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National Council for Air and Stream Improvement, Inc.

Biometrics Working Group Meeting

June 13, 2024

The Edgewater Hotel

Madison, Wisconsin

AGENDA

https://ncasi.zoom.us/j/4911783805?pwd=UnQ3OTRtNEZoa250TnU5Sy9KSFhKQT09&omn=88557875385

(All times are in Central Time)

Time	Description	Speaker
7:30	BREAKFAST (*Provided*)	
8:00	Welcome	Holly Munro, NCASI Dale Hogg, Green Diamond
8:05	Review of the agenda Antitrust statement Introductions	Holly Munro, NCASI
8:30	National FIA Program Update	Renate Bush, USDA Forest Service
9:00	Forest Carbon Modeling Group	Chris Woodall, USDA Forest Service
9:30	MMRV Platform	Edie Sonne Hall or Jane Alonso, Three Trees Consulting
9:50	BREAK	
10:10	FIA Plot Matching	John Coulston, USDA Forest Service
10:40	New FIA equations	Hector Restrepo, NCASI
11:00	Farm Bill Update	James McKitrick, National Association of State Foresters
11:20	Digital Soil Mapping	Michael Premer, University of Maine
11:40	Wrap-up Discussion	
12:00	ADJOURN *(Lunch provided)*	

Biometrics Working Group Meeting Notes

Date: June 13, 2024
Location: The Edgewater Hotel, Madison, Wisconsin
Organizer: NCASI Biometrics Working Group

The Biometrics Working Group meeting convened on June 13, 2024, in Madison, Wisconsin. The meeting included updates from the USDA Forest Service Forest Inventory and Analysis (FIA) program, presentations on forest carbon modeling initiatives, new analytical methods related to FIA data, and discussions of policy and technical developments affecting forest inventory and carbon reporting. The agenda included presentations from federal agencies, universities, and NCASI staff.

National FIA Program Update – Renate Bush (USDA Forest Service)

Renate Bush provided an update on the National Forest Inventory and Analysis (FIA) program, highlighting staffing challenges, funding limitations, and recent program developments. Although supplemental funding helped reduce field plot backlogs in recent years, ongoing hiring constraints across the Forest Service are limiting the program's ability to fully maintain data collection capacity. Renate Bush also discussed growing demand for FIA data products and spatial datasets, particularly those involving protected plot location information. Efforts are underway to develop standardized national workflows for reviewing and sharing sensitive spatial data while maintaining plot confidentiality. Additional updates included development of a new "One-Click Fact Sheet" tool that will provide standardized, regularly updated summaries of FIA data for each state.

Forest Carbon Modeling Group – Chris Woodall (USFS)

Chris Woodall presented an update on the Forest Carbon Modeling Group (FCMG), a collaborative effort between the U.S. Forest Service and NCASI designed to advance forest carbon modeling capabilities through coordinated research and partnerships. Chris Woodall emphasized that growing policy and market demand, including federal climate initiatives, voluntary carbon markets, and international regulations, is increasing the need for improved forest carbon modeling and measurement systems. The FCMG initiative aims to identify scientific priorities, develop peer-reviewed research, and foster collaboration among researchers, industry, and policymakers to improve modeling frameworks used for carbon accounting and decision making. Two recent manuscripts produced by the group address both strategic and technical challenges in forest carbon modeling, including growth and regeneration modeling, disturbance effects, belowground carbon dynamics, uncertainty estimation, and integration with modeling systems such as the Forest Vegetation Simulator (FVS). Chris Woodall emphasized that improving these models will be critical for advancing measurement, monitoring, reporting, and verification (MMRV) systems and supporting emerging climate policy frameworks.

MMRV Platform – Edie Sonne Hall or Jane Alonso (Three Trees Consulting)

The presentation on the Measurement, Monitoring, Reporting, and Verification (MMRV) platform discussed ongoing efforts to develop national frameworks for tracking greenhouse gas emissions and removals across forest systems. The platform is intended to facilitate consistent reporting of forest carbon dynamics at national, regional, and entity scales while improving transparency and data accessibility. Edie Sonne Hall also emphasized the importance of collaboration between government agencies, private sector organizations, and research institutions in building scalable systems capable of supporting emerging carbon reporting requirements.

FIA Plot Matching – John Coulston (US Forest Service)

John Coulston presented research exploring methods for aligning FIA inventory data to a common reference year. Because FIA uses rotating panel designs that measure subsets of plots each year, current estimates often rely on moving averages of data collected over multiple years. Coulston described limitations of this approach, particularly its inability to account for dynamic forest processes such as growth, harvest, and disturbance. He introduced a stochastic imputation approach based on matching techniques that identifies donor plots with similar characteristics to represent the future state of earlier measurements. This approach involves projecting key dynamic variables such as basal area and stand age forward using simplified models and then matching each plot to remeasured donor plots with similar attributes.

Impact of the New NSVB Equations on FIADB – Hector Restrepo (NCASI)

Hector Restrepo presented an analysis of the effects of implementing the new National Scale Volume and Biomass (NSVB) equations in the Forest Inventory and Analysis Database (FIADB). These equations replace earlier volume and biomass estimation methods and are applied retroactively across both current and historical FIA data. Using the EVALIDator API, Restrepo compared estimates produced under previous and updated equation systems. The analysis showed that while total volume estimates increased only modestly on average (approximately 2%), larger changes were observed for biomass and carbon pools. Aboveground biomass estimates increased by roughly 13% and aboveground carbon estimates increased by about 9%, while organic soil carbon estimates increased substantially. The results highlight that methodological updates in biomass and carbon equations can substantially influence forest carbon accounting and may affect long-term analyses relying on FIA data.

Farm Bill Update – James McKitrick (National Association of State Foresters)

James McKitrick provided a brief update on the status of the Farm Bill, noting that the current legislation is set to expire at the end of September. Both the House and Senate have released summary versions of proposed legislation, which include several provisions relevant to forestry and natural resource management. While details remain under negotiation, the discussion highlighted the potential implications of new legislation for forest monitoring programs, climate initiatives, and forestry research funding.

Wrap-Up Discussion

The meeting concluded with an open discussion among participants on several broader issues affecting the future of the Forest Inventory and Analysis (FIA) program and forest biometrics research. A key topic was the potential development of a new Blue Ribbon Panel for FIA, which would evaluate the current program and provide strategic recommendations for its future direction. Participants discussed the importance of ensuring that FIA continues to meet the evolving information needs of policymakers, industry, and researchers, particularly given increasing demands related to forest carbon accounting, climate reporting, and emerging regulatory frameworks. The discussion also emphasized the need to balance FIA's design-based statistical foundation with the growing use of model-based methods and new data sources such as remote sensing. Participants noted that a Blue Ribbon Panel could provide an opportunity to assess long-term priorities, funding needs, and methodological advancements required to maintain FIA as the nation's primary forest monitoring system.

Forest Inventory and Analysis

Program Update

Biometrics Working Group Meeting

June 13, 2024

Renate Bush, renate.bush@usda.gov
Forest Inventory and Analysis
National Program Lead

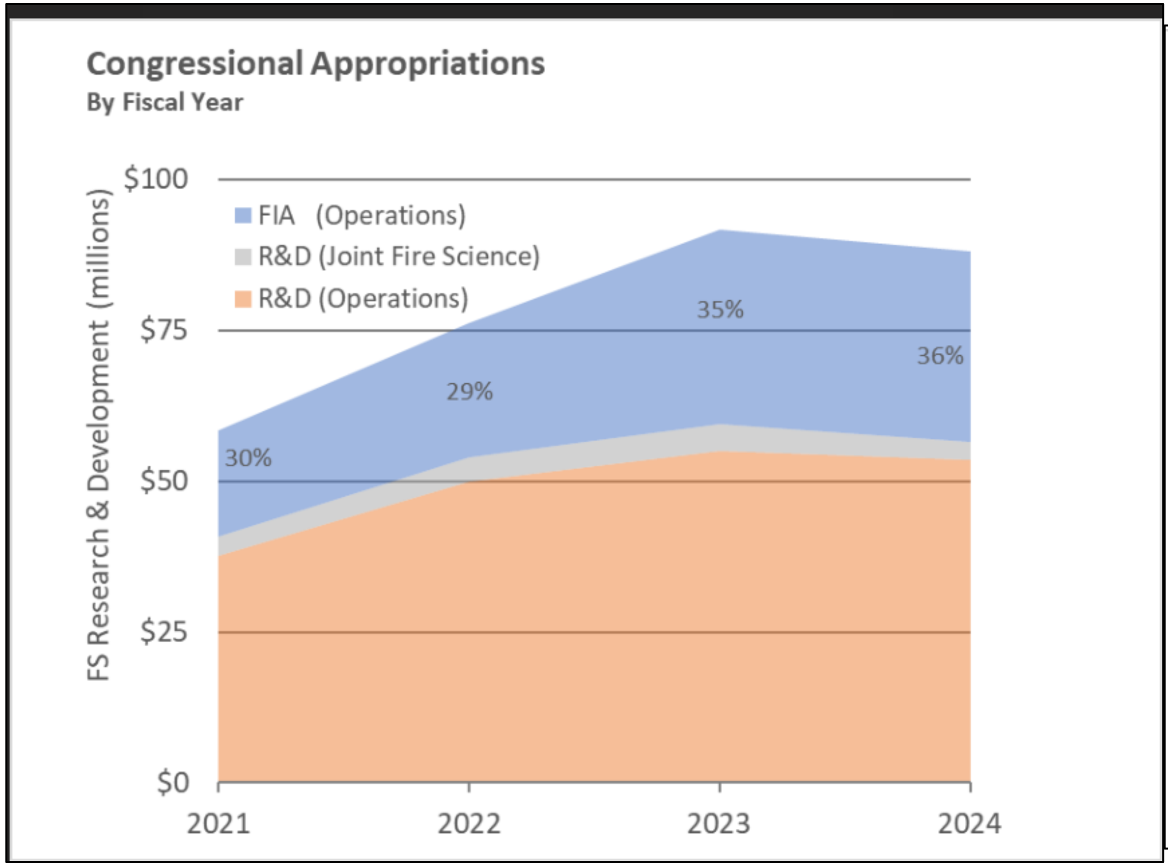
Update R&D IMAR FIA Positions

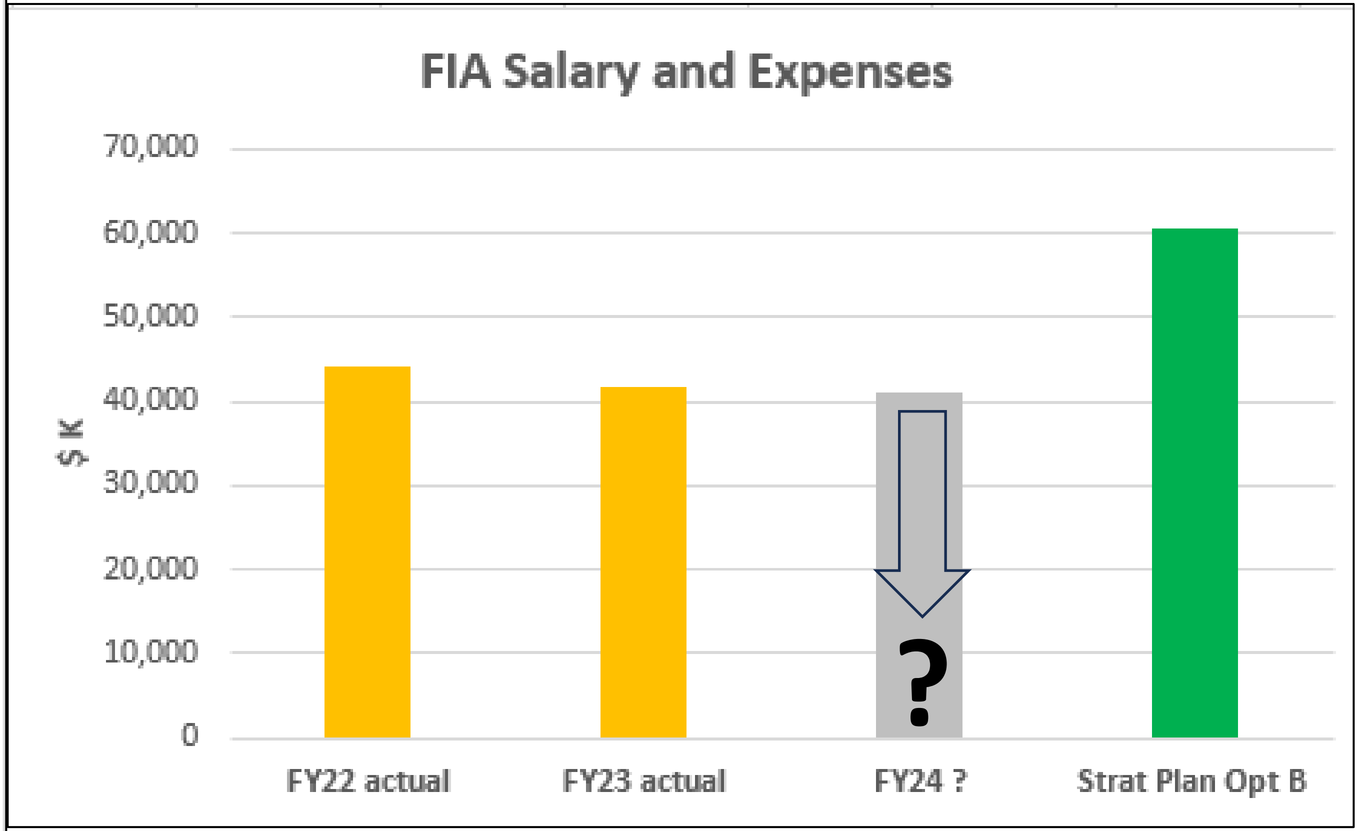
National Program Manager	**Sara Goeking started 9/26/2023**
IRA funded National Analysts (2)	**Katie Renwick- FIA National Analyst Lead-** through 4/26 **FIA National Analyst-** candidate selected, hiring paused
National Spatial Data Services Coordinator	**3-month detailer earlier this year. Hoping to fill term position.**

Allocations vs Strategic Plan Base FIA Program

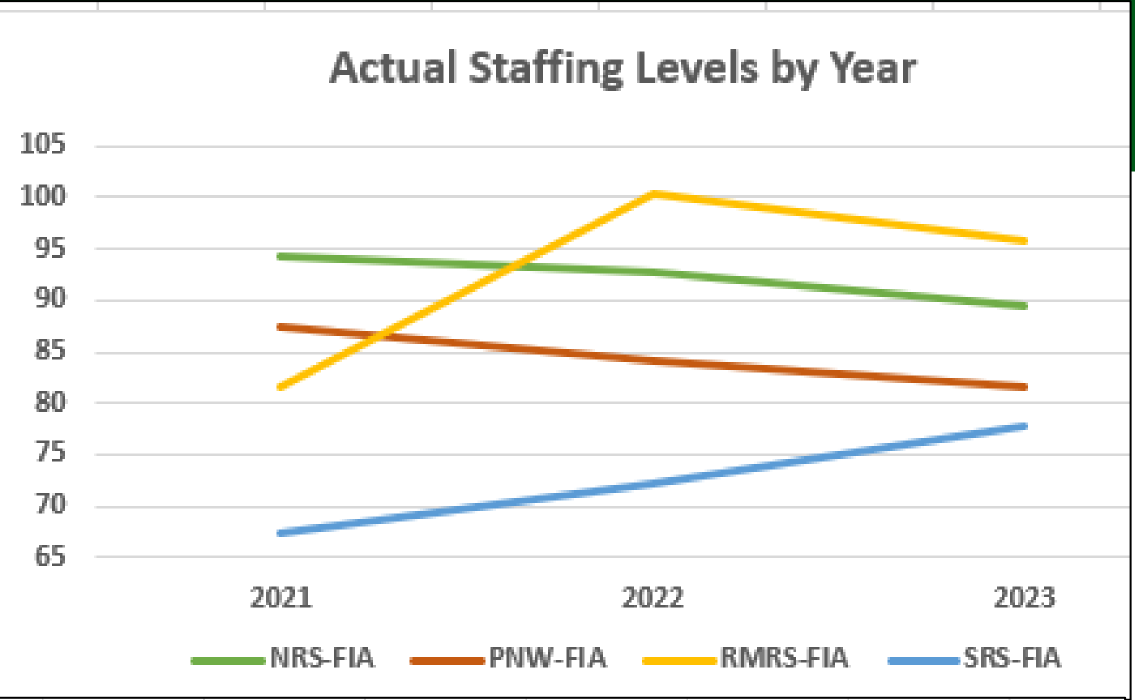
Base FIA Program (Option B in Strategic Plan): Nationwide forest inventory (P2), 5-7 yr cycle east, 10 yr cycle west. 3/16 plots have down-woody material (DWM), understory vegetation, and crown (dieback); 1/8 plots have soils

