Comparing Continuous Forest Inventory Program Methodologies Across the Northeast

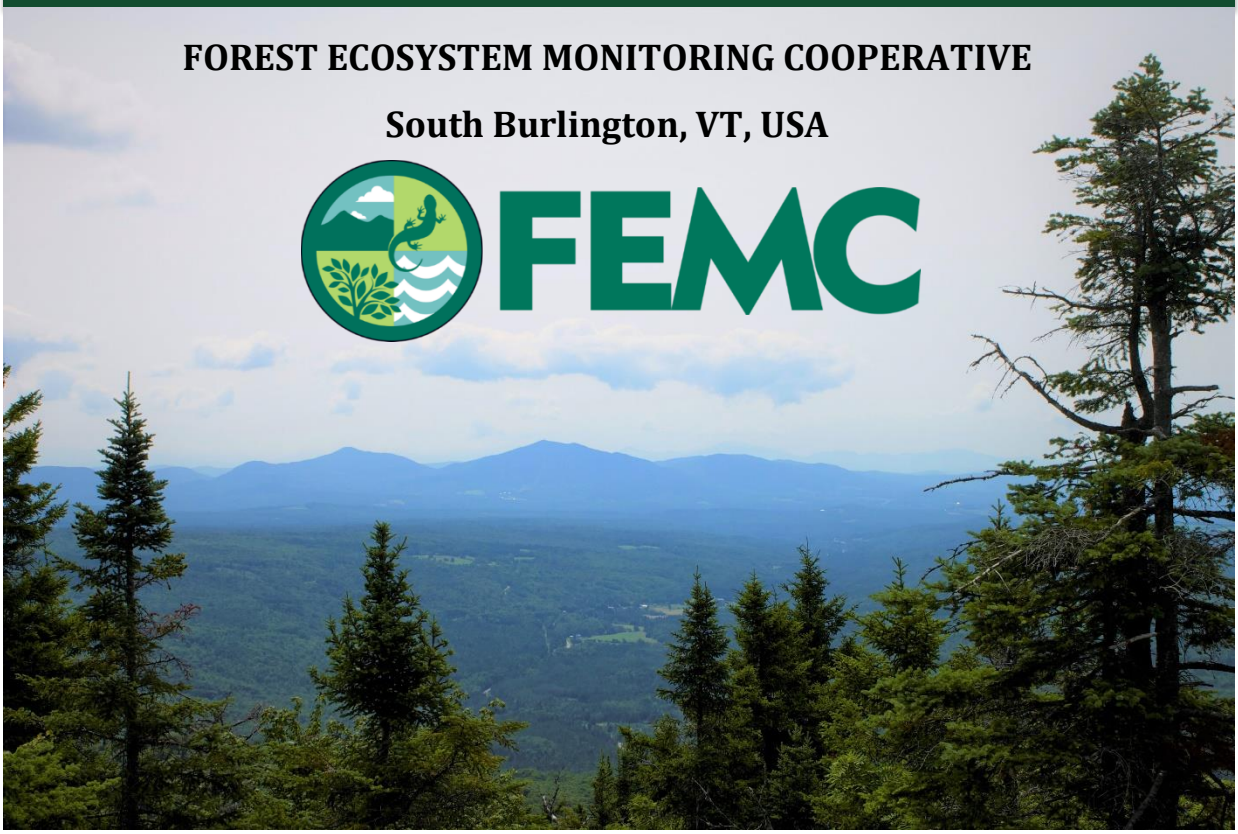

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Table of Contents

Executive Summary

Continuous forest inventories (CFI) and related methodologies have been used by a range of agencies and organizations to systematically collect information on forest growth and condition. While these data have local utility for the organization overseeing collection, if combined, they could provide a spatially broad dataset to answer regionally relevant questions on the condition and productivity of forests. To assess the feasibility of unifying these datasets, we systematically compared the methodology of 10 CFI programs from New York, New Hampshire, Maine, Massachusetts, and Vermont. These programs collectively account for inventories on a total of 1.56 million acres (or 3.3%) of forestland in the five-state region. We provide assessments of each program along with recommendations to increase the comparability among programs, with the following key deliverables:

- A *programmatic assessment table* documenting and describing each program's inventory methodology;
- A *programmatic analysis table* outlining the applicability of each program in conducting common forest inventory analysis tasks;
- An *opportunity matrix* showing each program's ability to address regionally significant question; and,
- A *programmatic timeline table* displaying when each inventory was conducted.

In addition to this report and accompanying files, a web page allowing users to explore the information gathered in this effort is availabel at https://www.uvm.edu/femc/forest_inventory_data_network/methods/comparison. Visitors can also download the full spreadsheet of assessment information from https://www.uvm.edu/femc/file/info/10905. Together, these tools document the methods and extent of a range of inventory program styles, and shed light on how these programs might be used by researchers and managers to address new and important questions facing the forests of our region.


49

Introduction

Continuous forest inventory (CFI) programs and related efforts have been developed, primarily by state agencies, to monitor forest growth and development across the Northeast. These programs are similar in scope but differ methodologically. There is an increased interest by forest scientists and resource managers to use CFI data to assist in analyses of forest growth and development at varied spatial and temporal scales. In addition, data from CFI programs offer the potential for improved initialization and validation of forest modeling efforts. Our primary goal for this project was to develop a framework and set of tools for cataloging and comparing CFI programs across the Northeast to determine what information is gathered at a local scale and to explore the applicability and compatibility of these programs in addressing questions of regional significance. The questions of regional significance we explore in this report are if individual CFI programs be used to:

- **Compare changes in tree species composition over time?**
- **Assess regeneration dynamics?**
- **Assess biomass and carbon pools?**
- **Assess regional changes forest health?**

In order to address the questions outlined above, the Forest Ecosystem Monitoring Cooperative (FEMC) has developed a set of tools for evaluating CFI programs across the Northeast. The tools include a **programmatic assessment table**, a **programmatic analysis table**, an **opportunity matrix,** and a **programmatic timeline table.** The *programmatic assessment table* is a tool which is used to comprehensively document and describe each program's inventory methodology, and the *programmatic analysis table* outlines the suitability of each program in conducting common forest inventory analysis tasks. The *opportunity matrix* synthesizes the results from the assessment and analysis tables and presents a description of each program's ability to address regionally significant questions. The *programmatic timeline table* provides a visual representation of when each inventory was conducted.

Together, these tools provide a structured framework for evaluating CFI programs that can be used to assist with individual CFI program development and provide a summary of the potential application of each program in local and regional forest assessment. These regional questions have traditionally been explored using the Forest Inventory and

Analysis (FIA) program, at least since 2006. Though FIA data can answer many of our regional comparison questions, the spatial scale can be too coarse for some applications. The CFI program data could better serve future researchers and modelers by providing additional spatial and temporal resolution.

Inventory Program Assessment Methodology

Programmatic Assessment Table

We developed a programmatic assessment table to evaluate each individual CFI program. This table provides detailed descriptions of how each inventory was conducted, when the inventory occurred, and what specific information was collected. The assessment table was designed so it can be applied easily to additional programs as information and interest in assessing methodologies develops or new information is made available. This assessment tool also allowed us to then compare the potential utility of each program for addressing questions such as those outlined in the introduction, and to identify gaps and/or potential points of enhancement.

The table contains column headers indicating specific questions related to the inventory methods. The description of each column header in the framework is included in the Appendix to this report.

Continuous Forest Inventory Programs Assessed

The following is a brief list of programs assessed as part of this effort. The extent of forestland ownerships covered by these programs is given in **Error! Reference source not found.**.

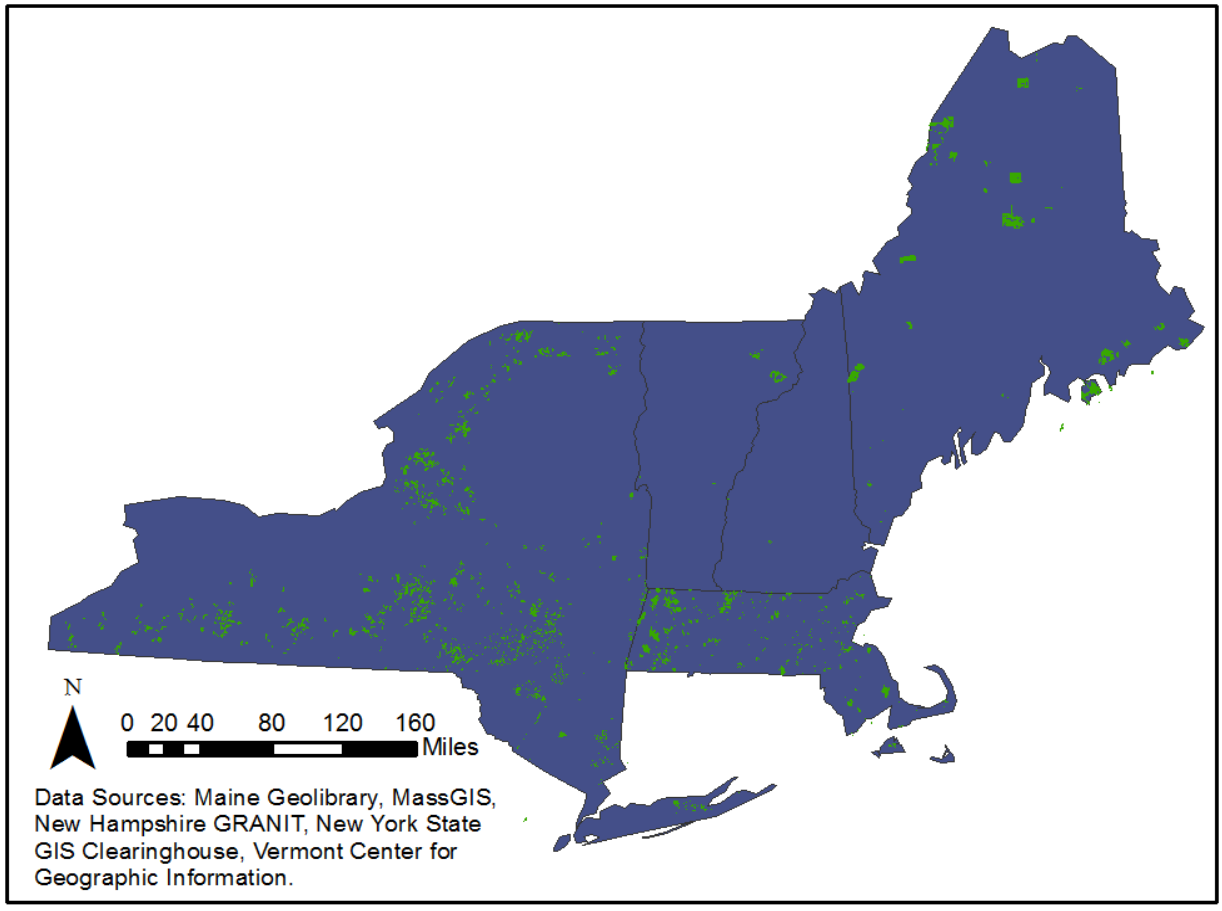

Figure 1. Lands in the Northeast with forest inventory programs. These lands have some type of forest inventory program occurring on them, which were assessed for their potential utility in answering regional-level questions of importance.

