highlighted mechanisms for bringing CSF to scale through developing nature-based climate financing mechanisms like the Greenhouse Gas Reduction Fund.

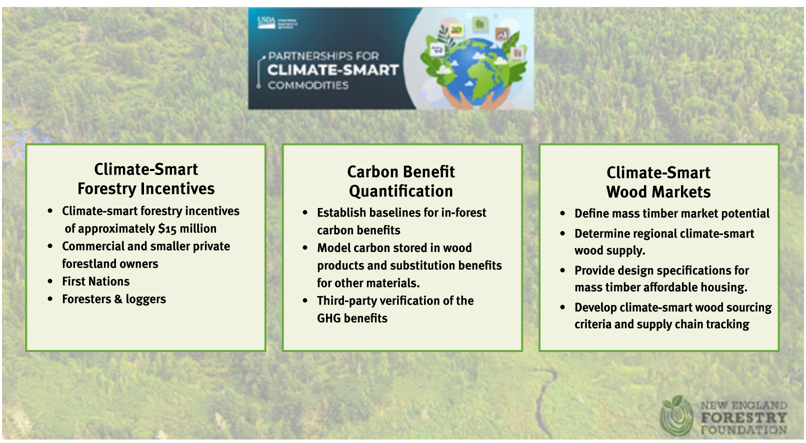
Colnes began her presentation by noting how forest management priorities have evolved over the past century from an early focus on sustained yield to integration of wildlife and biodiversity protection and, most recently, climate change related objectives. She graphically demonstrated how maximizing either forest production or carbon storage and biodiversity at the cost of other objectives yields a negative net climate impact. Colnes outlined how NEFF's Exemplary Forestry management practices integrate multiple objectives into a balanced approach that maximizes carbon storage in forests and protects wildlife. These practices also maintain the production of forest products as essential for a shift to a bioeconomy. NEFF's modeling suggests that such an integrated approach has the potential to meet 30% of New England's overall carbon reduction goals by sequestering approximately 646 million tons of carbon. Colnes explained how this projected carbon reduction potential — the "NEFF 30 Percent Solution" — has also been scientifically confirmed through a peer reviewed article in *Forests* and in additional collaborations.



NEFF uses an integrated systems approach for attaining the best combination of forest management outcomes. Figure courtesy of Andrea Colnes/NEFF.

NEFF's "Thirty Percent Solution": New England has the potential to sequester 30% of its regional carbon reduction goals, mostly through improving forest management, as well as through no net loss of forests, replacing steel and concrete, and building with wood. Figure courtesy of Andrea Colnes/NEFF.

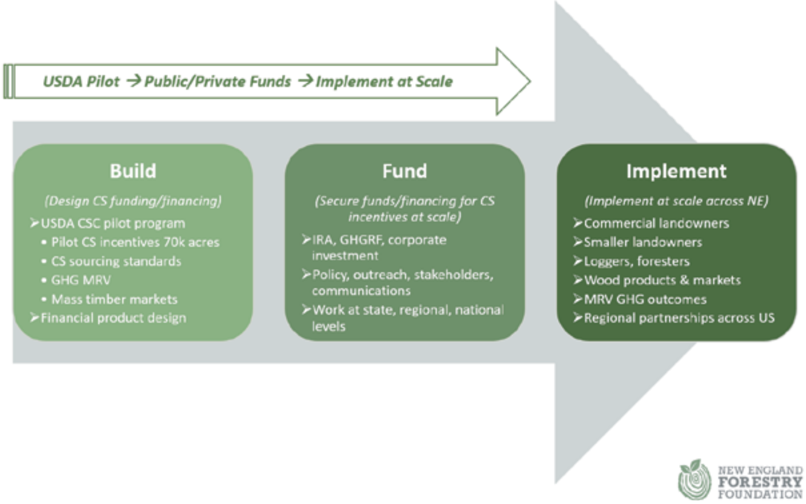
Colnes provided background on USDA's $3.1 billion Partnership for Climate Smart Commodities program and NEFF's $30 million 5-year project thereunder. She noted that it represents a major opportunity for New England to model and pilot the integrated forestry approaches NEFF has been developing and then scale them across New England and beyond. The Partnership for Climate Smart Commodities project has 12 formal subcontracted partners that NEFF will work with on implementation. Consistent with the structure of the USDA program, the project has three major components which Colnes proceeded to detail.



NEFF's $30 million USDA Partnership for Climate Smart Commodities project will focus largely on climate-smart forestry incentives in addition to carbon benefit quantification and promoting climate-smart wood as a commodity. Figure courtesy of Andrea Colnes/NEFF.

Approximately half of NEFF's program funding (around $15 million) will go toward providing direct incentives to commercial forest land-owners, small family woodlot owners, and tribal forestlands for climate-smart forestry practices that focus on carbon sequestration while maintaining sustainable wood harvesting. While these practices will be informed by NEFF's Exemplary Forestry standards, they will be customized to meet the changes each landowner is willing and able to implement on their lands. Colnes noted that the outcomes of NEFF's project will also have relevance to understanding climate-smart forestry practices across the U.S. and globe. The second project component is focused on developing markets for climate-smart wood as an alternative to more carbon-intensive materials, with a specific focus on using mass timber in the construction of affordable housing. This area of work is essential to support a shift to building a low-carbon bioeconomy. The third part of the project focuses on measurement, monitoring, reporting, and verification (MMRV) with the aim of developing baselines for verified carbon assessment and longer-term forest modeling capabilities to project long-term outcomes.