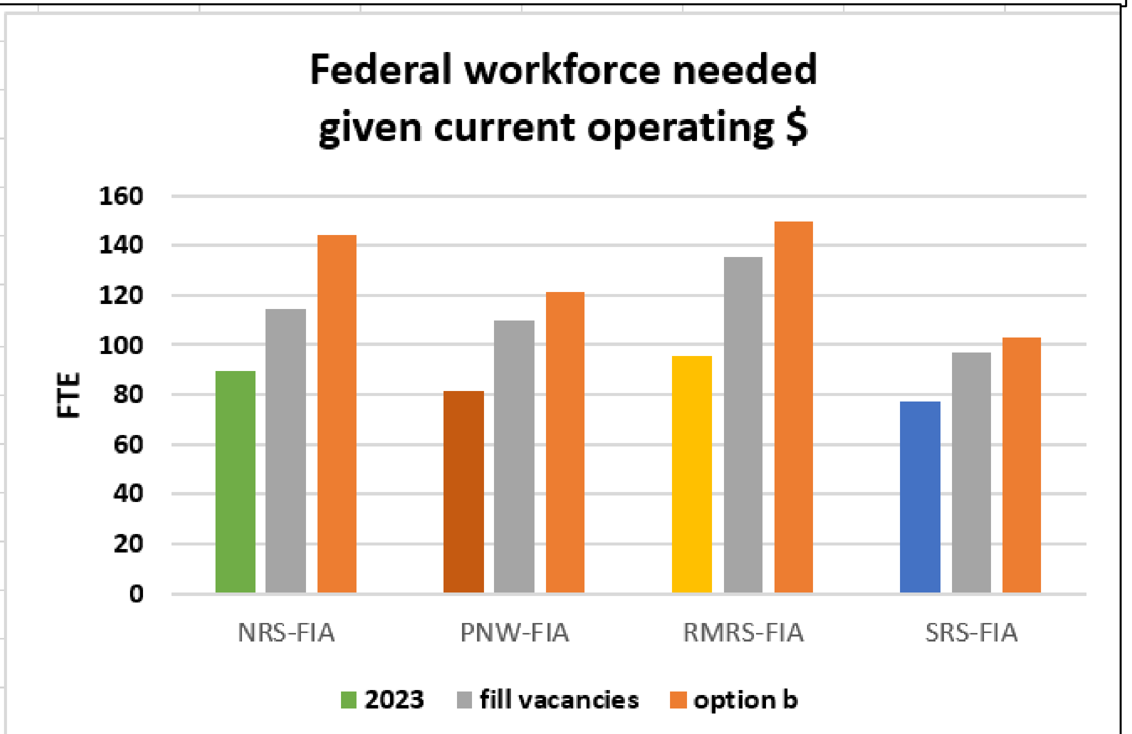
- FIA is receiving 91% of operating and 66% of S&E needed to implement Option B





Staffing



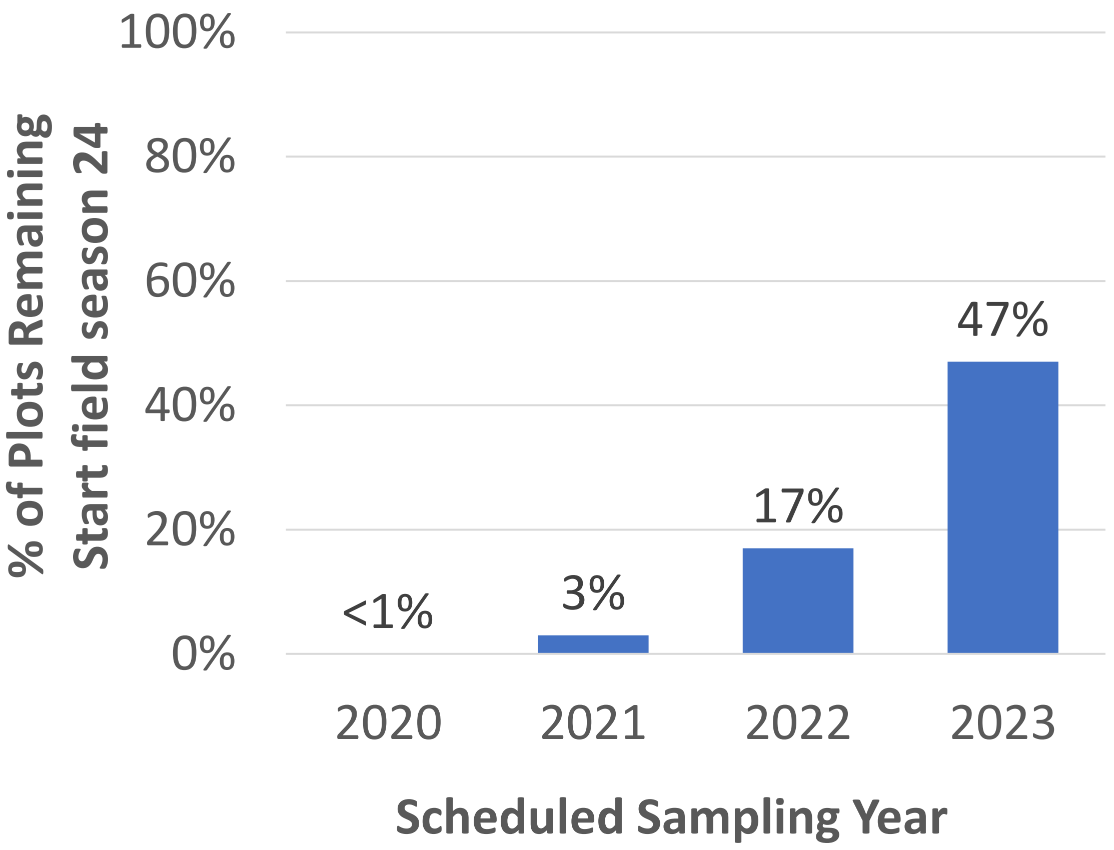


FIA can accomplish much of the program through agreements and contracting

- We are losing ground with the Federal workforce needed.
- Unable to prioritize hiring across FIA
- Very little recruiting and filling of positions happening in FS at this time
- Critical vacancies that need to be filled to avoid additional backlogs in data collection and reporting: NRS 9, PNW 22, RMRS 36

Status of NFI Plot Collection

Plot backlog in Nationwide Forest Inventory (NFI)



- Supplemental funding allowed substantial catchup in 2022 and 2023.
- Current data collection staffing levels are: 75% NRS, 60% PNW, 70% RMRS, 83% SRS
- Anticipated reduction in completed plots in 2024: NRS 10%, PNW 40%, RMRS 30%, SRS 0%
- Field data collection costs are increasing significantly

Farm Bill

- Current Farm Bill expires on Sept 30
- Summaries have been released by the House and Senate

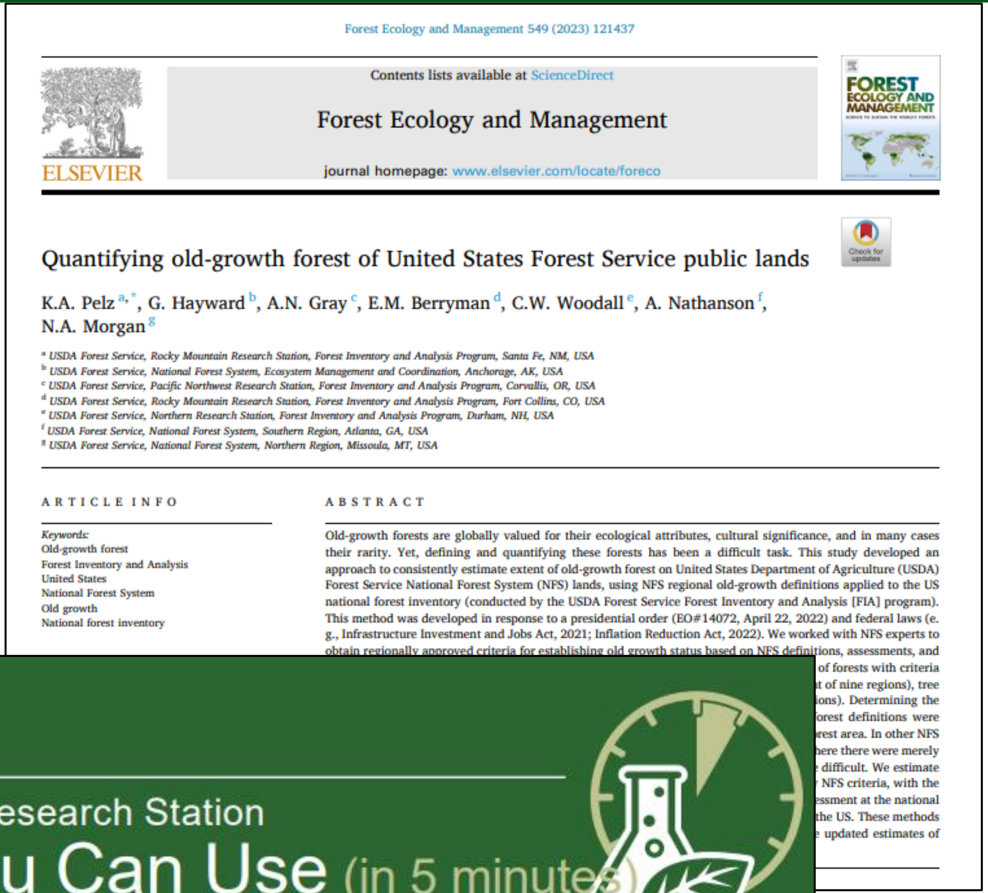

FORESTS IN THE FARM BILL
2023 FARM BILL
SUMMARIZED RECOMMENDATIONS

Below are concisely summarized recommendations organized by Farm Bil
are not listed in any priority order. Additional information on each recomm
need and policy solutions, can be found in FIFB Recommendations and Pol

FORESTRY

Old Growth and Mature Quantification

- **Showcases the utility of FIA data** in assessment and monitoring
- Mature and old growth analysis across publicly managed Forests **provided estimates to a group of users that have underutilized FIA data for assessment and monitoring**.
- Continued collaboration with NFS on the vulnerability assessment and Nationwide Old Growth Amendment (NOGA)
- IRA funding is supporting FIA National Analyst and BigMap development



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Quantifying old-growth forest of United States Forest Service public lands

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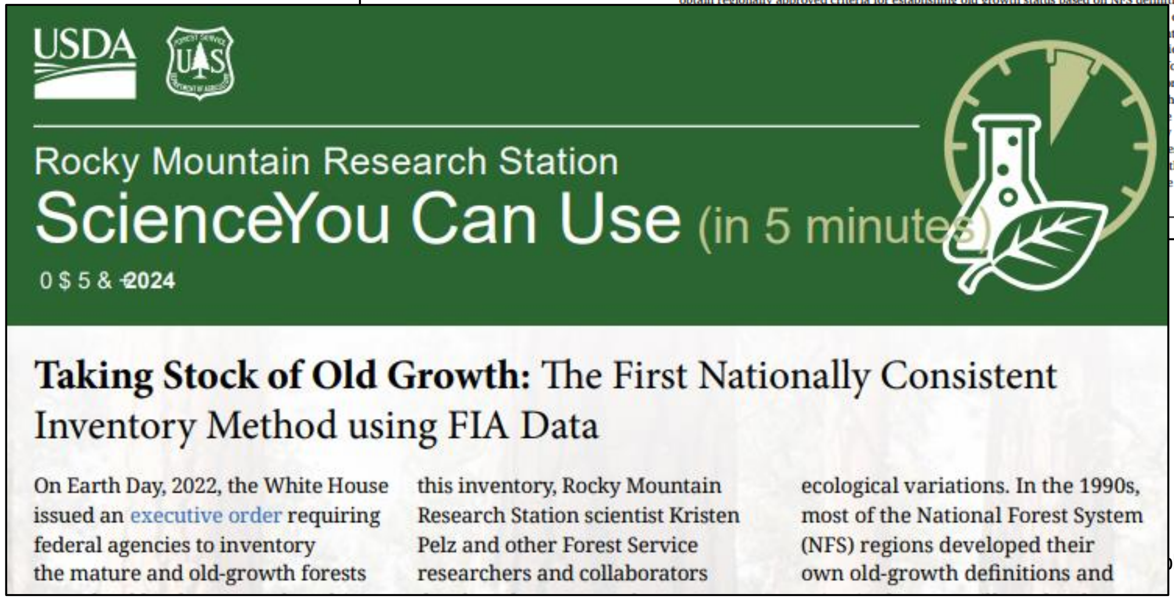
ABSTRACT

Old-growth forests are globally valued for their ecological attributes, cultural significance, and in many cases their rarity. Yet, defining and quantifying these forests has been a difficult task. This study developed an approach to consistently estimate extent of old-growth forest on United States Department of Agriculture (USDA) Forest Service National Forest System (NFS) lands, using NFS regional old-growth definitions applied to the US national forest inventory (conducted by the USDA Forest Service Forest Inventory and Analysis [FIA] program). This method was developed in response to a presidential order (EO#14072, April 22, 2022) and federal laws (e.g., Infrastructure Investment and Jobs Act, 2021; Inflation Reduction Act, 2022). We worked with NFS experts to obtain regionally approved criteria for establishing old growth status based on NFS definitions, assessments, and ... of forests with criteria ... t of nine regions), tree ... ions). Determining the ... orest definitions were ... rest area. In other NFS ... here there were merely ... difficult. We estimate ... NFS criteria, with the ... essment at the national ... the US. These methods ... updated estimates of


USDA

Rocky Mountain Research Station

ScienceYou Can Use (in 5 minutes)

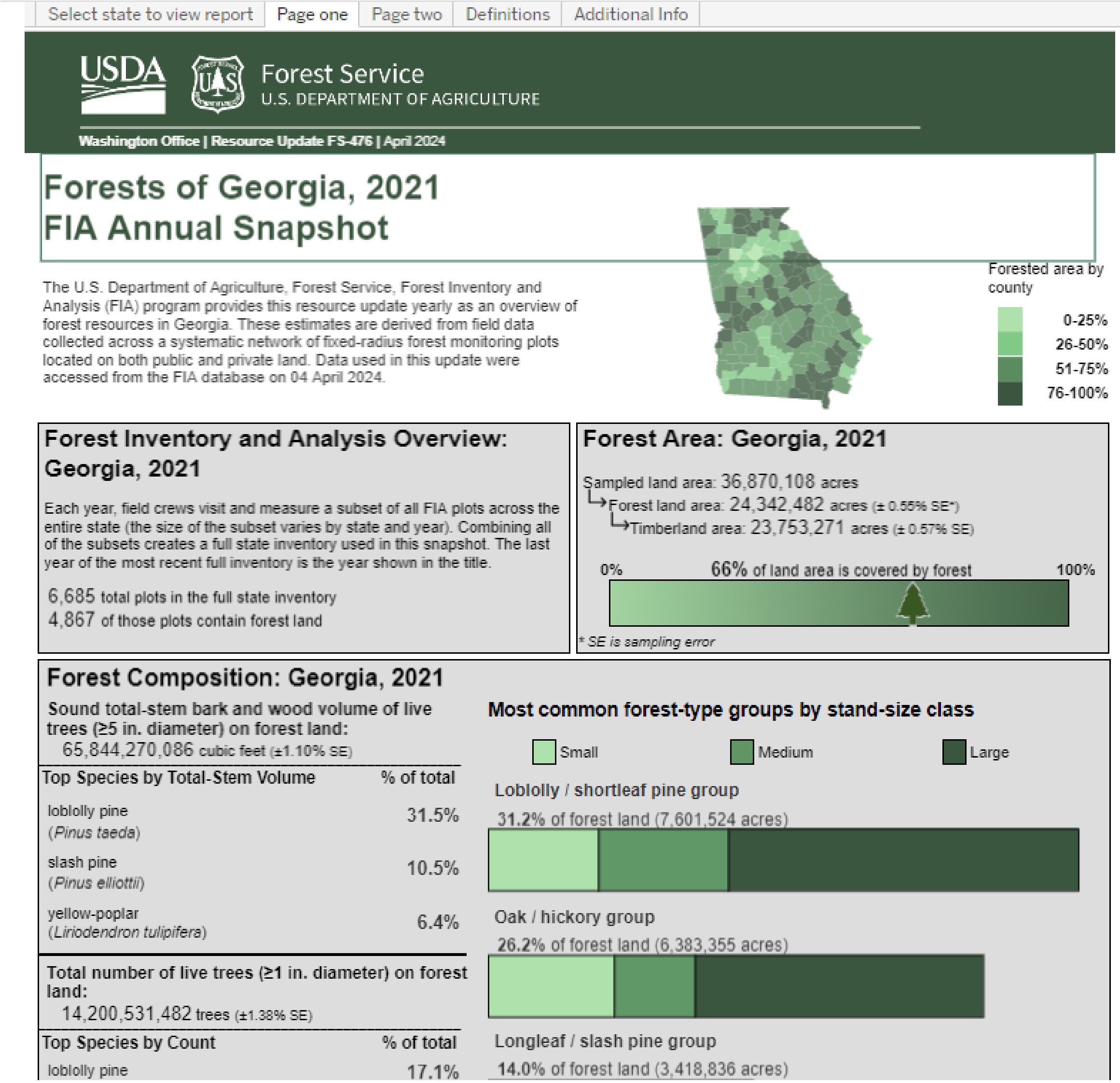
0 $ 5 & 2024

Taking Stock of Old Growth: The First Nationally Consistent Inventory Method using FIA Data

