Governor's Task Force
on the
Creation of a Forest Carbon Program

Final Report

October 29, 2021

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Maine Forest Carbon Program Task Force

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Executive Summary

The Governor's Task Force on the Creation of a Forest Carbon Program was established by Executive Order on January 13, 2021. The Executive Order directs the Task Force to develop incentives to encourage forestland management practices that increase carbon storage specifically on woodland owners of 10 to 10,000 acres while maintaining harvest levels overall. It notes the negative impacts climate change is having on Maine, and recognizes that Maine's forests, which cover 89% of the state, currently sequester an amount of carbon equal to at least 60% of the state's annual carbon emissions, or 75% when durable forest products are included. It also notes that Maine is losing an estimated 10,000 acres of natural and working lands to development each year, and that this development is a direct source of carbon emissions and hinders the growth of natural climate solutions. The work of the Task Force advances that recommendation of the Maine Climate Council's Natural and Working Lands Work Group to develop incentives that increase carbon storage on this forestland size category while maintaining harvest levels.

The Task Force also identified certain overarching principles that are foundational to the success of Maine's forests in sequestering more carbon. These include:

- Maintaining existing forestland ("keeping forests as forests") is fundamentally important if forests are to make a growing contribution toward achieving the State's climate goals. The Task Force supports increasing state, federal, and private funding for forestland protection, including funding for conservation easements or fee purchase. To monitor Maine's progress in this regard, the Task Force recommends that the Department of Agriculture, Conservation and Forestry (DACF) be permanently tasked with tracking the amount and type of conserved land in Maine (including municipal, NGO, state, and federal lands), and also tracking forestland loss.

- It is equally important to increase forest carbon on existing forestland by improving forest condition through the widespread adoption of sustainable forest practices that increase carbon sequestration, both through more intensive silvicultural management of stands that will increase forest growth, and by delayed harvests that allow trees to mature into older forest, resulting in greater carbon storage, which also increases the opportunity to store more carbon in long-lived forest products.

- The adoption of carbon-enhancing forest practices depends on the existence of economically viable markets for low-grade wood. Such markets incentivize Maine woodland owners and loggers to practice sustainable forestry that results in improved silviculture. The lack of such markets is a particular and ongoing challenge for Maine woodland owners and loggers. While markets alone do not inherently produce climate benefits, they are a necessary part of the equation as they can either reduce the costs of climate-beneficial practices or even make

them profitable. Expanded, financially viable markets for low-grade wood will also help to counteract pressures to convert forestland to non-forest uses.

In offering its ambitious recommendations, the Task Force also offers a note of caution, acknowledging the significant uncertainties that influence the health and productivity of Maine's forests. These vulnerabilities, exacerbated by climate change, include impacts from pest outbreaks, disease, extreme weather events, wildfire and invasives, all of which can have a negative bearing on the ability of Maine's forestland to sequester carbon. Despite these risks, the Task Force enthusiastically supports the recommendations in this report, understanding the important role Maine's forests currently play in sequestering carbon, and the potential of Maine's forests to continue to make significant contributions to achieving Maine's climate goals.

This report is structured to align with the nine directives outlined in the Governor's Executive Order. These directives provide the framework for actions the Task Force is recommending be taken to develop a voluntary, incentive-based program for woodland owners of 10 to 10,000 acres and forestry practitioners to increase carbon storage in Maine's forests. In broad terms, these actions aim to:

- Increase investment in forestland conservation
- Encourage, promote, and incentivize the voluntary adoption of climate-friendly forest management practices
- Promote the expansion of markets for low-grade wood
- Highlight the need for better data regarding harvest levels within this broad landowner size class, and the relative effectiveness of various forest management practices in increasing carbon sequestration
- Significantly increase technical assistance to landowners by expanding Maine Forest Service capacity and engaging licensed consulting foresters
- Increase alignment with federal funding programs that support forest carbon sequestration efforts
- Explore partnerships with a private entity or entities to support the development of a voluntary credit-based and/or practice-oriented carbon program
- Promote climate-friendly timber harvesting practices and support the use of low-impact harvesting equipment
- Identify a suite of potential changes to the Open Space Current Use Taxation program that integrate carbon management elements into the program
- Encourage coordination between landowners of 10-10,000 acres and large, commercial forestland owners for mutual learning and benefit
- Recognize the potential of collaborating with other states to increase investment in forest carbon sequestration
- Establish a statewide total forest sector carbon sequestration target

These and many other supporting recommendations are further articulated in the report sections that follow.