- **MASSACHUSETTS CFI (MACFI):** The MACFI program consists of a network of 1761 plots located on State Forest lands across Massachusetts. Established in the 1960s, these permanent fixed radius plots have been remeasured multiple times since they were established. This program is maintained by the Massachusetts Department of Conservation and Recreation. The manual is available online at https://www.mass.gov/files/documents/2016/08/pz/cfi-manual-2014-t.pdf.
- **BAXTER STATE PARK CFI (BAXCFI):** The BAXCFI program consists of 111 plots maintained within Baxter State Park's Sustainable Forest Management Area in northern Maine. Established in 1996 and remeasured in 2008, this program provides detailed assessment of the forest conditions. Data and information on this program can be found at https://www.uvm.edu/femc/data/archive/project/baxter_park_sfma_cfi.
- **MAINE ECOLOGICAL RESERVES (MEER):** The MEER program was established to monitor properties within the ecological reserve system in the State of Maine. These

lands are managed by the Bureau of Parks and Public Lands, and the Maine Natural Areas Program oversees the long-term ecological monitoring plan. The Maine Chapter of the Nature Conservancy has established monitoring plots on ecological reserves it has designated on its properties as well. As of 2013, Maine has designated more than 90,000 acres of Ecological Reserves on 17 public land units. Informaton about this program can be found at https://www.maine.gov/dacf/mnap/reservesys/index.htm

- N**ORTHEAST TEMPERATE INVENTORY AND MONITORING NETWORK (NETN):** The NETN program is maintained by the National Park Service and is carried out on national parks in the Northeast, with 350 continuous forest monitoring plots in eight different locations across the region. These plots have been maintained since their establishment in 2006 and four repeat measures have been completed on a four-year measurement interval. Information and data for this program can be found at https://www.nps.gov/im/netn/forest-health.htm.
- **FOX RESEARCH AND DEMONSTRATION FOREST (NHFOX):** The NHFOX CFI program was established in 1955 by the New Hampshire Division of Forests and Lands with 52 permanent plots located throughout the 1,445 acre Caroline A. Fox Research and Demonstration Forest. 42 of these plots have complete inventory data and include four remeasurements. Information about the Forest can be found at https://www.nhdfl.org/Natural-Heritage/State-Owned-Reservations/Fox-Forest.
- **NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION (NYCFI)**: This CFI program maintains 482 forest monitoring plots within the watershed lands owned by New York City Department of Environmental Protection. This program was established in 2002 and has repeated measures at ten year intervals. Information about this program is available at https://www.uvm.edu/femc/data/archive/project/Forest_inventory_nyc_dep.
- **NEW YORK STATE FOREST INVENTORY DATABASE (NYSFID)**: The NYSFID program is designed similar to a timber cruise meant to provide a quick overview of composition and structure of the forest stands within the state forest network in New York. It is maintained by the New York Department of Environmental Conservation.
- **NEW YORK CITY STANDS PROGRAM (NYSTANDS):** The NYSTANDS program began in 2008 and has collected forest inventory data on 9,377 plots located on New York City watershed forest lands managed by the New York Department of Environmental Protection. Information about this program is available at https://www.uvm.edu/femc/data/archive/project/NYC_DEP_forest_stand_delineation.

- **VERMONT CFI (VTCFI):** The VTCFI program was established by Vermont Department of Forest Parks and Recreation in 2015 to monitor forest conditions in the Northeast Kingdom of Vermont. 53 fixed radius plots have been established in Willoughby and Victory State Forests. Information and data for this program can be found at https://www.uvm.edu/femc/data/archive/project/continuous-forest-inventory.
- **SHAW MOUNTAIN NATURAL AREA (VTSHAW):** The VTSHAW program contains four long-term monitoring plots located in Benson, Vermont on the Shaw Mountain Natural Area which is owned and managed by the Nature Conservancy. This program was established following the 1998 ice storm to study the impacts of this disturbance on forest structure and composition.

Programmatic Analysis Table

The programmatic analysis table synthesizes the findings from the programmatic assessment table and outlines the applicability of each program in conducting common forest inventory analysis tasks. Based on the information collected by each program, this table highlights the types of analysis that can be conducted. Each column in the table describes a common forest assessment measure (e.g. overstory basal area, trees per acre, coarse woody debris volume, etc.) and identifies whether or not the program has the data available to address each forest assessment measure. This assessment step provides a measure of standardization by extracting key information about the suitability of a given program to analysis. The resulting table is used to develop the opportunity matrix detailing how these programs might be used to answer regional questions of interest.

Opportunity Matrix

The opportunity matrix provides a simple visual comparison across programs, based on the information collected in the previous two steps. This matrix identifies opportunities for cross-program synthesis to address key questions that go above and beyond the original intent of continuous forest inventory as a timber assessment tool. The opportunity matrix synthesizes the findings from the programmatic assessment table and allows interested users to look across programs and variables related to forest condition to quickly reference the types of questions that can be explored when using these data. We noted if the data set was *suitable, partially suitable*, or *not suitable* for addressing each key variable or question. With this tool, users can quickly see how programs compare across the region for a given question, such as assessing regeneration trends. "Suitable" programs have all the necessary basic information for including data in an analysis for a given question, while "partially suitable" programs may have some of the required measures, but would require some degree of estimation or assumption for other measures in order to use the data. Programs marked as "not suitable" are missing information and cannot be used in analysis for a given question. Metadata on each column header is included in the Appendix.

Programmatic Timeline Table

The programmatic timeline table is another visual tool that provides a simple overview of when in time inventories were collected, allowing potential CFI data users to see overlaps and gaps among forest inventory programs across the region.

Comparability of Programs for Key Regional Issues

The CFI programs assessed here are robust and provide detailed information about the forest conditions across the region. While there are strengths and weaknesses of each program, all programs can provide a basic analysis of forest condition. Individual programs

can be used, if data is made available, for local assessments and validating forest models. Based on input from FEMC stakeholders, we examine how easily these programs can be utilized to answer new questions outside the original scope of the CFI program, looking specifically at four major questions in this section. Programs were determined to be suitable, partially suitable, or not suitable for answering these questions.

Assessing Change in Composition Over Time

When looking at species composition of the overstory, all programs provide the information needed make basic observations related to species composition and density. NETN, MACFI, MEBAX, MEER, NHFOX, and NYSFID all record heights of trees which does allow for more detailed analysis of volume and biomass (Table 1). In addition, heights can be predicted which does not rule out these calculations for the remaining four programs that did not measure tree height explicitly. Except the NYSFID, all programs tag individual trees which allows for repeat measures of individual trees and can enable detailed analysis of growth, mortality, and ingrowth. The NYSFID program is used for rapid forest assessment to assist in management planning. The MACFI, MEBAX, MEER, and NYCFI programs have detailed economic assessments and the NHFOX, NYSFID, NYSTANDS, and VTCFI programs are partially suitable for detailed economic assessment.

Table 1. Comparison between overstory metrics across different CFI programs in the northeast forest region. Datasets were classified as *suitable (dark green)*, *partially suitable (light green)*, or *not suitable (yellow)* for addressing each key topic.

INVENTORY	OVERSTORY SPECIES COMPOSITION	OVERSTORY DIAMETER DISTRIBUTION	OVERSTORY STRUCTURE	OVERSTORY VOLUME, BIOMASS, CARBON	MORTALITY & INGROWTH (DBH inches of "TREE" noted in box)	MERCHANTABLE VOLUME AND PRODUCT VALUATION
MACFI					5	
MEBAX					4.5	
MEER					5	
NETN					3.94	
NHFOX					3	
NYCFI					4	
NYSFID					1	
NYSTANDS					5	
VTCFI					4.5	
VTSHAW					>=1.3 m tall	

Assessing Regeneration Dynamics

Regeneration is measured by examining the emergent understory of the forest, usually through the measurement of saplings and/or tallying seedlings of tree species. All programs except the NHFOX and NYSFID programs have regeneration data that summarizes sapling

composition and density (Table 2). NYSTANDS, NYCFI, VTCFI, VTSHAW, MACFI, NETN, and MEER all provide fully suitable information on seedling composition and density. NYSTANDS, NYCFI, VTCFI, VTSHAW, MACFI, NETN, and MEER provide fully suitable information related to species diversity in the understory beyond tree species. While regeneration is measured in the majority of the programs, each program does approach these measurements differently. It is typical to group small/young trees into seedlings and saplings. How each program defines these two groups by height and diameter differs across programs which would require additional data manipulation in order to make comparisons between programs.

Table 2. Comparison between regeneration metrics across different CFI programs in the northeast forest region. Datasets were classified as suitable (dark green), partially suitable (light green), or not suitable (yellow) for addressing each key topic.