On Earth Day, 2022, the White House issued an executive order requiring federal agencies to inventory the mature and old-growth forests this inventory, Rocky Mountain Research Station scientist Kristen Pelz and other Forest Service researchers and collaborators ecological variations. In the 1990s, most of the National Forest System (NFS) regions developed their own old-growth definitions and

One-Click Fact Sheet

- Releasing new, more comprehensive State Fact Sheet visualization tool
- Data is updated on a quarterly cycle to ensure new FIADB data is displayed
- An annual Resource Update will be created for each state
  - in Treesearch, citable
- Working with the Station Publication Shops to standardize workflows and minimize impact in producing Resource Updates
- **One-click Fact Sheet SAF-FIA Tech Transfer Session,** June 24, 2:00-4:00 eastern
- **Register here:** REGISTER NOW


Select state to view report | Page one | Page two | Definitions | Additional Info

USDA Forest Service U.S. DEPARTMENT OF AGRICULTURE

Washington Office | Resource Update FS-476 | April 2024

Forests of Georgia, 2021
FIA Annual Snapshot

The U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) program provides this resource update yearly as an overview of forest resources in Georgia. These estimates are derived from field data collected across a systematic network of fixed-radius forest monitoring plots located on both public and private land. Data used in this update were accessed from the FIA database on 04 April 2024.

Forest Inventory and Analysis Overview: Georgia, 2021

Each year, field crews visit and measure a subset of all FIA plots across the entire state (the size of the subset varies by state and year). Combining all of the subsets creates a full state inventory used in this snapshot. The last year of the most recent full inventory is the year shown in the title.

6,685 total plots in the full state inventory
4,867 of those plots contain forest land

Forest Area: Georgia, 2021

Sampled land area: 36,870,108 acres
Forest land area: 24,342,482 acres (± 0.55% SE*)
Timberland area: 23,753,271 acres (± 0.57% SE)

0% 66% of land area is covered by forest 100%

* SE is sampling error

Forest Composition: Georgia, 2021

Sound total-stem bark and wood volume of live trees (≥5 in. diameter) on forest land:
65,844,270,086 cubic feet (±1.10% SE)

Top Species by Total-Stem Volume	% of total
loblolly pine (*Pinus taeda*)	31.5%
slash pine (*Pinus elliottii*)	10.5%
yellow-poplar (*Liriodendron tulipifera*)	6.4%

Total number of live trees (≥1 in. diameter) on forest land:
14,200,531,482 trees (±1.38% SE)

Top Species by Count	% of total
loblolly pine	17.1%

Most common forest-type groups by stand-size class

Small | Medium | Large

Loblolly / shortleaf pine group
31.2% of forest land (7,601,524 acres)

Oak / hickory group
26.2% of forest land (6,383,355 acres)

Longleaf / slash pine group
14.0% of forest land (3,418,836 acres)

Spatial Data Services (SDS)

Increased interest in working with protected information

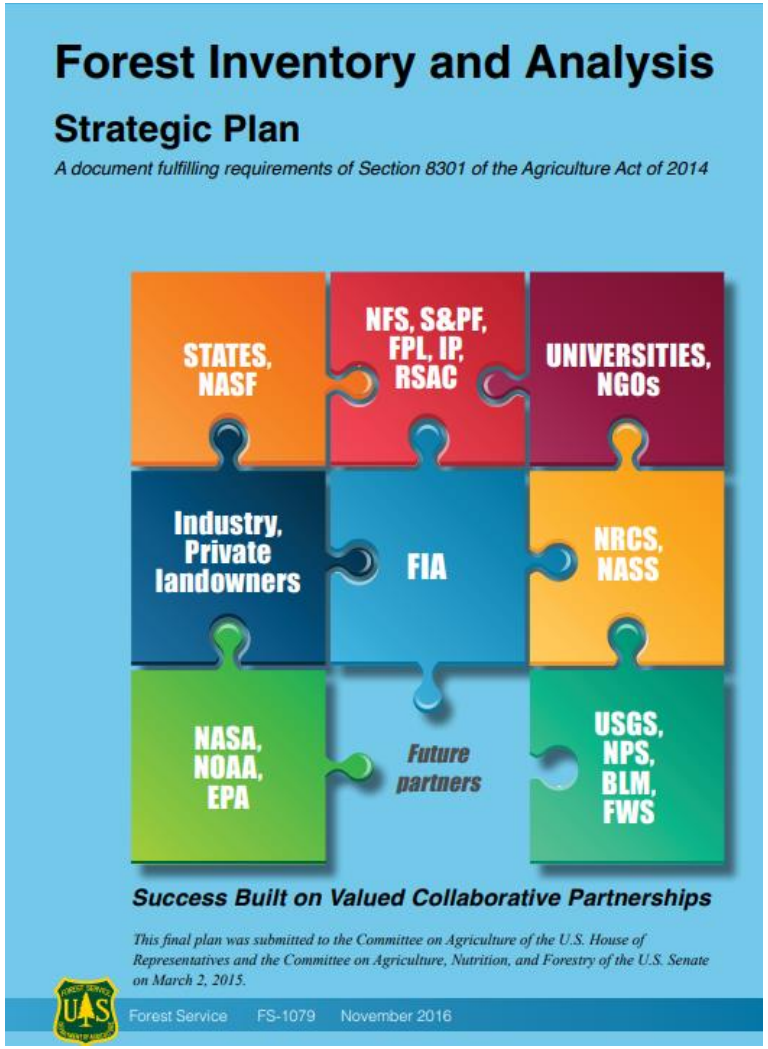
Members of the SDS Team and FIA program and Portfolio leadership met to **outline national solutions for managing and sharing confidential data that is implementable across all FIA Regions**

Identified the strengths and weaknesses of our current systems and processes. A **workflow / decision tree for managing and reviewing data requests and assessing risk is under development.**

PNW has developed **a standard way to review spatial datasets** that are created **to ensure plot location information is protected**

Currently unable to fill SDS vacancies in FIA Units and nationally which is impacting oversite and coordination

FIA 2015 Strategic Plan National Priorities



- Fully **annualized inventory** program including **interior Alaska**.
- Annualized **inventory** of trees in **urban** settings
- **Report biomass and carbon** stocks
- Reevaluate the list of core data variables collected
- **Timber products output (TPO)**
- **Foster cooperation** among users of FIA information
- **Promote availability and access** to non-Fed to improve information analysis and management.
- Integrate **remote sensing, spatial analysis techniques**, and other new technologies
- Understand and report on **land cover and land-use change**.
- Increase understanding of **family forest owners (NWOS)**
- Improve estimates at the sub-State level (**small-area estimation**)

Note: the program does not have full funding to complete all these priorities.

USDA United States Department of Agriculture

Communication

FIA National Program Lead mailing list to communicate with people outside of FIA about the program and items that may be of interest

Good morning-

On behalf of FIA, we would like to wish you a Happy New Year and to provide you some updates from FIA.

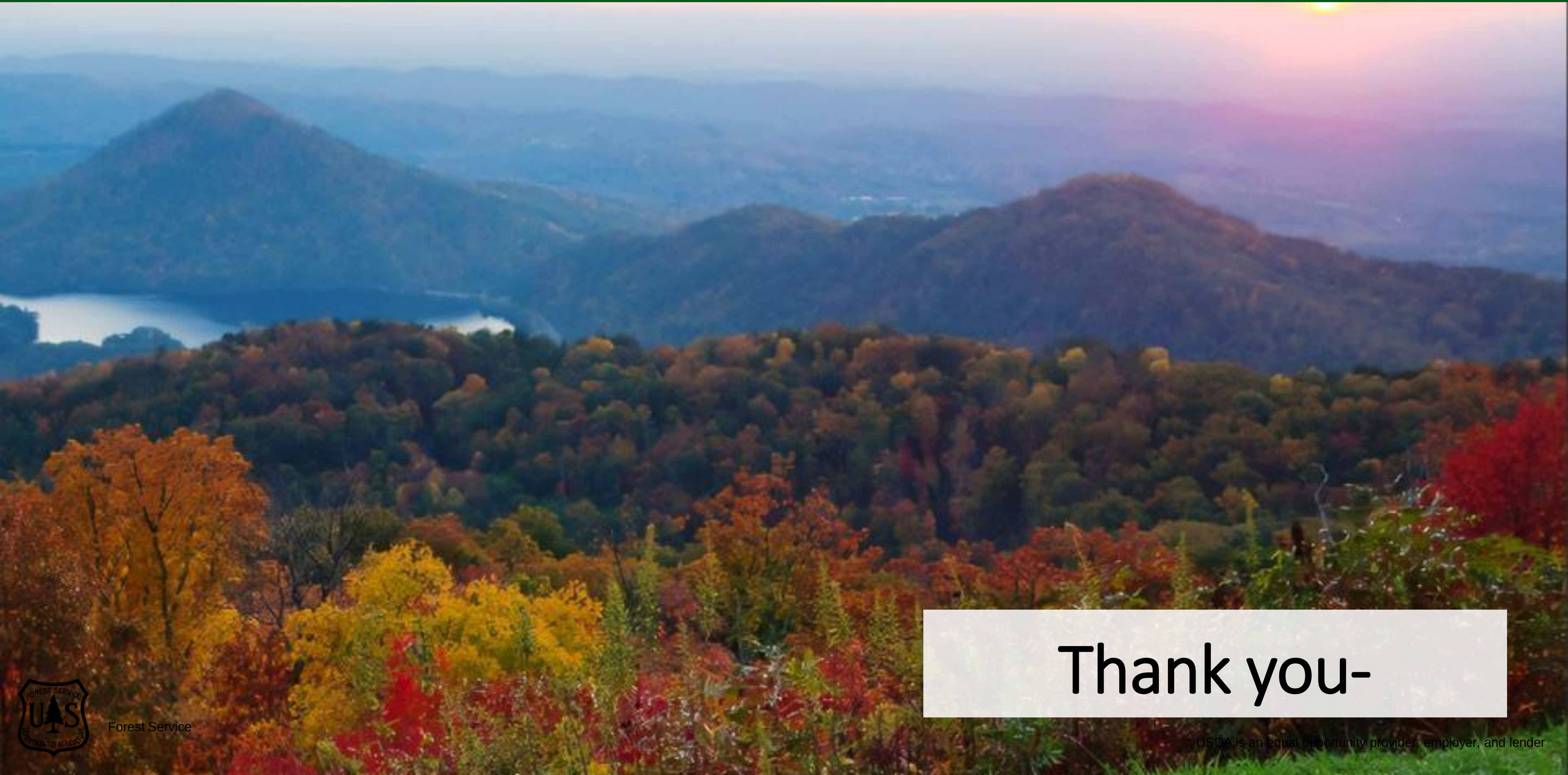
Sara Goeking is now the FIA National Program Manager. Prior to starting this position at the end of September, she worked at RMRS FIA for more than 19 years, most recently as deputy program manager but has also been an analyst and field crew leader. Sara is responsible for compilation of the annual business report, overseeing national agreements, and various program management and coordination activities for headquarters' FIA.

FIA's annual business reports have provided transparency and accountability to Congress, the public, and FIA's partners since 1998. The **25th annual Forest Inventory and Analysis (FIA) Business Report** is now available and summarizes FIA's FY22 finances

Mailing list form access

National FIA mailing list

United States Department of Agriculture



Thank you-

Forest Service

Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Forest Carbon Modeling Group

Biometrics Working Group Briefing

Chris Woodall and Courtney Giebink (USFS)

Holly Munro (NCASI)

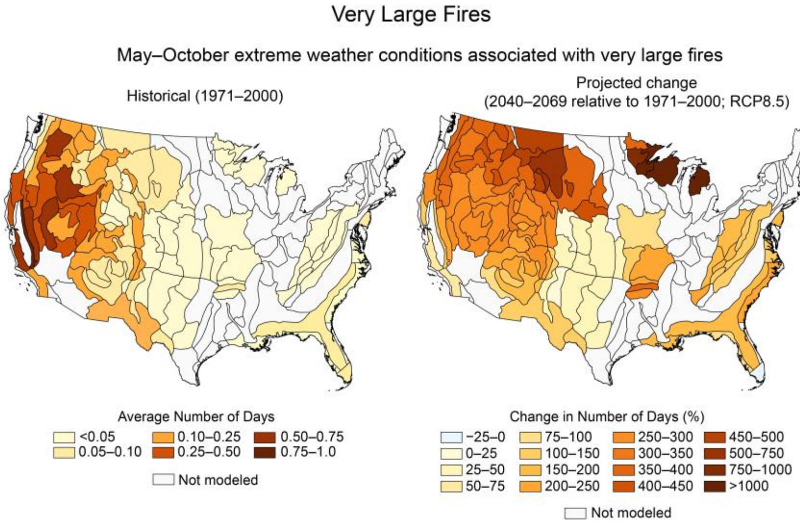
June 13, 2024

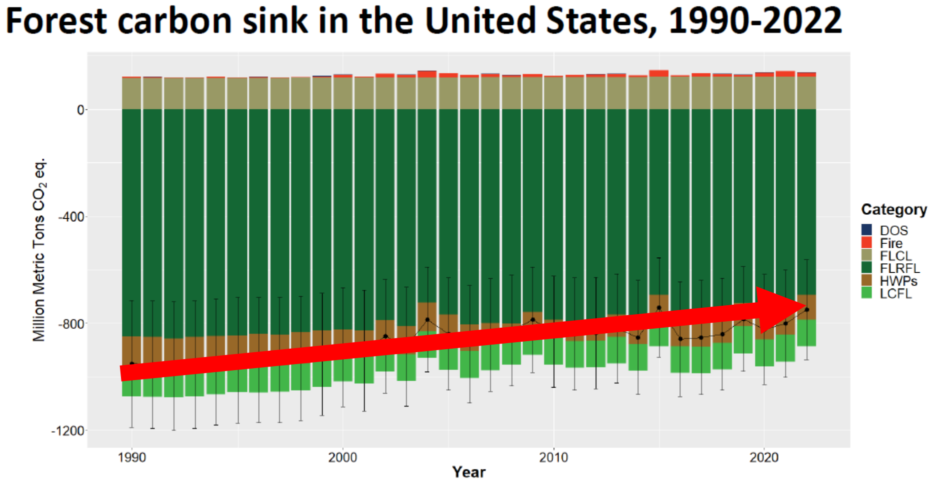
Policy Environment in Need of Forest Modeling

- Bipartisan Infrastructure Law - Wildfire Crisis Strategy
- Executive Order on Mature and Old-Growth Forests
- Inflation Reduction Act Program Implementation
- Voluntary Carbon Markets and ESG
- Federal Greenhouse Gas Information System
- Growing Climate Solutions Act
- US International Commitments
- EU Green Deal

