Overview of MassWildlife Carbon Analysis

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In 2018, MassWildlife continued an ongoing process of accounting for carbon sequestration and emissions from agency forest land to ensure that we are able to meet our agency mandates while remaining in compliance with the Global Warming Solutions Act. Prior to this accounting, we had relied on a growth and yield analysis developed during forest certification efforts early in the century, which ensured that our habitat management operations removed far less volume of wood products than the annual growth. While this analysis led us to believe that the same would be true for carbon emissions vs. carbon sequestration, we wanted to apply as much rigor to the carbon question as we were able. We recognized that as a small program within a small agency, we lacked the funding or staff to compile data on a rolling continuous forest inventory basis with frequent carbon monitoring in the field, but part of our goal was to determine the overall magnitude of our net carbon sequestration and to determine future tasks and projects that would best refine our analysis.

Regulatory Background

> "The people shall have the right to clean air and water, freedom from excessive and unnecessary noise, and the natural, scenic, historic, and esthetic qualities of their environment; and the protection of the people in their right to the conservation, development and utilization of the agricultural, mineral, forest, water, air and other natural resources is hereby declared to be a public purpose."
>
> –from Article XCVII of the Massachusetts Constitution

In 2019, we presented a preliminary analysis to the Fisheries & Wildlife Board (FWB), the citizen board that sets policy for MassWildlife, and to numerous other boards, committees, and public venues. A popular article based on this analysis was published in the December 2019 issue of *Massachusetts Wildlife* magazine. The FWB presentation began with a review of the constitutional, legislative, and executive background underlying this issue. The Commonwealth's constitutional provision on natural resources, Article XCVII, includes the conservation, development, and utilization of natural resources as a public purpose. The Global Warming Solutions Act (GWSA) in 2008 set state-wide carbon emissions reduction targets: 25% below the 1990 level by 2020, 80% below the 1990 level by 2050. A series of executive orders implemented this act for executive agencies, including Executive Order No. 569 (EO-569), which established an integrated climate change strategy for the Commonwealth to meet the GWSA targets. This order includes in section EO-569 3-1(vi) a requirement for "strategies that conserve and sustainably employ the natural resources of the Commonwealth to enhance climate adaptation, build resilience, and mitigate climate change."

As described on the agency's website, "MassWildlife is responsible for the conservation of freshwater fish and wildlife in the Commonwealth, including endangered plants and animals. MassWildlife restores, protects, and manages land for wildlife to thrive and for people to enjoy." The FWB has previously adopted habitat composition goals to support this mission. These goals include reserving 10-15% of MassWildlife upland habitat as biologically mature forests dominated by trees greater than 120 years

old with forest reserves intended to grow into that condition; 20-25% of our upland habitat as grassland, shrubland, and young forest less than 30 years old, and the remainder as full canopy forests dominated by trees 30-120 years old.

In preparing for our carbon analysis, we identified carbon stocks or storage (carbon "in the bank") as including carbon in the soil, forest floor, down dead wood, standing dead, coarse roots, shrubs and herbs, and aboveground live trees, and the carbon sequestration rate (carbon "interest") as the amount added each year through growth and accumulation net of mortality and removals. Carbon release was defined as carbon that was removed from storage and released to the atmosphere, primarily as carbon dioxide, through the decay of biomass and the harvest and utilization of short-term forest products.

Estimating 2006 Forest Carbon Stocks

As MassWildlife does not yet have a continuous forest inventory program (in which a portion of permanent inventory plots would be sampled each year on a rolling basis), we used projections from our existing 2008 allowable harvest analysis that had used remote sensing and field inventory data through 2006 to estimate wood volumes (total merchantable volume) by tree species and forest type. Conversion factors from a USDA Forest Service publication, Carbon Storage and Accumulation in United States Forest Ecosystems, were used to estimate above- and below-ground carbon in biomass by forest type. These data and analysis appear in the MassWildlife Carbon Analysis (MCA) spreadsheet beginning with the tab labelled "Volumes by Cover Type." The calculated carbon stocks in 2006 ranged from 17 tons/acre (in a few acres of Pitch pine-Northern Hardwoods forest or PpNH) to 75 tons/acre (Wp), with an average weighted by acres of forest type of 43.9 tons/acre of carbon in biomass on MassWildlife forests. The GWSA analysis from the Executive Office of Energy and Environmental Affairs (EEA) estimated a statewide average of 55 tons/acre of forest soil carbon stocks in 2006, which we used as an initial estimate until we are able to refine this based on soil types. This was added to the above figures to arrive at total carbon stocks in 2006. Those per-acre averages were then used as the starting points for forest biomass and soil carbon stocks in the MCA Summary spreadsheet.