INVENTORY	REGENERATION: SAPLING COMPOSITION AND DENSITY	REGENERATION: SAPLING MORTALITY & INGROWTH	REGENERATION: SEEDLING COMPOSITION AND DENSITY	UNDERSTORY: SPECIES DIVERSITY	UNDERSTORY: PERCENT COVER
MACFI					
MEBAX			Only saplings	Only saplings	
MEER					
NETN					
NHFOX					
NYCFI					
NYSFID					
NYSTANDS					
VTCFI					
VTSHAW					

Assessing Biomass and Carbon

Forest biomass and carbon can be measured when sufficient information about tree volume and down woody material is available. The MACFI, VTCFI, MEBAX, MEER, NHFOX, NYSFID, and NYCFI programs have collected the data suitable for easy and accurate estimation of volume, biomass, and carbon by species (Table 3). An analysis of volume, biomass, and carbon can be obtained by using the remaining four programs' data with some minor modification. Typically, volume estimations rely on an accurate estimation of tree height. The measurement of live tree height (total, bole, etc.) allows for easy volume estimation. When tree height is not recorded then height must be predicted using allometric equations which rely on species, diameter, and additional site variables (site index and plot basal area).

When it comes to measuring dead wood pools, all but the NYSFID program measure standing dead trees (Table 3). The typical approach for these measurements is to record dead trees

that are standing within the overstory plot. While dead standing trees density can be measured easily, only the MACFI, MEBAX, MEER, and NHFOX programs collect the height and decay class information needed to assess the volume and biomass of standing dead trees. Of the ten programs assessed, MACFI, MEBAX, MEER, NETN, VTCFI, and VTSHAW are assessing downed woody debris within the inventory plots and did collect the necessary information to estimate downed wood volumes. Only the VTCFI program included fine woody debris measurements in their inventory.

Table 3. Comparison between biomass and carbon metrics across different CFI programs in the northeast forest region. In addition to the overstory characteristics defined above, additional information below is useful for calculating these values. Datasets were classified as suitable (dark green), partially suitable (light green), or not suitable (yellow) for addressing each key topic.

INVENTORY	STANDING DEAD (SNAG) DENSITY (TPA)	SNAG VOLUME	SNAG BIOMASS/ CARBON	COARSE WOODY DEBRIS VOLUME	COARSE WOODY DEBRIS BIOMASS/ CARBON	FINE WOODY DEBRIS
MACFI						
MEBAX						
MEER						
NETN						
NHFOX						
NYCFI						
NYSFID						
NYSTANDS						
VTCFI						
VTSHAW						

Assessing Forest Health

Tree vigor and crown condition are measured in the MACFI, MEBAX, MEER, NETN, NYCFI, NYSTANDS, NYCFI, and VTSHAW programs (Table 4). Instances of insect and disease damage are recorded in MACFI, MEER, NETN, NHFOX, NYCFI and the NYSTANDS programs (Table 4). Forest health indicators include tree vigor, crown condition, and observed signs of pest or pathogen presence or impacts. Stand level health indicators can also be assessed by other measures included in the assessment.

Table 4. Comparison between forest health and disturbance metrics across different CFI programs in the northeast forest region. Datasets were classified as suitable (dark green), partially suitable (light green), or not suitable (yellow) for addressing each key variable or question.

INVENTORY	TREE HEALTH	INVASIVE SPECIES	INSECT/DISEASE	BROWSE	MERCHANTABLE VOLUME AND PRODUCT VALUATION
MACFI					
MEBAX					
MEER					
NETN					
NHFOX					
NYCFI					
NYSFID					
NYSTANDS					
VTCFI					
VTSHAW					

Programmatic Timeline Table

This visualization tool allows potential CFI data users to see when forest inventory measurements were conducted for individual programs, and the nature of the inventory rotation if one is used (Table 5, **Error! Reference source not found.**). Some programs completed full measurements of all plots within a single year while others completed plot measurement over the course of multiple years. Dark green fill under a specific date indicates that all plots were measured in that year. Light green fill represents a multi-year measurement process. The measurement period is outlined with a solid line to indicate the period of measurement. A pattern fill indicates that the measurement protocols were changed in that given year.

Table 5. Timeline of when forest inventory measurements were conducted between the different northeastern CFI programs from 1955 to 1986 (top) and 1987 to 2018 (bottom). A cell with dark green fill under a specific date indicates that all plots were measured in that year. Light green fill represents a multi-year measurement process. The measurement period is outlined with a solid line to indicate the period of measurement. A dot fill indicates that the measurement protocols were changed in that given year.

INVENTORY	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
MACFI																																
MEBAX																																
MEER																																
NETN																																
NHFOX																																
NYDEP																																
NYSFID																																
NYSTANDS																																
VTCFI																																
VTSHAW																																

INVENTORY	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
MACFI																																
MEBAX																																
MEER																																
NETN																																
NHFOX																																
NYDEP																																
NYSFID																																
NYSTANDS																																
VTCFI																																
VTSHAW																																

General Recommendations for Increasing Regional Comparability

As part of the assessment, we noted areas in each program where specific changes could be made to increase the regional utility of this data. We separate these into *minor improvements*, *high-impact but resource-intensive adjustments*, and *gaps and serious challenges.*

Minor Improvements

There are several adjustments that could be made to a few programs that would allow their data to be compared with other programs, thus increasing the overall pool of data and the utility of these programs for answering novel questions about the region's forests.

- Measuring live tree height would improve volume and biomass estimations for the NETN, NYCFI, NYSTANDS, and VTSHAW programs.
- If snags are measured, then it would be valuable to include a rough height estimation (ocular estimation would be sufficient) along with a decay/fragmentation class determination to assist in volume and biomass calculations. The MEER, NETN, and NHFOX programs would benefit most from this minor addition given they already measure standing dead trees.
- Making a determination about the tree condition as it relates to its marketability (e.g. AGS/UGS, saw, pulp, cull, etc.) would allow for more economic analysis.

High-Impact but Resource-Intensive Adjustments

A second group of changes that could be considered for these programs would require more resources to complete, but could deliver significant benefits for regional data utility. These changes may involve increased time in the field to collect new metrics, modifying the collection methodology, and/or performing some one-time additional work to upgrade a given metric.

- While the inclusion of a regeneration analysis would likely be more time- and resource-intensive, it would be highly impactful to measure. Simple methods are available which would allow programs to efficiently measure regeneration. An example of this would be the inclusion of a single nested subplot within the overstory plot where saplings and seedlings species are tallied and DBH and size class is recorded would be highly impactful. NHFOX and NYSFID would could be good candidates for this addition.

- The inclusion of CWD measurements would allow for more detailed accounting of biomass and carbon pools in the forest. NHFOX, NYSFID, NYSTANDS, and NYCFI could consider the inclusion of this measure.
- Identifying individual trees within the plots allows for repeat measures of individual trees, and this change would enable analysis of growth, mortality, and ingrowth. Some programs use individual ID tags for each tree along with distance and direction measures which allows for rapid relocation of individual trees. Regardless of whether trees are tagged with ID number or not, ensuring a way to relocate trees for remeasurement is highly desirable.

Gaps and Serious Challenges

There are some areas where few or no programs are capturing specific? information, meaning that many programs would have to adjust in order to start collecting this information, and there is limited historical data available. We document two important gaps below, recognizing that these may not be priorities for programs based on continuous forest inventory techniques.

- Measurement of fine woody debris is lacking across the board (with the exception of VTCFI) and given limited resources might not be feasible to incorporate. Fine woody debris measurements can allow for more detailed biomass and carbon accounting.
- Measuring mortality and ingrowth for overstory trees can be assessed for the majority of the programs. However, measuring rates of mortality of saplings and seedlings is underrepresented and, while it is a difficult thing to measure, it might be worth exploring considering the importance of regeneration dynamics to the assessment of future forest growth and development.

Massachusetts CFI (MACFI)

The MACFI program is maintained by the Massachusetts Department of Conservation and Recreation. It has excellent documentation of data collection methods in the publically available handbook and is extensive in its measurements. There are detailed product or economic data collected that allow for analysis of timber products and changes in value.

This program is collected across the state and currently has a maintained network of 1761 plots. Established in the 1960s, these permanent fixed radius circular plots have been remeasured multiple times since they were established. Live trees are measured at 4.5' at breast height and a minimum DBH is 5". Tree, height, status, and product considerations are recorded. Dead standing trees are recorded with an estimation of standing height and decay class. A full regeneration inventory is conducted and saplings and seedlings are each tallied and grouped into two size classes based on height and DBH.

Massachusetts CFI (MACFI) – Elevation range and forest type distribution

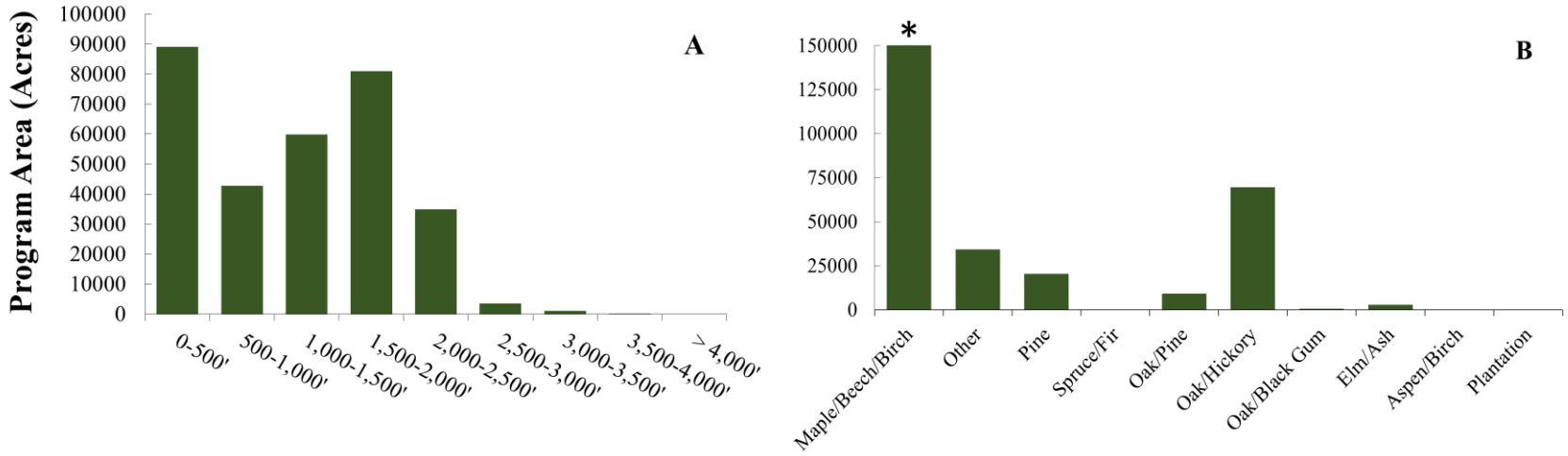

Figure 2. Total Massachusetts CFI program area acreage displayed by the distribution of (A) elevation (in feet above sea level) and (B) forest type (National Forest Type dataset). * Total acreage within Maple/Beech/Birch forest type equals 174,348 acres.