White House VCM Announcement

National Assessments Highlight Role of Forest C Modeling



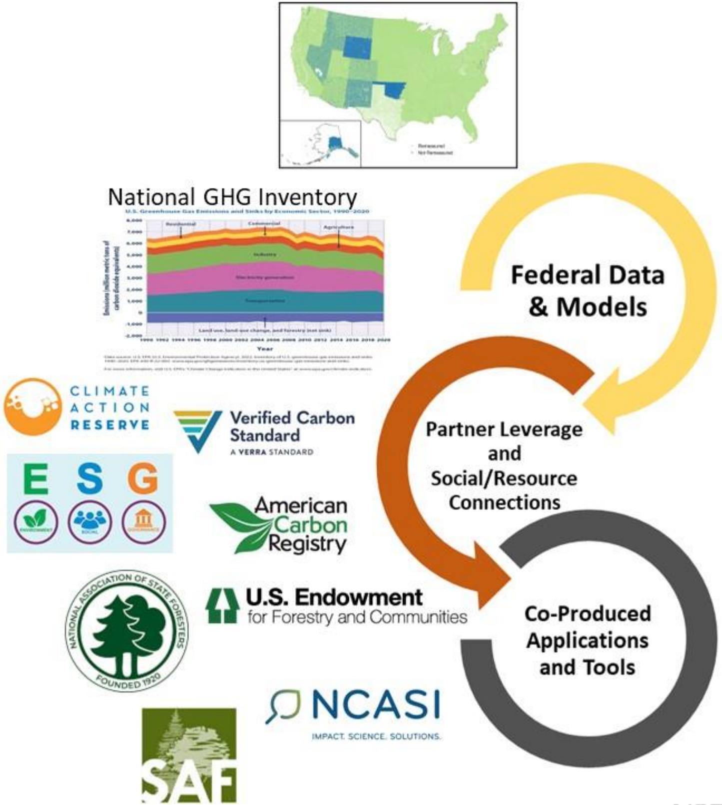


- Ability of US forests to pull carbon from atmosphere is weakening
- Uncertainty across space, time, and forest conditions

Domke, G.M., et al. 2023: Ch. 7. Forests. In: Fifth National Climate Assessment. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH7

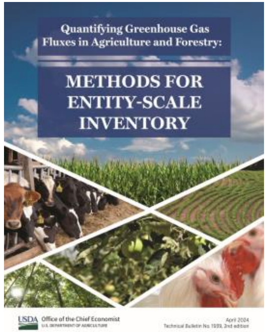
Federal Program Deployment

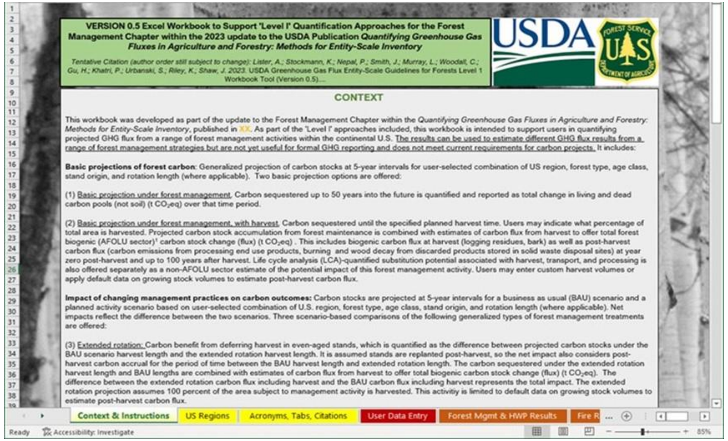
- USFS Carbon Partnership Program Pilots
- Climate Smart Commodity Grants
- USFS State, Private, and Tribal Carbon Payments
- NRCS Climate Smart Practices
- Mature/Old-Growth Environmental Impact Statement
- Federal Focus on Standards and Role as Convener



USDA Entity Guidelines Officially Released in April (version 2.0)

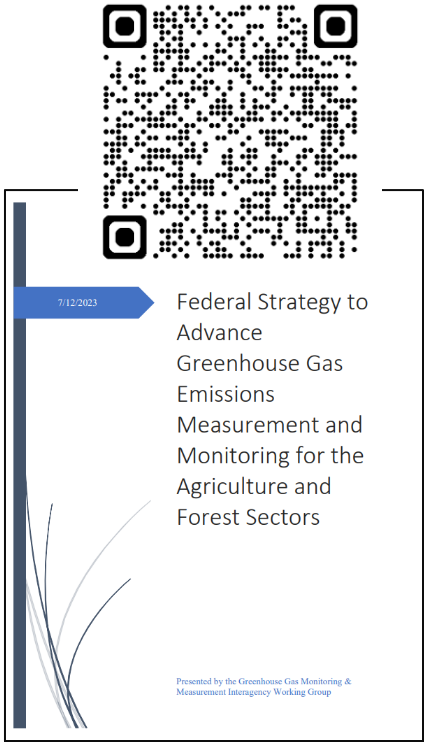
- Update forest greenhouse gas accounting standards using best available science
- Lower barriers to carbon markets
- Promote public and partner co-development
  - –Connect forest ecosystem to forest industry
  - –Fire emissions
  - –Displacement benefits
- Highlights work that remains
  - –Expand menu of forest management practices
  - –Non-tree carbon pools
  - –**IMPROVED FOREST MODELING!!!!!**

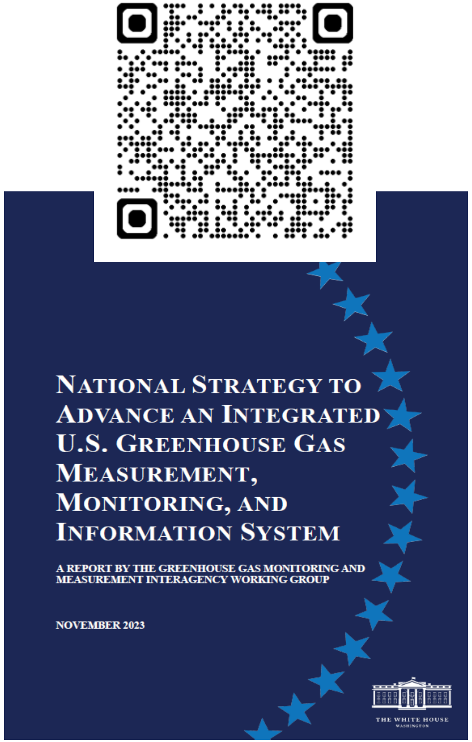




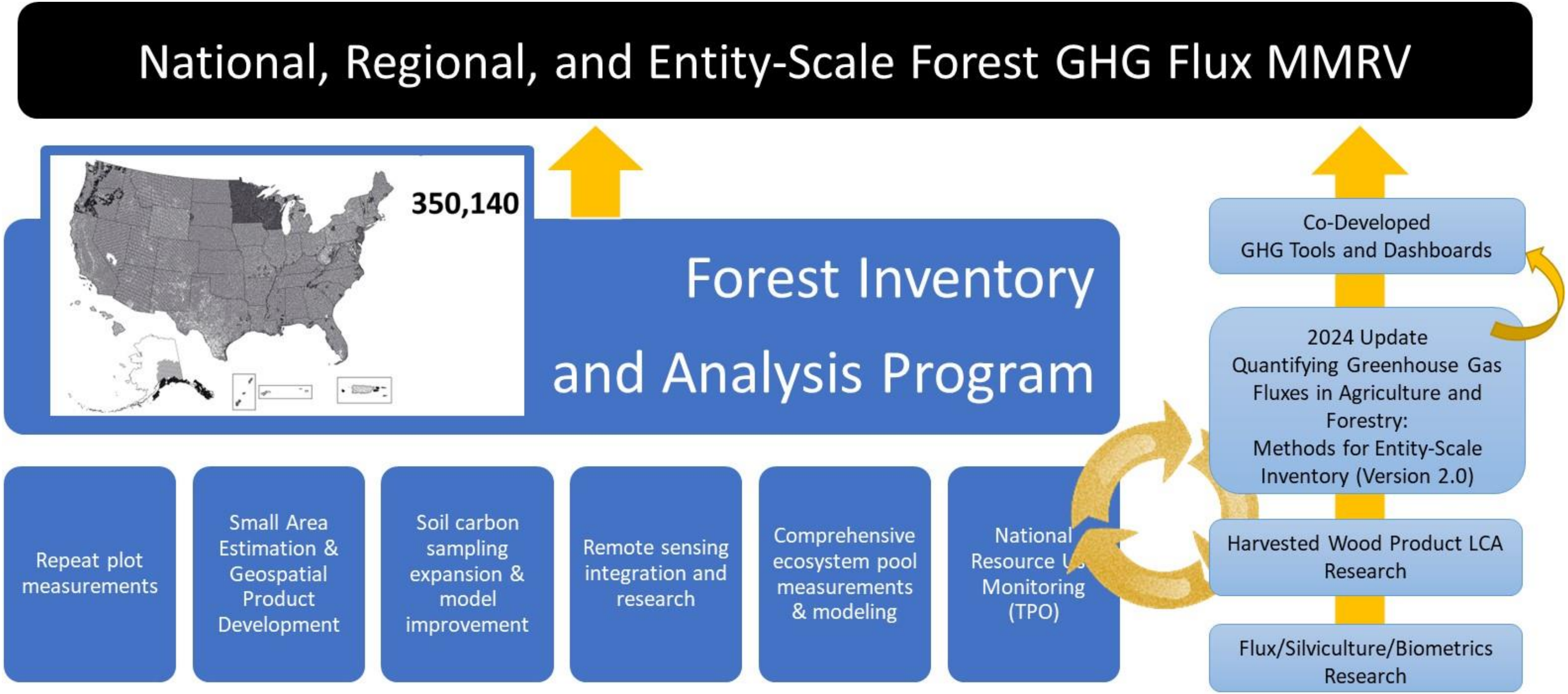
MMRV Federal Plans Release

- USDA Ag/Forest Sector
  - –Forest modeling broadly highlighted with specific identification of FVS
- White House Strategy
  - –GHGMMIS
  - –Focused on fossil fuel emissions
  - –Forest modeling identified
- Forest MMRV Workshop
  - –Explore integration of modeling approaches (bottom-up and top-down)



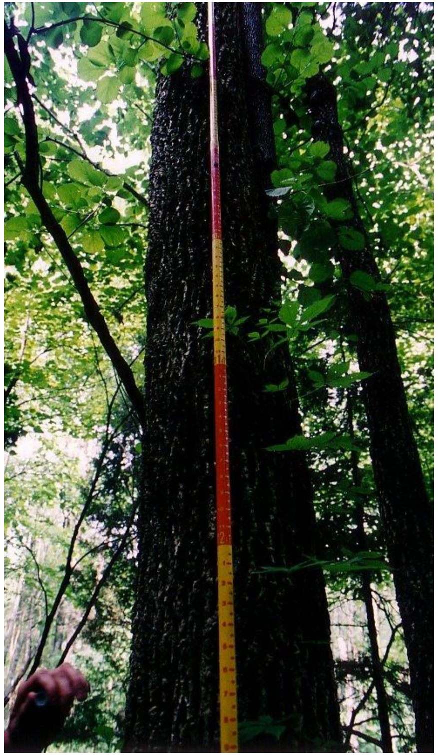


US Forest Service and MMRV



MMRV Scope of Work Submitted to White House OMB

- Forest Carbon Data Platform
- Cooperative Research and Development Agreements with Partners: NCASI and CTrees
- Release USDA Entity Guidelines 2.0 and scope Version 3.0 (Fall 2024)
- Advance SAE for Refined Carbon Estimates across Space and Time
- Continue NRCS and USFS Agreement on Soil Carbon
- Fully Implement National Scale Vol/Biomass Models
- **Achieve FCMG Objectives**



FCMG Objective

Finalize and publish peer-reviewed examination of refinements to forest carbon models used by forest carbon project developers, states, industry, and NGOs through a Joint Research Venture Agreement between US Forest Service and the National Council on Air and Stream Improvement, Inc. (NCASI), as part of a larger Forest Carbon Modeling Group that will empower the co-development of associated modeling improvements.

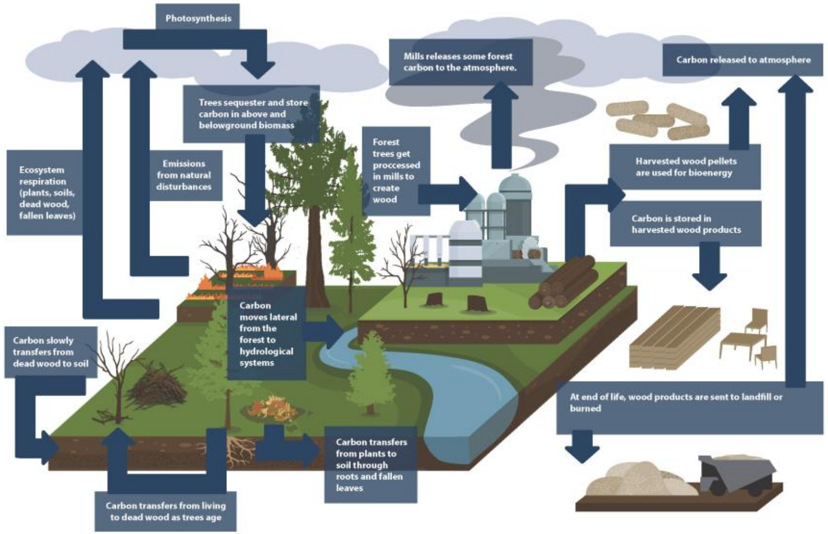


Illustration of Economy-Wide Flow of Forest Carbon

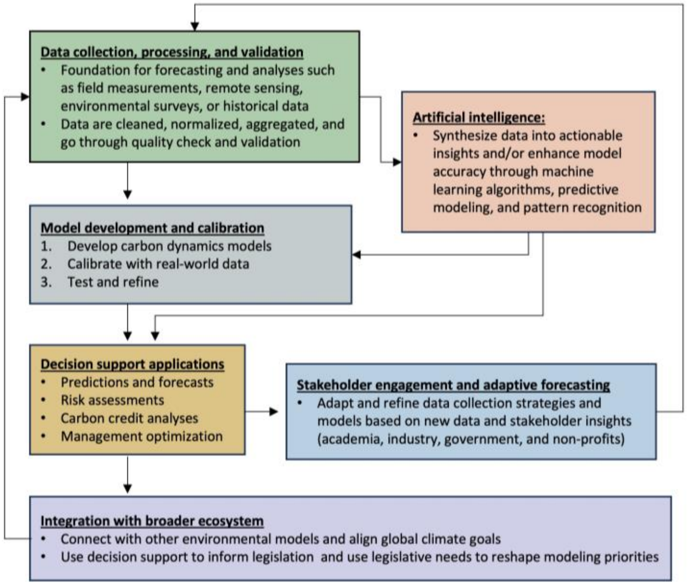
Forest Carbon Modeling Group Refresher

- USFS and NCASI Partnership to Advance Biometric Models (RJVA)
- Convene biometricians across sectors to identify and meet emergent forest carbon modeling needs
- Progress To-Date
  - –Facilitated discussions towards strategic plans
  - –Article series developed and submitted
  - –$1.9 million Cooperative Agreement under USFS consideration
  - –Onboard FVS R&D Liaison

PotlatchDeltic
Weyerhaesuer
NCX
Roseburg Forest Products
Seven Islands Land Company
U of Florida
NAFO
Campbell Global
U of Alabama
Mass Dept of Conservation
TTG Forestry Services
NC State U
U of Maine
Stephen F Austin State U
RMS
U of Tennessee
Three Trees Consulting
US Endowment
International Paper
BTG Pactual
MS State U
SUNY ESF
UGA
TNC
Va Tech
Rayonier
ArborGen
American Forests
Ecotrust
UBC
Paul Smith’s
Maine FS
U of Alberta
Mason Bruce and Girard
OSU
Green Diamond
Molpus Woodlands Group
U New Brunswick
Timberland Investment Resources
F&W Forestry Services
Michigan State U
Southern Cross Biometrics
CARB

FCMG Paper #1

- Title: Forest Modeling Innovation: Opportunities to Empower Forest Carbon Decision Making
- Outlet: Journal of Forestry
- Conclusion: We propose a scalable, hierarchical, and transdisciplinary design that can address short-term needs (e.g., improved tree regeneration modeling) and drive long-term scientific advances (e.g., albedo and lateral flux modeling) and science delivery to inform strategic deployment of NCS across landscapes while empowering GHG measurement, monitoring, reporting and verification.



