Carbon Stocks and Sequestration on Ecological Reserves in Maine

General Technical Report

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2021

Suggested Citation

Puhlick, J.J., and Weiskittel, A.R. 2021. Carbon stocks and sequestration on ecological reserves in Maine. General Technical Report. Available online: https://www.maine.gov/dacf/mnap/index.html

Acknowledgements

Funding for this project was provided by The Nature Conservancy. We thank Nancy Sferra (The Nature Conservancy) and Justin Schlawin (Maine Natural Areas Program) for reviewing initial drafts of the report. We also thank the Maine Ecological Reserves Scientific Advisory Committee for discussions about our findings and providing constructive feedback. We thank Andy Whitman (Manomet), Andrew Barton (University of Maine at Farmington), and David Publicover (Appalachian Mountain Club) for their thorough reviews of the report.

Cover Photo

Low elevation spruce-fir forest at Deboullie Ecological Reserve. Courtesy of J.J. Puhlick.

Summary

In Maine, a system of long-term monitoring plots was established on state-owned Ecological Reserves and preserves owned by The Nature Conservancy (TNC). The first vegetation monitoring plots were established on state and TNC lands in 2002 and 2004, respectively. Plots in forest ecosystems were remeasured approximately 10 years after initial measurement. This study uses plots (n = 682) from 37 reserves with repeated measurements of forest attributes. We also used 10,503 USDA Forest Service Forest Inventory and Analysis (FIA) subplots across managed forests in Maine to compare carbon (C) stocks and sequestration between Maine's managed forests and reserves.

The most recent inventory of forest reserve plots had aboveground C in live trees, standing dead trees, and downed coarse woody debris of 89.4 ± 37.7 (mean ± SD) Mg ha^{-1}. Mean aboveground C increased 11% over the 10-year interval between plot measurements. C stocks significantly varied between some Natural Community Types and Ecological Reserves. For example, the Hemlock Forest type had greater C stocks than the Pitch Pine - Scrub Oak Barren and Early Successional Forest types. Average annual net change in C (AAC) in live trees, standing dead trees, and downed coarse woody debris was 0.894 ± 1.949 Mg ha^{-1} yr^{-1}.

For reserve and FIA plots, dominant Forest Type Groups were Aspen - Birch, Elm - Ash - Cottonwood, Maple - Beech - Birch, Oak - Hickory, Oak - Pine, Spruce - Fir, and White - Red - Jack Pine. For plots from these groups, C in live trees, standing dead trees, downed coarse woody debris, and harvested wood products was 90.2 ± 37.1 and 67.7 ± 36.3 Mg ha^{-1} for Ecological Reserve Monitoring (ERM) and FIA programs, respectively. Our models indicated that the difference in C stocks between programs was dependent on Forest Type Group. For these same plots, AAC in live trees, standing dead trees, downed coarse woody debris, and harvested wood products was 0.901 ± 1.957 and 0.581 ± 3.661 Mg ha^{-1} yr^{-1} for ERM and FIA programs, respectively. Program, Forest Type Group, and their interactions only explained 1% or less of the variation in ACC.

We modelled projections of live tree C stocks and sequestration on the reserves to 2040. From the most recent inventory to 2040, AAC in the aboveground portions of live trees was 1.096 ± 0.539 Mg ha^{-1} yr^{-1}. We used the Natural Resources Conservation Service (NRCS) Gridded Soil Survey Geographic (gSSURGO) Database to estimate and compare soil C among Natural Community Types and Ecological Reserves. Overall, soil C represented 67 ± 13% of the total forest C stock, and forested plots on hydric soils had some of the greatest C stocks. Finally, we compared aboveground biomass estimates for individual Ecological Reserves using plot data and Light Detection and Ranging (LiDAR) data. Forest C objectives can be achieved with forests managed using silvicultural treatments to maintain or enhance C accumulation and with Ecological Reserves where timber is not harvested. The benefits of C storage in Maine's Ecological Reserves lends support for the expansion of reserves in Maine and the establishment and monitoring of reserves in other states.

1.0. Background

Maine's Ecological Reserve system includes Ecological Reserves on state lands managed by the Maine Department of Agriculture, Conservation, and Forestry (DACF), and lands owned the Maine Department of Inland Fisheries and Wildlife (DIFW). It also includes preserves owned by The Nature Conservancy (TNC), which are managed in a way that is consistent with the ecological objectives of the Ecological Reserves on Maine Public Lands. In Maine, other agencies and organizations (e.g., the White Mountain National Forest, US Fish and Wildlife Service, Appalachian Mountain Club, and Northeast Wilderness Trust) maintain reserves that generally meet state Ecological Reserve system standards, but were not included in this study. An Ecological Reserve is generally defined as an area where timber harvesting is restricted and natural disturbance events are allowed to proceed without significant human influence (Maine Ecological Reserves Scientific Advisory Committee, 2009).

To date, 51 reserves (state: 27, TNC: 24) with a total area of approximately 74,708 ha are included in Maine's Ecological Reserve Monitoring system. These reserves encompass some of the most remote and ecologically important places in Maine and support vulnerable habitats such as old forests, alpine meadows, vast open peatlands, and coastal headlands. Beginning in 2002, monitoring plots were established in state-owned Ecological Reserves using a measurement protocol similar to the USDA Forest Service Forest Inventory and Analysis (FIA) methodology. TNC began monitoring their reserves in 2004. All plots within reserves are inventoried approximately every 10 years.

Each monitoring plot is assigned a natural community type (Gawler and Cutko, 2018). In this study, we assessed differences in forest carbon (C) stocks and sequestration among natural communities and reserves. Specific information about each natural community type is provided on the Maine Natural Area Program website.

This report was prepared to address four questions related to C storage in Maine's forests:

(1) What are the C stocks and sequestration rates of natural communities and reserves in the Ecological Reserve system?
(2) Which natural communities are most susceptible to having C emissions due to widespread tree mortality?
(3) Do Ecological Reserves and managed forests have different C stocks and sequestration rates?
(4) What are the projected live tree C stocks and projected C sequestration rates of reserves over the next approximately 20 years?

The answers to these questions are important because they can inform actions recommended in the Maine Climate Action Plan from December, 2020. For example, our research can inform decisions on where acquisitions of land for conservation and easements for working forests would be most strategic for C stocks and sequestration. Specifically, C sequestration could be a consideration in addition to other ecosystem services (e.g., drinking water supplies) for prioritizing parcels for land conservation.

2.0. Methods

2.1. Data Collection and Calculations of Carbon Stocks and Sequestration

2.1.1. Forest Inventory and Analysis Program

The FIA network of permanent plots is based on a sampling intensity of approximately one plot per 2,428 ha (O'Connell *et al.*, 2015). For our inventory of C in managed forests, we used data (USDA, 2020) from the FIA database (USDA, 2014; O'Connell *et al.*, 2015) that included the forest inventory of 3,594 permanent plots in Maine. Each plot consisted of four, circular subplots (radius = 7.32 m) spaced 36.6 m apart in a triangular arrangement with one subplot in the center (O'Connell *et al.*, 2015). FIA crews measured all trees (live and standing dead) with a diameter at breast height (dbh) ≥ 12.7 cm on forested subplots. Within each subplot, a circular microplot (radius = 2.07 m) was offset 3.66 m from subplot center for measuring live trees with a dbh ≥ 2.5 and < 12.7 cm. On a subset of FIA plots, FIA crews also measured downed woody debris along three, 7.3 m horizontal distance transects originating from subplot centers at azimuths of 30, 150, and 270 degrees. They identified each live tree, snag, and log to species or finest level of taxonomic group when species could not be determined.

We used data from the three most recent FIA inventories (spanning the years of 2000–2015) because these data correspond to the time period of the Maine Ecological Reserve inventories (2002–2017). Forest attributes on FIA subplots were measured approximately every five years.

We used four criteria for selecting FIA subplots that were representative of conditions across managed forests in Maine. First, we selected FIA subplots on private and public land without reserve status. Reserve status is a classification assigned to public lands where management for the production of forest products is permanently restricted through statute or mandate (USDA, 2015). Second, our analyses only included the forested portions of FIA subplots to avoid inclusion of non-forest land uses such as cropland or development in our per unit area values of C stocks and sequestration. We also selected subplots without gains or reductions in forest area over the approximately ten-year timespan of measurements. Finally, the area occupied by all microplots of a plot had to be in forest land use. These criteria resulted in the selection of 10,503 subplots with live and standing dead tree measurements; 1,170 of these subplots also included measurements of downed woody debris.

2.1.2. Maine Ecological Reserve Monitoring Program

Forest attributes on plots in Ecological Reserves were measured on five to six permanent sample plots per randomly placed transect (Maine Department of Conservation, 2003). Plots were spaced 241 m apart along transects. Baseline sampling of forest attributes (Visit 1 hereafter) occurred between 2002 and 2008. Re-sampling (Visit 2 hereafter) occurred from 2011 to 2020 (*n* = 682). Each plot was also assigned to a primary Natural Community Type (Gawler and Cutko, 2018) (**Table 1**).

Table 1. Number of Ecological Reserve Monitoring plots with repeated inventories of trees and downed coarse woody debris by Natural Community Type. Natural Community Types are also grouped by FIA Forest Type Group (in bold).

Forest Type Group & Natural Community Type	Number of plots
Spruce - Fir	
Atlantic White Cedar Swamp	3
Tall Grass Meadow	1
Evergreen Seepage Forest	13
Subalpine Fir Forest	13
Maritime Spruce - Fir Forest	11
Northern White Cedar Swamp	8
Open Cedar Fen	2
Spruce - Pine Woodland	4
Spruce - Fir Krummholz	2
Lower Elevation Spruce - Fir Forest	123
Spruce - Fir Wet Flat	18
Montane Spruce - Fir Forest	37
Black Spruce Barren	1
Black Spruce Bog	7
Spruce - Northern Hardwoods Forest	129
Miscellaneous Softwoods	
Dwarf Shrub Bog	1
Oak - Pine	
Oak - Pine Forest	24
Oak - Pine Woodland	5
Oak - Hickory	
Chestnut Oak Woodland	1
Oak - Northern Hardwoods Forest	16
White Oak - Red Oak Forest	6
Elm - Ash - Cottonwood	
Upper Floodplain Hardwood Forest	4
Hardwood Seepage Forest	6
High Gradient Floodplain Forest	2
Red Maple Swamp	7
Silver Maple Floodplain Forest	5
Maple - Beech - Birch	
Northern Hardwoods Forest	104
Enriched Northern Hardwood Forest	1

Table 1. Extended.

Forest Type Group & Natural Community Type	Number of plots
Aspen – Birch	
Early Successional Forest[a]	50
Minor Hardwoods	
Alder Thicket	6
White Pine - Red Pine - Jack Pine	
Hemlock Forest	19
Pocket Swamp	1
Red Pine - White Pine Forest	5
White Pine Forest	25
Loblolly - Shortleaf Pine	
Pitch Pine - Heath Barren	3
Pitch Pine Rocky Woodland	5
Pitch Pine - Scrub Oak Barren	14

[a]A complex of post fire associations including aspens, birches, and other species.

Measurements of live and standing dead trees, and downed woody debris followed the USDA Forest Service FIA protocol (Maine Department of Conservation, 2003; O'Connell *et al.*, 2015). Sampling of tree species occurred in a series of nested plots. Trees ≥ 51.0 cm dbh were measured in a 0.101-ha (radius = 17.95 m) plot, trees ≥ 12.7 cm were measured in a 0.017-ha (radius = 7.32 m) plot, and trees ≥ 2.5 cm were measured in a 0.001-ha (radius = 2.07 m) plot. Field crews recorded tree species, dbh, and condition (live or dead). Records of tree height varied by reserve, with some plots having heights for all trees ≥ 12.7 cm and other plots having records of height for only some trees ≥ 12.7 cm. For C calculations, if heights of standing dead trees were missing in Visit 1, then Visit 1 heights were estimated by using the smaller of the Visit 2 height multiplied by 1.67, or the predicted height of a live tree of the same species and diameter. If Visit 2 heights were not available, then height-diameter equations for live trees in Dixon and Keyser (2019) were used to estimate Visit 1 and Visit 2 standing dead tree heights, which were multiplied by 0.33 as an estimate of height reduction. For Visit 1, standing dead trees were assigned a decay class code of 3. For Visit 2, standing dead trees that were also dead in Visit 1 were assigned a decay class code of 4. Standing trees that had died between inventories were assigned a decay class code of 2. Two transects for measuring downed woody debris were sampled on each plot. Transects extended for 17.95 m at azimuths of 30 and 150 degrees from plot center; see figure 2 in Kuehne *et al.* (2018).

2.1.3 Calculations of Carbon Stocks

For each inventory, aboveground C in live trees was estimated with regional biomass equations (Young *et al.*, 1980) and species-specific C concentrations by Lamlom and Savidge (2003). For each standing dead tree, volume above the stump was calculated by: (1) dividing the tree into 100 sections of equal length, (2) determining the large- and small-end diameters of each section using taper equations developed by Li *et al.* (2012), (3) using Smalian's formula to calculate the volume of each section, and (4) summing the section volumes (Husch *et al.*, 2003). Then, biomass was calculated using non-decayed species-specific wood and bark specific gravity, and average bark volume as a percentage of wood volume (Miles and Smith, 2009), and a decay class reduction factor (Harmon *et al.*, 2011). Finally, biomass to C conversion factors developed by Harmon *et al.* (2008) were used to estimate C in standing dead trees. Individual tree C stocks were summed and expansion factors were used to derive per ha values for each subplot.

For subplots with measurements of downed woody debris, equation 4 of Table 3.1 in Woodall and Monleon (2008) was used to calculate the C in coarse downed woody debris (i.e., woody debris with diameters ≥ 7.6 cm at the intersection with transect lines) on per ha basis. For each coarse woody debris piece that intersected a transect, its biomass was calculated using species, decay class, and diameter measurements along with specific gravity values and decay class reduction factors reported in Miles and Smith (2009) and Harmon *et al.* (2011). Biomass to C conversion factors developed by Harmon *et al.* (2008) were used to estimate the C in each coarse woody debris piece.

For each subplot, FIA crews record trees that were cut during the inventory period. For each cut tree ≥ 12.7 cm, we used FIA estimates of net total and sawlog volume (O'Connell *et al.*, 2015) to estimate the amount of C that was stored in wood products and landfills. To estimate pulpwood volume, we subtracted each tree's net sawlog volume from its total merchantable volume. Then, the amount of wood biomass in products was calculated using equations from Miles and Smith (2009) and C concentration estimates by Lamlom and Savidge (2003) were used to calculate C stocks. Finally, the amount of C in wood products and landfills for each inventory was estimated using residence times for hardwoods and softwoods, and for pulpwood and sawlogs from Smith *et al.* (2006). Our estimates of C in products and landfills are only from trees that were cut after the first inventory of subplots used in the analyses, which approximately coincides with the first inventories of subplots under the FIA annual inventory system.

2.1.4. Carbon Sequestration

A stock change approach described by Puhlick *et al.* (2019) was used to calculate the average annual net change (AAC) in C stocks for time periods between inventories:

$$\frac{(C\ stocks\ in\ time\ 2\ -\ C\ stocks\ in\ time\ 1)}{time\ between\ inventories\ in\ years}$$

For each FIA subplot, AAC was derived by summing the net change in C stocks for each inventory period and dividing the sum by the total timespan of measurements. For Ecological Reserve plots, the AAC calculation involved one inventory period. The denominators of these equations were computed using values that included the month and year of inventory: year + (month/12); with January = 1, February = 2, etc.

For FIA subplots, the dominant forest type (based on plot area) for the most recent inventory was used to group subplots by forest type group. From the starting inventories to the most recent inventories, 14% of subplots had a change in forest type group. FIA field crews recorded forest types on the area around subplots and trees sampled on subplots (O'Connell *et al.*, 2015). The Natural Community Type recorded for each reserve plot was used to define a FIA forest type group for each reserve plot (**Table 1 and Table 2**).

Table 2. Number of Ecological Reserve Monitoring plots and FIA subplots with repeated inventories of live trees, snags, and downed coarse woody debris (CWD) by Forest Type Group.

Forest Type Group	Ecological Reserves	FIA; live trees and snags only	FIA; including downed CWD
Spruce - Fir	372	4812	569
Miscellaneous Softwoods	1	17	4
Oak - Pine	29	370	36
Oak - Hickory	23	119	12
Elm - Ash - Cottonwood	24	223	34
Maple - Beech - Birch	105	3287	353
Aspen - Birch	50	746	78
Minor Hardwoods	6	NA	NA
White Pine - Red Pine - Jack Pine	50	929	84
Loblolly - Shortleaf Pine	22	NA	NA

NA = not applicable, there were no FIA subplots in this Forest Type Group.