Baxter State Park CFI (MEBAX)

This program is comprehensive with 111 plots maintained within Baxter State Park's Sustainable Forest Management Area. Fixed radius plot were established in 1996 and were remeasured in 2008. Overstory analysis is exceptional and includes detailed assessments of overstory composition and structure (trees are larger than 4.5" in DBH). Live tree condition and health is also included which provides a nice layer of detail. Quick volume and biomass estimation is possible with the data collected in this program. Regeneration analysis is limited to saplings and does not include measurements of trees less than 0.5" DBH.

Baxter State Forest CFI (BAXCFI) – Elevation range and forest type distribution

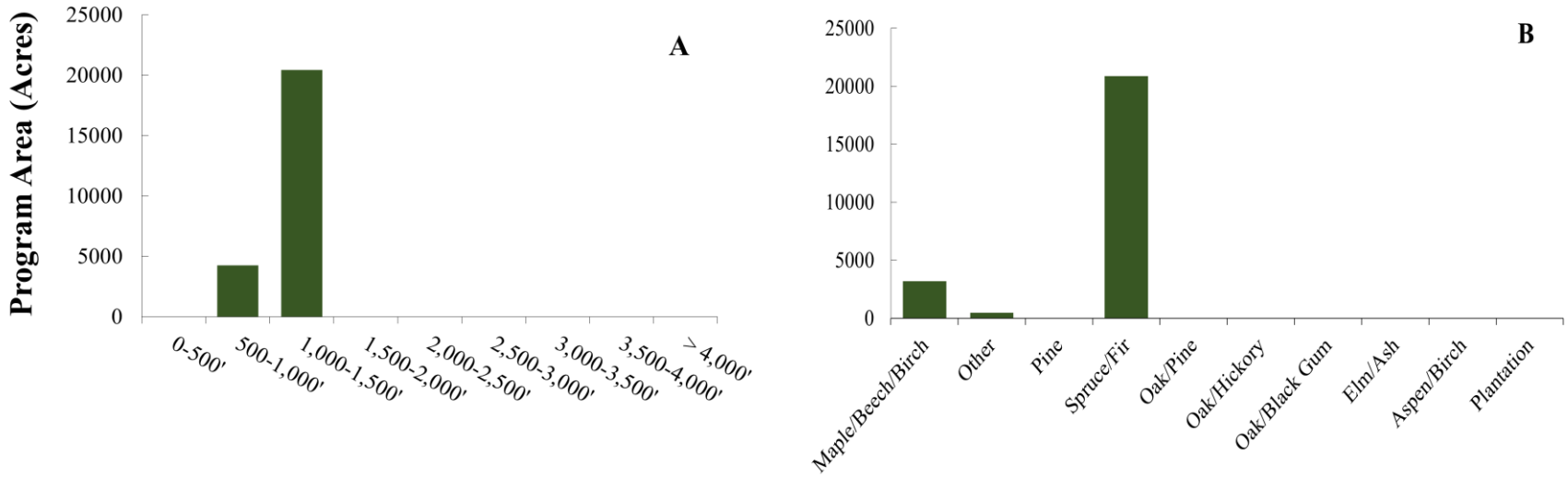

Figure 3. Total Baxter State Park CFI program area acreage displayed by the distribution of (A) elevation (in feet above sea level) and (B) forest type (National Forest Type dataset).

Maine Ecological Reserve Monitoring Program (MEER)

This program, which is maintained by the Maine Natural Areas Program and The Nature Conservancy of Maine, is highly detailed and provides a robust data set. Lands in this monitoring program include areas managed by the Bureau of Parks and Lands, The

Nature Conservancy, the Maine Department of Inland Fisheries and Wildlife and Baxter State Park. Over 500 plots have been remeasured at over 20 sites. These plots are representative of an area of over 200,000 acres. Sites range in elevation and forest type and are somewhat regionally unique because timber harvesting is prohibited in these areas. Plots were established using a stratified random design and utilize variable radius plots. Live trees larger than 5" DBH are recorded. Unique to this program is the collection of data on trees larger than 20" DBH within a larger 58.9' radius plot. Detailed overstory analysis is possible using the data collected including robust volume and biomass estimation. Tree condition measurements could be included to allow for a more varied assessment of tree and forest health.

Regeneration measurements are comprehensive including saplings and seedlings. Snag decay class could be estimated in the field to increase the capacity to measure dead wood biomass and carbon pools at high levels of accuracy.

Maine Ecological Reserve Monitoring Program (MEER) – Elevation range and forest type distribution

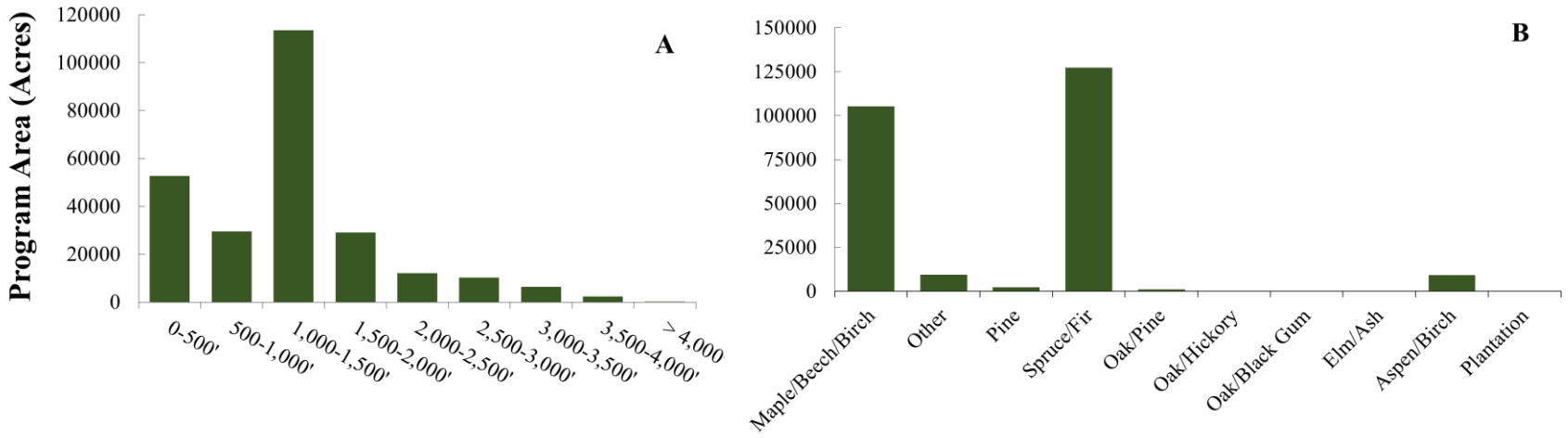

Figure 4. Total Maine Ecological Reserve Monitoring program area acreage displayed by the distribution of (A) elevation (in feet above sea level) and (B) forest type (National Forest Type dataset).

Northeast Temperate Inventory and Monitoring Network (NETN)

This program is carried out in national parks in the Northeast by the National Park Service and is another highly detailed and comprehensive program. 350 plots have been established in eight different locations across the region (sampling intensity of

one plot per 42 acres) and have been maintained since 2005. Four repeat measures have been completed on a four-year measurement interval.

The inventory is highly detailed and provides information on overstory composition and structure, dead wood pools, and regeneration. Given the focus of national parks on ecological function, it is understandable that economic considerations are not included in this inventory. If desired, inventory protocols could be changed to include an AGS/UGS tree condition determination and/or a measurement of merchantable height with a classification of potential product class (saw, veneer, cull). In addition, total tree height and decay class of snags could also be recorded to improve volume and biomass estimations.

Northeast Temperate Inventory and Monitoring Network (NETN) – Elevation range and forest type distribution

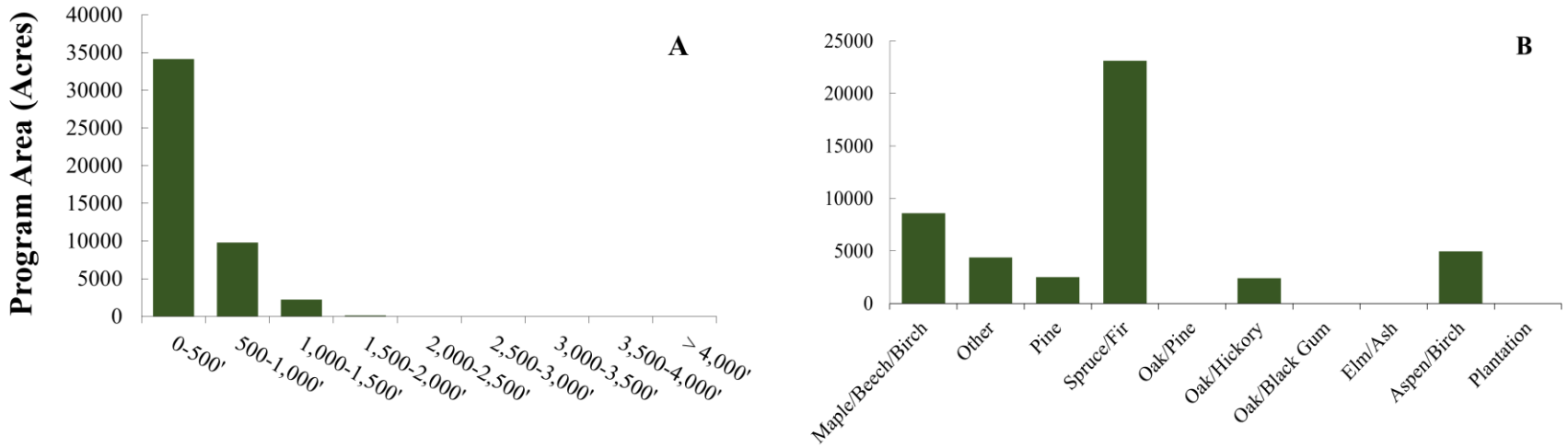

Figure 5. Total Northeast Temperate Inventory and Monitoring Network (NETN) program area acreage displayed by the distribution of (A) elevation (in feet above sea level) and (B) forest type (National Forest Type dataset).