Workflow of Forest Carbon Modeling in Support of Natural Climate Solutions

FCMG Paper #2

- Title: Forest modeling at the forefront: Complexities of carbon modeling and ecosystem dynamics
- Outlet: Forest Ecology and Management
- Conclusions: Seven focus areas are discussed with proposed actions achievable over the long-term with opportunities to empower mitigation and adaptation in the near-term. Addressing these priority areas not only helps inform policy decisions essential for effective climate change mitigation strategies, but it also enhances our capacity to measure, monitor, and manage forest carbon stocks, aligning with the growing emphasis on Environmental, Social, and Governance (ESG) criteria and bolstering efforts towards sustainable forestry practices and corporate carbon neutrality commitments.

FCMG Paper #2: Strategic Investments

Strategic area	Example
Growth, Mortality, and Regen Models with Application to Silviculture	• Dynamic equation calibration process
Genetics and G&Y Models	• Calibrate public versus industrial/proprietary models
Belowground Carbon	• Explore fractal root models
Natural Disturbances	• Model-data integration to constrain uncertainties
Carbon Reporting and Uncertainty	• Establish uncertainty reporting best practices
Carbon Tools and Applications	• Standards for code transparency
Forest Vegetation Simulator	• Error estimates for secondary effects such as height growth

- Seven strategic areas identified
- Examples of tactical research and applications

FCMG Paper #2: Research to Application Process

Basic Forest Carbon Research

- Enhance validation data to limit error propagation
- Collect and compile data on growth, yield, and mortality across diverse management practices and genetic varieties and species compositions
- Expand research on belowground carbon and relationships with forest management practices including soil organic carbon, and microbial and mineral reactions
- Continue research on forest product utilization pathways, carbon flux in harvested wood products, and life cycle assessment
- Enhance research on disturbance impacts, including interactions between multiple disturbances across time

Model Development

- Advance growth, mortality, and regeneration models
- Develop broader, comprehensive, and nationally consistent forest dynamics datasets and model frameworks that rely on climate-sensitive measures of local site productivity
- Construct, test, and implement a statistically-sound dynamic equation calibration process for continual model refinement over space and time
- Quantify and separate uncertainty through stochastic modeling and probabilistic programming approaches (e.g., Bayesian modeling approaches).

Science Delivery

Forest Vegetation Simulator

- Dynamically calibrate mortality or regeneration models based on inventory measurements
- More comprehensively report on and disclose sources of uncertainty
- Integrate modeling of effects of forest management on belowground carbon and research lateral transfers

Other Carbon Modeling Platforms

Expand online tools that produce spatially-explicit estimates of key carbon pool and fluxes for assessment and reporting of:

- Harvested wood products
- Carbon sequestration potentials across forest types, future scenarios, and end uses of forest products

Increasing Focus on Refining FVS as One Vital Tool

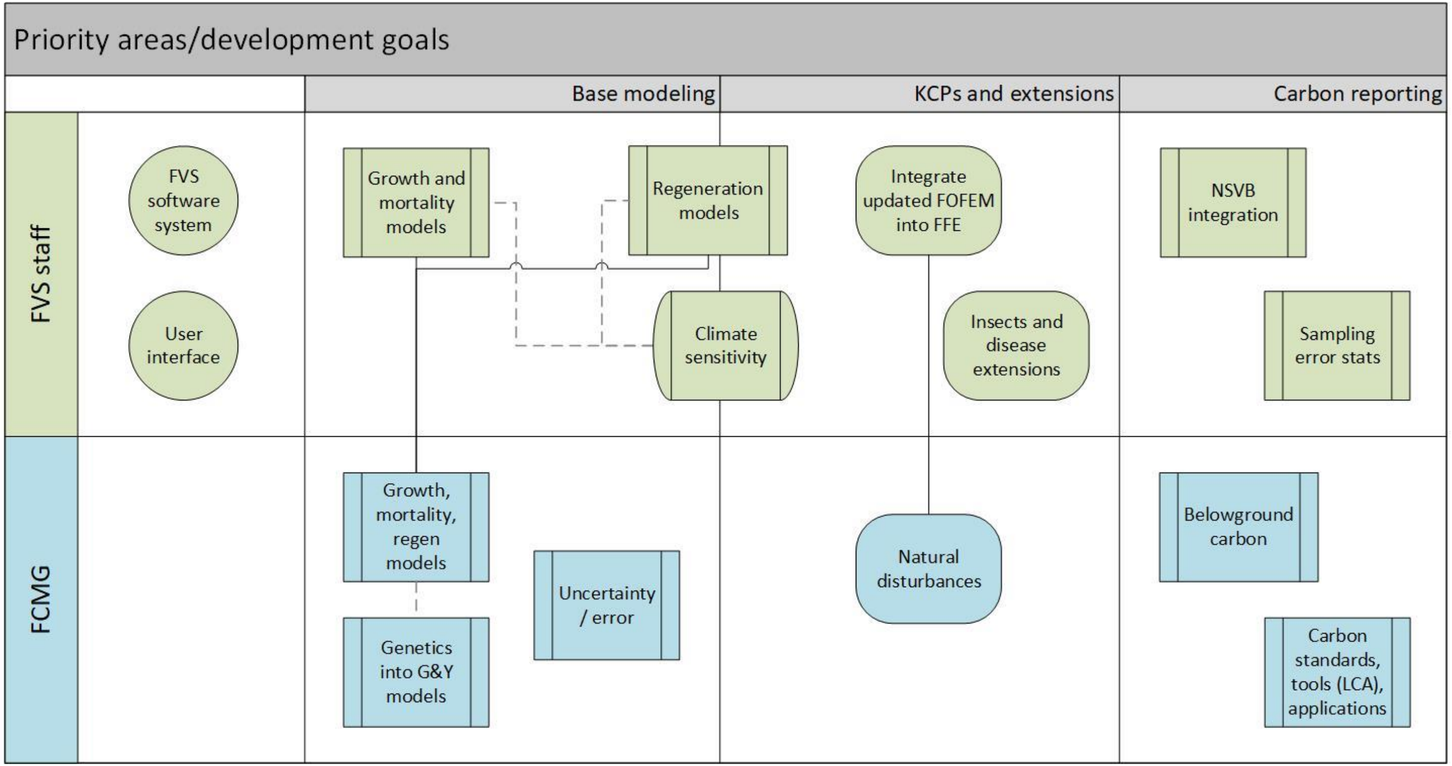
FVS development goals, identified by FVS staff and FVS steering team, overlap with priority areas identified by the FCMG

FVS Development Goals

- Nationally consistent growth and mortality models
- Nationally consistent regeneration framework
- Methodology for integrating climate sensitivity
- Improvements to carbon reporting
- Integrate latest fuel consumption models
- Simplify base software system
- Enhance insect and disease extensions

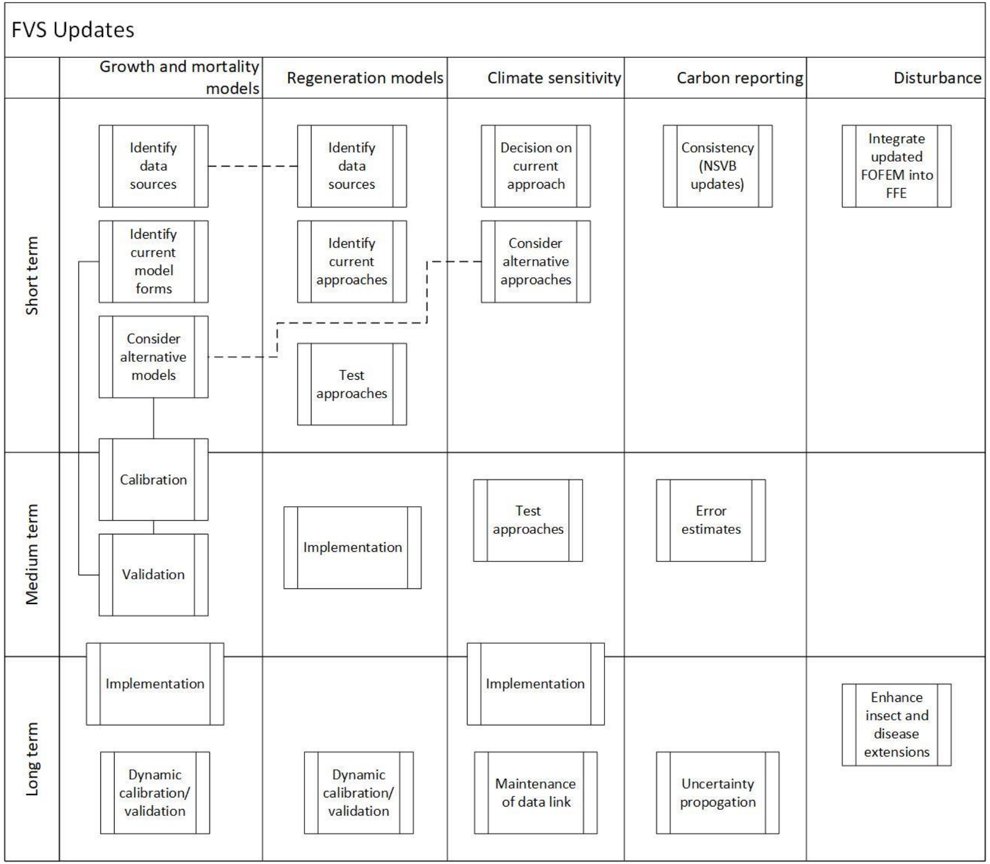
Coordination Between Research Community and FVS Staff

Synergy in advancement of forest carbon modeling



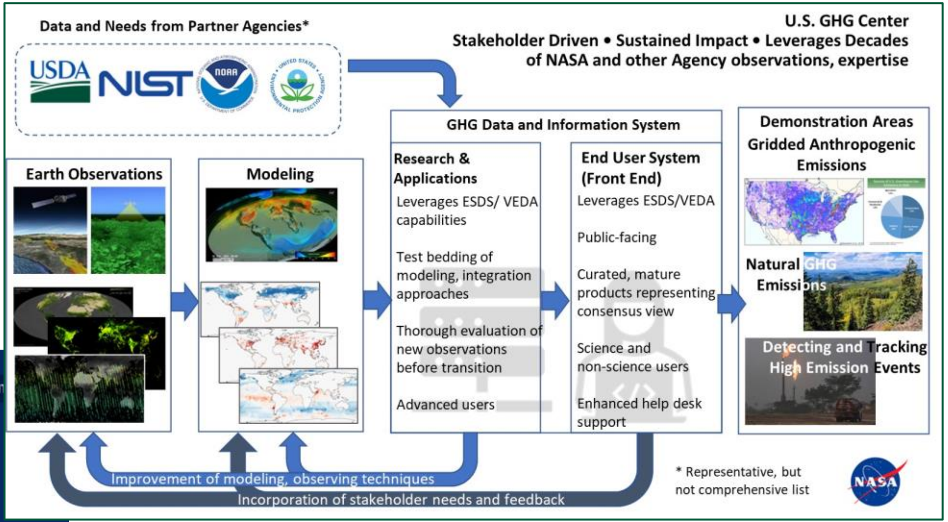
From Strategic Plans to Tactical Steps

Identifying resources available for near-term advancements and where groundwork will need to be laid for more long-term strategic plans



Federal Greenhouse Gas Center (NASA-led)

- US forests not immediate focus
- Opportunity to feed data/models into system
- Longevity of Center beyond current administration unclear



Application: Future Vision of USDA Entity Guidelines (V3.0+)

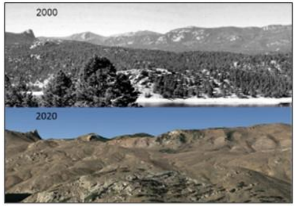
Geospatial website of forest GHG attributes across all pools, with baseline to present, and menu of future management options with projections of future C attributes, emission risks, sequestration opportunities, resilience ratings, robust uncertainty estimation, disturbance probabilities, offsetting/insetting facilitation, transparent code/data, and much more for every acre in the US

Application: European Union Deforestation Regulations

- Future of forest carbon quantification is scalable, transparent, co-produced, and data intensive
- Future of ag/forest trade may become inextricably linked to the ecosystem from where it came and the GHG intensity of the supply chain
- Forest C Models may become driver of future trade

Definitions

Forests & Degradation



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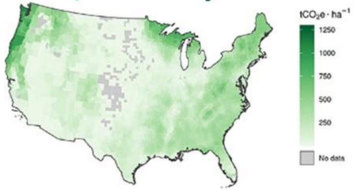
Monitoring Data and Science

National Plot Networks
Remotely Sensed Obs
Algos/Models
Experiments
State/Industry Data



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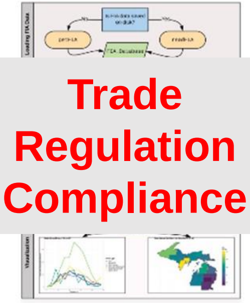
Data Architecture Tools

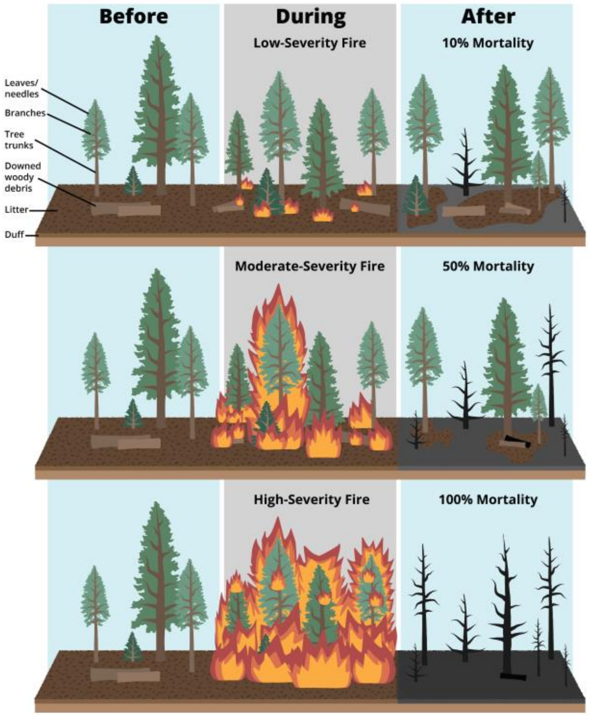
Transparency



Trade Regulation Compliance

Closeout

- Forest modeling highlighted in strategic plans from White House to USDA to Partners
- Public/Private Partnerships being codified to advance modelling improvements
- IRA/BIL funding that serves as a down payment on collaborative partnerships to advance modeling refinements still in process
- Emerging Efforts such as MMRV, GCSA, and Entity Guidelines V3.0 will necessitate modeling advances and draw upon the FCMG



USFS 2024 Entity Guidelines Fire Emission Modeling

USDA

Forest Service
U.S. DEPARTMENT OF AGRICULTURE

USDA is an equal opportunity provider, employer, and lender.

Matching Techniques to Move the FIA Inventory to a Common Year

John Coulston
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Southern Research Station
US Forest Service

Center for Integrated Forest Science

Problem

- FIA uses a rotating panel design.
- 5 and 7 panel designs are implemented in the East
- 10 panel design is implemented in the West.
- The number of panel ~= remeasurement period.
- Leads to, for example,
  - The current data and the previous 4 years of data used to construct current estimates.
  - Described as temporal indifference in Bechtold and Patterson (2005) and Westfall et al. (2023).
- How can we move ‘older’ panels to the current year to construct a current estimate?

	Year				
Panel	2020	2021	2022	2023	2024
1	X →	→	→	→	?
2		X →	→	→	?
3			X →	→	?
4				X →	?
5					X

Why

- Lots of things happen over 4+ years.
  - Growth
  - Harvest
  - Disturbance
  - Land use change
  - Etc.
- Temporally indifferent moving average does not account for these dynamics.