Estimating Annual Change in Forest Carbon

To estimate annual changes in forest carbon, we took a similar approach. Our original allowable harvest analysis had determined growth rates in merchantable volume by species (net of mortality), and applied these to each forest type. This average growth rate was then used to estimate volume growth in above-ground biomass and to grow forest forward. One implication of using a net growth rate is that it does not account for mortality transferring carbon from live biomass to standing dead, downed woody material, or other carbon pools, thus underestimating overall sequestration rate. A future refinement should take these additional carbon pools into account. We used an average of these growth rates weighted by tree species and forest type to calculate that net sequestration of carbon in biomass due to growth averaged 0.74 tons/acre/year on MassWildlife forest. We recognize that using a fixed increment of carbon accumulation, rather than a percentage, likely also underestimates the sequestration of carbon. However, we took this conservative approach as an initial step, until we are able to refine it with annual estimates of species growth from FIA data. The EEA GWSA analysis used an estimated average of 0.09 tons/acre/year of carbon sequestration in forest soils in Massachusetts, and we adopted that figure until we are able to refine it based on individual soil types. These per-acre averages were used to project forest biomass and soil carbon forward from our 2006 baseline in the MCA Summary sheet.

The primary removal of forest carbon from MassWildlife forests is due to habitat management activities to meet MassWildlife's habitat goals described above. MassWildlife maintains a database of wood products harvest practices used for habitat management on Wildlife Management Areas (WMAs), and we are in the process of collecting data for harvests on privately-owned lands that are subject to a Wildlife Conservation Easement (WCEs). These WCE data are incomplete at the time, thus underestimating carbon removals by an unknown amount. We distinguished between short-lived products (fuelwood, pulpwood, harvest residues, mill/construction waste) and long-lived products (e.g., furniture and construction), accounting for short-lived products as representing immediate carbon emissions. We used an analysis published by the Wilderness Society on Wood Products and Carbon Storage Reduction to determine the amount of long-lived wood products to account as immediate emissions and the amount of carbon remaining stored in those products after 100 years.

Finally, since 2006, MassWildlife has protected an additional 57,000 acres of WMAs and WCEs. For the purposes of this analysis, we assumed that new acquisitions are similar in storage and growth to already inventoried forests on a per-acre basis at the time of their acquisition. We recognize that this introduces additional uncertainty into our analysis, and hope to complete forest inventories on these recent acquisitions, subject to funding and staff time.

Worksheets in the MassWildlife Carbon Analysis

Although originally located in several linked spreadsheets, we have integrated all of the relevant sheets into a single Excel workbook for ease of viewing.

Worksheet	Description
ToDo	List of assumptions made, improvements needed, implications, future refinements desired, data needs, and blocking factors.
Summary	Pulls together data from other worksheets and projects carbon sequestration by year.
Budget	Simplified presentation of outputs from Summary worksheet
Graphs	Selection of graphs based on output of Summary worksheet
DFG Fee	Export from MassGIS OpenSpace data on acres of land acquired in fee simple by DFG
DFG CR	Export from MassGIS OpenSpace data on acres of land on which a wildlife conservation interest was acquired by DFG
Harvests	Export from MassWildlife Wood Products Harvest database
Harvests by Year	Summary report from Harvests worksheet
Constants	Constants used in calculations in Harvests worksheet
Forest Soil C	Converts GWSA Mg CO2e to tons C
Long-term Losses	Calculation of carbon remaining in long-termed forest products after 100 years, used to determine amount of carbon released from long-term forest products
gwsa-appc 2018 C Seq Forests	Export from GWSA 2018 estimate of forest carbon. Used only for carbon in forest soils
Volumes by Cover Type	Export from 2008 allowable harvest analysis of merchantable timber volume by forest type and tree species, with added columns to estimate carbon in biomass

Download the MassWildlife Carbon Analysis