Fox Research and Demonstration Forest (NHFOX)

The Caroline A. Fox Research and Demonstration Forest CFI program was established in 1955 by the New Hampshire Division of Forests and Lands with 52 permanent plots located throughout the 1,445-acre property (1 plot per 28 acres). 42 of these plots have complete inventory data and include four remeasurements. Live tree measurements within these fixed radius plots vary slightly throughout the measurement period. In order to manage some inconsistencies with the original live tree DBH

measurements, in 2001 all trees ≥ 3" DBH were measured. In 1984 plot center locations were shifted and trees were retagged and renumbered which allows for tree-to-tree comparisons for the period before and after 1984.

This program has detailed overstory measurements and is unique because of the duration of the program and because active forest management has been conducted throughout the property, which could allow for some interesting explorations of management outcomes. Improvements could be made to include regeneration in future measurements. Snags are currently measured but the inclusion of a decay class measurement for snags and a CWD would allow for more detailed dead wood analysis.

Fox Research and Demonstration Forest (NHFOX) – Elevation range and forest type distribution

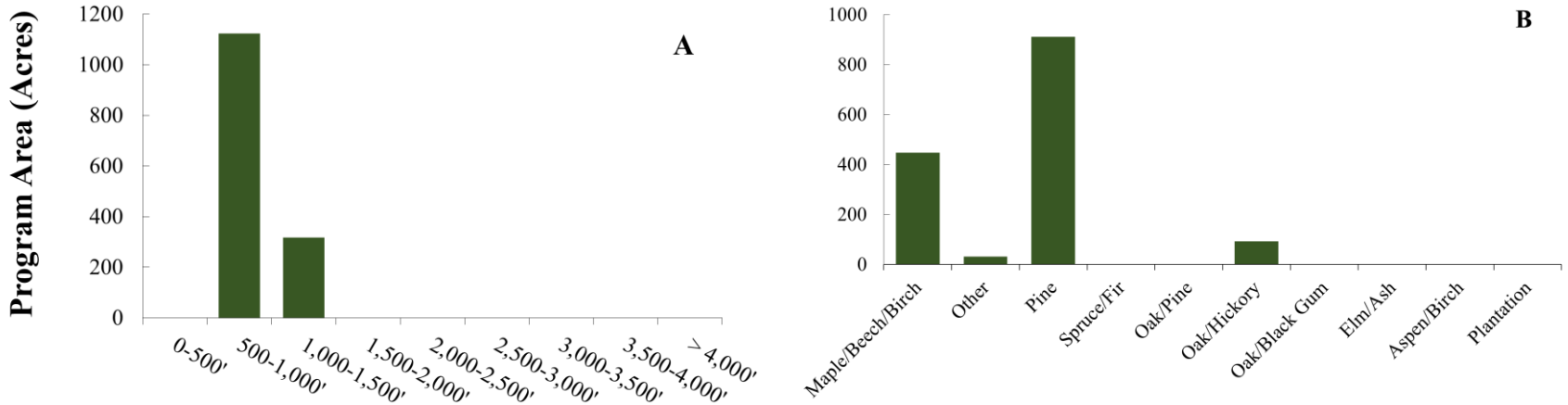

Figure 6. Total Fox Forest Research and Demonstration Forest CFI program area acreage displayed by the distribution of (A) elevation (in feet above sea level) and (B) forest type (National Forest Type dataset).

New York City Department of Environmental Protection CFI Program (NYCFI)

This program, managed by the New York City Department of Environmental Protection, is detailed and includes excellent overstory merchantability measures. Overstory volume and biomass can be calculated for the bole and can be expanded out to the whole tree and even below ground volume with some additional work. Individual trees are not tagged and therefore it is not possible to track ingrowth and mortality with repeat measures. Standing dead trees are measured but the height and decay class is not recorded making volume and biomass estimation difficult.

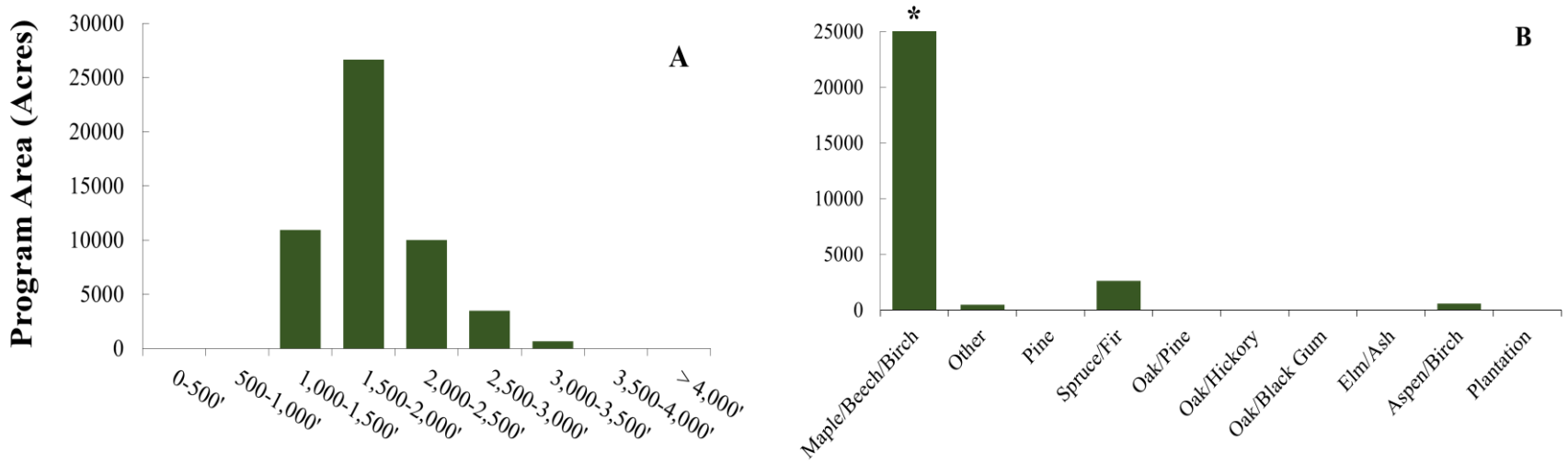

Figure 7. Total NYCFI program area acreage displayed by the distribution of (A) elevation (in feet above sea level) and (B) forest type (National Forest Type dataset). * Total acreage within Maple/Beech/Birch forest type equals 87,135 acres.

State Forest Inventory Database (NYSFID)

This program, managed by the New York Department of Environmental Conservation, is designed similar to a timber cruise meant to provide a quick overview of composition and structure of the stands. Variable radius plot design is used and trees of all sizes are tallied which does capture trees less than 4" DBH. Trees in the overstory are classified based on their form and market potential, allowing for an analysis of marketability. This program is easily established with a random plot layout and variable radius plot design allowing for a rapid assessment of forest conditions. Because plots are not permanently placed, repeat measures of the same plots are not possible, limiting the program's ability to track growth, mortality, and ingrowth. Regeneration is not included in the current methodology but could be easily included with a single nested regeneration plot. Regeneration plots could be 1/100 acre for saplings and 1/1000 acre for seedlings. The strength of the program is its ability to be implemented easily and quickly. The inclusion of regeneration would be an easy and high impact addition while not altering the methods. If the program would like to have more detailed analysis of forest conditions, programs such as MACFI could be a model to guide future development.

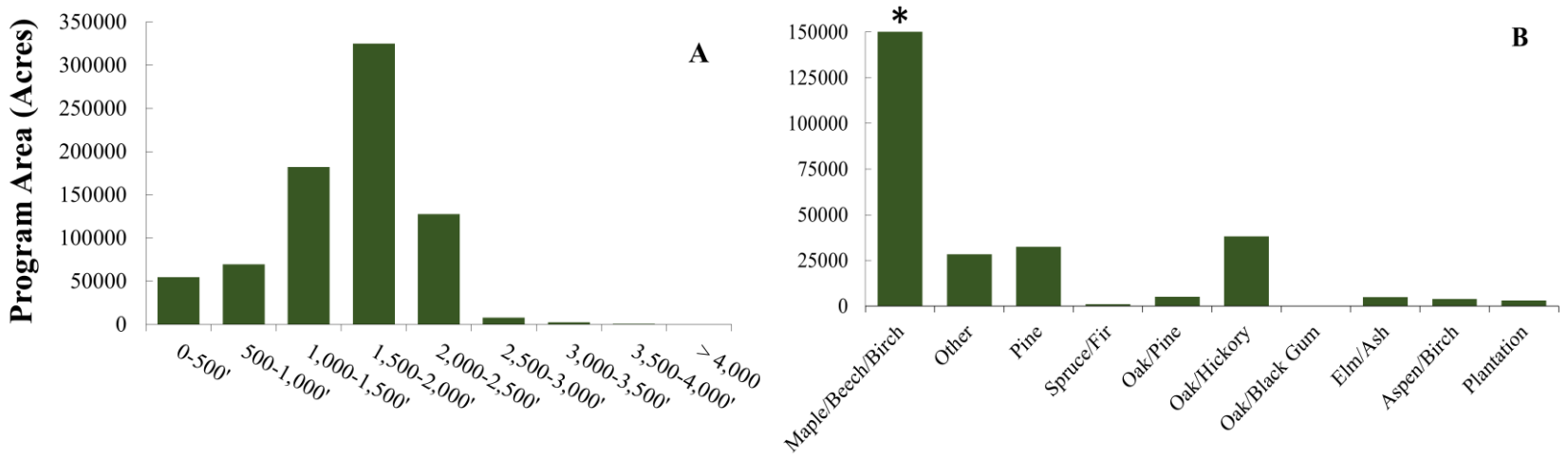

Figure 8. Total NYSFID program area acreage displayed by the distribution of (A) elevation (in feet above sea level) and (B) forest type (National Forest Type dataset). * Total acreage within Maple/Beech/Birch forest type equals 651,183 acres.