	Year				
Panel	2020	2021	2022	2023	2024
1	X →				?
2		X →			?
3			X →		?
4				X →	?
5					X

Some Approaches

In place

- Forest Vegetation Simulator (FVS)
  - Currently used in some western areas to move inventory to a common point in time.
  - Relies on internal FVS models (growth, mortality, disturbance, etc.) to model a future state of each plot.
- FIA tree diameter and height growth models could be leveraged.
- Other G&Y models can also be used.
- Mixed estimator (Van Deusen 1999) if only one variable of interest.
- These approaches are deterministic.

An alternative

- Imputation via matching techniques
  - Goal: for each measured plot(condition) (not measured in the current year) find an existing FIA plot (donor) to represent the future state of the plot.
  - This approach is not a plot prediction method – rather an inventory realization method.
  - This is a stochastic method.

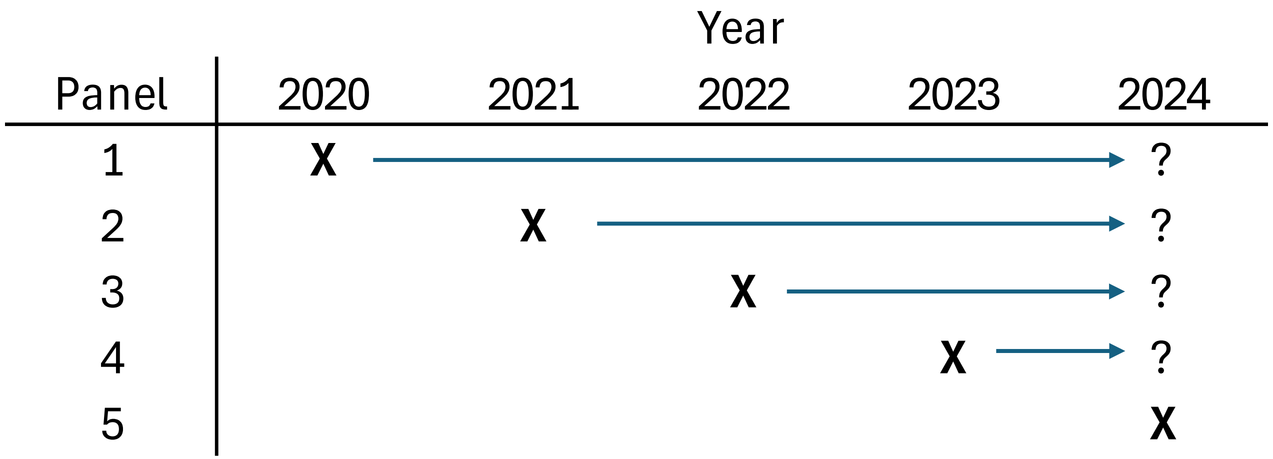
Imputation via matching

- Van Deusen and Roesch (2013)
  - Proposed a Coarsened Exact Matching (CEM) approach based on ownership, age, basal area, forest type, stand origin, and site class to identify donors.
  - Identified two approaches
    - Project then match (requires predictions)
    - Match then project (requires remeasured data).
- Coulston et al. (2023) suggests multivariate partitioning, rather than CEM, to identify donors.

- Match then project.
  - For each inventory plot match a donor plot (remeasured) based on the time 1 donor plot measurement.
  - Accept the time 2 donor plot measurement for the future state.
  - Note the number of panels ~= remeasurement period.
- Project then match.
  - Move the dynamic components you want to match on forward with a model. Then match.
  - This allows for shortening the remeasurement period.

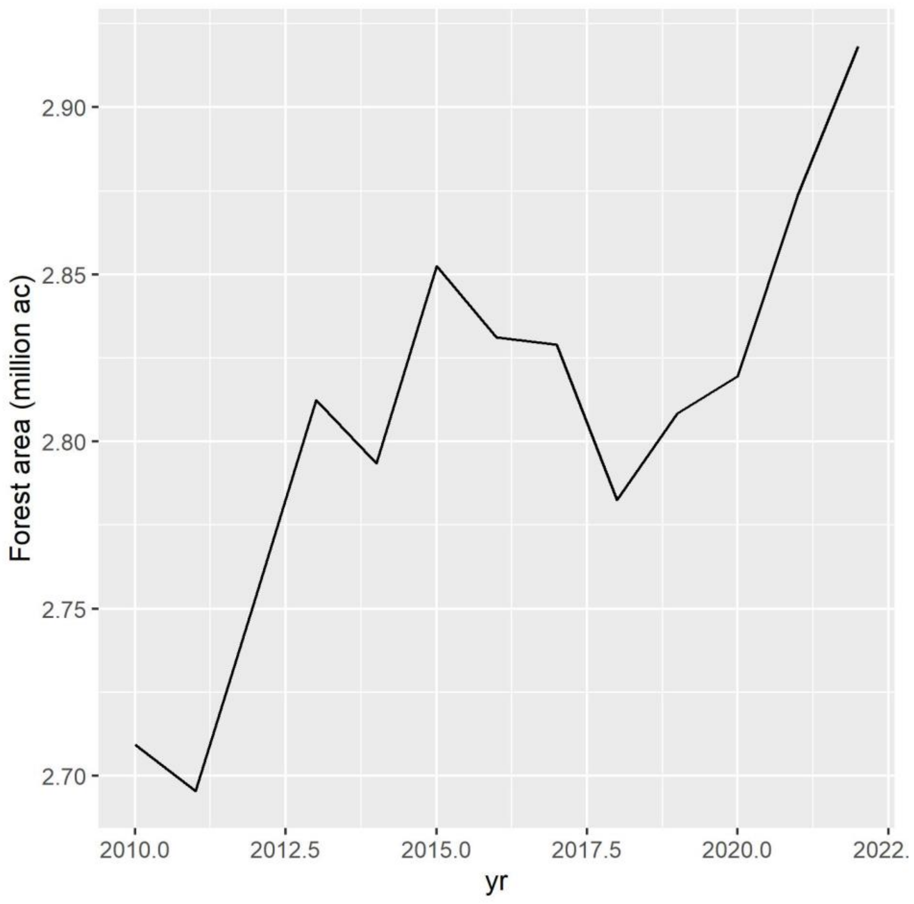
Project then match: a simple example:

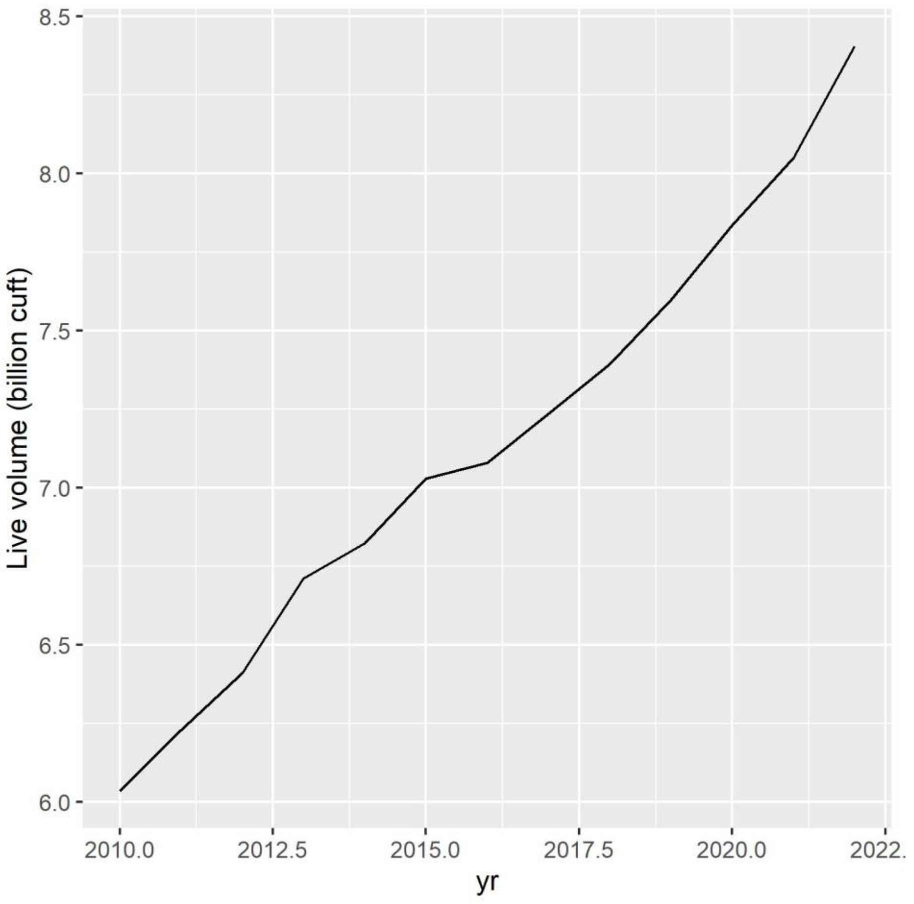
- Suppose we wanted to match on the variables outlined by Van Deusen and Roesch (2013).
  - Static variables: *forest type*, *site class*, *owner*, *condition proportion* and *stand origin*.
  - Dynamic variables: *basal area* and *age*.
- Once age and basal area are moved forward, we can use the project then match.
- Move GA natural loblolly pine forward via imputation.



- Important note: though we match on a key few variables – all relevant donor attributes are transferred.

GA natural loblolly pine over time based on moving average



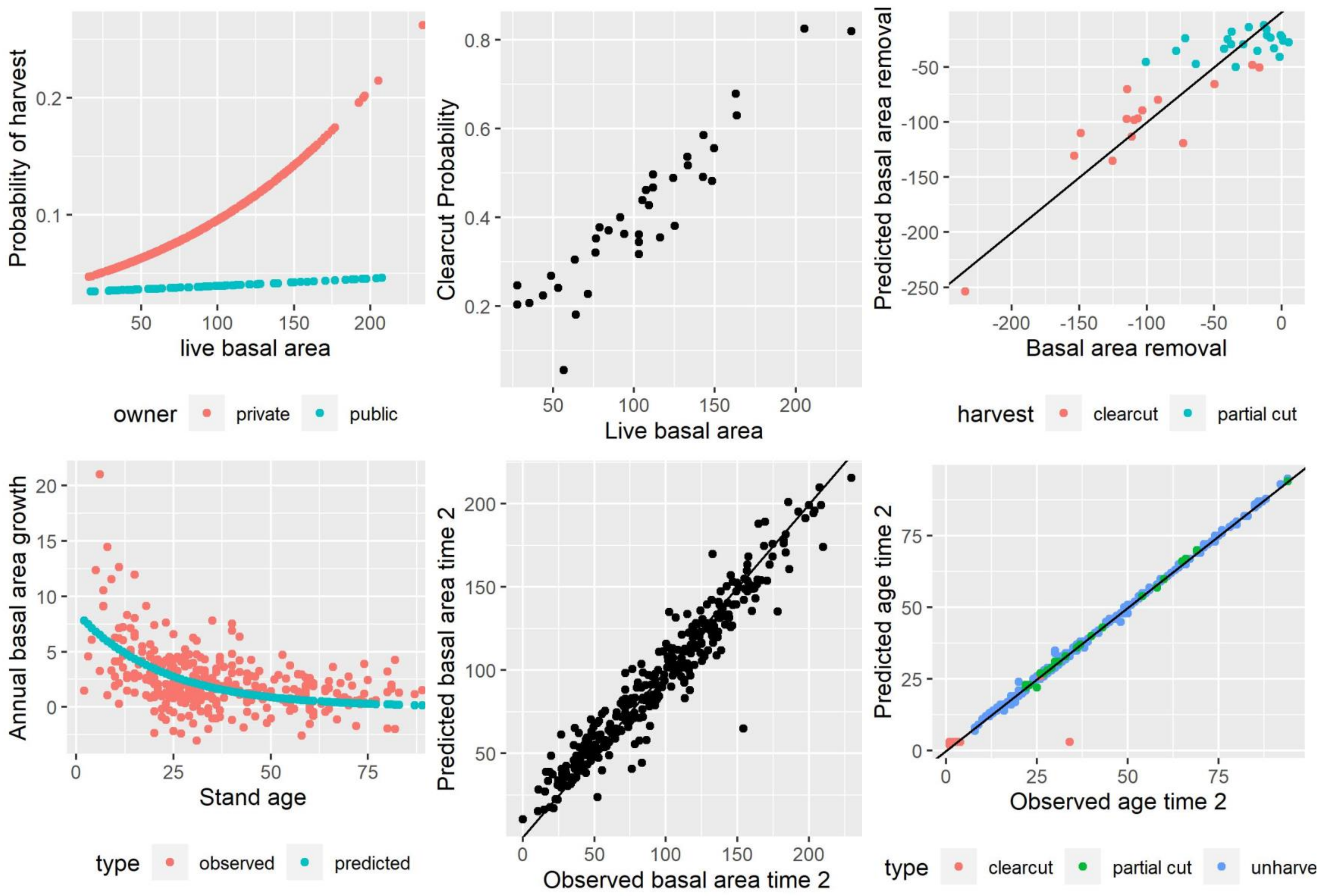


Project then match: assumptions & models

- For moving the inventory forward to a common date (2022), the projections are short-term 1-4 years (if under 5 panel design)
- For the example, I'll ignore the following
  - Land use change
  - Disturbance (most of the disturbance was ground fire damage – little mortality).
  - Forest type shifts.
- I'll include forest growth, aging, and removals (cutting treatments).

Project then match: modeling system

- Example based on natural loblolly in GA
- Modeling system
  - Model harvest probability (determine which plots to harvest – account for ownership)
  - Model harvest removal (account for partial harvest vs clearcut)
  - Model age after harvest (account for partial harvest vs clearcut)
  - Model growth on unharvested stands
  - Model age on unharvested stands.
- Used most recent remeasured data to estimate models
- All model tied to remeasurement period (R) either directly or indirectly.
- This allow for user to input a new R to move forward.

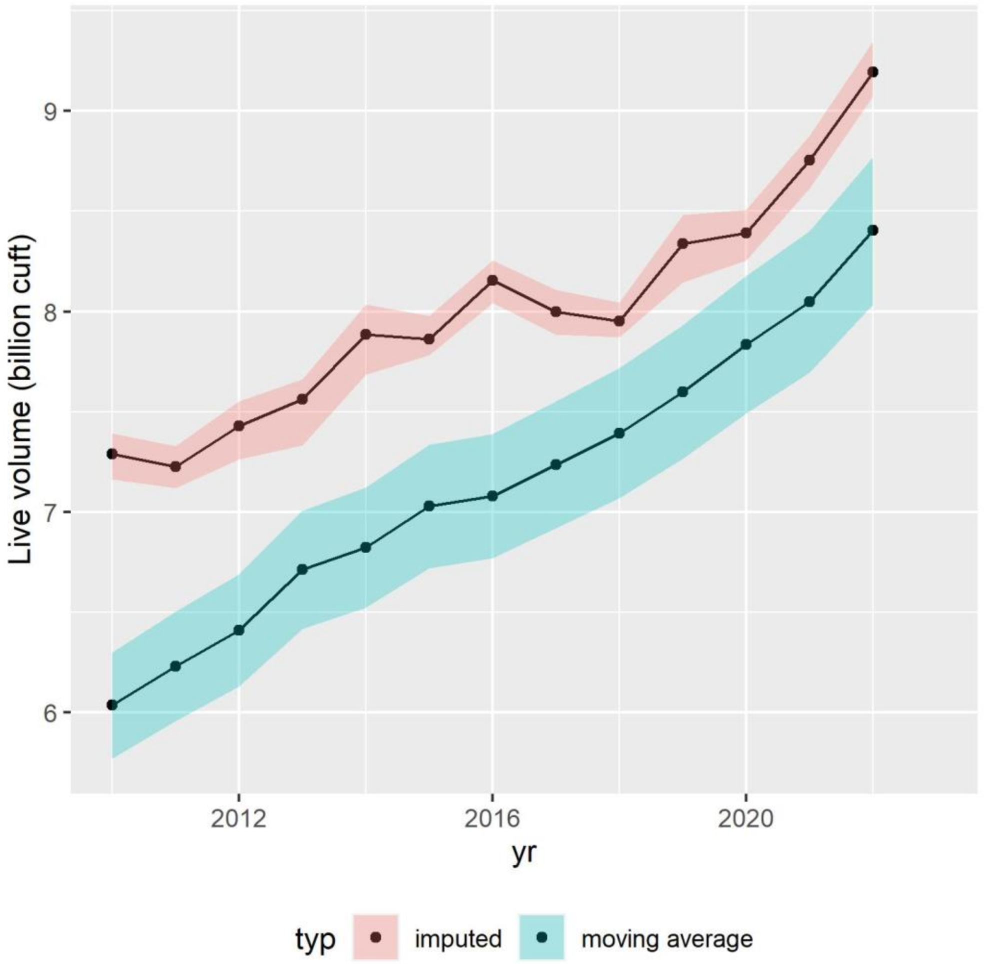


Coarsened Exact Matching

- Donors taken from 2010-2022 natural loblolly pine plots in GA, SC, and AL.
- Matching
  - Condition proportion rounded to nearest 0.125
  - Basal Area rounded to nearest 10 sqft
  - 5-year age class
  - Site class code
  - Owner group code
- If no match found, then matching categories were broadened. E.g. condition proportion rounded to nearest 0.25, basal area to nearest 20 sqft, etc.