The most recent inventories of live trees were used to simulate future growth and mortality on Ecological Reserve plots using the Northeast variant of the USDA Forest Service, Forest Vegetation Simulator (FVS-NE). We also used FVS-Online, which is the online interface to the FVS modeling system. Simulations were done over an approximately 20-year period to the year 2040. This timeframe was chosen because of the high level of confidence associated with 20-year model projections of tree growth and yield. Visit 1 inventory data associated with live and standing dead trees were also included in the stand and tree lists supplied to FVS so that diameter and height growth could be calibrated based on observed tree growth and stocking. Tree growth and mortality were predicted on a yearly basis and C stocks were computed as described in section 2.1.3.

For Ecological Reserve plots with repeated measurements of forest attributes and location information (*n* = 677 plots), soil C estimates were derived using the Natural Resources Conservation Service (NRCS) Gridded Soil Survey Geographic (gSSURGO) Database. Specifically, the soil map unit (i.e., the Map Unit Key) associated with the center of each plot was used to extract soil C attributes using Value Added Look Up Table in the database (Soil Survey Staff, 2020).

For Ecological Reserves with at least 20 plots with repeated measurements, aboveground biomass in live trees > 10 cm dbh was estimated using plot inventory data and equations by Young *et al.* (1980). These estimates were compared to those calculated using Light Detection and Ranging (LiDAR) data (Ayrey *et al.*). From the Maine Conserved Lands shapefile (https://www.maine.gov/geolib/catalog.html), a unique polygon for each Ecological Reserve was delineated based on one or more polygons associated with each Ecological Reserve. For Ecological Reserves with numerous polygons (due to different land acquisition times, etc.), the unique (single) polygon for each Ecological Reserve was developed from polygons that contained Ecological Reserve plots. Using the LiDAR raster image, biomass estimates associated with 10 x 10 m grid cells whose centers were completely within the unique polygon for each Ecological Reserve were extracted and used to derive summary statistics.

2.2. Data Analyses

For the Ecological Reserve Monitoring plots, generalized linear mixed effects modeling was used to evaluate the influence of Natural Community Type on C stocks and sequestration in the aboveground components of live trees, standing dead trees, and downed coarse woody debris. In these models, Ecological Reserve was included as a random effect. Additionally, generalized linear modeling was used to test for differences in C stocks and sequestration among individual Ecological Reserves. We also used data from both programs [ERM (Ecological Reserve Monitoring) and FIA] to evaluate the influence of Program, Forest Type Group, and their interaction on C stocks and sequestration in the aboveground portions of live trees, standing dead trees, downed coarse woody debris, as well as, harvested wood products. In these generalized linear mixed effects models, Ecological Reserve (county for FIA subplots) and transect within Ecological Reserve (plot within county for FIA) were used as random effects. For all models, variance weighting functions in the nlme package (Pinheiro *et al.*, 2014) within R (R Development Core Team, 2020) were used to account for heterogeneity in the standardized residuals. Likelihood ratio tests were used to determine the optimal models in terms of fixed effects. The gls and lme functions in the nlme package (Pinheiro *et al.*, 2014) in R (R Development Core Team, 2020) were used to fit the generalized linear and generalized linear mixed effects models. Least-squares (LS) means and pairwise comparisons were calculated using the lsmeans and cld functions in the lsmeans (Lenth, 2014) and multcompView (Graves *et al.*, 2012) packages, respectively, in R. For the pairwise comparisons, differences between C stock LS means were considered significant if $P < 0.05$ after applying a Tukey's honestly significant difference multiple comparisons adjustment.

3.0. Results

3.1. Observed C Stocks on the Ecological Reserve Monitoring Plots

- Across monitoring plots with repeated measurements, aboveground C in live trees, standing dead trees, and downed coarse woody debris was 80.6 ± 37.7 Mg ha^{-1} (mean ± SD) in inventory Visit 1 and 89.4 ± 37.7 Mg ha^{-1} in inventory Visit 2.
- For Natural Community Types with at least 10 permanent plots, mean aboveground live tree C ranged from 61.8 to 109.1 Mg ha^{-1}, for the Pitch Pine - Scrub Oak Barren and Hemlock Forest types, respectively (**Figure 1**).
- When statistical analyses were restricted to Natural Community Types with at least 10 permanent plots, pairwise comparisons indicated that least-squares (LS) mean aboveground C in live trees, standing dead trees, and downed coarse woody debris differed among some Natural Community Types (**Figure 2**, **Table 2**, and **Table 3**).
- For these analyses, one model was developed using Visit 1 data and a second model using Visit 2 data. Natural Community Type explained 11 and 10% of the variation in aboveground C in Visit 1 and Visit 2, respectively.
- For separate models of C in live trees, standing dead trees, and downed coarse woody debris as a function of Ecological Reserve, which included data from all permanent plots, pairwise comparisons indicated that C stocks differed among some Ecological Reserves in Visit 1 and Visit 2 (**Table A1 and Table A2**).
- For these analyses, one model was developed using Visit 1 data and a second model using Visit 2 data. Ecological Reserve (i.e., the effect of individual reserves) explained 18 and 14% of the variation in aboveground C in Visit 1 and Visit 2, respectively.

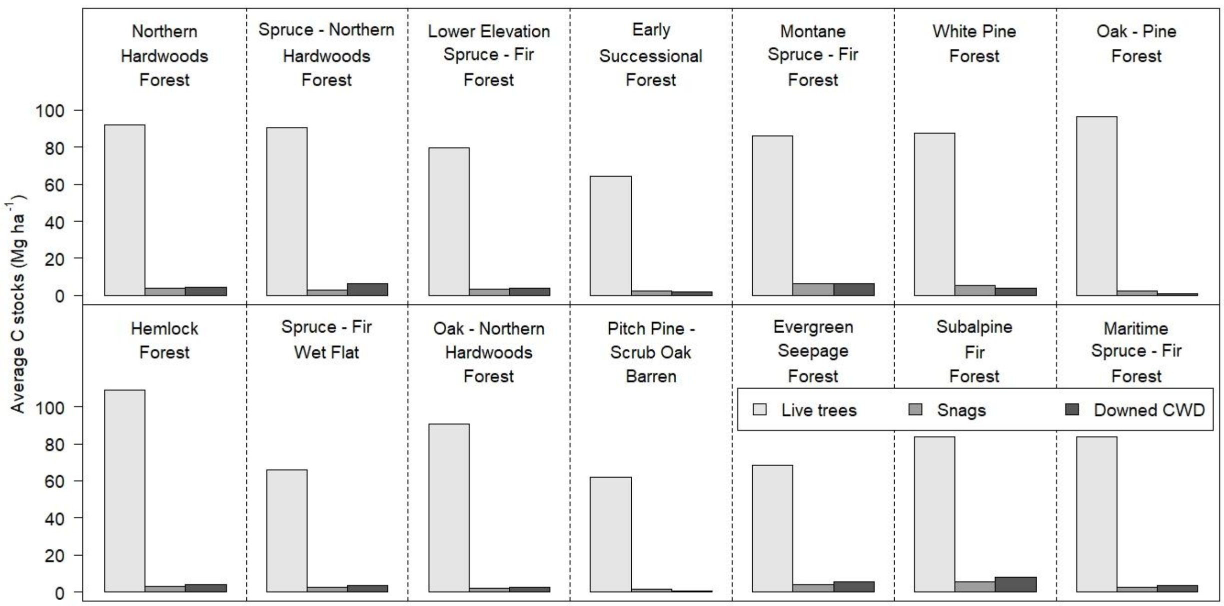

Figure 1. Mean aboveground C (Mg ha^{-1}) in the live trees, standing dead trees, and downed coarse woody debris (CWD) on Ecological Reserve Monitoring plots in Visit 2 by Natural Community Type. Note: The Early Successional Forest type is based on composition and not age, and is a complex of post fire associations including aspens, birches, and other species.

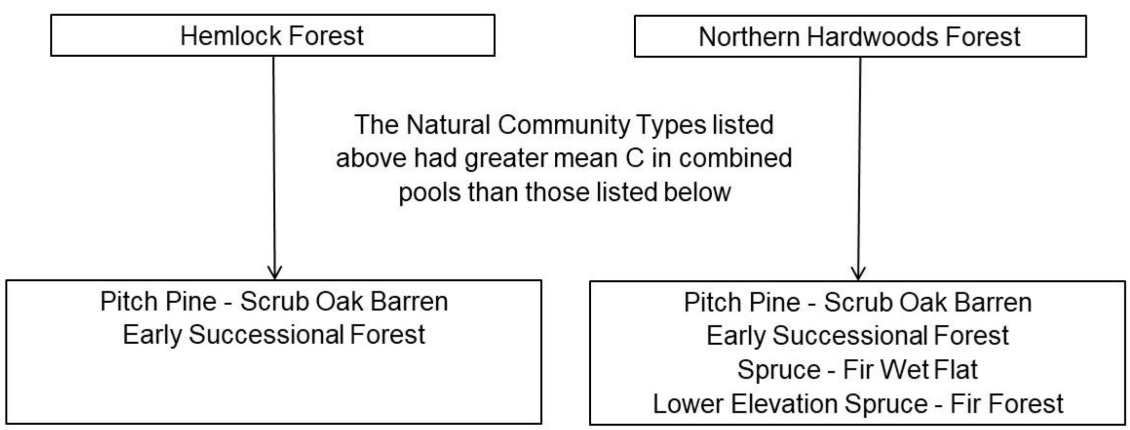

Figure 2. Selected pairwise comparisons of least-squares (LS) mean aboveground C in live trees, standing dead trees, and downed coarse woody debris on Ecological Reserve Monitoring plots in Visit 1; see **Table 2** for all comparisons.

Table 2. Least-squares (LS) mean and standard error (SE) aboveground C (Mg ha^{-1}) in live trees, standing dead trees, and downed coarse woody debris on Ecological Reserve Monitoring plots in Visit 1 by Natural Community Type.

Natural Community Type	Mean	SE	Group
Pitch Pine - Scrub Oak Barren	55.8	8.6	12
Early Successional Forest	56.6	4.7	1
Spruce - Fir Wet Flat	67.3	7.1	123
Maritime Spruce - Fir Forest	75.5	11.0	1234
Evergreen Seepage Forest	80.3	10.0	1234
Lower Elevation Spruce - Fir Forest	81.0	3.6	23
Oak - Northern Hardwoods Forest	82.9	8.2	1234
Subalpine Fir Forest	83.2	9.8	1234
White Pine Forest	84.2	6.6	234
Oak - Pine Forest	84.6	9.1	1234
Montane Spruce - Fir Forest	88.5	5.6	234
Spruce - Northern Hardwoods Forest	89.0	4.0	34
Northern Hardwoods Forest	99.0	5.0	4
Hemlock Forest	103.1	9.9	34

Note: Different group numbers indicate significant differences between LS mean C stocks among Natural Community Types at $P < 0.05$.

Table 3. Least-squares (LS) mean and standard error (SE) aboveground C (Mg ha^{-1}) in the live trees, standing dead trees, and downed coarse woody debris on Ecological Reserve Monitoring plots in Visit 2 by Natural Community Type.

Natural Community Type	Mean	SE	Group
Pitch Pine - Scrub Oak Barren	61.8	8.3	12
Early Successional Forest	69.8	5.0	1
Spruce - Fir Wet Flat	73.3	7.2	123
Evergreen Seepage Forest	81.6	7.8	1234
Lower Elevation Spruce - Fir Forest	89.4	3.1	234
Maritime Spruce - Fir Forest	91.0	10.3	1234
Subalpine Fir Forest	91.0	13.6	1234
White Pine Forest	94.5	7.3	1234
Oak - Northern Hardwoods Forest	96.2	8.8	1234
Montane Spruce - Fir Forest	96.6	5.0	34
Oak - Pine Forest	99.0	8.7	1234
Spruce - Northern Hardwoods Forest	100.2	3.8	4
Northern Hardwoods Forest	102.5	4.7	4
Hemlock Forest	117.4	9.1	4

Note: Different group numbers indicate significant differences between LS mean C stocks among Natural Community Types at $P < 0.05$.

3.2. Observed C Sequestration on the Ecological Reserve Monitoring Plots

- Across monitoring plots with repeated measurements, average annual net change in C (AAC) in live trees, standing dead trees, and downed coarse woody debris was 0.894 ± 1.949 Mg ha^{-1} yr^{-1}.
- For Natural Community Types with at least 10 permanent plots, mean AAC in live trees, standing dead trees, and downed coarse woody debris was relatively similar among Natural Community Types (**Figure 3**).
- When statistical analyses were restricted to Natural Community Types with at least 10 permanent plots, LS mean AAC was similar among Natural Community Types. For this subset of plots, AAC in live trees, standing dead trees, and downed coarse woody debris was 0.897 ± 1.984 Mg ha^{-1} yr^{-1}.
- For a separate model of AAC in live trees, standing dead trees, and downed coarse woody debris as a function of Ecological Reserve, which included data from all permanent plots, pairwise comparisons indicated that AAC differed among some Ecological Reserves (**Table B1**).
- Ecological Reserve explained 6% of the variation in AAC in live trees, standing dead trees, and downed coarse woody debris.

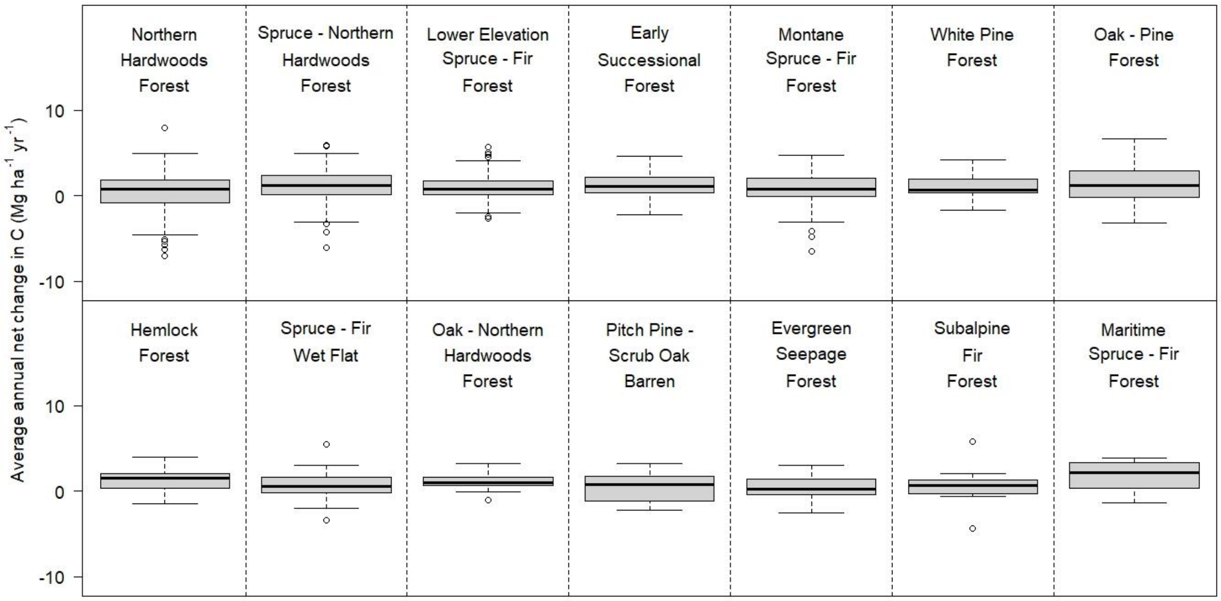

Figure 3. Average annual net change in C (AAC; Mg ha^{-1} yr^{-1}) for the aboveground portions of live trees, standing dead trees, and downed coarse woody debris on Ecological Reserve Monitoring plots from inventory Visit 1 to Visit 2 by Natural Community Type. Horizontal lines within boxes represent the median. The boxes define the interquartile range (25-75% quartile) and the vertical lines represent the whiskers of maximal 1.5 times the interquartile range. Observations outside the whisker range may be considered outliers.

3.3. Tree Mortality on the Ecological Reserve Monitoring Plots

- Over short-term time scales (decades), C emissions can occur in forests if extensive tree mortality is not preceded by increased growth on residual live trees, the establishment of new cohorts of trees, and other stand dynamics.
- *Median values* of aboveground C in trees that died during the inventory period were examined due to the large number of plots with no mortality and some plots with a high amount of C in trees that died during the inventory period.
- For Natural Community Types with at least 10 permanent plots, median aboveground C in trees that died during the inventory period was greatest for the Subalpine Fir Forest (5.5 Mg ha^{-1}) (**Table 4**). Despite this level of mortality, this Natural Community Type remained a C sink during the study period (**Figure 3**).
- Median aboveground C in trees that died during the inventory period was also notable for the Northern White Cedar Swamp (4.7 Mg ha^{-1}), Upper Floodplain Hardwood Forest (3.7 Mg ha^{-1}), and Black Spruce Bog (3.7 Mg ha^{-1}).

Table 4. Median and maximum aboveground C (Mg ha^{-1}) in trees that died during the inventory period on Ecological Reserve Monitoring plots. Statistics are for Natural Community Types with at least 10 plots; for these types, the minimum observed C in mortality was 0 Mg ha^{-1}.