New York Stands Program (NYSTANDS)

This program is maintained by New York City Department of Environmental Protection on New York City water supply forest lands and measures many aspects of forest conditions. The inclusion of tree heights could be an improvement made to the program which would increase its capacity to measure volume and biomass accurately. Estimations of merchantable height and product classification would be another easy component to consider including in the methodology. The use of tree tags with unique ID numbers would allow for easier remeasurements but might be cost prohibitive. In addition to these recommendations, the program could incorporate dead and downed woody material analysis. This could include measurement of snags in the overstory and single- or multiple-line transects to measure CWD. The inclusion of a height estimation on snags along with a decay class would greatly increase the program's ability to easily assess volume and biomass of dead wood.

New York Stands Program (NYSTANDS) – Elevation range and forest type distribution

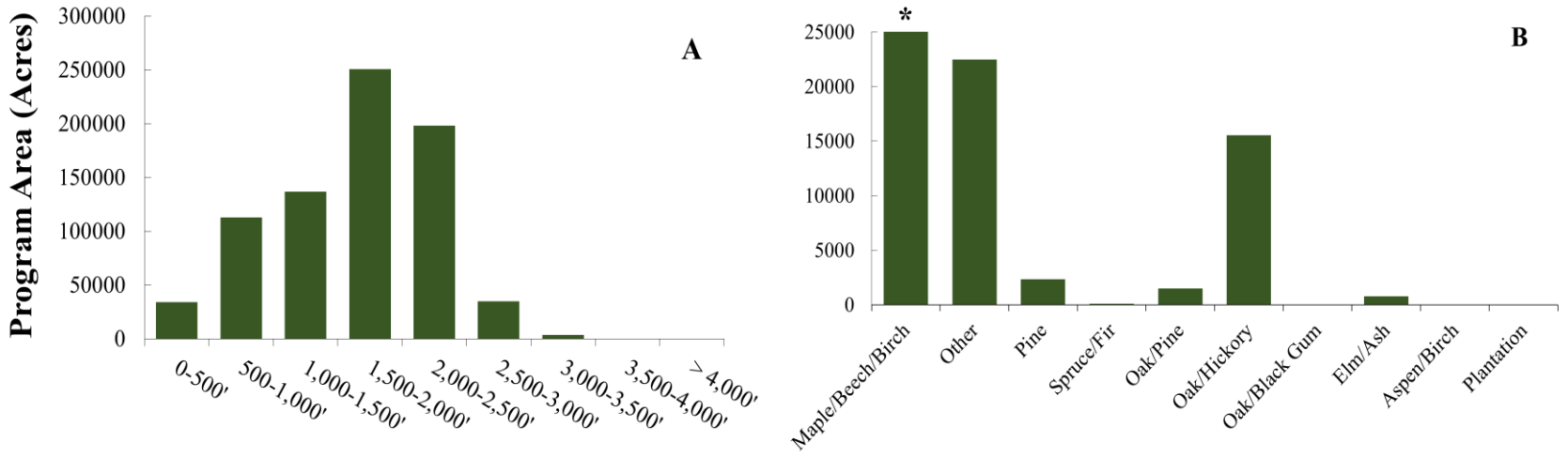

Figure 9. Total NYSTANDS program area acreage displayed by the distribution of (A) elevation (in feet above sea level) and (B) forest type (National Forest Type dataset). * Total acreage within Maple/Beech/Birch forest type equals 87,135 acres.

Vermont CFI Program (VTCFI)

This program, maintained by the Vermont Agency of Natural Resources' Department of Forests, Parks, and Recreation, has excellent overstory and regeneration protocols. Detailed merchantability and economic valuation is slightly limited and could be improved with a AGS/UGS determination or a product classification (veneer, saw, pulp, cordwood, cull, etc.). This program is robust and has excellent protocols including coarse woody debris measurements. Low resource demand improvements could include the notation of any invasive species present on site, signs of deer browse, or other indicators of forest health issues.

Vermont CFI Program (VTCFI) – Elevation range and forest type distribution

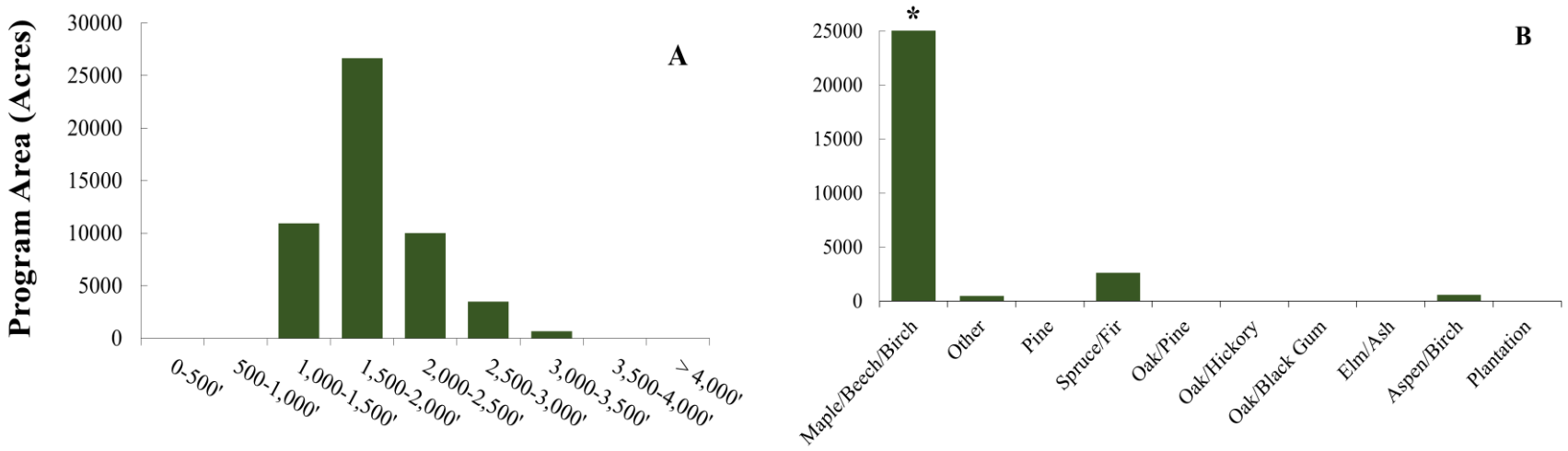

Figure 10. Total VTCFI program area acreage displayed by the distribution of (A) elevation (in feet above sea level) and (B) forest type (National Forest Type dataset). * Total acreage within Maple/Beech/Birch forest type equals 480,737 acres.

Shaw Mountain Forest (VTSHAW)

This program is maintained by the Nature Conservancy and is very detailed in its environmental assessment. This program is different than the other programs assessed because it is looking closely at the impacts of ice damage on forest conditions.

Detailed information about tree condition is provided and understory analysis is robust. This program's strength is the detail it provides on other environmental factors in addition to information on trees. Because the focus of this program is not on timber, it has limited information related to economic value or marketability.

Shaw Mountain Forest (VTSHAW) – Elevation range and forest type distribution

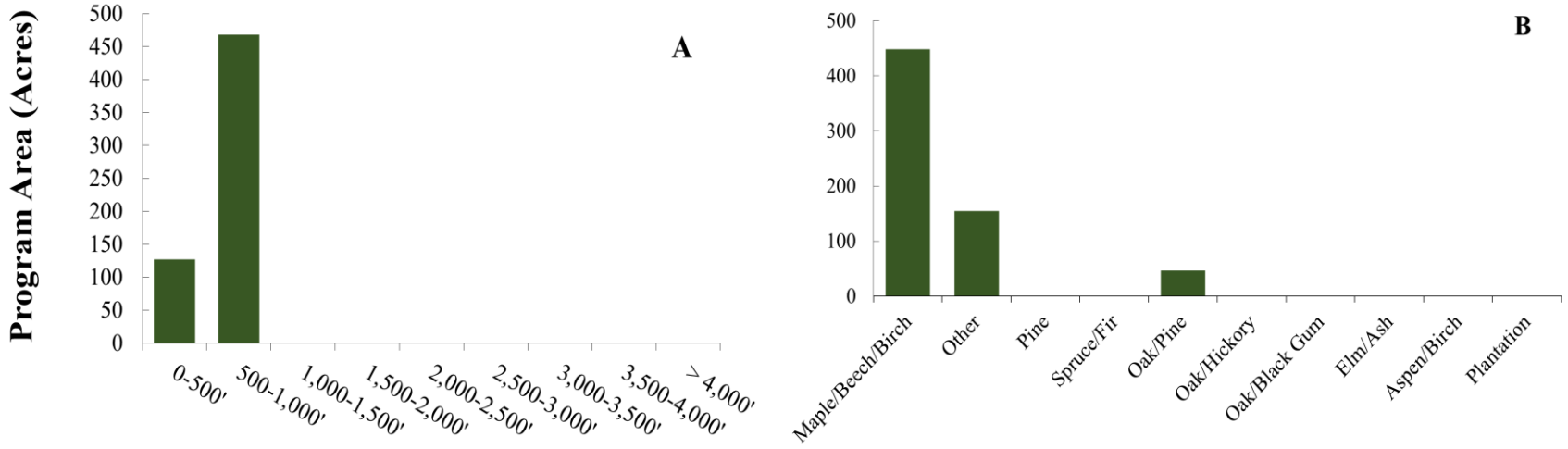

Figure 11. Total VTSHAW program area acreage displayed by the distribution of (A) elevation (feet above sea level) and (B) forest type (National Forest Type dataset).