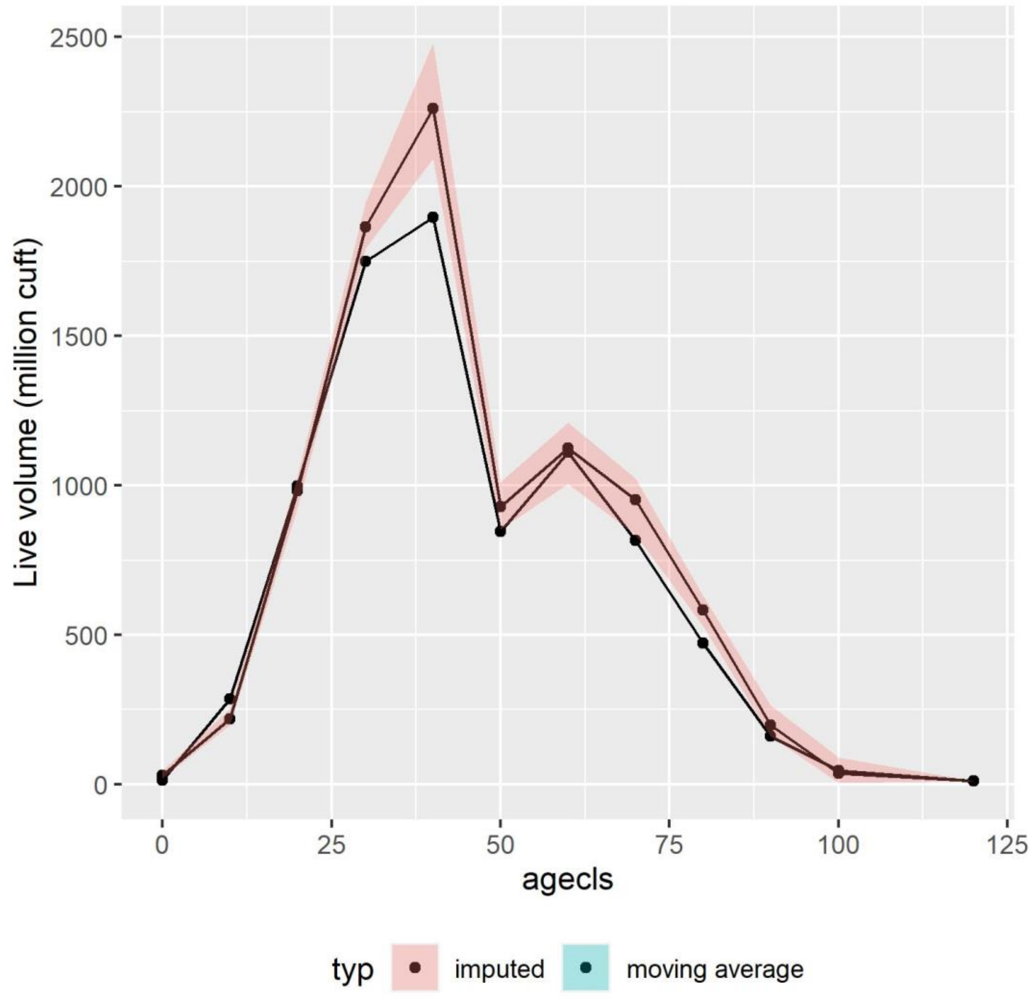
Results: natural loblolly pine volume in GA

- 20 reps of imputation for each evaluation.
- Mean presented for imputed inventory (band is min and max)
- Moving average band is 1 SE
- 2022 results: ~790 million cuft of additional volume.
- Does this make sense?
    - Net change in live volume ~ 290 million cuft per year.
    - On average I moved plots forward 2.7 years.
    - 290*2.7~780 million cuft.
- If I included the standard error for the imputed inventory – error band would generally overlap at 1 SE.



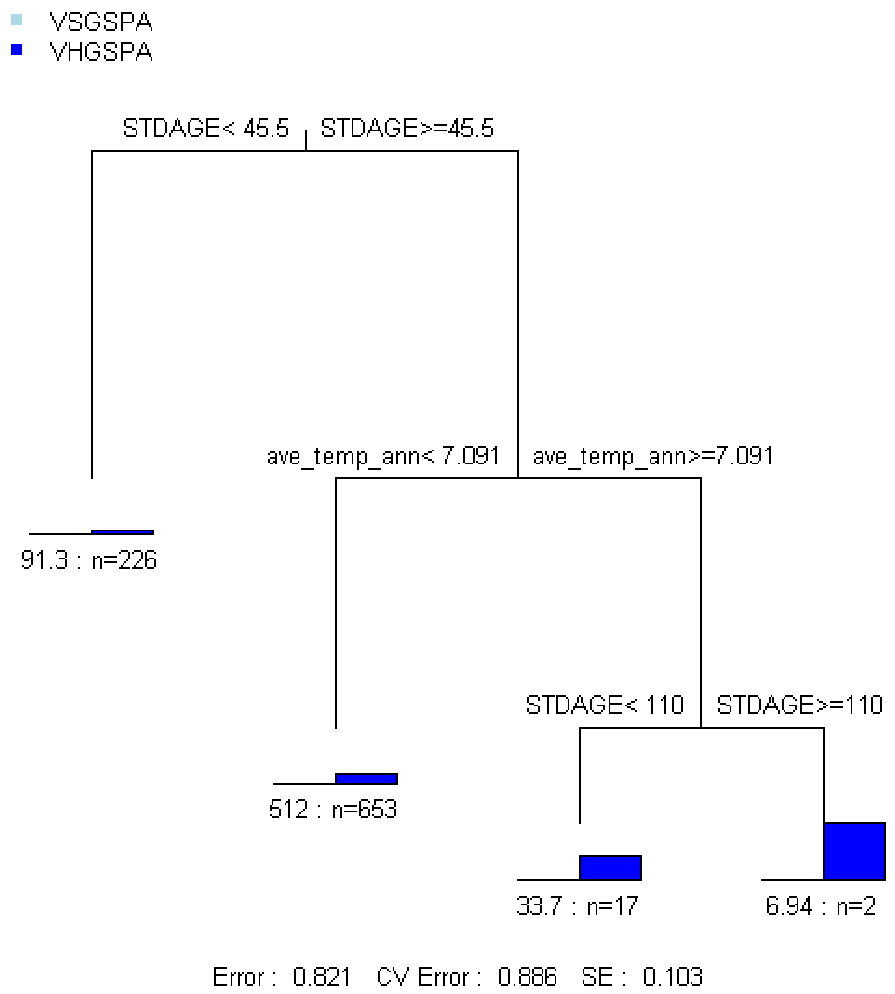
Results: volume by age class 2022

- Largest difference seen in the 30 -40 and 40-50 year age classes.
- In most cases, imputed inventory vol by age class > moving average estimate.
- 10-20 year age class imputed inventory estimate<moving average estimate.
    - Likely due to partial harvest (thinning).



Some Other Matching Approaches

- Nearest Neighbor
  - Calculated Euclidean or Mahalanobis distance among inventory plots you want to move forward in time and donor plots.
  - Select the donor plot with the smallest distance.
- Regression trees
  - Fit univariate or multivariate (LHS) model.
    - E.g. (pulpwood vol, sawtimber vol)=F(age, condition proportion, owner, basal area, site class)
  - Use terminal notes to identify 'empirical' bins
  - Assign each inventory plot and donor plot to a bin.
  - Randomly select a donor plot from the same bin as the inventory plot.



*This is just an example I had handy – its purpose is to show terminal nodes. It does not reflect a model for GA natural lob.

Closing Thoughts

- Natural Loblolly pine in GA selected because one would expect to see a difference. Other forest types and other locations would have different results.
- The modeling system I used was intentionally simplistic. The complexity of the modeling system will be driven by the types of inventory estimates needed.
- The choice of matching approach can have a big impact on the end result.

Questions?

- john.coulston@usda.gov

Models used & processing steps used

- Harvest Probability over average remeasurement period (models fit separately for public and private ownerships).
  - $\text{Logit}(h) = a+bBA_1$
  - h=harvest, BA_1 = basal area per acre at time 1, a and b =estimated parameters
- Adjustment to P(h=1) when shortening remeasurement period.
  - Assume P(h=1) for a fixed rate (r) over a remeasurement period R.
  - $P(h-1)=1-\exp^{-rR}$
  - Solve for r
  - r=-1 log(1-P(h=1))/R. Plug back into first equation and provide a new R to adjust P(h=1).
- Clearcut probability given a harvest occurred
  - $\text{Logit}(cc)=c+dA_1+eBA_1$
  - cc=clearcut, A_1=Age at time 1, c, d, and e are estimated.
- Basal area removed during harvest (separate models for clearcut and partial cut)
  - $dBA=fA_1+gBA_1+hO$
  - dBA=basal area change, O=binary for public-private ownership, f, g, and h are estimated.
- Age
  - $A_2= R/2$ for clearcut stands with < 50 ft^2 of basal area remaining.
  - A_2 is stand age at time 2.
  - $A_2 = A_1 + R$ for all other plots
- Basal area
  - $BA_2 = BA_1 + R\left(ij\ \exp^{-jA_1}\right)$
  - BA_2 = basal area per acre at time 2; i and j are estimated parameters

For natural lob plots/conds measured before 2022:

1. Predict P(h=1) for all plots. Adjust P(h=1) for the R. Sum the adjusted P(h=1) to determine the number of harvest plots (n_h). Select n_h plots with probability proportional to P(h=1).
2. For those plots selected to be harvested predict P(cc=1), sum P(cc=1) to determine n_{cc} and select n_{cc} plots with probability proportional to P(cc=1).
3. Calculate amount of basal area removed for clearcut and partial cut plots. Calculate $BA_2=BA_1-dBA$. Use BA_2 for matching.
4. Calculate time 2 age for all plots/conds
5. Predict BA_2 for unharvested plots/conds.
6. Assign each plot/cond to a bin via CEM.
7. Select a donor from the same bin to serve as the imputed value. Donors from GA, AL, and SC were used.
8. Repeat 20 times.
9. Calculate inventor totals for each rep.

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What is the impact of the new NSVB equations on the FIADB?

Hector Restrepo

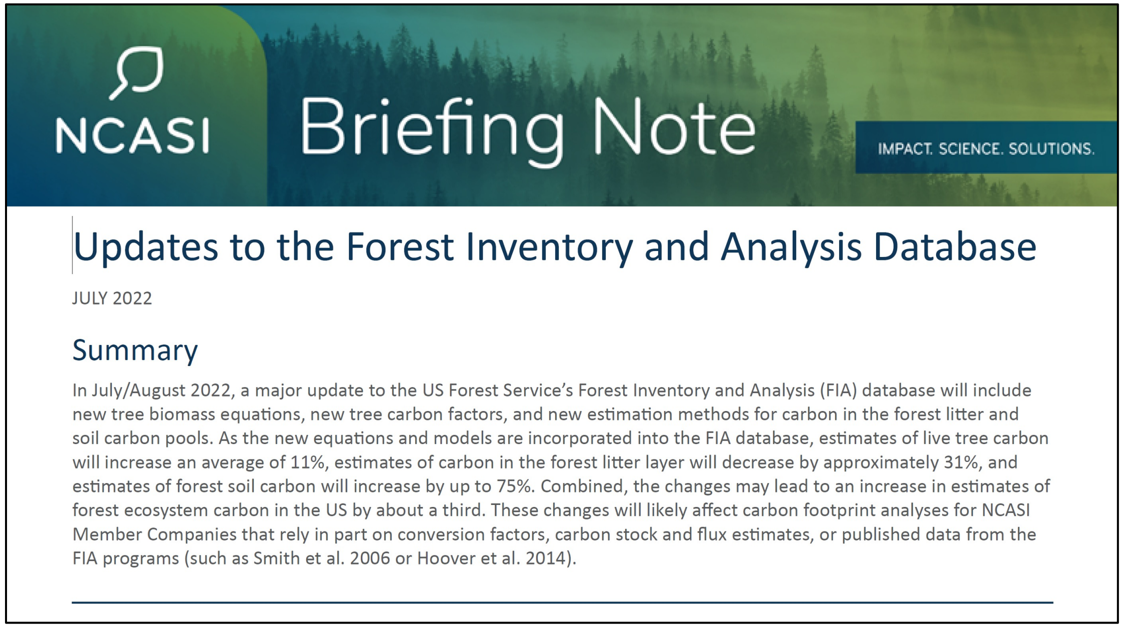
June 13, 2024

Background

- New equations **(National Scale Volume and Biomass, NSVB)** to estimate volume, biomass, and carbon in the FIADB

- Affects **current and historical** data across the U.S.

- May affect **carbon analyses**



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Updates to the Forest Inventory and Analysis Database

JULY 2022

Summary

In July/August 2022, a major update to the US Forest Service's Forest Inventory and Analysis (FIA) database will include new tree biomass equations, new tree carbon factors, and new estimation methods for carbon in the forest litter and soil carbon pools. As the new equations and models are incorporated into the FIA database, estimates of live tree carbon will increase an average of 11%, estimates of carbon in the forest litter layer will decrease by approximately 31%, and estimates of forest soil carbon will increase by up to 75%. Combined, the changes may lead to an increase in estimates of forest ecosystem carbon in the US by about a third. These changes will likely affect carbon footprint analyses for NCASI Member Companies that rely in part on conversion factors, carbon stock and flux estimates, or published data from the FIA programs (such as Smith et al. 2006 or Hoover et al. 2014).