Natural Community Type	Median	Maximum
Early Successional Forest	2.1	26.3
Northern Hardwoods Forest	0.0	41.7
Evergreen Seepage Forest	0.0	30.8
Subalpine Fir Forest	5.5	14.6
Hemlock Forest	0.0	13.8
Maritime Spruce - Fir Forest	0.0	25.5
Oak - Pine Forest	0.0	31.8
Pitch Pine - Scrub Oak Barren	0.7	6.8
Oak - Northern Hardwoods Forest	1.9	17.5
Lower Elevation Spruce - Fir Forest	1.6	79.4
Spruce - Fir Wet Flat	0.0	21.5
Montane Spruce - Fir Forest	3.4	50.4
Spruce - Northern Hardwoods Forest	1.7	51.0
White Pine Forest	4.2	43.3

3.4. Comparisons of Observed C Stocks and Sequestration between the Ecological Reserves and the Managed Landscape

- For plots with repeated inventories and a Forest Type Group shown in **Figure 4**, C in live trees, standing dead trees, and harvested wood products for the most recent inventory of permanent plots was 86.0 ± 36.3 and 62.6 ± 36.5 Mg ha^{-1} for ERM and FIA programs, respectively. For plots in the managed forest, harvested wood product C accounted for 11.5 ± 26.1% of the total C.

- For plots with repeated inventories and a Forest Type Group shown in **Figure 5**, C in live trees, standing dead trees, downed coarse woody debris, and harvested wood products for the most recent inventory of plots was 90.2 ± 37.1 and 67.7 ± 36.3 Mg ha^{-1} for ERM and FIA programs, respectively. For plots in the managed forest, harvested wood product C accounted for 9.5 ± 22.6% of the total C.

- Separate models of C stocks were developed using plots without and with downed coarse woody debris data. For both models, Program, Forest Type Group, and their interaction influenced C stocks (**Table 5 and Table 6**).

- For the model that was developed without downed coarse woody debris data, Program, Forest Type Group, and their interaction explained 8% of the variation in C stocks. For the model that was developed with downed coarse woody debris data, Program, Forest Type Group, and their interaction explained 14% of the variation in C stocks.

- For plots with repeated inventories and a Forest Type Group shown in **Figure 6**, AAC in live trees, standing dead trees, and harvested wood products from the 2000s to 2010s was 0.937 ± 1.902 and 1.483 ± 1.680 Mg ha^{-1} yr^{-1} for ERM and FIA programs, respectively.

- For plots with repeated inventories and a Forest Type Group shown in **Figure 7**, AAC in live trees, standing dead trees, downed coarse woody debris, and harvested wood products from the 2000s to 2010s was 0.901 ± 1.957 and 0.581 ± 3.661 Mg ha^{-1} yr^{-1} for ERM and FIA programs, respectively.

- Separate models of C stocks were developed using plots without and with downed coarse woody debris data. For the model that was developed without downed coarse woody debris data, Program, Forest Type Group, and their interaction influenced AAC (**Table 7**). For the model that was developed with downed coarse woody debris data, likelihood ratio tests suggested that Forest Type Group be retained in the model, but there was no statistically significant difference in AAC between ERM and FIA programs (**Table 8**).

- For the model that was developed without downed coarse woody debris data, Program, Forest Type Group, and their interaction explained 1% of the variation in AAC. For the model that was developed with downed coarse woody debris data, Forest Type Group explained 1% of the variation in AAC.

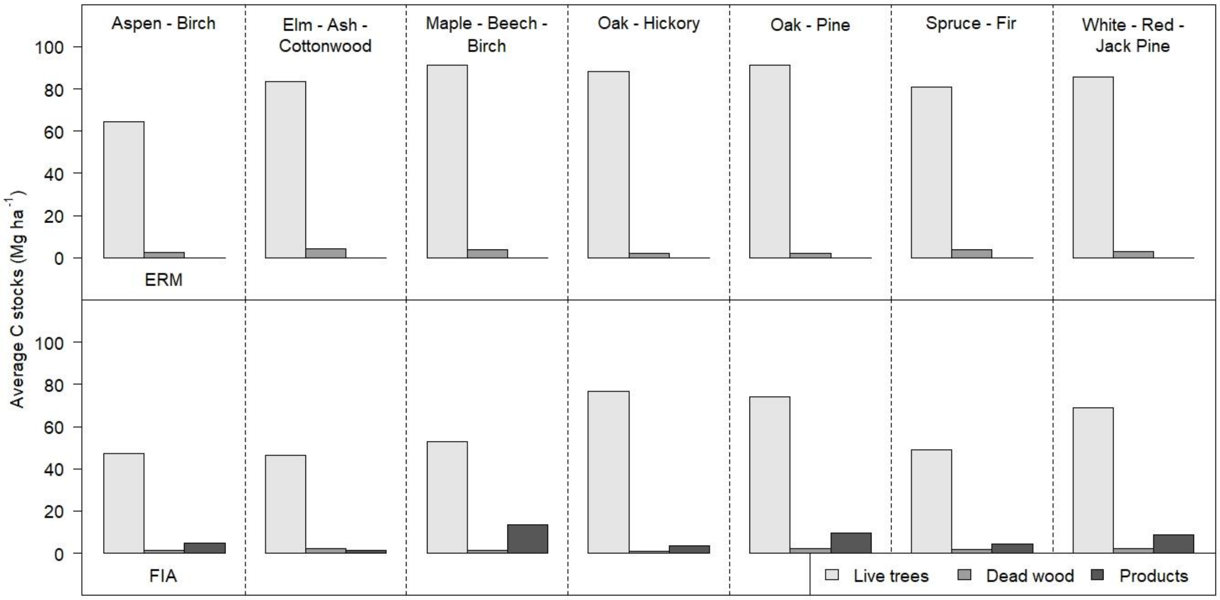

Figure 4. Mean C (Mg ha^{-1}) in the aboveground portions of live trees and dead wood (standing dead trees), as well as, harvested wood products for the most recent inventory of permanent plots by Program (ERM and FIA) and Forest Type Group.

Table 5. Least-squares (LS) mean and standard error (SE) C (Mg ha^{-1}) in the aboveground portions of live trees and standing dead trees, as well as, harvested wood products for the most recent inventory of permanent plots by Program and Forest Type Group combination.

Program	Forest Type Group	Mean	SE	Group
FIA	Elm - Ash - Cottonwood	47.6	3.2	1
FIA	Aspen - Birch	56.0	2.1	12
FIA	Spruce - Fir	59.0	1.5	23
FIA	Maple - Beech - Birch	69.8	1.6	4
ERM	Aspen - Birch	71.8	5.0	2345
FIA	Oak - Hickory	78.1	4.9	45
FIA	White Pine - Red Pine - Jack Pine	81.4	2.0	5
ERM	Elm - Ash - Cottonwood	82.4	7.7	2345
FIA	Oak - Pine	82.6	3.1	5
ERM	Spruce - Fir	84.7	2.5	5
ERM	Oak - Hickory	89.5	8.9	345
ERM	White Pine - Red Pine - Jack Pine	90.3	5.2	5
ERM	Maple - Beech - Birch	90.8	4.1	5
ERM	Oak - Pine	94.2	9.3	45

Note: Different group numbers indicate significant differences between LS mean C stocks among Program and Forest Type Group combinations at $P < 0.05$.

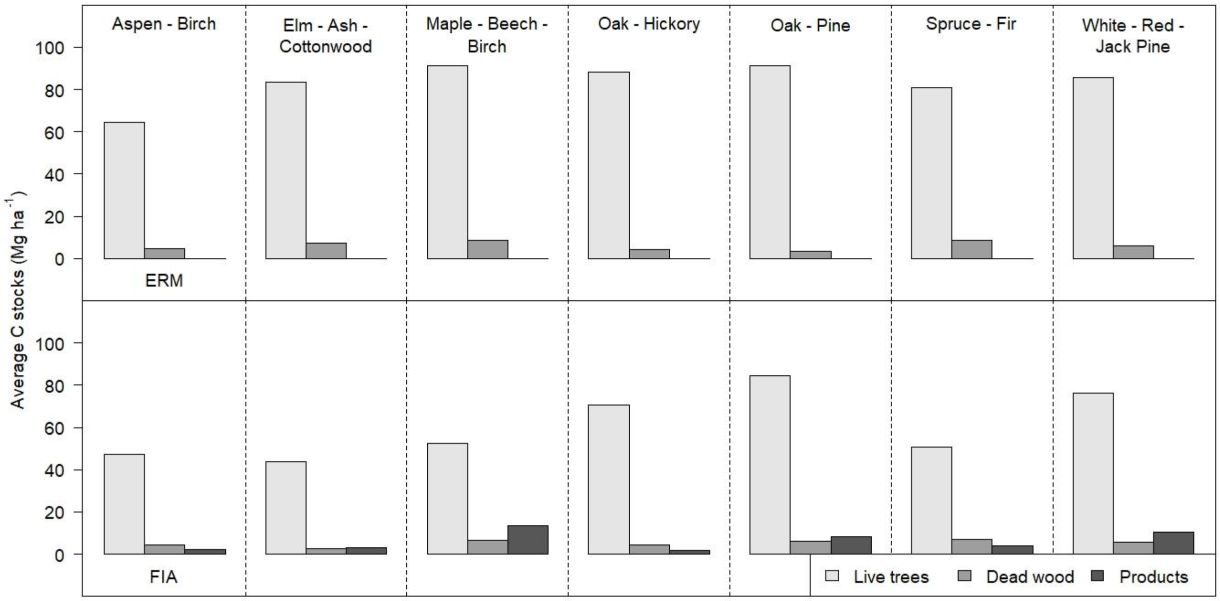

Figure 5. Mean C (Mg ha^{-1}) in the aboveground portions of live trees and dead wood (standing dead trees and downed woody debris), as well as, harvested wood products for the most recent inventory of permanent plots by Program (ERM and FIA) and Forest Type Group.

Table 6. Least-squares (LS) mean and standard error (SE) C (Mg ha^{-1}) in the aboveground portions of live trees, standing dead trees, and downed coarse woody debris, as well as, harvested wood products for the most recent inventory of permanent plots by Program and Forest Type Group combination.

Program	Forest Type Group	Mean	SE	Group
FIA	Elm - Ash - Cottonwood	45.9	8.2	1
FIA	Aspen - Birch	54.7	4.9	1
FIA	Spruce - Fir	62.1	2.5	1
FIA	Maple - Beech - Birch	71.9	3.0	12
ERM	Aspen - Birch	73.8	4.9	123
FIA	Oak - Hickory	74.1	11.9	1234
ERM	Elm - Ash - Cottonwood	86.5	8.3	1234
ERM	Spruce - Fir	89.5	2.5	34
FIA	White Pine - Red Pine - Jack Pine	92.4	5.7	234
ERM	Oak - Hickory	92.6	7.3	234
ERM	White Pine - Red Pine - Jack Pine	93.1	5.4	234
ERM	Oak - Pine	95.6	8.6	234
ERM	Maple - Beech - Birch	95.9	4.2	4
FIA	Oak - Pine	98.2	8.7	234

Note: Different group numbers indicate significant differences between LS mean C stocks among Program and Forest Type Group combinations at $P < 0.05$.

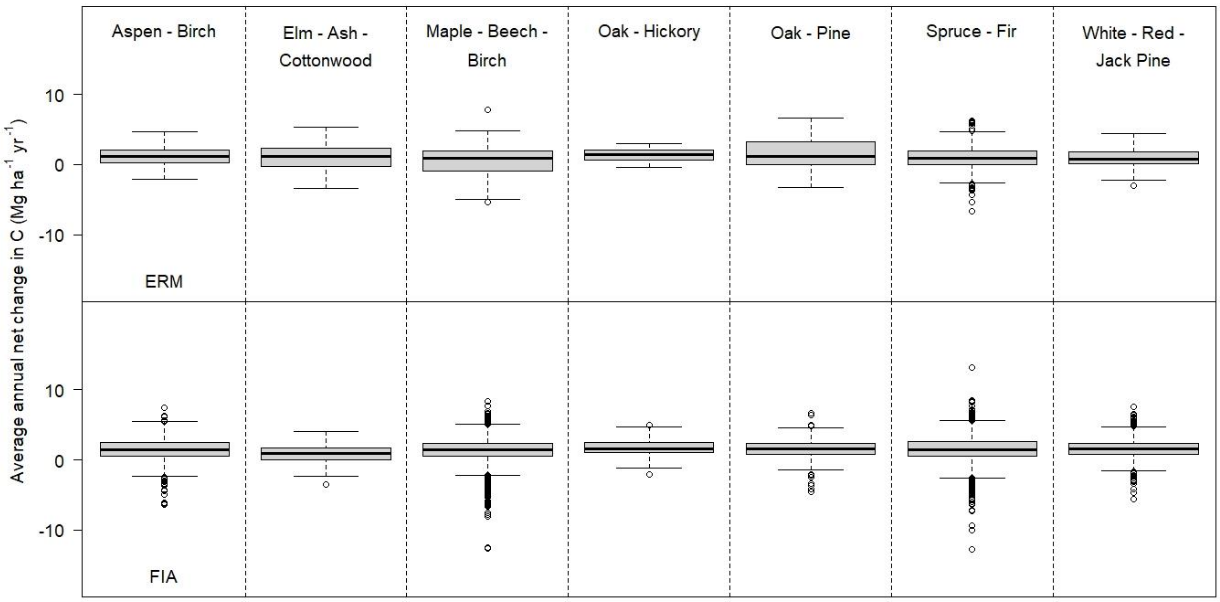

Figure 6. Average annual net change in C (AAC; Mg ha^{-1} yr^{-1}) for the aboveground portions of live trees and standing dead trees, as well as, harvested wood products from the 2000s to 2010s by Program and Forest Type Group. Horizontal lines within boxes represent the median. The boxes define the interquartile range (25-75% quartile) and the vertical lines represent the whiskers of maximal 1.5 times the interquartile range. Observations outside the whisker range may be considered outliers.

Table 7. Least-squares (LS) mean and standard error (SE) average annual net change in C (AAC; Mg ha^{-1} yr^{-1}) for the aboveground portions of live trees and standing dead trees, as well as, harvested wood products from the 2000s to 2010s by Program and Forest Type Group combination.

Program	Forest Type Group	Mean	SE	Group
ERM	Maple - Beech - Birch	0.396	0.193	1
ERM	Elm - Ash - Cottonwood	0.766	0.304	12345
ERM	White Pine - Red Pine - Jack Pine	0.794	0.202	1234
FIA	Elm - Ash - Cottonwood	0.962	0.124	1 3
ERM	Spruce - Fir	1.029	0.111	123
ERM	Aspen - Birch	1.257	0.245	12345
FIA	Maple - Beech - Birch	1.42	0.041	2 45
FIA	Aspen - Birch	1.455	0.08	2 45
FIA	Spruce - Fir	1.51	0.033	45
FIA	Oak - Pine	1.565	0.109	2 45
ERM	Oak - Hickory	1.571	0.297	2345
FIA	White Pine - Red Pine - Jack Pine	1.596	0.068	5
ERM	Oak - Pine	1.629	0.321	12345
FIA	Oak - Hickory	1.687	0.179	2 45

Note: Different group numbers indicate significant differences between LS mean AAC among Program and Forest Type Group combinations at $P < 0.05$.

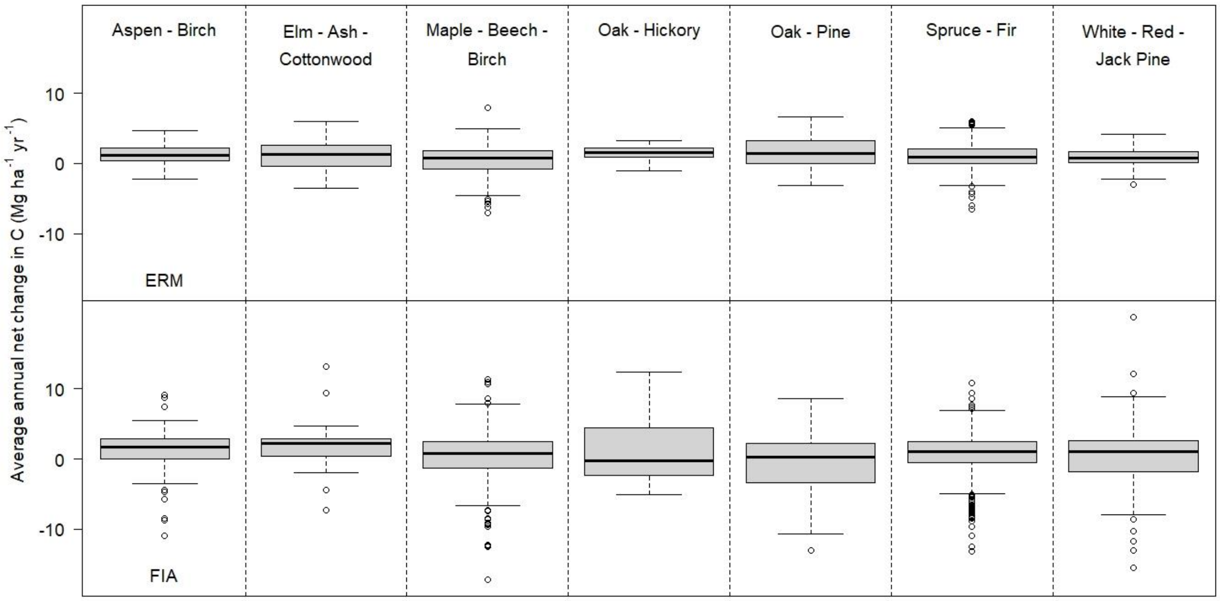

Figure 7. Average annual net change in C (AAC; Mg ha^{-1} yr^{-1}) for the aboveground portions of live trees, standing dead trees, and downed coarse woody debris, as well as, harvested wood products from the 2000s to 2010s by Program and Forest Type Group. Horizontal lines within boxes represent the median. The boxes define the interquartile range (25-75% quartile) and the vertical lines represent the whiskers of maximal 1.5 times the interquartile range. Observations outside the whisker range may be considered outliers.