Products and Outputs

FEMC has made as much evaluative information available as possible from this effort at https://www.uvm.edu/femc/forest_inventory_data_network/methods/comparison. This simple comparision web page allows a user to view the outputs of this effort, and drill down to specific information such as details contained in the program assessment and analysis tables. This will extend the tabular and text information presented here and ease the search for data sources that fit a given management, assessment or research need across programs. In addition, the full assessment is available for download at https://www.uvm.edu/femc/file/info/10905.

Conclusions and Next Steps

This report demonstrates the potential utility of a number of inventory programs in the Northeast to contribute towards regional assessments of a range of important issues including changing patterns in regeneration success of tree species, emerging threats to forest health, and accounting for and tracking carbon in our forests. The methodology for comparing programs is easily expanded to other programs, and the resulting visualizations make it easy to compare general patterns across programs for given questions.

Additional funds have been secured by FEMC to explore the feasibility of an information technology system that will make it easier to process and compare inventory data from disparate sources for regional assessments, as well as expand upon the pool of potential inventory programs to include in this effort.

Together, these tools and this methodology document a range of inventory program styles, and shed light on how these programs might be used by researchers and managers to address new and important questions facing the forests of our region.

Appendix – Column Definitions for Tables

Programmatic Assessment Table Column Definitions

The **Programmatic Assessment Table** is the long form Excel table that was created to evaluate each individual CFI program. It includes columns of information related to how the CFI program was conducted and what data was collected. Below is a brief definition of each column in this table. Note that most column headers below contain a general assessment, such as "YES"/"NO" or a number, and there is an associated details column which includes notes and other information related to that assessment.

Basic Program Information

Program Name: The name of the inventory program or the name given to the program as part of this effort.

Program Code: Abbreviated letter code for each program.

Program ID: The ID number given to the program for GIS analysis.

Inventory State: The state in which the CFI program takes place

Location/area: Describes the specific geographies of where the CFI plots are established.

Program Details: This section provides a general description of the program, such as when the program was established, where plots are located, and how many plots were established if that information is available.

Number of Plots: The number of inventory plots established.

Density/intensity of plots and desired level of sampling accuracy: This is an indication of how many plots per acre were established. We also note if a desired level of sampling accuracy is recorded.

Collection Period: When was the inventory collected?

Rotation: How often the plots have been re-measured, and any information on the prescribed interval between repeat measures.

Repeat Measures: Have the initial plots been remeasured? This allow for analysis of change/development over time,

Sampling Method: How were the plots established? Are they permanent plots or random plots? This allows us to assess the ability to do repeat measures and conduct analysis of change over time.

Plot Type: Are the plots that have been established measured using a fixed or variable radius method? This helps when doing basic calculations related to plot level basal area and trees per acre.

Plot Size if Fixed: If fixed radius plots are used, then what is the radius or the area of a square plot?

Plot Layout: This describes if the plot layout was circular or square. The details column associated with this field describes the plot layout. For example, a typical plot layout is a fixed radius circular plot with nested smaller circular plots to measure sapling and seedlings and may include line transects radiating from plot center to measure CWD.

Spatial Layout: Describes the sampling layout (systematic, stratified, stratified-random, etc.) of plots across the stand or forest block.

BAF (if variable): If a variable radius plot layout was used then a prism or angle gauge was implemented to measure overstory tree density. Basal Area Factor (BAF) indicates the type of prism used (i.e. 5,10,20,40). Knowing the BAF used allows you to do basic plot level calculations related to tree density.

Expansion Factor: This is related to fixed area plot size and is typically measured in acres or hectares. For example, in a 1/5th acre plot, each individual overstory tree measured is "worth" 5 trees per acre.

Notes: Used as a catch-all for any additional comments.

Overstory

Min DBH: For overstory measurement, what is the minimum diameter measured at breast height (DBH) to be included as an overstory tree? This value typically ranges between 3-5 inches DBH.

Species (code type): Describes how tree species are coded. Species codes vary across programs. Some use numeric codes for individual tree species, while others use text. Some programs develop their own codes while others use existing standards such as the USDA PLANTS Database.

Trees Tagged: YES/NO if trees within the plot are permanently tagged allowing for repeat measures of individual trees and analysis of mortality and ingrowth.

AZ from plot center: YES/NO indicating if the azimuth from plot center to individual trees are measured. These measures allow for analysis of the influence of spatial arrangement of trees within the plot (stem mapping, neighborhood dynamics etc.).

Distance from plot center: YES/NO indicating if distance from plot center to individual trees is measured or not. Distance along with azimuth allows for spatial arrangement analysis and repeat measures.

Trees measured (AGS/UGS): YES/NO if live trees are classified as Acceptable Growing Stock (AGS) or Unacceptable Growing Stock (UGS). Assists in analysis of economic value or tree "quality".

Height of Live: YES/NO if the height of live trees is measured.

Crown Class: YES/NO if crown class is recorded for individual live trees. Crown classes are the position of the live tree within the canopy (e.g. open-grown, dominant, codominant, intermediate, suppressed).

Product Consideration: YES/NO if there are any merchantability measures recorded such as merchantable height, or product class (saw, pulp, cordwood etc.).

Trees Measured (Standing Dead): YES/NO if snags/standing dead trees are measured within the plots.

Snag Height: YES/NO if the height of the snags is recorded. Allows for volume estimation.

Decay Class of Snag: YES/NO if the decay class (1-5) is recorded for individual snags. This allows you to accurately estimate biomass.

Tree Status: YES/NO if there is some indication if the tree is live, dead, a new tree or even AGS and UGS.

Tree condition: YES/NO if there is consideration of the condition of the tree as it relates to its health. Any health issues or noticeable damage would be recorded.

Other: Any other information that is collected on overstory trees.

Understory - Saplings

Saplings measured: YES/NO if saplings are measured within plot.

Plot size: This is the size of the plot in which the tree saplings are measured. It is important to know the size of the plot when calculating density.

Number of subplots: Saplings and seedlings are often measured within a smaller plot or subplot that is nested within the larger overstory plot. Sometimes there are multiple subplots within the larger overstory plot.

Size class: This section is a place to note how saplings are classified. Typical inventory procedures will measure saplings of different diameters or size classes (i.e. 1-2 inches, 2-3 inches, and 3-4 inches etc.).

Species Code: How are the sapling species recorded? Do they use the same code as the overstory trees, etc.? Do they group by hardwood or softwood?

Other: Any additional information regarding sapling measurements.

Understory - Seedlings

Seedlings measured: YES/NO to indicate if seedlings are measured.

Plot size: The size of the subplot used to measure seedlings.

Number of subplots: Indicates the number of seedling plots within the larger overstory plot.

Size class: YES/NO if seedlings are tallied based on their size (i.e. DBH, height etc.).

Species: YES/NO if the species of the seedling is noted. If so, how (text, code, same as overstory)?

Understory - Other

Other measures: YES/NO if there any additional understory measures in addition to saplings (e.g. percent cover in microplot).

Plot Type and Size: Describes the type of plot used.

Strata: Describes any vertical strata used in taking understory measures.

Coarse Woody Debris

Measure CWD: YES/NO if coarse woody debris measured.

Method: How CWD is measured. Typically done using a transect and the line intercept method.

If transect: Number: This will indicate the number of transects used to measure CWD within the plot.

If transect: Length: The length, typically in feet, of the CWD transect.

DBH Recorded: YES/NO if the diameter of the downed woody material is measured.

Min Diam: The minimum diameter required for tallying a piece of CWD.

Length Recorded: YES/NO if the length of the CWD piece is recorded.

Min Length: The minimum length required for tallying a piece of CWD.

Decay Class: YES/NO if the decay class (1-5) is recorded for each piece.

Species: Is the species of the CWD recorded? If so, how?

Fine Woody Debris: YES/NO if fine woody debris is measured.

Other

Other Measures: YES/NO if there are any additional metrics recorded, and what they are.

Cover or Forest Type or Natural Community: Is there any classification or description provided about the type of forest represented at the plot? These could include a cover type, forest type description, or a natural community classification.

SAF_<<evt code>_<<vegetation type>>: Based on the LANDFIRE existing vegetation type map[1], this indicates the proportion of the CFI program area in each of SAF 24 forest types. Columns will include the SAF code and the name of the forest type, e.g. SAF_60_SUGAR_MAPLE_BEECH.

<<vegetation type>> e.g. SUGAR_MAPLE_BEECH: TRUE/FALSE if the forest type is represented within the CFI program area for each LANDFIRE existing vegetation type e.g. SUGAR_MAPLE_BEECH

Management: YES/NO if the management history of the site/plot is recorded.

Disturbance History: YES/NO if there is any information recorded related to the disturbance history of the site. (e.g. logging, ice storm damage, blow down, etc.).

Forest Structure: Any notation pertaining to the structure of the forest (e.g. even, two, or uneven-aged stand, etc.).

Stand Condition: YES/NO if there is a description or coding of stand condition.

Soil Type: YES/NO if any information is provided about the soil type at the plot.

Stand Age: YES/NO if the age of the stand is noted. Often measured by taking a tree core of a dominant tree near the plot.

Site Index: YES/NO if a measure of site quality is recorded.

Invasive Spp: YES/NO if presence of invasives species within plot are noted.

Forest Health Indicators: YES/NO if indicators of forest health were captured.

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[1] https://www.landfire.gov/evt.php

Slope/Aspect: YES/NO if slope and/or aspect is recorded

Min Elevation(m): Based on an analysis of 30 x 30-meter digital elevation model provided by USGS. Provides the minimum elevation that is present within the program area.

Max Elevation(m): Based on an analysis of the USGS 30 x 30-meter resolution digital elevation model. Provides the maximum elevation that is present within the program area.