1. Review current harvest levels and carbon stocking data on woodland owners of 10 to 10,000 acres.

To better understand current harvest levels and carbon stocking on 10-10,000-acre woodland ownerships, the Task Force first sought information from University of Maine representatives and the Maine Forest Service (MFS) on the distinction between carbon storage and sequestration, how and where carbon is stored in forests, and the capacity of Maine's forests to sequester more carbon. **Carbon storage is the amount (stock) of carbon stored in the forest ecosystem and in harvested wood products at a specific point in time. Carbon sequestration is the change in that stock over a given period of time, typically one year.**

Non-profit and state agency personnel provided the Task Force with an understanding of Maine woodland owner demographics. Maine woodland owners with 10-10,000 acres comprise a highly diverse group. There are approximately 86,000 Maine family woodland owners of 10 acres or more, and according to the USDA Forest Service's National Woodland Owner Survey (NWOS), family woodland ownerships (10+ acres) represent 29% of Maine's private land base. There are some corporate owners that fall into this size class category too. Sixty percent of landowners with between 10 to 10,000 acres are individuals 65 years or older, while only 4% of this landbase is owned by individuals 45 years or younger. Only 27% of landowners with 10-10,000 acres have a management plan, but 90% of those with a plan report they have implemented at least part of their plan. This points to the importance of helping more woodland owners develop forest management plans as an effective step toward the adoption of forest stewardship practices that increase carbon sequestration and storage.

Active forest stewardship is considerably less prevalent on the smaller end of the 10-10,000- acre ownership spectrum than on its larger end. Yet taken as a whole, 10-10,000-acre ownerships, which account for at least 24% of the private land area and 27% of the standing aboveground carbon, produce at least 24% of the state's annual wood harvest (Table 1). Estimates of acres, standing aboveground biomass, and harvest vary greatly depending on which data source is being used, highlighting that more definitive data are needed to better understand this ownership class. Forest Inventory and Analysis Program (FIA) data on all small private ownerships (family and corporate) estimate that the area may comprise 43% of the private forest. However, the ownership data that are presently available are incomplete, leaving many acres that could not be assigned to an appropriate ownership size class (see Appendix B). Despite the variation between data sources, it is apparent that small woodland owners make up a sizable amount of Maine's forest area, stored carbon, and harvest base. These data also support conducting further analysis

to estimate how improving forest stewardship for this ownership size class could influence the state's forest carbon sequestration.

Table 1. Task Force estimates of acres owned, stocking, removals, and potential harvested wood in long-term storage for Maine's 10 - 10,000 acres forest ownership size class.

Estimate	Low End	High End	Best Guess	All Private Forest	% Total Private – Best Guess (low, high)
Total Acres Owned (million acres)					
NWOS acres (family forests only)	N/A	N/A	4.7	16.1	29%
FIA acres (family and corporate)	3.9	10.9	6.9	16.1	43% (24%, 68%)
Total Carbon Stock (million metric tons of carbon)					
FIA aboveground carbon	78.1	199.3	134.3	289.5	46% (27%, 69%)
*Total carbon stock (million metric tons of carbon dioxide equivalents) **					
FIA aboveground carbon (assuming released as CO_2 only)	286.6	731.4	492.9	1,062.5	46% (27%, 369%)
Total Harvest (million dry tons)					
FIA bole removals (2019)	2.2	6.0	3.8	9.1	42% (24%, 66%)
*Total Long-Term Harvested Wood Product Storage (green tons)***					
Sawlog wood products	0.8	1.2	1.0	2.3	44% (36%, 51%)

NWOS: National Woodland Owners Survey; FIA: Forest Inventory and Analysis

*Forest carbon (C) stocks are typically reported in tons of C (a solid that is a relatively constant proportion of total forest biomass), while the standard unit for reporting GHG emissions and removals is metric tons of carbon dioxide equivalents (CO_2e). Because the dominant gas phase of C in the atmosphere is CO_2, the CO_2e standard of expression has been widely adopted to normalize the comparison of different forest C forms or atmospheric GHGs. If we assume C is released into the atmosphere as CO_2 (ignoring minor forms of C gas emissions from forests, such as methane (CH_4)), the atomic weight of each element (i.e., C and oxygen (O)) in the CO_2 molecule can be used to calculate the expression of C in the form of CO_2 (that is the mass of the gas if we add O and C molecules). The atomic weight of C and CO_2 are 12 and 44 grams per mole, respectively; therefore, one ton of C equals approximately 44/12 or 3.67 tons of CO_2.