Table 8. Least-squares (LS) mean and standard error (SE) average annual net change in C (AAC; Mg ha^{-1} yr^{-1}) for the aboveground portions of live trees, standing dead trees, and downed coarse woody debris, as well as, harvested wood products from the 2000s to 2010s by Forest Type Group. There was no statistically significant difference in AAC between ERM and FIA programs.

Forest Type Group	Mean	SE	Group
Oak - Pine	0.111	0.514	1
Maple - Beech - Birch	0.379	0.163	1
White Pine - Red Pine - Jack Pine	0.518	0.325	1
Spruce - Fir	0.783	0.089	1
Aspen - Birch	1.144	0.247	1
Oak - Hickory	1.342	0.509	1
Elm - Ash - Cottonwood	1.603	0.393	1

Note: Different group numbers indicate significant differences between LS mean AAC among Forest Type Groups at $P < 0.05$.

3.5. Projected C Stocks and Sequestration on the Ecological Reserve Monitoring Plots

- Across monitoring plots with repeated measurements, aboveground C in live trees was projected to be 108.9 ± 34.6 Mg ha^{-1} (mean ± SD) in 2040.
- For these same plots, AAC for aboveground portions of live trees was 1.096 ± 0.539 Mg ha^{-1} yr^{-1} from inventory Visit 2 to 2040.
- When statistical analyses were restricted to Natural Community Types with at least 10 permanent plots, pairwise comparisons indicated that aboveground live tree C stocks differed among some Natural Community Types (**Table 9**). For example, the Hemlock Forest had greater live C than the Pitch Pine - Scrub Oak Barren, Evergreen Seepage Forest, Early Successional Forest, and Lower Elevation Spruce - Fir Forest.
- Natural Community Type explained 6% of the variation in projected aboveground live tree C stocks in 2040.
- For a separate model of C stocks in 2040 as a function of Ecological Reserve, which included data from all permanent plots, pairwise comparisons indicated that aboveground live tree C stocks differed among some Ecological Reserves (**Table C1**).
- The categorical variable, Ecological Reserve, explained 10% of the variation in projected aboveground live tree C stocks in 2040; meaning that there was significant variation in projected C stocks among Ecological Reserves.
- When statistical analyses were restricted to Natural Community Types with at least 10 permanent plots, pairwise comparisons indicated that AAC for the aboveground portions of live trees differed among some Natural Community Types (**Table 10**). For example, the Early Successional Forest had greater AAC than the Hemlock Forest, Evergreen Seepage Forest, Northern Hardwoods Forest, Spruce - Northern Hardwoods Forest, Lower Elevation Spruce - Fir Forest, and Montane Spruce - Fir Forest.
- Natural Community Type explained 12% of the variation in AAC for the aboveground portions of live trees from Visit 2 to 2040.
- For a separate model of AAC as a function of Ecological Reserve, which included data from all permanent plots, pairwise comparisons indicated that AAC for the aboveground portions of live trees differed among some Ecological Reserves (**Table C2**).
- Ecological Reserve explained 9% of the variation in AAC for the aboveground portions of live trees from Visit 2 to 2040.

Table 9. Least-squares (LS) mean and standard error (SE) projected aboveground live tree C (Mg ha^{-1}) on Ecological Reserve Monitoring plots in 2040 by Natural Community Type.

Natural Community Type	Mean	SE	Group
Pitch Pine - Scrub Oak Barren	89.2	7.1	1
Evergreen Seepage Forest	91.2	7.0	12
Spruce - Fir Wet Flat	99.0	7.6	123
Early Successional Forest	103.8	5.4	12
Lower Elevation Spruce - Fir Forest	108.6	2.6	12
Maritime Spruce - Fir Forest	110.4	8.3	123
White Pine Forest	114.1	5.8	123
Montane Spruce - Fir Forest	115.5	4.3	123
Spruce - Northern Hardwoods Forest	115.8	3.2	23
Northern Hardwoods Forest	117.0	3.9	23
Subalpine Fir Forest	118.1	15.5	123
Oak - Pine Forest	121.9	7.1	123
Oak - Northern Hardwoods Forest	124.1	7.6	23
Hemlock Forest	130.9	6.0	3

Note: Different group numbers indicate significant differences between LS mean C stocks among Natural Community Types at $P < 0.05$.

Table 10. Least-squares (LS) mean and standard error (SE) projected average annual net change in C (AAC; Mg ha^{-1} yr^{-1}) for the aboveground portions of live trees on Ecological Reserve Monitoring plots from inventory Visit 2 to 2040 by Natural Community Type.

Natural Community Type	Mean	SE	Group
Hemlock Forest	0.860	0.125	12
Evergreen Seepage Forest	0.865	0.105	1
Northern Hardwoods Forest	0.955	0.051	1
Spruce - Northern Hardwoods Forest	1.016	0.042	1
Maritime Spruce - Fir Forest	1.068	0.226	123
White Pine Forest	1.122	0.124	123
Lower Elevation Spruce - Fir Forest	1.128	0.042	12
Oak - Pine Forest	1.170	0.152	123
Pitch Pine - Scrub Oak Barren	1.204	0.117	123
Montane Spruce - Fir Forest	1.234	0.071	12
Spruce - Fir Wet Flat	1.280	0.112	123
Oak - Northern Hardwoods Forest	1.386	0.098	23
Subalpine Fir Forest	1.480	0.152	123
Early Successional Forest	1.574	0.068	3

Note: Different group numbers indicate significant differences between LS mean AAC among Natural Community Types at $P < 0.05$.

3.6. Soil C Stocks of the Ecological Reserve Monitoring Plots

- For the 0–5, 5–20, 20–50, 50–100, 100–150, and 150–200 cm depth increments, estimated soil C stocks were 31.5 ± 12.2, 53.9 ± 25.8, 64.7 ± 45.5, 39.4 ± 72.8, 23.8 ± 62.9, and 7.0 ± 19.1 Mg ha^{-1}, respectively. Depth to bedrock varied by plot, which influenced the overall number of soil C estimates per depth increment in the data set (**Appendix D**).

- From the soil surface to depths of 20, 30, 100, and 150 cm, estimated soil C stocks were 85.4 ± 34.1, 111.8 ± 48.6, 189.2 ± 142.7, and 211.0 ± 200.4 Mg ha^{-1}, respectively. Total soil C to 200 cm or bedrock was 217.2 ± 218.0 Mg ha^{-1}.

- Across the major Natural Community Types, plots on soils associated with wetlands had some of the greatest estimated C stocks (**Figure 8**).

- Based on total soil C and the aboveground C in live trees, standing dead trees, and downed coarse woody debris, estimated soil C represented 67 ± 13% of the total forest C stock (**Figure 9**).

- When analyses were restricted to Natural Communities with at least 10 plots and total estimated forest C stocks < 600 Mg ha^{-1}, pairwise comparisons indicated that total estimated forest C stocks differed among some Natural Community Types (**Table 11)**. Natural Community Type explained 7% of the variation in total forest C stocks.

Table 11. Least-squares (LS) mean and standard error (SE) total forest C (Mg ha^{-1}) on Ecological Reserve Monitoring plots in Visit 2 by Natural Community Type.

Natural Community Type	Mean	SE	Group
Pitch Pine - Scrub Oak Barren	188.8	23.8	1
Maritime Spruce - Fir Forest	217.5	22.4	123
Subalpine Fir Forest	232.1	20.2	123
Oak - Pine Forest	238.9	16.1	123
Early Successional Forest	245.0	10.7	12
Montane Spruce - Fir Forest	255.7	12.6	123
White Pine Forest	257.4	13.8	123
Spruce - Fir Wet Flat	258.6	16.4	123
Oak - Northern Hardwoods Forest	264.2	17.3	123
Evergreen Seepage Forest	264.3	19.5	123
Lower Elevation Spruce - Fir Forest	278.1	8.6	23
Hemlock Forest	281.4	15.4	123
Northern Hardwoods Forest	288.9	9.3	3
Spruce - Northern Hardwoods Forest	289.6	8.8	3

Note: Different group numbers indicate significant differences between LS mean C stocks among Natural Community Types at $P < 0.05$.

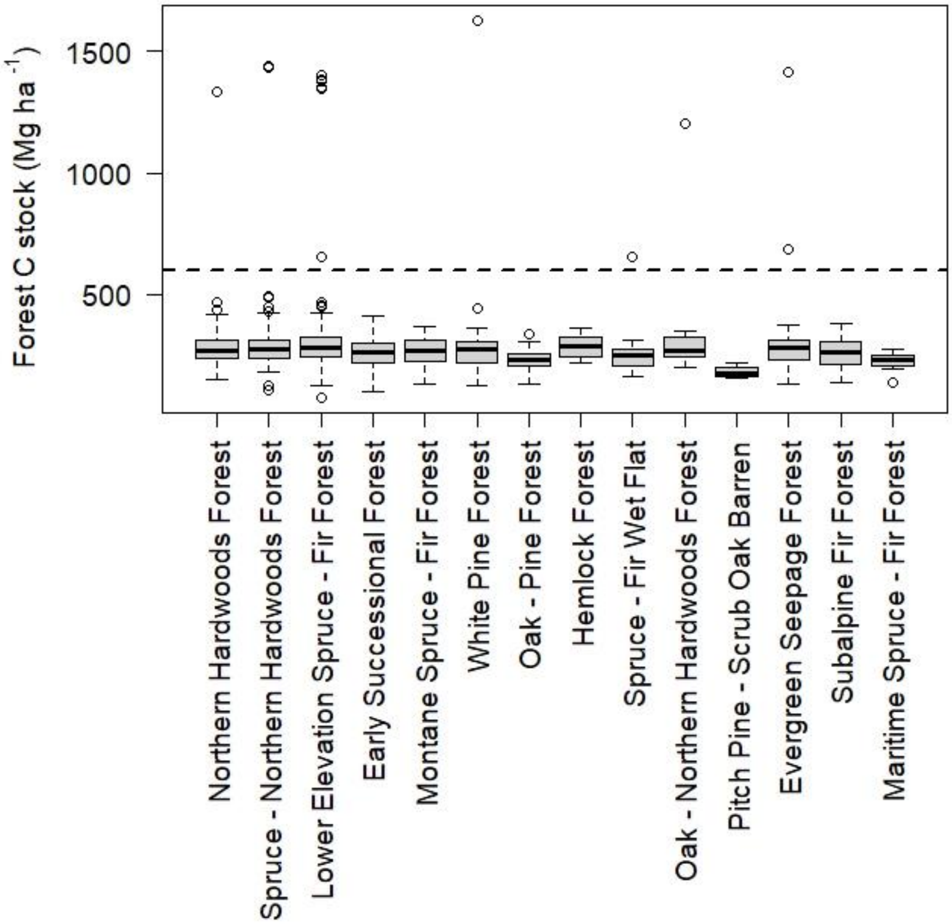

Figure 8. Total forest C stocks (Mg ha^{-1}) including live trees, standing dead trees, downed coarse woody debris, and soils on Ecological Reserve Monitoring plots in Visit 2 by Natural Community Type. Horizontal lines within boxes represent the median. The boxes define the interquartile range (25-75% quartile) and the vertical lines represent the whiskers of maximal 1.5 times the interquartile range. Observations outside the whisker range may be considered outliers. Points above the reference line of 600 Mg ha^{-1} represent plots on Bucksport and Wonsqueak mucks (n = 8), Peat and Muck (n = 4), and Borosaprists, ponded (n = 1).

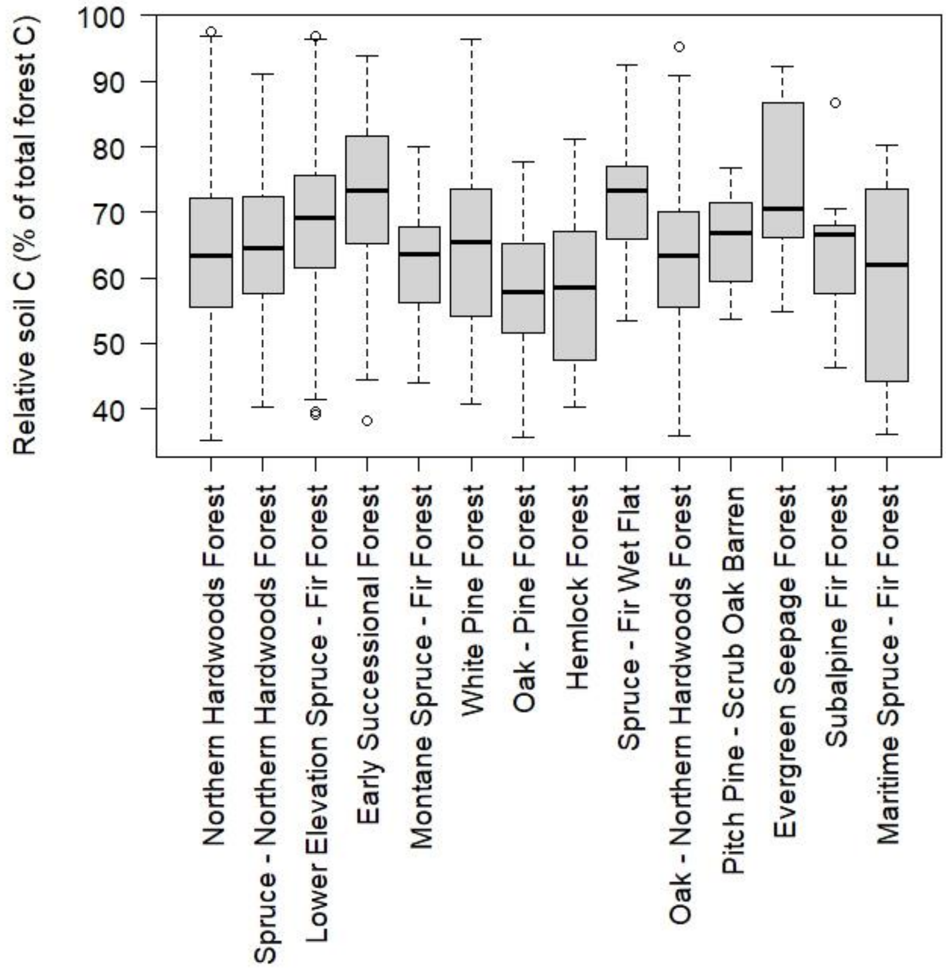

Figure 9. Estimated soil C stock as a percentage of the total forest C stock on Ecological Reserve Monitoring plots in Visit 2 by Natural Community Type. Horizontal lines within boxes represent the median. The boxes define the interquartile range (25-75% quartile) and the vertical lines represent the whiskers of maximal 1.5 times the interquartile range. Observations outside the whisker range may be considered outliers.

3.7. Ecological Reserve Biomass Estimates

- For reserve-level estimates of mean aboveground biomass in trees > 10 cm dbh, there was a 35 ± 17% difference between estimates derived from permanent plot data and LiDAR data (**Table 11**).

Table 11. Mean and standard deviation (SD) of aboveground biomass (Mg ha^{-1}) in trees > 10 cm dbh derived using Visit 2 plot data, as well as LiDAR data by Ecological Reserve. Also, the percent difference between plot and LiDAR estimates of mean biomass.

Ecological Reserve	Plot Mean	Plot SD	LiDAR Mean	LiDAR SD	% difference
Big Reed Forest Reserve	143.4	46.5	116.1	49.8	19
Big Spencer	165.3	94	89.6	53.8	46
Bigelow	178.1	83.3	92.2	51.4	48
Cutler	97.2	58.2	59.3	34.3	39
Duck Lake	163.5	61.8	149.5	74.8	9
Gero Island	155.7	77.2	123.3	54.5	21
Mahoosucs	188.1	67.2	70.3	46.6	63
Mt. Abraham	122.3	100.1	71.7	43.3	41
Nahmakanta	141.5	86.2	116	55.1	18
Spring River Lake	129.9	56.1	69	45.9	47

4.0. Discussion

4.1. Revisiting the Research Questions

(1) What are the C stocks and sequestration rates of natural communities and reserves in the Ecological Reserve system?