Browse: YES/NO if the presence of deer browse or other herbivory is noted.

Programmatic Analysis Table Column Definitions

The **Opportunity Matrix** is a tool that synthesizes information collected on each CFI program in the **Programmatic Assessment Table** and is used to highlight the suitability of each program in addressing regionally important questions.

Overstory Analysis

Overstory analysis is focused on describing the condition and composition of the tree typically larger than 4 inches in diameter. We assessed the data collected by each program to determine if common and useful metrics could be calculated. These metrics can allow for comparison between programs and in some cases integration of multiple program data.

TPA: YES/NO if trees per acre can be calculated. The user would need to know the type and size of the plot. In fixed radius plots, TPA is calculated based on the size of the plot. For variable radius plots, DBH and basal area are used to calculate TPA.

BA: YES/NO if basal area (ft^2/acre) can be calculated. If variable radius plots are used, the basal area factor used to determine "in" trees is the amount of basal area each "in" tree occupies on an acre. If fixed radius plot you will need to know DBH.

Composition: YES/NO if species composition can be measured with available data. Typically summarized as trees per acre or basal area per species.

Structure: YES/NO if the diameter distribution by TPA and/or BA can be created. Species are binned into DBH classes compared to TPA or BA.

Vertical structure: YES/NO if heights are recorded, then you could summarize the vertical structure.

Volume: YES/NO if the volume can be calculated. Volume is a precursor to other measures like biomass and carbon. Typically needs to have heights recorded but can be calculated with a predicted height for individual trees.

Biomass: YES/NO if the biomass for individual overstory trees can be calculated.

Carbon: YES/NO if carbon for plots can be calculated.

Mortality: Typically, if trees are tagged, then with repeat measures you can assess rates of mortality. Same goes for ingrowth.

Merchantable Volume: YES/MAYBE/NO if merchantable volume can be calculated.

Sapling Analysis

Analysis of the sapling layer pertains to the small trees larger than an inch in diameter (typically) and larger than a foot in height. We reviewed each program and determined which common sapling metrics could be obtained from the available data.

TPA/Stems per acre: YES/NO if this can be calculated when the plot/subplot size is known.

Composition: YES/NO if species is recorded and TPA is available, then composition can be summarized.

Mortality: YES/NO if individual trees are tagged or if dead stems are counted during measurement, mortality can be calculated

Seedling Analysis

Seedlings are typically considered young trees that are less than 1 inch in diameter. We assessed each program to determine if the data was available to calculate several different metrics related to seedling condition and composition.

Stems/acre: YES/NO if this can be calculated when the plot/subplot size is known.

Composition: YES/NO if species is recorded and stems per acre is known, then species composition can be summarized on a per-acre basis.

Understory analysis: This column relates to other understory measures in addition to seedlings per acre and composition of tree seedlings, such as percent cover.

Diversity measures: Ability to calculate measures of diversity from percent cover.

Deadwood Analysis

The dead wood analysis section provides information on each program's ability to calculate common metrics related to dead and decomposing woody material. Measurement of standing dead trees and downed woody material allow for detailed description of the forest structure, wildlife habitat, and downed woody biomass among other metrics.

Snags

Snag density: YES/NO if standing dead trees are measured within the plots then the density (snags/acre) can be calculated.

BA: YES/NO if the DBH is measured in fixed area plots or if snags are included in variable radius plots, then Basal Area (BA) can be calculated. Used to assess BA of standing dead trees.

Volume: YES/NO if the snag volume can be calculated, which requires height.

Biomass: YES/NO if biomass can be calculated, which generally requires decay class in addition to height.

Carbon: This is derived from biomass.

Coarse Woody Debris

Volume: Based on the measurement approach (transect, etc.) volume can be calculated.

Biomass: YES/NO if biomass can be calculated, which generally requires decay class.

Carbon: This is derived from biomass.

Fine Woody Debris: YES/NO if fine woody debris volume can be calculated.

Forest Health Indicators

There are many indicators of forest health so we assessed a wide range of possible indicators in this assessment.

Invasive species presence/absence: YES/NO if invasive species presence/absence can be calculated.

Insect/disease instances: YES/NO if instances or presence/absence of tree damage related to insect and or disease.

Other: YES/NO if other forest health indicators are measured such as tree vigor, crown condition, and/or instances of damage related to physical or biological agents.

Opportunity Matrix Column Definitions

The **Programmatic Timeline Table** is a simple Excel table that is colored conditionally based on the questions each program can answer or explore with their available data. This tool allows interested users to quickly look across programs and variables to see what questions they can answer related to forest condition. We note whether the program has a *fully suitable* data set needed to look into specific variables or questions, *partial suitability* which would require some estimation or assumptions, or *not suitable* for a given purpose. For example, estimating overstory volume is a good method for assessing forest productivity. Programs which collect total tree height would be considered suitable because biomass could be calculated without using predicted height values. For the program which do not have recorded height, they could still obtain volume estimates if individual tree heights were

predicted using tree species and DBH; but these program would be considered partially suitable given the need for this extra step. Below are definitions of each column in the table. Programs which do not collect any of the data needed to explore certain questions would be considered not suitable. For example, if a program did not collect CWD information they would not be suitable for a regional comparison of dead wood volumes in managed or unmanaged forests.

Overstory: Species composition: This column indicates if the program is suitable for an assessment of the current or past species composition. Typically, this is done using TPA and basal area (BA) by species. With full data available you can summarize species richness, diversity, and percent composition by density or area occupied per acre for individual tree species.

Overstory diameter distribution: The diameter distribution is a standard way of presenting the current condition and structure of the overstory in a forest. When Trees Per Acre (TPA or per hectare) is known along with diameter then TPA can be plotted based on DBH class by species.

Overstory structure: The structure of the overstory can be assessed in many ways. Structure can pertain to the vertical structure of the trees (i.e. the distribution of heights). One could also look at the density of large trees. Overstory structure in this context relates to the vertical distribution of heights. If tree heights are recorded, then this analysis is possible.

Overstory volume, biomass, carbon: Overstory volume can be calculated when the species is known along with its DBH and height. If the total height of the live tree is measured in the field, then the program would be considered fully suitable. It would be considered to have partial suitability if height is not recorded because height can be easily predicted to get an estimation of volume. Overstory biomass can be calculated with basic formulas using species-specific coefficients and DBH. More accurate measures can be obtained when the sound volume of the tree is known. Carbon is derived from overstory biomass. If biomass can be calculated, then carbon can be calculated.

Mortality and ingrowth: If individual trees within the plots are permanently tagged or identified in a way which allows for repeat measures of the same tree, then measuring rates of ingrowth and mortality is possible. Repeat measures are also required to measure this variable.

Merchantable volume and product valuation: There are several programs that record information related to merchantability of individual trees. Simple measures of AGS/UGS allow for basic value estimations. Other programs record merchantable height and cull reductions, allowing for detailed estimation of merchantable volume.

Regeneration: Sapling composition and density: Saplings are typically trees that are greater than or equal to 1 inch and less than 4 or 5 inches (depending on the program) in diameter at breast height (DBH). While the classification of saplings might vary across programs, if this smaller size class of trees are measured then questions related to regeneration, composition and density can be explored. Basic requirements would be to record the species and DBH of individual saplings found within the plot or sub plot. This will allow for summaries of species composition and the number of individuals per unit area (acre, hectare).

Regeneration: Sapling mortality & ingrowth: This is not typically measured given that it can be time intensive to tag individual saplings and track their progress overtime.

Regeneration: Seedling composition and density: Seedlings are typically classified as being less than 1 inch DBH and less than 4.5 feet in height. Some programs may also require that seedlings meet a minimum height in order to be recorded. If seedlings are counted by species, then questions relating to composition and density per unit area can be explored. Seedlings are typically measured in smaller sub-plots nested or located within the larger overstory plot.

Understory diversity: Diversity measures such as richness and evenness can be calculated when individual species and density is recorded (density is not needed for richness). This column relates to the ability of a program to assess understory diversity looking at both tree seedlings and other plants.

Understory: Percent cover: Percent cover is a way of measuring the diversity of life forms within the plot along with the area they occupy. Many programs will measure the percent of a unit area that is occupied by individual species or genus (i.e. ferns, grasses, sedges, etc.).

Standing dead (snag) density (TPA): If standing dead trees are measured in the overstory plots then the density of snags can be summarized.

Snag volume: The height of the snag if needed to estimate volume with accuracy.

Snag biomass/carbon: To calculate biomass it is best to know the decay class or fragmentation class of the snag. If this is not available, then partial data is noted. Volume could be calculated but some assumptions would need to be made based on the species, height, and decay class.

Coarse woody debris volume: Volume of CWD can be calculated based on the sampling method. Typically, CWD is measured using a line intercept method and DBH and length is typically measured.

Coarse woody debris biomass/carbon: CWD decay class would need to be recorded to have a suitable data consideration. Species is also an important component in improving quality of estimations. Decay class could be assumed to be a set value for the plot but this would be considered partial suitability.

Fine woody debris: Fine woody debris (typically less than 10 cm) is rarely measured but is typically done in a small micro plot or along a short section of a transect.

Invasive species: If invasive species were recorded or noted at all in the data collections then questions related to invasive species presence or absence can be examined.

Insect/disease: Full suitability for this column would require the measurement or notation of instances of presence of insect- or disease-related changes in tree condition.

Tree health: Tree vigor and health can be assessed in the field. If there is any notation of tree condition as it relates to vigor or instances of damage related to biological or physical agents, then full suitability determination is given.

Management history: If the management history of the plot or area is included in the data collection methodology then a full suitability determination is given.

Forest type: If the forest type (natural community or other classification) is noted during data collection the forest type can be used as a way of potentially differentiating plots or CFI programs.

Soils and Site indicators: These can include the actual collection of soil samples or note of USGS soil classification. Other site indicators could be recorded such aspect/slope or any site indicator plant species.

FEMC

Forest Ecosystem Monitoring Cooperative

Providing the information needed to understand, manage, and protect the region's forested ecosystems in a changing global environment

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