Objective

To identify and quantify the impact of NSVB on FIADB forest attribute estimates using EVALIDator API

Methods

- Mapped out the variables in EVALIDator v2.0.7 (FIADB v1.9.0.02) with the corresponding EVALIDator v2.1.X (FIADB v1.9.1)

- Quantified differences in estimates between the two versions

$$Estimate_{diff} = Estimate_{v2.1.X} - Estimate_{v2.0.7}$$

Summary of tree variables (number of variables)

Tree variable category	v2.0.7			V2.1.X			Difference
	Forestland	Timberland	Total	Forestland	Timberland	Total	
Tree basal area	2	2	4	2	2	4	0
Tree carbon	4*	4*	8	6	6	12	4
Tree dry weight	12*	10	22	20	20	40	18
Tree green weight	10	9	19	7	7	14	-5
Tree number	3	3	6	4	4	8	2
Tree total-stem volume				22	22	44	44
Tree volume	10	8	18	23	20	43	25
Total	41	36	76	84	81	165	88

Total carbon change
(million tons)

Forest type	Region				Total
	Northern	Pacific Northwest	South	West	
Bottomland hardwood	75 (7)	9 (20.4)	346 (10.9)	16 (30.2)	446 (11.5)
Mixed softwood-hardwood	89 (21.7)		341 (22.8)		430 (29.2)
Natural softwood	-42 (-2.1)	1,081 (19.6)	731 (21.1)	4,211 (38.3)	5,980 (37.4)
Planted softwood	31 (9.9)	172 (13.9)	410 (13.3)	51 (36.4)	664 (16.2)
Upland hardwood	2,631 (24.2)	92 (14.8)	2,854 (32)	901 (34.8)	6,479 (39.2)
Total	2,784 (23.4)	1,354 (22.3)	4,682 (30.3)	5,179 (60.3)	13,998 (33.3)

The number in parentheses represents the percent change, $Change(\%) = \left(\frac{New - Old}{Old}\right)100$

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Contribution (%) to total carbon change by pool

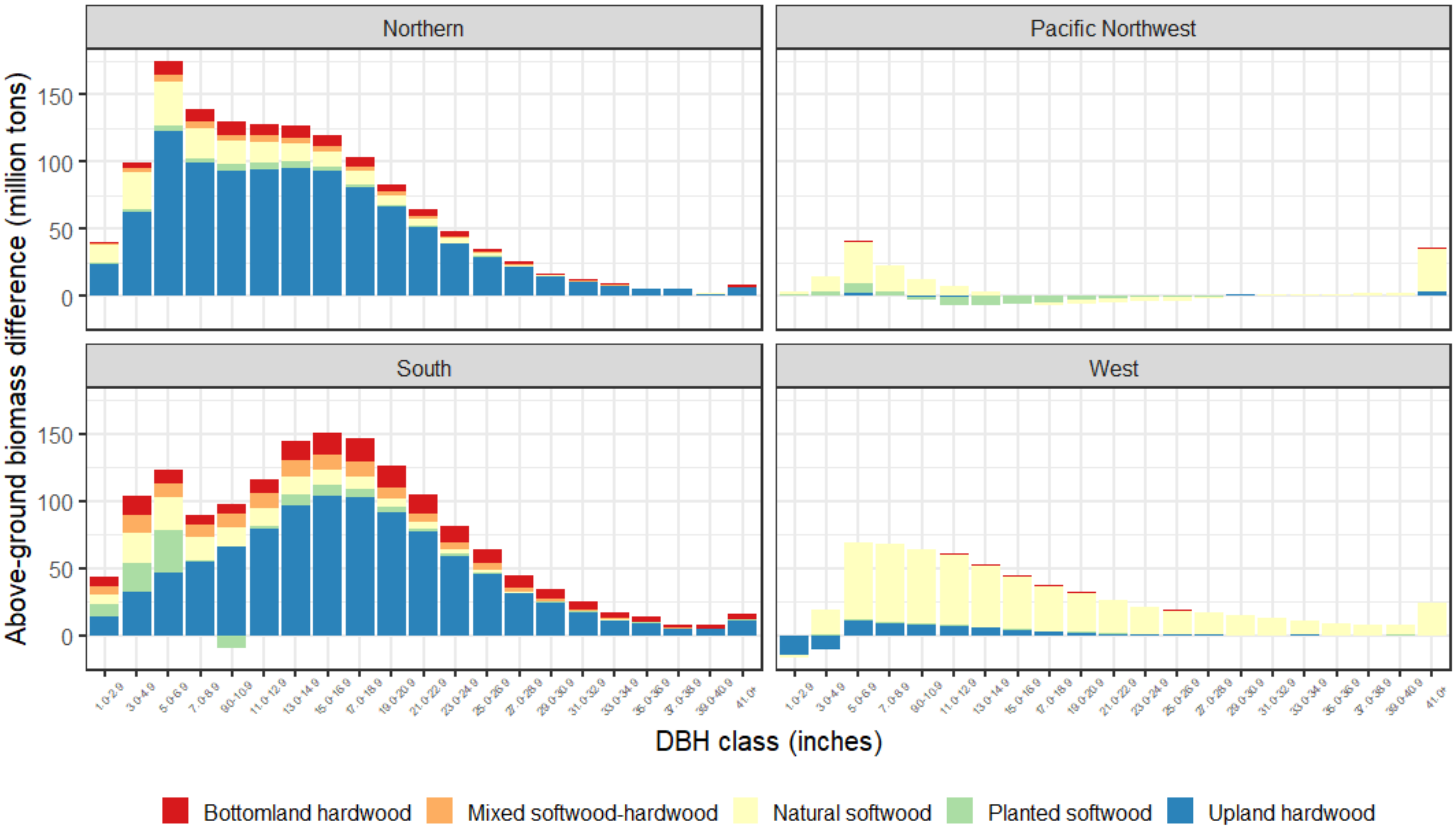
Pools	Region				Total
	Northern	Pacific Northwest	South	West	
Above-ground	19	5	10	5	**9**
Below-ground	1	0	0	0	**0**
Litter	-11	-32	-3	-25	**-16**
Organic soil	74	102	81	108	**87**
Other	18	25	13	12	**20**

Average changes

Variable	Change (%)
Volume	+2
Above-ground biomass	+13
Above-ground carbon	+9
Below-ground biomass	+3
Below-ground carbon	~0
Litter	-48
Organic soil carbon	+83

$$Change(\%) = \left(\frac{New - Old}{Old}\right)100$$

AGB changes by DBH classes

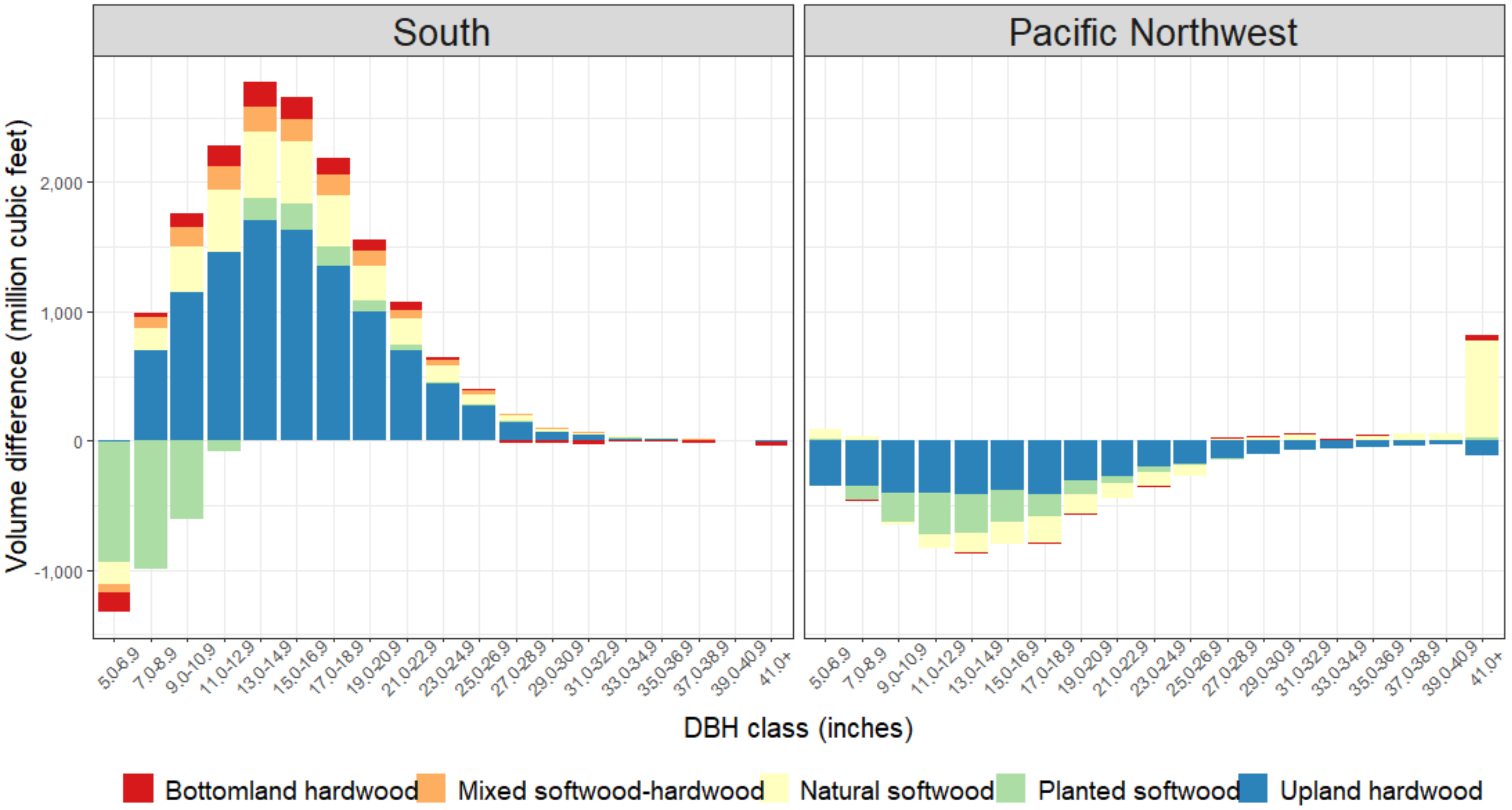


Carbon fractions in AGB

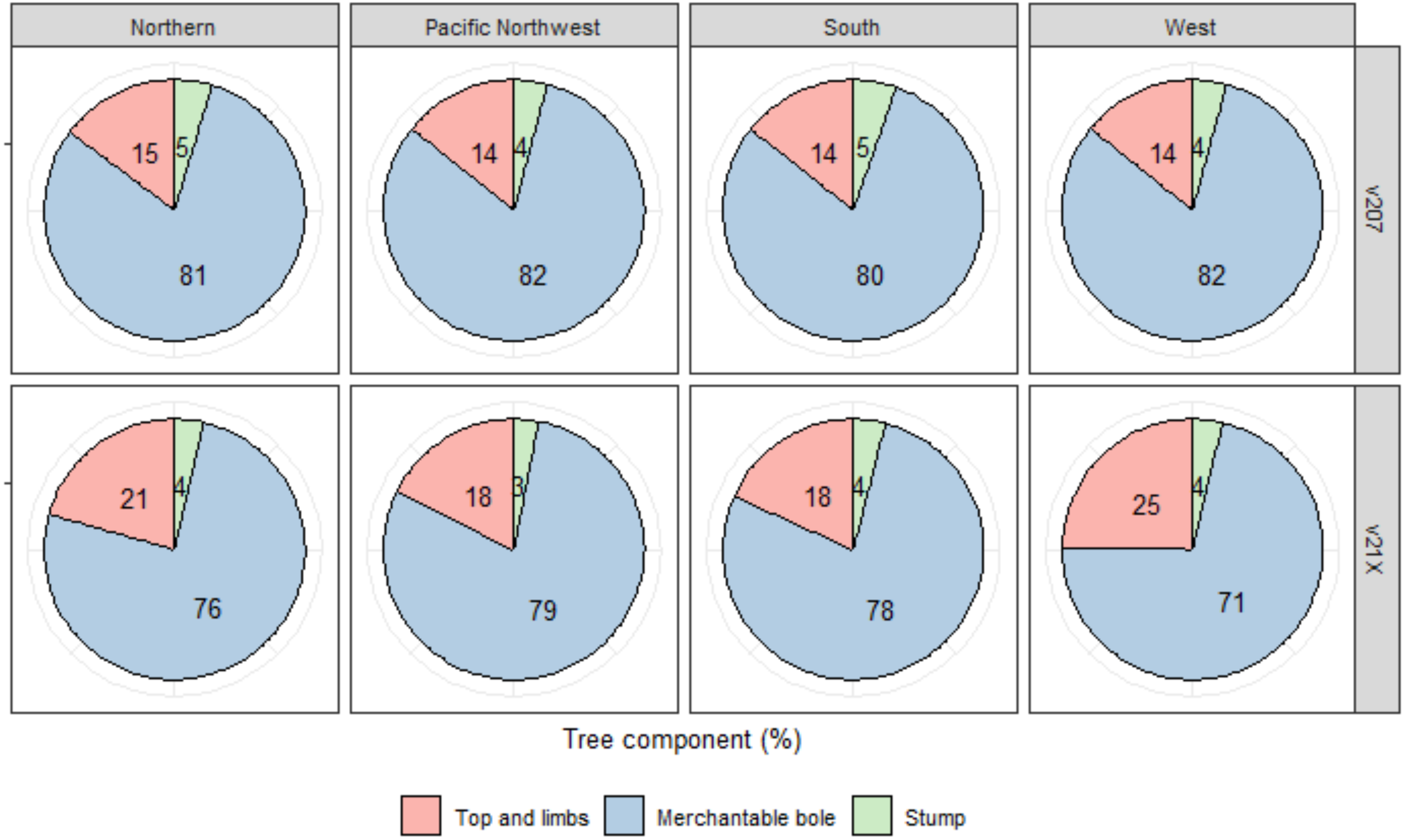
Forest type	Region				Total
	Northern	Pacific Northwest	South	West	
Bottomland hardwood	0.479	0.488	0.472	0.482	0.474
Mixed softwood-hardwood	0.490		0.476		0.479
Natural softwood	0.493	0.505	0.479	0.500	0.497
Planted softwood	0.503	0.512	0.479	0.511	0.489
Upland hardwood	0.480	0.493	0.474	0.481	0.478
Total	0.482	0.505	0.476	0.497	0.485

Cubic-foot volume

Regional, forest-type, and tree-size differences



Planted softwoods AGB distribution



Conclusions

- In quantity, **organic soil carbon (+)** and **litter (-)** drive most changes in total carbon
- Volume, aboveground biomass and carbon, and belowground biomass **increased**; belowground carbon had a **negligible change**
- Regional, forest-type, species, and tree-size differences
- Allocates more tree biomass in tree tops, which reduces **merchantable bole biomass**

Objective

To identify and quantify the impact of NSVB on FIADB **forest attribute estimates** using EVALIDator API

$$\hat{\sigma}^2$$

Total carbon variance comparison

$$Estimate_{diff} = Estimate_{v2.1.X} - Estimate_{v2.0.7}$$

$$V(X - Y) = V(X) + V(Y)$$

X and Y independent

No useful to assess variance (uncertainty) change

DEFINITION 9.1

Given two unbiased estimators $\hat{\theta}_1$ and $\hat{\theta}_2$ of a parameter θ, with variances $V(\hat{\theta}_1)$ and $V(\hat{\theta}_2)$, respectively, then the *efficiency* of $\hat{\theta}_1$ relative to $\hat{\theta}_2$, denoted eff $(\hat{\theta}_1, \hat{\theta}_2)$, is defined to be the ratio

$$\text{eff}(\hat{\theta}_1, \hat{\theta}_2) = \frac{V(\hat{\theta}_2)}{V(\hat{\theta}_1)}.$$

$$F = \frac{V(Etimate_{v2.1.X,n-1})}{V(Etimate_{v2.0.7,m-1})}$$

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Total carbon variance comparison

Forest type	Region				Total
	Northern	Pacific Northwest	South	West	
Bottomland hardwood	1.26 (<0.001)	1.53 (0.013)	1.19 (<0.001)	1.98 (<0.001)	1.22 (<0.001)
Mixed softwood-hardwood	1.72 (<0.001)		1.65 (<0.001)		1.67 (<0.001)
Natural softwood	1.15 (<0.001)	1.4 (<0.001)	1.53 (<0.001)	2.14 (<0.001)	1.68 (<0.001)
Planted softwood	1.47 (<0.001)	1.3 (<0.001)	1.3 (<0.001)	2.25 (<0.001)	1.34 (<0.001)
Upland hardwood	1.79 (<0.001)	1.32 (<0.001)	2.07 (<0.001)	2.1 (<0.001)	1.88 (<0.001)
Total	1.59 (<0.001)	1.38 (<0.001)	1.56 (<0.001)	2.13 (<0.001)	1.65 (<0.001)

$$F = \frac{V\left(Etimate_{v2.1.X,n-1}\right)}{V\left(Etimate_{v2.0.7,m-1}\right)}$$

Questions?

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Notes

Regions

- West (AZ, CA, CO, ID, MT, NM, NV, WY, UT)
- Pacific Northwest (OR, WA); AK and HI excluded from this analysis
- Northern (CT, DE, IA, IL, IN, KS, MA, MD, ME, MI, MN, MO, ND, NE, NH, NJ, NY, OH, PA, RI, SD, VT, WI, WV)
- South (AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA)

Notes

Forest types

- Upland hardwood: oak/hickory, maple/beech/birch, aspen/birch, alder/maple, tanoak/laurel, and other hardwoods, tropical hardwoods, and exotic hardwoods groups
- Bottomland hardwood: oak/gum/cypress and elm/ash/cottonwood groups
- Mixed softwood-hardwood: oak/pine group
- Naturally-regenerated softwood: all pines, spruce/fir, Douglas-fir, fir/spruce/mountain hemlock, hemlock/Sitka spruce, Western larch, redwood, other Western softwoods, California mixed conifer, and exotic softwoods groups
- Planted softwood: same as naturally-regenerated softwood and oak/pine group