Aboveground C in live trees, standing dead trees, and downed coarse woody debris was 89.4 ± 37.7 (mean ± SD) Mg ha^{-1} in inventory Visit 2. There was an 11% increase in mean aboveground C from inventory Visit 1 to inventory Visit 2. While we were able to detect differences in C stocks among Natural Community Types and Ecological Reserves, the relatively low amount of variation explained by our models suggests that additional factors are also influential drivers of C stocks across the study system.

Average annual net change in C (AAC) in live trees, standing dead trees, and downed coarse woody debris was 0.894 ± 1.949 Mg ha^{-1} yr^{-1}. Surprisingly, C sequestration was similar among Natural Community Types. While there were some differences in C sequestration among reserves, Ecological Reserves only explained 6% of the variation in AAC in live trees, standing dead trees, and downed coarse woody debris. Future studies that include additional factors such as time since last major disturbance and site quality would be useful for explaining more of the variation in C stocks and sequestration across the study system.

For monitoring plots with repeated measurements of forest attributes and location information, soil C represented 67 ± 13% of the total forest C stock. When only the first meter of soil was considered, this percentage was 66% ± 13%. For comparison, mean soil C to a depth of 1 m below the top of the mineral soil represented 60 ± 6% of the total forest C stock in managed stands on soils derived from glacial till on the Penobscot Experimental Forest (Puhlick *et al.*, 2016). For stands with no harvesting since the late 1800s on the Penobscot Experimental Forest, mean soil C to a depth of 1 m below the top of the mineral soil represented 49% of the total forest C stock on soils derived from marine sediment, and 41% of the total forest C stock on soils derived from glacial till (Puhlick *et al.*, 2019).

For permanent plots in Ecological Reserves, wetlands had some of greatest soil C stocks making them important components of the forested landscape from a C management perspective (**Table D13**). Forest management practices that ensure wetland function is maintained could be a key part of achieving C objectives. Future research studies on the influence of different forest management treatments on the hydrology of wetlands that are within or adjacent to harvest areas will be important for C management.

(2) Which natural communities are most susceptible to having C emissions due to widespread tree mortality?

For the Subalpine Fir Forest, median aboveground C in trees that died during the inventory period was 73% greater than the grand median C value for Natural Community Types with at least 10 plots. Despite this level of mortality, this Natural Community Type remained a C sink during the study period. For the Early Successional Forest, field crews observed mortality of older aspens and birches with recruitment of spruces and balsam firs.

While the Northern White Cedar Swamp, Upper Floodplain Hardwood Forest, and Black Spruce Bog each had fewer than 10 plots, median aboveground C in trees that died during the inventory period was also notable for these Natural Community Types. Drought and changing hydrology patterns could be potential drivers of mortality in these natural communities. However, more investigation would be required to elucidate factors driving mortality.

Plots in southern Maine and along the coast could be at risk of C emissions due to the hemlock woolly adelgid. However, high amounts of hemlock mortality were not detected on monitoring plots in Visit 1 or Visit 2. Mt. Agamenticus is one reserve that field crews have detected hemlock woolly adelgid and expect there to be increased mortality. Potential implications of spruce and balsam fir growth reductions and mortality due to defoliation by the spruce budworm will also have to be evaluated over time.

(3) Do Ecological Reserves and managed forests have different C stocks and sequestration rates?

For the subset of plots within the dominant Forest Type Groups, C in live trees, standing dead trees, downed coarse woody debris, and harvested wood products for the most recent inventory of plots was 90.2 ± 37.1 and 67.7 ± 36.3 Mg ha^{-1} for ERM and FIA programs, respectively. For this same subset of Forest Type Groups, AAC in live trees, standing dead trees, downed coarse woody debris, and harvested wood products was 0.901 ± 1.957 and 0.581 ± 3.661 Mg ha^{-1} yr^{-1} for ERM and FIA programs, respectively. When using the larger subset of FIA subplots (i.e., including subplots without downed coarse woody debris data) and excluding changes in downed coarse woody debris from the AAC calculations, AAC was 0.937 ± 1.902 and 1.483 ± 1.680 Mg ha^{-1} yr^{-1} for ERM and FIA programs, respectively. The greater number of FIA subplots (10,503 compared to 1,170) used to derive the second set of AAC values should be considered when comparing AAC values between programs.

Our models indicated that the difference in C stocks between programs depended on forest type group. For example, across managed forests, mean C in aboveground pools and harvested wood products was similar for the Maple - Beech - Birch and the Spruce - Fir forest type groups. However, across reserves, the Maple - Beech - Birch forest type group had greater C stocks than the Spruce - Fir forest type group. For these two forest type groups, the mean C stocks were greater across reserves than for managed forests. Factors included in models of AAC explained only a small amount of the variation in C sequestration.

In addition to reserve status and forest type group, other factors (or correlated factors) are likely influencing C stocks. For example, across managed forests, some forest type groups (e.g., Oak - Pine) might be associated with geographic locations where relatively few trees are typically removed during harvests. The correlation of forest type group and proximity to urban areas has been shown to influence human attitudes about harvesting intensity and the motivation to harvest for supplemental income.

(4) What are the projected live tree C stocks and projected C sequestration rates of reserves over the next approximately 20 years?

In 2040, aboveground C in live trees was projected to be 108.9 ± 34.6 Mg ha^{-1}. From inventory Visit 2 to 2040, AAC in the aboveground portions of live trees was 1.096 ± 0.539 Mg ha^{-1} yr^{-1}. The Early Successional Forest had greater AAC than the Hemlock Forest, Evergreen Seepage Forest, Northern Hardwoods Forest, Spruce - Northern Hardwoods Forest, Lower Elevation Spruce - Fir Forest, and Montane Spruce - Fir Forest. The relatively high rates of C sequestration for the Early Successional Forest may be associated with fast-growing species within the community type. While our simulations did not account for changes in climatic conditions, many of species typically found in the Early Successional Forest are predicted to be “winners” with regards to climate change.

4.2. Study Limitations

(1) For plots in Ecological Reserves, we had to estimate standing dead tree heights to a broken top (when not available) and decay class. We recommend that height and decay class be recorded for all standing dead trees ≥ 12.7 cm dbh to improve predictions of C in dead wood pools.

(2) For this study, reductions in live tree biomass based on defect and cull were not made for either program. A live tree, dead tree, or rough cull code is assigned to trees on plots in Ecological Reserves. FIA protocols include additional codes with more detail about tree defect and sound and rotten cull. We recommend refining the ERM protocols to include additional information on defect and cull which can be important for C accounting and related objectives.

(3) For the plots in Ecological Reserves, our results do not include C sequestered in harvested wood products. While tree cutting is relatively minimal on the reserves, future studies could include the transfers of C from, for instance, the removal of trees from Pitch Pine - Scrub Oak Barren natural community type during fuel reduction treatments. Cut trees are usually chipped, so the end products may have short residence times. Only one of 14 plots in this naturally community type had notes indicating that cutting occurred between inventory periods. Two plots had notes indicating that natural or prescribed burning occurred between inventories. As additional fuel reduction treatments are planned for this natural community type, accounting for product C will be important. For C accounting purposes, it would be useful to include a "cut" code as an option for the tree condition class in the inventory protocols.

(4) Our projections of growth and yield do not account for climate change or changing disturbance regimes. Future studies should consider these influences on C dynamics. For example, hemlock wooly adelgid will likely influence C dynamics in reserves that are located in southern and coastal Maine over the next few decades.

(5) Our calculations of mean aboveground biomass for individual reserves were derived from permanent plot values and from LiDAR grid cell values across reserves. Future studies could also compare differences between aboveground biomass estimates at the plot level (i.e., using values from LiDAR grid cells associated with individual plots and comparing those values with the field inventory data).

References

Ayrey, E., Hayes, D., Fraver, S., Weiskittel, A., Cook, B., Kershaw, J., New England Enhanced Forest Inventory Report.

Dixon, G.E., Keyser, C.E., 2019. Northeast (NE) Variant Overview - Forest Vegetation Simulator. USDA For. Serv., (Internal Rep.

Gawler, S.C., Cutko, A., 2018. Natural landscapes of Maine: A guide to natural communities and ecosystems. Maine Natural Areas Program. p. 348

Graves, S., Piepho, H.P., Selzer, L., Dorai-Raj, S., 2012. *multcompView: Visualizations of paired comparisons*. R package version 0.1-5. http://CRAN.R-project.org/package=multcompView

Harmon, M.E., Woodall, C.W., Fasth, B., Sexton, J., 2008. Woody detritus density and density reduction factors for tree species in the United States: a synthesis. USDA For. Serv., Newtown Square, PA. p. 84 (Gen. Tech. Rep. NRS-29).

Harmon, M.E., Woodall, C.W., Fasth, B., Sexton, J., Yatkov, M., 2011. Differences between standing and downed dead tree wood density reduction factors: A comparison across decay classes and tree species. USDA For. Serv., Newtown Square, PA. p. 40 (Res. Pap. NRS-15).

Husch, B., Beers, T., Kershaw, J.A., Jr., 2003. Forest mensuration. John Wiley & Sons, Inc., Hoboken, New Jersey, USA.

Kuehne, C., Puhlick, J.J., Weiskittel, A.R., 2018. Ecological reserves in Maine: Initial results of long-term monitoring [online]. University of Maine, Center for Research on Sustainable Forests. Orono, ME. Available from http://www.nefismembers.org/documents/ecological-reserves-in-maine-initial-results-of-long-term-monitoring [accessed 21 January 2021].

Lamlom, S.H., Savidge, R.A., 2003. A reassessment of carbon content in wood: variation within and between 41 North American species. Biomass Bioenerg. 25, 381-388.

Lenth, R.V., 2014. *lsmeans: Least-squares means*. R package version 2.13. http://CRAN.R-project.org/package=lsmeans

Li, R., Weiskittel, A., Dick, A.R., Kershaw, J.A., Seymour, R.S., 2012. Regional stem taper equations for eleven conifer species in the Acadian Region of North America: Development and assessment. North. J. App. For. 29, 5-14.

Maine Department of Conservation, 2003. Ecological Reserve Monitoring Plan. p. 26

Maine Ecological Reserves Scientific Advisory Committee, 2009. Ecological Reserves in Maine: A Status Report on Designation, Monitoring, and Uses. p. 27

Miles, P.D., Smith, W.B., 2009. Specific gravity and other properties of wood and bark for 156 tree species found in North America. USDA For. Serv., Newtown Square, PA. p. 35 (Res. Note NRS-38).

O'Connell, B.M., LaPoint, E.B., Turner, J.A., Ridley, T., Pugh, S.A., Wilson, A.M., Waddell, K.L., Conkling, B.L., 2015. The Forest Inventory and Analysis Database: Database description and user guide version 6.0.2 for Phase 2. USDA For Serv. 784 pp. https://www.fia.fs.fed.us/library/database-documentation/.

O'Connell, B.M., LaPoint, E.B., Turner, J.A., Ridley, T., Pugh, S.A., Wilson, A.M., Waddell, K.L., Conkling, B.L., 2015. The Forest Inventory and Analysis Database: Database description and user guide version 6.0.2 for Phase 2. USDA For. Serv. 748 pp. Available Online: http://www.fia.fs.fed.us/library/database-documentation/.

Pinheiro, J.C., Bates, D.M., DebRoy, S., Sarkar, D., R Development Core Team, 2014. *nlme: Linear and nonlinear mixed effects models*. R package version 3.1-117. http://CRAN.R-project.org/package=nlme Accessed on 10-30-2020

Puhlick, J.J., Fraver, S., Fernandez, I.J., Teets, A., Weiskittel, A.R., Kenefic, L.S., 2019. Site quality, disturbance, and vegetation effects on carbon storage and accumulation in old, mixed-species stands in central Maine, USA. Nat. Area. J. 39, 429-441.

Puhlick, J.J., Weiskittel, A.R., Fernandez, I.J., Fraver, S., Kenefic, L.S., Seymour, R.S., Kolka, R.K., Rustad, L.E., Brissette, J.C., 2016. Long-term influence of alternative forest management treatments on total ecosystem and wood product carbon storage. Can. J. For. Res. 46, 1404-1412.

R Development Core Team, 2020. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/

Smith, J.E., Heath, L.S., Skog, K.E., Birdsey, R.A., 2006. Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. USDA For. Serv., Newtown Square, PA. p. 216 (Gen. Tech. Rep. NE-343).

Soil Survey Staff, 2020. Gridded Soil Survey Geographic (gSSURGO) Database for Maine. United States Department of Agriculture, Natural Resources Conservation Service. Available online at https://gdg.sc.egov.usda.gov/. July, 2020.

USDA, 2014. The Forest Inventory and Analysis Database: Database description and user guide version 6.0.1 for Phase 3. USDA For. Serv. 182 pp. Available Online: http://www.fia.fs.fed.us/library/database-documentation/.

USDA, 2015. The Forest Inventory and Analysis Database: Database Description and User Guide for Phase 2 (version 6.0.2).

USDA, 2020. Forest Inventory and Analysis Database. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Northern Research Station. https://apps.fs.usda.gov/fia/datamart/datamart.html (files downloaded on 02-22-2017).

Woodall, C.W., Monleon, V.J., 2008. Sampling protocol, estimation, and analysis procedures for the down woody materials indicator of the FIA program. USDA For. Serv., Newtown Square, PA. p. 68 (Gen. Tech. Rep. NRS-22).

Young, H.E., Ribe, J.H., Wainwright, K., 1980. Weight tables for tree and shrub species in Maine. University of Maine, Life Sciences and Agriculture Experiment Station, Orono, ME. p. 84 (Misc. Rep. Misc. Rep. 230).

Table A1. Least-squares (LS) mean (standard error in parentheses) aboveground C (Mg ha^{-1}) in live trees, standing dead trees, and downed coarse woody debris on Ecological Reserve Monitoring plots in Visit 1 and Visit 2 by Ecological Reserve.

Ecological Reserve	Visit 1			Visit 2		
	Mean	SE	Group	Mean	SE	Group
Appleton Bog	76.8	6.5	1234567	86.5	6.4	12
Back River IFW	103.4	11.5	12345	104.6	25.4	12
Bald Head Preserve	68.8	3.6	12 567	88.9	5.5	12
Basin Preserve	64.7	9.8	1234567	75	9.9	12
Berry Woods	83.5	14.4	1234567	93	13.8	12
Big Reed Forest Reserve	78.4	5.6	123456	87.7	5	12
Big Spencer	95	7.1	1 345	97	7.2	12
Bigelow	103.5	6.2	3	104.3	5.6	1
Brownfield Bog	108.7	27.4	1234567	129.5	32	12
Bufflehead Corner	78	2.4	123456	97.7	18.9	12
Chamberlain Lake	102	5.9	34	105.5	6.9	1
Cutler	54	6.3	2 67	62.7	5.7	2
Deboullie	81.2	5.9	123456	91.1	6.5	12
Debsconeags	78	3.4	123456	88.1	3.4	12
Donnell Pond	73.1	7.8	1234567	83.2	7.9	12
Duck Lake	82.9	5.5	123456	91.2	6	12
Flying Point	118.8	19.8	1234567	127.6	21.2	12
Forest City	95.7	16.1	1234567	100.3	15.2	12
Gero Island	92.2	6.2	1 345	103.8	6.8	1
Great Duck Island	92.8	8	12345	117.3	12.3	1
Great Heath	70.3	10.6	1234567	73.7	9.6	12
Kennebunk Plains	62.8	8.5	12 4567	74.8	7.2	12
Killick/Little Ossipee	35.7	11	67	53.2	17.3	12
Lower Kennebec Arrowsic	86.8	14.4	1234567	90.9	19	12
Lower Kennebec Hammond	112.4	20	1234567	126.7	20.1	12
Mahoosucs	100.9	5.7	34	106.6	6	1
Mt. Abraham	89.5	6.1	1 345	98.8	7.6	12
Mt. Agamenticus	116.3	13.1	1 34	126.6	13.8	1
Nahmakanta	78	5.8	123456	86.9	5.6	12
Narraguagus	60.5	7.9	12 567	65.2	9.6	12
Rocky Lake	58.2	10.3	1234567	71.3	8.7	12
Salmon Brook Lake	74.7	6.7	1234567	80.1	6.7	12
Spring River Lake	69.8	5.6	12 567	79.1	5.2	12
St. John Ponds	54.1	8.6	2 567	70	9.1	12
Wassataquoik	97.3	8.9	1 345	109.5	9.6	1
Waterboro Barrens Preserve	65.3	8.3	1234567	72	8.5	12
Wells Barrens	44.9	5.6	7	77.4	18.4	12

Note: Different group numbers indicate significant differences between LS mean C stocks among Ecological Reserves at $P < 0.05$.

Table B1. Least-squares (LS) mean and standard error (SE) average annual net change in C (AAC; Mg ha^{-1} yr^{-1}) for the aboveground portions of live trees, standing dead trees, and downed coarse woody debris on Ecological Reserve Monitoring plots from inventory Visit 1 to Visit 2 by Ecological Reserve.