Colnes concluded by noting that the NEFF Partnership for Climate Smart Commodities project will utilize these pilots to inform how climate-smart forest practices can be implemented at scale. NEFF is interested in identifying nature-based financial approaches that can support climate-smart practices at scale to deliver nationally significant carbon benefits. This will be pursued through the leveraging of partnerships with financiers including funds from the Inflation Reduction Act's Greenhouse Gas Reduction Fund. Continuing to build understanding, alignment, and potential for partnership with commercial landowners, smaller landowners, and tribes across the region will be an essential underpinning for this effort.



NEFF's USDA Partnership for Climate Smart Commodities project will focus on building climate-smart forestry pilots as well as scaling them through funding and implementation partnerships. Figure courtesy of Andrea Colnes/NEFF.

Conclusion

By: Katie Michels

Over the past few years, the term climate-smart forestry has become increasingly popular both within and beyond the discipline of forestry. In the United States, funding programs through the Inflation Reduction Act, Farm Bill, and Climate Smart Commodities Program have created new resources for implementing climate-smart practices on the ground. The Yale Forest Forum's fall 2023 speaker series, "Climate-Smart Forestry in Practice," brought together experts and practitioners to explore different understandings and applications of climate-smart forestry.

Series speakers shared a variety of definitions of climate-smart forestry. Steve McNulty shared a definition from Bowditch et al. (2020): climate-smart forestry enables "forests and society to transform, adapt to, and mitigate climate-induced changes." Sara Kuebbing described climate-smart forestry as building on sustainable forest management with three objectives: reducing or removing carbon dioxide, building forest resilience to climate change, and sustainably increasing forest productivity and incomes. McNulty emphasized that climate-smart forestry practices often achieve multiple objectives (i.e. increasing species diversity tends to increase resilience to forest pests), in part because of how the practices tend to increase the resilience of forests to change. All speakers emphasized how climate-smart forestry increases the capacity of forests to adapt to unknown future weather patterns.

Climate-smart forestry includes practices that both mitigate and adapt to the effects of climate change. Forestry offers great potential to serve as a climate solution. Kuebbing described forests as "highly evolved, sophisticated 'direct air capture' facilities," which use 100% renewable solar energy to draw carbon down from the atmosphere. U.S. forests store over 58 billion metric tons of carbon in living vegetation, downed woody debris, and soils, and they sequester the equivalent of 593 million metric tons of carbon dioxide each year.

Community members increase urban canopy coverage by planting trees in a New Haven, Connecticut park. Photo: Cloe Poisson.

However, speakers cautioned against solely managing forests for carbon sequestration. Measures that increase forests' adaptive capacity and resilience to change are critically important to maintain forests as forests, especially when the carbon stored in forests is at risk due to climate-induced disturbances like fire. Maria Janowiak described the "resistance, resilience, transition" framework as an organizing principle for forest adaptation strategies. Resistance strategies help forests resist change and disturbance, resilience strategies allow forests to absorb change while returning to their prior state, and transition strategies help forests move into new states and conditions. She applied this framework to describe different approaches to adaptive silviculture across the United States.

Climate-smart forestry must be specific to local conditions. Climate-smart silviculture looks different in the western United States, where fire is a major disturbance, as opposed to wetter regions of the country. The focus on site-specific themes carried through in both Scott Stephens' discussion of restoring fire regimes in partnership with Native nations, and Kyle Burdick's discussion of the Baskahegan Company's ecological approach to forest management.

Sam Cook, Stephanie Chizmar, and Andrea Colnes each discussed public funding programs that educate and provide financial assistance to private landowners. Colnes and Burdick both emphasized how funding programs must be geared toward the specific needs of different types of landowners.

Mike Dockry challenged the perception of forests as static entities. He urged attendees to consider all forests as novel ecosystems, or dynamic, changing ecosystems that have long co-evolved with human communities. Many Indigenous communities have practiced sustainable forestry for generations. Dockry reminded listeners that Indigenous practitioners have much to teach about concepts of adaptation, resilience, sustainability, and change — perspectives which should be central to the practice of climate-smart forestry.

Lecturer Marlyse Duguid teaches dendrology and restoration in an edge habitat in Branford, Connecticut. Photo: Ian Christmann.

Given this emphasis on change, remaining in constant dialogue is a key lesson from this lecture series. Practitioners — ranging from foresters to policymakers to the communities that make their homes in and around forests — must talk to and learn from each other. By learning from experimentation, monitoring results on the ground, and taking special care to learn from Indigenous communities and other experts who have deep connections to and understandings of the dynamism of forests, climate-smart forestry can be a tool to ensure that forests can persist and thrive in a climate-changed future.

ACKNOWLEDGEMENTS

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