Ecological Reserve	Mean	SE	Group
Bigelow	0.071	0.308	1
Back River IFW	0.097	1.156	12
Big Spencer	0.203	0.374	1
Great Heath	0.333	0.307	1
Chamberlain Lake	0.346	0.429	12
Lower Kennebec Arrowsic	0.419	0.782	12
Salmon Brook Lake	0.446	0.429	12
Forest City	0.466	0.323	12
Narraguagus	0.474	0.538	12
Mahoosucs	0.578	0.409	12
Waterboro Barrens Preserve	0.670	0.369	12
Duck Lake	0.753	0.296	12
Spring River Lake	0.850	0.318	12
Flying Point	0.881	1.046	12
Cutler	0.887	0.312	12
Deboullie	0.896	0.397	12
Nahmakanta	0.903	0.305	12
Donnell Pond	0.913	0.324	12
Mt. Abraham	0.921	0.365	12
Berry Woods	0.945	1.082	12
Basin Preserve	1.027	0.281	12
Gero Island	1.040	0.289	12
Mt. Agamenticus	1.057	0.268	12
Debsconeags	1.084	0.188	12
Big Reed Forest Reserve	1.123	0.605	12
Rocky Lake	1.204	0.462	12
Appleton Bog	1.206	0.301	12
Wassataquoik	1.257	0.643	12
Lower Kennebec Hammond	1.442	0.514	12
Kennebunk Plains	1.496	0.566	12
St. John Ponds	1.571	0.406	12
Killick/Little Ossipee	1.740	0.691	12
Bufflehead Corner	1.947	1.723	12
Bald Head Preserve	1.988	0.586	12
Brownfield Bog	2.119	0.558	12
Great Duck Island	2.678	0.507	2
Wells Barrens	3.169	2.042	12

Note: Different group numbers indicate significant differences between LS mean AAC among Ecological Reserves at $P < 0.05$.

Table C1. Least-squares (LS) mean and standard error (SE) projected aboveground live tree C (Mg ha^{-1}) on Ecological Reserve Monitoring plots in 2040 by Ecological Reserve.

Ecological Reserve	Mean	SE	Group
Killick/Little Ossipee	73.5	20.5	12
Narraguagus	87.5	15.4	12
St. John Ponds	88	8.2	1
Cutler	90.9	7.4	1
Great Heath	94.8	9	12
Rocky Lake	95.2	8.9	12
Waterboro Barrens Preserve	97.7	6.7	12
Basin Preserve	98.6	8.4	12
Big Reed Forest Reserve	99.7	6.1	12
Salmon Brook Lake	101.8	8	12
Kennebunk Plains	102.5	7.7	12
Donnell Pond	105.8	5.9	12
Debsconeags	107.6	3.2	12
Spring River Lake	108.2	4.7	12
Deboullie	108.2	6.9	12
Lower Kennebec Arrowsic	108.8	19.5	12
Nahmakanta	109	4.8	12
Wells Barrens	111.4	30.8	12
Berry Woods	114.2	12.1	12
Gero Island	114.7	6	12
Appleton Bog	115.1	6	12
Big Spencer	115.3	6.2	12
Back River IFW	115.3	17.2	12
Forest City	115.4	12	12
Wassataquoik	115.9	9	12
Chamberlain Lake	116.7	5.8	12
Duck Lake	116.9	5.4	12
Bufflehead Corner	117.4	17.5	12
Mt. Abraham	118.7	7.8	12
Mahoosucs	119.7	5.9	12
Bigelow	121.1	4.8	12
Great Duck Island	122.8	11.1	12
Bald Head Preserve	123.9	6.8	12
Lower Kennebec Hammond	137.6	10.4	12
Mt. Agamenticus	138.4	9	2
Flying Point	139.8	13.7	12
Brownfield Bog	142.1	34.8	12

Note: Different group numbers indicate significant differences between LS mean C stocks among Ecological Reserves at $P < 0.05$.

Table C2. Least-squares (LS) mean and standard error (SE) projected average annual net change in C (AAC; Mg ha^{-1} yr^{-1}) for the aboveground portions of live trees on Ecological Reserve Monitoring plots from inventory Visit 2 to 2040 by Ecological Reserve.

Ecological Reserve	Mean	SE	Group
Great Duck Island	0.385	0.176	1
Brownfield Bog	0.718	0.224	12345
Lower Kennebec Hammond	0.743	0.637	12345
Wassataquoik	0.761	0.126	123
Mt. Agamenticus	0.817	0.203	12345
Flying Point	0.91	0.434	12345
Killick/Little Ossipee	0.938	0.215	12345
St. John Ponds	0.949	0.104	12345
Chamberlain Lake	0.953	0.087	12345
Big Reed Forest Reserve	0.989	0.077	12345
Bufflehead Corner	0.989	0.257	12345
Back River IFW	0.997	0.006	12 4
Deboullie	1.001	0.093	12345
Gero Island	1.013	0.095	12345
Forest City	1.049	0.246	12345
Bigelow	1.049	0.087	12345
Donnell Pond	1.055	0.081	12345
Mahoosucs	1.059	0.094	12345
Debsconeags	1.063	0.044	12345
Appleton Bog	1.097	0.166	12345
Big Spencer	1.104	0.104	12345
Rocky Lake	1.106	0.099	12345
Lower Kennebec Arrowsic	1.107	0.171	12345
Nahmakanta	1.127	0.079	12345
Salmon Brook Lake	1.159	0.16	12345
Waterboro Barrens Preserve	1.162	0.142	12345
Basin Preserve	1.198	0.141	12345
Berry Woods	1.206	0.223	12345
Duck Lake	1.226	0.11	2345
Great Heath	1.246	0.131	2345
Mt. Abraham	1.255	0.113	2345
Spring River Lake	1.282	0.067	3 5
Cutler	1.331	0.11	2345
Narraguagus	1.428	0.388	12345
Kennebunk Plains	1.511	0.138	45
Bald Head Preserve	1.576	0.166	45
Wells Barrens	1.591	0.585	12345

Note: Different group numbers indicate significant differences between LS mean AAC among Ecological Reserves at $P < 0.05$.

Table D1. Descriptive statistics for soil C (Mg ha^{-1}) estimates corresponding to the 0–5 cm depth increment on Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Killick/Little Ossipee	5	11.4	0.1	11.4	11.6
Kennebunk Plains	12	11.6	1	11.2	14.8
Waterboro Barrens Preserve	18	16.8	13.3	11.2	57.9
Brownfield Bog	3	20.9	0	20.9	20.9
Wassataquoik	17	22.7	6.3	10.5	30.7
Big Spencer	30	23.1	9.6	6.6	29.5
Great Duck Island	5	24.2	3.3	22.7	30
Debsconeags	89	24.6	9.2	7.8	55.1
Berry Woods	6	25.9	12.3	9.1	39.3
St. John Ponds	35	26.3	5.5	18.8	50.1
Deboullie	31	27	8.6	7.8	50.1
Salmon Brook Lake	13	28.1	7.3	15.9	35.4
Nahmakanta	50	28.2	13.8	7.8	55.1
Chamberlain Lake	16	28.4	1.2	26.8	29.5
Big Reed Forest Reserve	24	29.1	0.3	28.7	29.5
Gero Island	23	29.2	0.2	28.8	29.5
Narraguagus	5	30.5	0	30.5	30.5
Basin Preserve	18	33	9.5	9.1	39.6
Mahoosucs	28	33.2	9.8	25.8	55.1
Back River IFW	2	34.4	7	29.5	39.3
Bigelow	47	34.6	8.9	22.5	56.8
Cutler	29	35.6	9.8	22.2	50.1
Mt. Abraham	32	37	8.8	29.7	52
Mt. Agamenticus	8	37	10.6	29.8	57.9
Lower Kennebec Hammond	3	39.1	0.3	38.7	39.3
Bufflehead Corner	4	39.2	0.3	38.7	39.3
Bald Head Preserve	3	39.3	0	39.3	39.3
Flying Point	5	39.3	0	39.3	39.3
Lower Kennebec Arrowsic	3	39.3	0	39.3	39.3
Spring River Lake	29	43	4.5	30.7	52.9
Forest City	8	43.7	6.1	33.5	52
Appleton Bog	10	44.7	10.3	35	55.1
Rocky Lake	9	44.7	13.5	27.4	57.5
Donnell Pond	18	46.2	6.2	34.7	55.7
Duck Lake	26	51.9	6.6	40.5	56.9
Great Heath	13	52.1	7	32.4	57.5

n = number of monitoring plots with soil C values for the 0–5 cm depth increment; SD = standard deviation

Table D2. Descriptive statistics for soil C (Mg ha^{-1}) estimates corresponding to the 5–20 cm depth increment on Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Great Duck Island	5	29.2	9.5	25	46.3
Killick/Little Ossipee	5	32.5	0.1	32.5	32.8
Kennebunk Plains	12	33.1	2.5	31.9	41.1
Big Spencer	30	34.7	10.6	16.6	46.7
Waterboro Barrens Preserve	18	35.9	8.4	31.9	60.2
Berry Woods	6	37.5	10.7	28.9	50.7
Back River IFW	2	40.5	14.5	30.2	50.7
Debsconeags	89	44.4	22.3	21.3	112.2
St. John Ponds	35	44.7	19.4	27.9	148.9
Gero Island	23	45.3	3.2	39.6	51.6
Big Reed Forest Reserve	24	46.5	5.9	35.4	56.5
Chamberlain Lake	16	47.9	5.3	39.6	54.6
Nahmakanta	50	48.3	21.6	22.2	112.2
Basin Preserve	18	48.5	19.4	29.1	116.4
Lower Kennebec Hammond	3	49.5	2.1	47	50.7
Bufflehead Corner	4	49.8	1.8	47	50.7
Bald Head Preserve	3	50.7	0	50.7	50.7
Flying Point	5	50.7	0	50.7	50.7
Lower Kennebec Arrowsic	3	50.7	0	50.7	50.7
Wassataquoik	17	50.9	14.8	31.3	71.2
Deboullie	31	52.1	26.7	23.2	148.9
Donnell Pond	18	52.7	11.4	27.4	60.8
Narraguagus	5	54.1	0	54.1	54.1
Mt. Agamenticus	8	58.7	36.3	42.7	148
Bigelow	47	58.8	24.3	31.9	148.9
Mahoosucs	28	59.2	18.9	41.1	93.9
Mt. Abraham	32	61.5	7.5	53.1	70.1
Spring River Lake	29	62.3	22.5	18.3	112.2
Brownfield Bog	3	62.6	0	62.6	62.6
Cutler	29	68	30.1	32	148.9
Duck Lake	26	75.8	32.5	50	148.9
Forest City	8	77.1	22.1	60.8	112.2
Salmon Brook Lake	13	79.8	24.5	47.7	104.9
Rocky Lake	9	90.2	42.5	53	148.9
Great Heath	13	90.5	48	53	148.9
Appleton Bog	10	101.4	56.3	52.2	165.3

n = number of monitoring plots with soil C values for the 5–20 cm depth increment; SD = standard deviation

Table D3. Descriptive statistics for soil C (Mg ha^{-1}) estimates corresponding to the 20–50 cm depth increment on Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Great Duck Island	5	19.4	11.6	14.2	40.2
Back River IFW	2	26.2	20.9	11.4	41
Berry Woods	6	36.2	25.2	12.4	80.6
Lower Kennebec Hammond	3	39.6	2.3	37	41
Bufflehead Corner	4	40	2	37	41
Bald Head Preserve	3	41	0	41	41
Flying Point	5	41	0	41	41
Kennebunk Plains	12	41	1.2	39.2	44.1
Killick/Little Ossipee	5	41	0.4	40.4	41.1
Lower Kennebec Arrowsic	3	41	0	41	41
Wassataquoik	17	42.4	18.6	25.4	97.1
Waterboro Barrens Preserve	18	42.5	6.8	33.7	66.9
Brownfield Bog	3	44.3	0	44.3	44.3
Basin Preserve	18	46.1	45.4	11.4	215.2
St. John Ponds	35	48	42.2	23.4	279.3
Big Spencer	30	51.2	18.5	4.9	71.8
Big Reed Forest Reserve	24	51.5	9.9	37.1	71.8
Gero Island	23	52.7	5.2	40.6	62.2
Mt. Abraham	32	53.4	21.1	16.6	84.6
Chamberlain Lake	16	58	7.8	50.2	68.4
Bigelow	47	61.1	35.5	33.6	279.3
Donnell Pond	18	62.7	20.3	11.3	82.6
Spring River Lake	29	63.5	23.4	11.3	99.1
Debsconeags	89	64.4	25.6	12.9	99.1
Nahmakanta	50	64.4	23.3	12.9	99.1
Narraguagus	5	71.4	0	71.4	71.4
Mahoosucs	28	72.3	15.2	49.6	91.4
Deboullie	31	75.7	56.6	12.9	279.3
Mt. Agamenticus	8	77.9	88.3	33.7	295.9
Duck Lake	26	81.9	61.3	49.2	279.3
Cutler	29	83.9	70.9	9.5	279.3
Forest City	8	84.7	12.3	59.7	99.1
Salmon Brook Lake	13	96.7	36.1	36.9	132.6
Great Heath	13	140	114.7	50	279.3
Rocky Lake	9	141.9	103.5	50	279.3
Appleton Bog	10	149.1	114.7	53.9	281.5

n = number of monitoring plots with soil C values for the 20–50 cm depth increment; SD = standard deviation

Table D4. Descriptive statistics for soil C (Mg ha^{-1}) estimates corresponding to the 50–100 cm depth increment on Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Back River IFW	2	2.8	1.9	1.5	4.1
Lower Kennebec Hammond	3	3.6	1	2.4	4.1
Bufflehead Corner	4	3.7	0.9	2.4	4.1
Bald Head Preserve	3	4.1	0	4.1	4.1
Flying Point	5	4.1	0	4.1	4.1
Lower Kennebec Arrowsic	3	4.1	0	4.1	4.1
Big Reed Forest Reserve	24	13.8	4	6.3	19.8
Gero Island	23	14.3	3.1	11.8	19.3
Big Spencer	30	14.4	4.6	2	19.8
Chamberlain Lake	16	15.7	2.7	11.8	19.3
Mahoosucs	28	16.1	10.5	5.8	43.3
Donnell Pond	18	18.2	10.6	0.3	28.9
Great Duck Island	5	18.2	8.2	14.6	32.8
Berry Woods	6	18.9	31.7	2.4	82.6
Waterboro Barrens Preserve	18	20.9	4.5	3	24.6
Killick/Little Ossipee	5	21.6	0.3	21.1	21.8
Kennebunk Plains	12	22.5	3.2	21	32.5
Mt. Abraham	32	23	8	9.5	29.6
Spring River Lake	29	24.6	13.4	1.7	55.6
St. John Ponds	35	28.6	66.5	11.8	410.4
Basin Preserve	18	28.8	80.2	1.5	340.7
Forest City	8	31.2	16.5	15.8	55.6
Debsconeags	89	33.7	17	6.4	55.6
Nahmakanta	50	34.2	15.9	2.6	55.6
Bigelow	47	35.2	58.5	0.4	410.4
Narraguagus	5	37.8	0	37.8	37.8
Brownfield Bog	3	43.5	0	43.5	43.5
Wassataquoik	17	44.1	28.6	8.6	74.1
Deboullie	31	47.9	98	6.3	410.4
Mt. Agamenticus	4	50.1	114.3	3.8	332
Duck Lake	26	65.4	102.5	20.3	410.4
Cutler	29	78.6	115.1	2.9	410.4
Salmon Brook Lake	13	102.8	74	19.2	178.8
Rocky Lake	9	158.4	177.4	23.7	410.4
Great Heath	13	174	194.6	23.7	410.4
Appleton Bog	10	189.6	219	15.3	443.9

n = number of monitoring plots with soil C values for the 50–100 cm depth increment; SD = standard deviation

Table D5. Descriptive statistics for soil C (Mg ha^{-1}) estimates corresponding to the 100–150 cm depth increment on Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Big Reed Forest Reserve	24	6.4	4.6	0.2	13.1
Mahoosucs	28	6.7	8	1.2	24.6
Great Duck Island	5	7.2	3	1.9	8.5
Donnell Pond	17	7.5	6.9	0.1	14
Gero Island	23	8.3	3.2	0.6	13.1
Big Spencer	21	8.6	2.1	5.5	11.3
Debsconeags	89	8.9	5.1	0.6	25.6
Kennebunk Plains	12	8.9	0.2	8.5	9
Killick/Little Ossipee	5	8.9	0.1	8.8	9
Chamberlain Lake	16	9	4.2	1.2	13.1
Waterboro Barrens Preserve	18	9	2.7	0.4	15.3
Mt. Abraham	28	10.8	8	2.2	21.4
Nahmakanta	50	10.9	6.2	0.8	25.6
Spring River Lake	26	12	6.9	0.1	21.4
Mt. Agamenticus	8	12.5	23.7	0.4	69.1
Forest City	8	13.4	10.6	0.6	21.5
St. John Ponds	35	16.2	52.9	0.6	319.4
Berry Woods	2	20.3	12.5	11.5	29.1
Narraguagus	5	20.4	0	20.4	20.4
Bigelow	44	21.3	47.8	0.4	319.4
Deboullie	31	26.7	78.3	0.2	319.4
Brownfield Bog	3	31.9	0	31.9	31.9
Wassataquoik	17	36.9	26.9	4.7	67.4
Duck Lake	26	39.4	82.5	13	319.4
Cutler	28	47.1	96.3	0.7	319.4
Salmon Brook Lake	13	65.8	53.7	9.7	121
Basin Preserve	4	93.7	159.8	1.7	332.8
Rocky Lake	9	104.8	137.9	11.8	319.4
Great Heath	13	131.2	154.8	11.8	319.4
Appleton Bog	10	178.2	228.4	1.3	443.6
Back River IFW	NA	NA	NA	NA	NA
Bald Head Preserve	NA	NA	NA	NA	NA
Bufflehead Corner	NA	NA	NA	NA	NA
Flying Point	NA	NA	NA	NA	NA
Lower Kennebec Arrowsic	NA	NA	NA	NA	NA
Lower Kennebec Hammond	NA	NA	NA	NA	NA

n = number of monitoring plots with soil C values for the 100–150 cm depth increment; SD = standard deviation; NA = NA = not applicable, no values were estimated for this depth increment for the given reserve

Table D6. Descriptive statistics for soil C (Mg ha^{-1}) estimates corresponding to the 150–200 cm depth increment on Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Debsconeags	83	1.8	2	0.2	7.7
Big Reed Forest Reserve	24	1.9	1.4	0.1	3.9
Mahoosucs	28	2	2.4	0.2	7.4
Donnell Pond	17	2.2	2.1	0	4.2
Great Duck Island	5	2.2	0.9	0.6	2.5
Gero Island	23	2.5	1	0.2	3.9
Big Spencer	21	2.6	0.6	1.7	3.4
Chamberlain Lake	16	2.7	1.3	0.3	3.9
Kennebunk Plains	12	2.7	0.1	2.5	2.7
Killick/Little Ossipee	5	2.7	0	2.6	2.7
Waterboro Barrens Preserve	18	2.7	0.8	0.1	4.6
Mt. Abraham	28	3.2	2.4	0.7	6.4
Nahmakanta	45	3.4	2.2	0.2	7.7
Spring River Lake	26	3.7	2.2	0	7.1
Mt. Agamenticus	8	3.8	7.1	0.1	20.7
Forest City	8	4	3.2	0.2	6.4
Berry Woods	2	4.8	5.6	0.8	8.7
St. John Ponds	35	4.9	15.9	0.2	95.8
Narraguagus	5	5.9	0	5.9	5.9
Bigelow	44	6.3	14.4	0.1	95.8
Deboullie	30	7.8	24	0.1	95.8
Brownfield Bog	3	9.5	0	9.5	9.5
Wassataquoik	17	10	8.8	1.3	20.2
Duck Lake	26	11.8	24.7	3.9	95.8
Cutler	28	13.9	28.9	0.2	95.8
Salmon Brook Lake	13	19.7	16.1	2.9	36.2
Basin Preserve	4	28	47.8	0.4	99.5
Rocky Lake	9	30.8	41.7	3.5	95.8
Great Heath	13	39.4	46.5	3.5	95.8
Appleton Bog	10	53.5	68.6	0.4	133.2
Back River IFW	NA	NA	NA	NA	NA
Bald Head Preserve	NA	NA	NA	NA	NA
Bufflehead Corner	NA	NA	NA	NA	NA
Flying Point	NA	NA	NA	NA	NA
Lower Kennebec Arrowsic	NA	NA	NA	NA	NA
Lower Kennebec Hammond	NA	NA	NA	NA	NA

n = number of monitoring plots with soil C values for the 150–200 cm depth increment; SD = standard deviation; NA = not applicable, no values were estimated for this depth increment for the given reserve

Table D7. Descriptive statistics for soil C (Mg ha^{-1}) estimates from the soil surface to a depth of 20 cm associated with Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Killick/Little Ossipee	5	43.9	0.2	43.8	44.3
Kennebunk Plains	12	44.8	3.5	43.1	55.9
Waterboro Barrens Preserve	18	52.7	21.5	43.1	112.9
Great Duck Island	5	53.4	12.8	47.7	76.3
Big Spencer	30	57.8	19.9	23.2	75.8
Berry Woods	6	63.4	21.5	38.2	90
Debsconeags	89	68.9	28.5	30.9	152.7
St. John Ponds	35	70.9	24.5	46.7	199
Wassataquoik	17	73.6	16.4	41.8	100.6
Gero Island	23	74.5	3	69.2	80.4
Back River IFW	2	74.9	21.4	59.7	90
Big Reed Forest Reserve	24	75.6	5.7	64.5	85.1
Chamberlain Lake	16	76.3	4.2	69.2	81.4
Nahmakanta	50	76.5	31.8	30.9	152.7
Deboullie	31	79.1	33.7	30.9	199
Basin Preserve	18	81.5	24.7	38.2	155.3
Brownfield Bog	3	83.5	0	83.5	83.5
Narraguagus	5	84.6	0	84.6	84.6
Lower Kennebec Hammond	3	88.6	2.5	85.8	90
Bufflehead Corner	4	89	2.1	85.8	90
Bald Head Preserve	3	90	0	90	90
Flying Point	5	90	0	90	90
Lower Kennebec Arrowsic	3	90	0	90	90
Mahoosucs	28	92.5	21.3	68.4	119.7
Bigelow	47	93.4	29.8	56.2	199
Mt. Agamenticus	8	95.6	43.2	73.2	197.3
Mt. Abraham	32	98.4	15.1	82.9	121.4
Donnell Pond	18	98.8	14.3	63	112
Cutler	29	103.7	37.4	54.2	199
Spring River Lake	29	105.3	24.1	61.4	152.7
Salmon Brook Lake	13	108	31.7	63.6	140.3
Forest City	8	120.8	21.1	104	152.7
Duck Lake	26	127.6	27.5	106.8	199
Rocky Lake	9	134.9	45.4	99.3	199
Great Heath	13	142.6	46.7	91	199
Appleton Bog	10	146.1	66.2	87.2	220.4

n = number of monitoring plots; SD = standard deviation

Table D8. Descriptive statistics for soil C (Mg ha^{-1}) estimates from the soil surface to a depth of 30 cm associated with Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Killick/Little Ossipee	5	57.9	0.1	57.8	58.1
Kennebunk Plains	12	58.7	3.9	56.5	70.9
Great Duck Island	5	60.7	17.5	52.9	92
Waterboro Barrens Preserve	18	68.3	26.2	56.5	137.9
Big Spencer	30	78	27.8	26	100.1
Berry Woods	6	79	24.5	61.7	110.5
Back River IFW	2	88.2	31.6	65.8	110.5
Wassataquoik	17	90.4	22.5	57.3	142.2
St. John Ponds	35	92	37.6	62.3	295.1
Debsconeags	89	93	37.8	37.1	202.5
Gero Island	23	98.7	2.3	94.9	100.8
Big Reed Forest Reserve	24	99	3.8	89.4	105.1
Basin Preserve	18	101.6	37.7	65.1	228.4
Chamberlain Lake	16	101.8	6	94.9	109.9
Nahmakanta	50	101.9	39.5	37.1	202.5
Brownfield Bog	3	105.9	0	105.9	105.9
Deboullie	31	108.1	51.7	37.1	295.1
Lower Kennebec Hammond	3	108.5	3.5	104.4	110.5
Bufflehead Corner	4	109	3.1	104.4	110.5
Bald Head Preserve	3	110.5	0	110.5	110.5
Flying Point	5	110.5	0	110.5	110.5
Lower Kennebec Arrowsic	3	110.5	0	110.5	110.5
Narraguagus	5	112.8	0	112.8	112.8
Bigelow	47	120.1	42.2	76.9	295.1
Mt. Abraham	32	120.1	21.8	102.9	157.3
Donnell Pond	18	123.9	20.4	67.3	135.4
Mahoosucs	28	127.5	32.4	92.8	179.2
Mt. Agamenticus	8	127.7	69.6	88.1	295.9
Spring River Lake	29	132.1	34.6	67.3	202.5
Cutler	29	136.7	60.2	57.9	295.1
Salmon Brook Lake	13	143.5	41.5	76.6	185.1
Forest City	8	157.5	29.7	134.5	202.5
Duck Lake	26	163.2	48.2	130.6	295.1
Rocky Lake	9	188.8	75.9	134.2	295.1
Great Heath	13	194.5	82.8	118.9	295.1
Appleton Bog	10	202.8	104.6	111.6	321.6

n = number of monitoring plots; SD = standard deviation

Table D9. Descriptive statistics for soil C (Mg ha^{-1}) estimates from the soil surface to a depth of 100 cm associated with Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Great Duck Island	5	91	32.6	76.4	149.3
Back River IFW	2	103.8	44.3	72.5	135.1
Killick/Little Ossipee	5	106.5	0.5	105.7	106.8
Kennebunk Plains	12	108.2	7.8	103.2	132.5
Waterboro Barrens Preserve	18	116.1	24.5	103.2	188.4
Berry Woods	6	118.5	50	70	201.4
Big Spencer	30	123.4	40	30.1	156.1
Lower Kennebec Hammond	3	131.8	5.8	125.1	135.1
Bufflehead Corner	4	132.6	5	125.1	135.1
Bald Head Preserve	3	135.1	0	135.1	135.1
Flying Point	5	135.1	0	135.1	135.1
Lower Kennebec Arrowsic	3	135.1	0	135.1	135.1
Big Reed Forest Reserve	24	141	8.1	128.5	156.1
Gero Island	23	141.4	5.2	133.6	149.5
St. John Ponds	35	147.6	130.1	95.2	888.7
Chamberlain Lake	16	150	11.3	137.8	165.3
Basin Preserve	18	156.4	142.3	72.5	711.1
Wassataquoik	17	160	58.7	99.8	271.6
Debsconeags	89	167	59.5	50.2	307.4
Brownfield Bog	3	171.3	0	171.3	171.3
Mt. Abraham	32	171.9	39.5	117.1	235.5
Nahmakanta	50	175	56.8	50.2	307.4
Donnell Pond	18	179.7	40.2	76.7	204.7
Mahoosucs	28	180.9	37.7	139.1	222.3
Bigelow	47	189.6	114.5	102	888.7
Spring River Lake	29	193.4	57.9	76.7	307.4
Narraguagus	5	193.8	0	193.8	193.8
Deboullie	31	202.7	185.4	50.2	888.7
Mt. Agamenticus	8	223.7	244	123.8	825.2
Forest City	8	236.7	46.5	195.4	307.4
Cutler	29	266.1	219.2	66.6	888.7
Duck Lake	26	275	187.1	183.6	888.7
Salmon Brook Lake	13	307.5	141.4	119.7	451.7
Rocky Lake	9	435.2	324.6	184.2	888.7
Great Heath	13	456.6	355.6	184.2	888.7
Appleton Bog	10	484.8	398.6	156.5	945.8

n = number of monitoring plots; SD = standard deviation

Table D10. Descriptive statistics for soil C (Mg ha^{-1}) estimates from the soil surface to a depth of 150 cm associated with Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Great Duck Island	5	98.2	29.6	84.9	151.2
Back River IFW	2	103.8	44.3	72.5	135.1
Killick/Little Ossipee	5	115.5	0.5	114.5	115.7
Kennebunk Plains	12	117.1	7.7	111.9	141
Waterboro Barrens Preserve	18	125.1	24.4	111.9	200.8
Berry Woods	6	125.3	59.3	70	230.5
Big Spencer	30	129.4	43.8	30.1	161.6
Lower Kennebec Hammond	3	131.8	5.8	125.1	135.1
Bufflehead Corner	4	132.6	5	125.1	135.1
Bald Head Preserve	3	135.1	0	135.1	135.1
Flying Point	5	135.1	0	135.1	135.1
Lower Kennebec Arrowsic	3	135.1	0	135.1	135.1
Big Reed Forest Reserve	24	147.4	11.8	128.8	161.6
Gero Island	23	149.7	6.9	134.2	160.3
Chamberlain Lake	16	159	13.7	145	176.9
St. John Ponds	35	163.8	182.5	105.2	1208.1
Debsconeags	89	176	63.6	51.2	328
Basin Preserve	18	177.2	219.5	72.5	1043.9
Mt. Abraham	32	181.4	47.6	117.1	256.7
Nahmakanta	50	186	61.7	51.2	328
Donnell Pond	18	186.8	44	76.7	218.7
Mahoosucs	28	187.7	42.6	141.3	240.2
Wassataquoik	17	196.9	82.8	104.4	309.1
Brownfield Bog	3	203.2	0	203.2	203.2
Spring River Lake	29	204.2	63.3	76.7	328
Bigelow	47	209.6	160	102	1208.1
Narraguagus	5	214.3	0	214.3	214.3
Deboullie	31	229.4	263.2	51.2	1208.1
Mt. Agamenticus	8	236.2	267.1	124.3	894.4
Forest City	8	250.1	53.4	203.3	328
Cutler	29	311.6	312.9	66.6	1208.1
Duck Lake	26	314.4	268	196.6	1208.1
Salmon Brook Lake	13	373.3	195	129.4	572.6
Rocky Lake	9	539.9	461	196	1208.1
Great Heath	13	587.8	510.4	196	1208.1
Appleton Bog	10	663.1	626.4	157.8	1389.5

n = number of monitoring plots; SD = standard deviation

Table D11. Descriptive statistics for soil C (Mg ha^{-1}) estimates from the soil surface to 200 cm or bedrock associated with Ecological Reserve Monitoring plots by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Great Duck Island	5	100.3	28.7	87.5	151.7
Back River IFW	2	103.8	44.3	72.5	135.1
Killick/Little Ossipee	5	118.2	0.6	117.2	118.4
Kennebunk Plains	12	119.8	7.6	114.5	143.6
Berry Woods	6	126.9	62.4	70	239.2
Waterboro Barrens Preserve	18	127.8	24.4	114.5	204.6
Big Spencer	30	131.2	45	30.1	165
Lower Kennebec Hammond	3	131.8	5.8	125.1	135.1
Bufflehead Corner	4	132.6	5	125.1	135.1
Bald Head Preserve	3	135.1	0	135.1	135.1
Flying Point	5	135.1	0	135.1	135.1
Lower Kennebec Arrowsic	3	135.1	0	135.1	135.1
Big Reed Forest Reserve	24	149.3	13	128.8	164.2
Gero Island	23	152.2	7.6	134.3	164.2
Chamberlain Lake	16	161.7	14.6	145.4	180.3
St. John Ponds	35	168.6	198.3	108.2	1303.9
Debsconeags	89	177.7	64.7	51.2	334.2
Basin Preserve	18	183.5	242.7	72.5	1143.4
Mt. Abraham	32	184.3	50	117.1	263.1
Donnell Pond	18	188.9	45.3	76.7	222.9
Nahmakanta	50	189.1	63.4	51.2	334.2
Mahoosucs	28	189.6	44.2	142	245.5
Wassataquoik	17	206.9	90.9	105.8	318.5
Spring River Lake	29	207.5	65.1	76.7	334.2
Brownfield Bog	3	212.8	0	212.8	212.8
Bigelow	47	215.5	173.8	102	1303.9
Narraguagus	5	220.2	0	220.2	220.2
Deboullie	31	236.9	286.7	51.2	1303.9
Mt. Agamenticus	8	239.9	274.1	124.4	915.1
Forest City	8	254.1	55.7	203.5	334.2
Cutler	29	325.1	341.1	66.6	1303.9
Duck Lake	26	326.2	292.5	200.5	1303.9
Salmon Brook Lake	13	393	211	132.2	608.8
Rocky Lake	9	570.8	502.4	199.6	1303.9
Great Heath	13	627.2	556.9	199.6	1303.9
Appleton Bog	10	716.6	694.8	158.1	1522.6

n = number of monitoring plots; SD = standard deviation

Table D12. Descriptive statistics for the percentage (%, 0-100) of the total forest C stock represented by soil C from the soil surface to 200 cm or bedrock by Ecological Reserve.

Ecological Reserve	*n*	Mean	SD	Minimum	Maximum
Great Duck Island	5	46	11.4	36.1	65.5
Back River IFW	2	49.4	19.3	35.8	63.1
Lower Kennebec Hammond	3	51.6	7.4	45.8	59.9
Flying Point	5	52.6	8.5	39.8	61.6
Berry Woods	6	56.1	15	35.6	77.7
Big Spencer	30	57.4	10.1	39	72.3
Mt. Agamenticus	8	58	14.1	42.1	87.7
Bufflehead Corner	4	59	11.8	52.4	76.6
Bald Head Preserve	3	60.4	2.6	58.4	63.3
Gero Island	23	60.4	8.6	47.8	79.7
Lower Kennebec Arrowsic	3	60.6	8.2	51.2	66.3
Chamberlain Lake	16	61	7.9	47.6	81
Kennebunk Plains	12	62.4	7.8	47.6	79.1
Brownfield Bog	3	63.3	10.7	54.1	75.1
Big Reed Forest Reserve	24	63.7	8.4	48.6	91
Mahoosucs	28	63.7	10.4	43.1	81.2
Wassataquoik	17	63.8	14.1	43.4	92.3
Waterboro Barrens Preserve	18	65.2	10.6	39.3	84.7
Bigelow	47	65.3	9.1	45.9	91.1
Mt. Abraham	32	65.7	11.6	45	96.8
Basin Preserve	18	65.8	14.7	45	95.2
Debsconeags	89	66.1	11.3	39.6	89.9
Deboullie	31	67	12.7	41.4	94.3
Nahmakanta	50	67.8	12.4	38.2	96.6
Donnell Pond	18	69.6	10.2	44.4	88.8
St. John Ponds	35	70.2	16.5	35.2	97.7
Spring River Lake	29	71.5	11	41.8	90.8
Forest City	8	71.6	11.9	58.4	90
Killick/Little Ossipee	5	71.8	16.2	51.4	96.3
Duck Lake	26	74.6	8.4	57.5	96.1
Narraguagus	5	77.5	6.3	73.2	88.5
Cutler	29	78.1	12.2	48.5	99.9
Salmon Brook Lake	13	78.4	12.9	57.8	93.2
Appleton Bog	10	78.5	14.4	60.3	96.3
Great Heath	13	81	13.7	59.6	98.6
Rocky Lake	9	81.8	11.9	63.9	97.5

n = number of monitoring plots; SD = standard deviation

Table D13. Average aboveground (AG) and soil C (Mg ha^{-1}) by Ecological Reserve and Natural Community Type.

Ecological Reserve	Natural Community Type	*n*	AG C	Soil C
Appleton Bog	Atlantic White Cedar Swamp	3	82.9	1067.8
Appleton Bog	Northern Hardwoods Forest	2	97.3	158.1
Appleton Bog	Hemlock Forest	2	69	221.3
Appleton Bog	Open Cedar Fen	1	90.3	1522.6
Appleton Bog	White Pine Forest	2	96.6	840.4
Back River IFW	Oak - Northern Hardwoods Forest	1	130	72.5
Back River IFW	White Pine Forest	1	79.2	135.1
Bald Head Preserve	Early Successional Forest	1	92.1	135.1
Bald Head Preserve	Oak - Pine Forest	1	96.4	135.1
Bald Head Preserve	Oak - Northern Hardwoods Forest	1	78.2	135.1
Basin Preserve	Early Successional Forest	2	51.7	138.2
Basin Preserve	Hemlock Forest	2	135.8	140.5
Basin Preserve	Oak - Pine Forest	4	81.7	132.9
Basin Preserve	Pitch Pine Rocky Woodland	5	41.8	97.6
Basin Preserve	Oak - Northern Hardwoods Forest	1	57.8	1143.4
Basin Preserve	Lower Elevation Spruce - Fir Forest	2	117	103.8
Basin Preserve	Black Spruce Bog	1	26.2	239.2
Basin Preserve	White Pine Forest	1	121.9	135.1
Berry Woods	Oak - Pine Forest	6	93	126.9
Big Reed Forest Reserve	Northern Hardwoods Forest	7	90.9	137.4
Big Reed Forest Reserve	Evergreen Seepage Forest	1	68.4	164.2
Big Reed Forest Reserve	Enriched Northern Hardwoods Forest	1	16	161.1
Big Reed Forest Reserve	Montane Spruce - Fir Forest	1	110.4	149.1
Big Reed Forest Reserve	Spruce - Northern Hardwoods Forest	14	90.7	153.4
Big Spencer	Early Successional Forest	2	68	156.2
Big Spencer	Northern Hardwoods Forest	14	124.3	161.2
Big Spencer	Spruce - Fir Krummholz	1	13.8	30.1
Big Spencer	Lower Elevation Spruce - Fir Forest	4	66.9	86.3
Big Spencer	Montane Spruce - Fir Forest	4	83.4	76.9
Big Spencer	Spruce - Northern Hardwoods Forest	5	83.9	136.9
Bigelow	Early Successional Forest	3	88.3	152.5
Bigelow	Northern Hardwoods Forest	15	101.6	211.3
Bigelow	Subalpine Fir Forest	1	84.8	182.1
Bigelow	Lower Elevation Spruce - Fir Forest	3	78.3	143.9
Bigelow	Montane Spruce - Fir Forest	10	94.6	166.8
Bigelow	Spruce - Northern Hardwoods Forest	14	128.1	290.9
Bigelow	White Pine Forest	1	52.8	147.8
Brownfield Bog	Silver Maple Floodplain Forest	3	129.5	212.8
Bufflehead Corner	Hemlock Forest	1	121.5	135.1

n = number of monitoring plots

Table D13. Extended. Average aboveground (AG) and soil C (Mg ha^{-1}) by Ecological Reserve and Natural Community Type.

Ecological Reserve	Natural Community Type	*n*	AG C	Soil C
Bufflehead Corner	Oak - Pine Forest	2	77.8	135.1
Bufflehead Corner	White Cedar Woodland	1	113.7	125.1
Chamberlain Lake	Lower Elevation Spruce - Fir Forest	5	105.3	170.8
Chamberlain Lake	Spruce - Fir Wet Flat	3	72.4	174.9
Chamberlain Lake	Spruce - Northern Hardwoods Forest	4	112	149.3
Chamberlain Lake	White Pine Forest	4	124	152.9
Cutler	Alder Thicket	2	13.4	791.3
Cutler	Early Successional Forest	3	21.8	243.1
Cutler	Maritime Spruce - Fir Forest	5	70.2	156.8
Cutler	Red Maple Swamp	2	52.2	231.6
Cutler	Dwarf Shrub Bog	1	1.4	1303.9
Cutler	Lower Elevation Spruce - Fir Forest	15	79.6	288.4
Cutler	Spruce - Fir Wet Flat	1	75.9	238.5
Deboullie	Alder Thicket	1	10.8	180.3
Deboullie	Early Successional Forest	2	99	152.3
Deboullie	Northern Hardwoods Forest	8	78.7	164.9
Deboullie	Evergreen Seepage Forest	2	70.6	180.3
Deboullie	Northern White Cedar Swamp	2	120.2	1303.9
Deboullie	Lower Elevation Spruce - Fir Forest	5	98.4	141.5
Deboullie	Spruce - Northern Hardwoods Forest	11	101.1	169.5
Debsconeags	Early Successional Forest	5	65.1	211.4
Debsconeags	Northern Hardwoods Forest	6	79.6	168.9
Debsconeags	Evergreen Seepage Forest	2	62.1	219.7
Debsconeags	Hemlock Forest	4	134.5	107.3
Debsconeags	Northern White Cedar Swamp	1	58.8	334.2
Debsconeags	Spruce - Pine Woodland	3	23.7	51.2
Debsconeags	Lower Elevation Spruce - Fir Forest	28	91.5	199.1
Debsconeags	Spruce - Fir Wet Flat	1	65.9	209.5
Debsconeags	Montane Spruce - Fir Forest	7	95.7	162.5
Debsconeags	Spruce - Northern Hardwoods Forest	32	91.1	170.8
Donnell Pond	Early Successional Forest	2	31.8	202.3
Donnell Pond	Northern Hardwoods Forest	2	113.5	222.9
Donnell Pond	Lower Elevation Spruce - Fir Forest	11	85.5	178.5
Donnell Pond	Spruce - Northern Hardwoods Forest	3	88.6	195.6
Duck Lake	Early Successional Forest	6	94.5	230.1
Duck Lake	Northern Hardwoods Forest	1	115.3	230.7
Duck Lake	Northern White Cedar Swamp	2	57.4	267.3
Duck Lake	Red Maple Swamp	2	60.9	200.5
Duck Lake	Red Pine - White Pine Forest	4	120.4	267.3

n = number of monitoring plots

Table D13. Extended. Average aboveground (AG) and soil C (Mg ha^{-1}) by Ecological Reserve and Natural Community Type.

Ecological Reserve	Natural Community Type	*n*	AG C	Soil C
Duck Lake	Lower Elevation Spruce - Fir Forest	3	95.2	289.6
Duck Lake	Black Spruce Bog	3	55.8	568.3
Duck Lake	Spruce - Northern Hardwoods Forest	1	139.7	1303.9
Duck Lake	White Pine Forest	4	94.3	247.1
Flying Point	Oak - Pine Forest	4	138.5	135.1
Flying Point	White Pine Forest	1	84.4	135.1
Forest City	Early Successional Forest	1	141.7	265.3
Forest City	Hemlock Forest	3	136.4	203.5
Forest City	Red Pine - White Pine Forest	1	71.4	223.3
Forest City	Lower Elevation Spruce - Fir Forest	3	60	311.2
Gero Island	Hardwood Seepage Forest	1	128.7	149.1
Gero Island	Lower Elevation Spruce - Fir Forest	4	106.3	156.7
Gero Island	Spruce - Fir Wet Flat	6	81.3	151.6
Gero Island	Spruce - Northern Hardwoods Forest	10	113.8	153.2
Gero Island	White Pine Forest	2	104.4	141.7
Great Duck Island	Maritime Spruce - Fir Forest	5	117.3	100.3
Great Heath	Early Successional Forest	2	47	199.6
Great Heath	Evergreen Seepage Forest	1	108.8	1303.9
Great Heath	Lower Elevation Spruce - Fir Forest	7	87.1	516.8
Great Heath	Black Spruce Bog	2	32.2	1303.9
Great Heath	White Pine Forest	1	80.9	224.6
Kennebunk Plains	Hardwood Seepage Forest	2	100.8	115.8
Kennebunk Plains	Oak - Pine Woodland	3	81.4	117.1
Kennebunk Plains	Pitch Pine - Heath Barren	1	31.4	118.4
Kennebunk Plains	Pitch Pine - Scrub Oak Barren	1	50.1	118.4
Kennebunk Plains	White Oak - Red Oak Forest	5	74.1	123.5
Killick/Little Ossipee	Pitch Pine - Scrub Oak Barren	2	48.8	118.4
Killick/Little Ossipee	White Pine Forest	3	56.1	118
Lower Kennebec Arrowsic	Oak - Pine Forest	2	72.1	135.1
Lower Kennebec Arrowsic	Oak - Northern Hardwoods Forest	1	128.7	135.1
Lower Kennebec Hammond	Oak - Pine Forest	1	129.9	125.1
Lower Kennebec Hammond	Oak - Northern Hardwoods Forest	1	90.4	135.1
Lower Kennebec Hammond	White Pine Forest	1	159.8	135.1
Mahoosucs	Northern Hardwoods Forest	16	115.3	172
Mahoosucs	Subalpine Fir Forest	1	92.1	221.8
Mahoosucs	Maritime Spruce - Fir Forest	1	53.2	208.3
Mahoosucs	Oak - Northern Hardwoods Forest	1	125.7	142
Mahoosucs	Montane Spruce - Fir Forest	6	106.7	220.5
Mahoosucs	Spruce - Northern Hardwoods Forest	3	76.2	220.7
Mt. Abraham	Early Successional Forest	1	44	255.3

n = number of monitoring plots

Table D13. Extended. Average aboveground (AG) and soil C (Mg ha^{-1}) by Ecological Reserve and Natural Community Type.

Ecological Reserve	Natural Community Type	*n*	AG C	Soil C
Mt. Abraham	Northern Hardwoods Forest	4	75.9	250
Mt. Abraham	Subalpine Fir Forest	11	98.6	152.7
Mt. Abraham	Spruce - Fir Krummholz	1	38.2	142
Mt. Abraham	Lower Elevation Spruce - Fir Forest	2	121.7	219.3
Mt. Abraham	Montane Spruce - Fir Forest	9	107.2	164
Mt. Abraham	Spruce - Northern Hardwoods Forest	4	121	226.2
Mt. Agamenticus	Chestnut Oak Woodland	1	152.9	124.4
Mt. Agamenticus	Hemlock Forest	3	131.1	137.4
Mt. Agamenticus	Red Maple Swamp	1	128.2	915.1
Mt. Agamenticus	Oak - Northern Hardwoods Forest	3	113	155.9
Nahmakanta	Early Successional Forest	14	71.6	142.7
Nahmakanta	Northern Hardwoods Forest	3	74.7	186.4
Nahmakanta	Hardwood Seepage Forest	2	67.4	165.6
Nahmakanta	Pocket Swamp	1	176	229.3
Nahmakanta	Hemlock Forest	3	95.3	220.7
Nahmakanta	Northern White Cedar Swamp	1	89.7	244.4
Nahmakanta	Spruce - Pine Woodland	1	11.7	334.2
Nahmakanta	Lower Elevation Spruce - Fir Forest	6	90.8	188.7
Nahmakanta	Spruce - Fir Wet Flat	1	96.8	187.7
Nahmakanta	Spruce - Northern Hardwoods Forest	16	97.4	219.3
Nahmakanta	White Pine Forest	2	109.2	133.5
Narraguagus	Early Successional Forest	1	80.8	220.2
Narraguagus	Lower Elevation Spruce - Fir Forest	2	68.1	220.2
Narraguagus	Black Spruce Barren	1	28.6	220.2
Narraguagus	White Pine Forest	1	80.4	220.2
Rocky Lake	Alder Thicket	1	28.3	1094.6
Rocky Lake	Early Successional Forest	1	46.3	199.6
Rocky Lake	Evergreen Seepage Forest	1	112.7	199.6
Rocky Lake	Oak - Northern Hardwoods Forest	1	84	199.6
Rocky Lake	Lower Elevation Spruce - Fir Forest	5	74.1	688.7
Salmon Brook Lake	Evergreen Seepage Forest	4	89.6	305.1
Salmon Brook Lake	Northern White Cedar Swamp	2	71.3	608.8
Salmon Brook Lake	Lower Elevation Spruce - Fir Forest	3	78.3	338.8
Salmon Brook Lake	Spruce - Fir Wet Flat	1	49	608.8
Salmon Brook Lake	Black Spruce Bog	1	44.1	608.8
Salmon Brook Lake	Spruce - Northern Hardwoods Forest	2	106	218.6
Spring River Lake	Early Successional Forest	3	63	228.9
Spring River Lake	Northern Hardwoods Forest	3	70	181.8
Spring River Lake	Evergreen Seepage Forest	1	86.4	126.7
Spring River Lake	Hemlock Forest	1	57	245.8

n = number of monitoring plots

Table D13. Extended. Average aboveground (AG) and soil C (Mg ha^{-1}) by Ecological Reserve and Natural Community Type.

Ecological Reserve	Natural Community Type	*n*	AG C	Soil C
Spring River Lake	Oak - Pine Woodland	1	37	76.7
Spring River Lake	Red Maple Swamp	1	48.2	234.3
Spring River Lake	Oak - Northern Hardwoods Forest	6	82	220
Spring River Lake	Lower Elevation Spruce - Fir Forest	6	89.9	203.7
Spring River Lake	Spruce - Fir Wet Flat	1	70.3	234.3
Spring River Lake	Spruce - Northern Hardwoods Forest	5	94.2	220.5
Spring River Lake	White Pine Forest	1	94.3	222.9
St. John Ponds	Alder Thicket	2	14.2	123.6
St. John Ponds	Early Successional Forest	1	27.5	164.2
St. John Ponds	Northern Hardwoods Forest	18	97.9	201.5
St. John Ponds	Tall Grass Meadow	1	5.9	149.1
St. John Ponds	Evergreen Seepage Forest	1	17.7	115.5
St. John Ponds	Lower Elevation Spruce - Fir Forest	6	45.6	129.4
St. John Ponds	Spruce - Fir Wet Flat	4	59.8	123.6
St. John Ponds	Spruce - Northern Hardwoods Forest	2	47.3	164.2
Wassataquoik	Northern Hardwoods Forest	5	108.8	234.2
Wassataquoik	Upper Floodplain Hardwood Forest	4	97.9	263.7
Wassataquoik	High Gradient Floodplain Forest	2	157.5	202.8
Wassataquoik	Silver Maple Floodplain Forest	2	55.2	134
Wassataquoik	Lower Elevation Spruce - Fir Forest	3	125.6	171
Wassataquoik	Spruce - Northern Hardwoods Forest	1	124	105.8
Waterboro Barrens Preserve	Hardwood Seepage Forest	1	37	204.6
Waterboro Barrens Preserve	Oak - Pine Forest	3	110.1	129.1
Waterboro Barrens Preserve	Oak - Pine Woodland	1	52	118.4
Waterboro Barrens Preserve	Pitch Pine - Heath Barren	1	47.8	118.4
Waterboro Barrens Preserve	Pitch Pine - Scrub Oak Barren	11	68	118
Waterboro Barrens Preserve	White Oak - Red Oak Forest	1	80.3	174.3

n = number of monitoring plots