GHGs include a variety of compounds, most notably carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6). While CO_2 is the most abundant GHG, other GHGs also include C (e.g., CH_4) while still others contain no C (e.g., N_2O or SF_6) even though they all have the radiative properties that warm the atmosphere. Standard units of CO_2e are used to compare GHG emissions and removals by calculating the equivalent impact on atmospheric warming based on the unique global warming potential (GWP) of each gas as though they were all CO_2, and thus the concept of a CO_2 "equivalent."

When C is stored in the form of biomass in a forest, the C molecule is most commonly released back to the atmosphere by stem and root respiration from living trees, or microbial respiration resulting from the decomposition of dead organic materials dominated by tree mortality in the forest. However, other forms of the C molecule can be released, particularly in wet soils (e.g., CH_4) or when a tree is burned (e.g., GHGs including CO_2, CH_4, and N_2O are released to the atmosphere). The type of GHG is important because of the unique GWP of each GHG that encompasses both the radiative forcing of that particular molecule and the length of time that it remains in the atmosphere. Converting all GHG emissions into CO_2e requires knowledge of how much of each gas is emitted as well as the GWP for each gas. Based on the IPCC Sixth Assessment Report (2021, Table 7.15), the 100-year GWP (GWP-100) for non-fossil-fuel-based CH_4 is 27.2, for N_2O is 273, and for CO_2 is 1. GHGs must be multiplied by their GWP-100 to be converted to CO_2e, thus a single molecule of CO_2 equals 1 CO_2e while a single molecule of CH_4 equals 27.2 CO_2e.

**Sawlogs account for 31% of harvest; assume 60% of sawlog volume at time of harvest goes into long-term storage. Accounting for sawlog product decay over time would reduce this figure.

Additional data on the known area of small woodland owners provided by the U.S. Forest Service's FIA program (i.e., 4.0 million acres) can be used to better understand how the metrics presented above vary by stocking and stand size class, as listed in Table 2. These estimates highlight how different combinations of stand classifications have varying levels of biomass (and carbon) stock and density as well as their relative contribution to the total annual removals across this specific landowner size. This information can be used to help identify how forest carbon could be enhanced by making changes to the landscape, such as thinning overstocked stands or planting poorly stocked forests. As an illustrative example based on these data, the Task Force roughly estimates that implementing management practices that shift all 1.5 million acres of poorly and moderately stocked stands to well-stocked could increase the FIA's reported estimate of small woodland owners forest aboveground carbon stocks by about 57 million metric tons of carbon dioxide equivalent ($MtCO_2e$), a gain of 20% compared to their current state. Assuming this transition would occur over 30 years, this could result in about 1.9 $MtCO_2e$/yr in additional forest carbon sequestration. To be clear, the Task Force does not expect that every acre will experience this change. The Task Force also cautions that the data used to derive these estimates have high uncertainty, and thus should not be used to derive a specific mitigation target. Rather, it supports the idea that improving forest stewardship and stocking levels should result in increased carbon sequestration and storage in Maine's small woodlands.

Table 2. FIA reported estimates for aboveground biomass, removals, and area organized by stocking class and stand size class for all known ownerships of 10-10,000 acres

FIA Size Class*	Area (Acres)	Aboveground Biomass (dry tons)^	Biomass Density (dry tons/ac)	Annual Removals (dry tons/yr)	% Total Removals	Opportunity to Increase Forest C
			Overstocked			
Large	51,713	5,720,547	111	13,359	1%	
Medium	74,820	4,976,064	67	0	0%	Thin
Small	216,187	4,616,750	21	104,496	5%	Thin
Total	342,720	15,313,361	45	117,855	5%	
			Well stocked			
Large	777,686	54,957,311	71	145,667	6%	
Medium	844,108	42,568,368	50	62,570	3%	
Small	427,575	8,891,641	21	322,435	14%	
Total	2,049,369	106,417,320	52	530,672	23%	
			Moderately Stocked			
Large	522,934	23,364,121	45	627,561	28%	
Medium	613,812	19,576,937	32	332,761	15%	
Small	150,097	2,696,456	18	317,020	14%	Enrich. Plant
Total	1,286,843	45,637,513	35	1,277,341	56%	
			Poorly stocked			
Large	104,419	3,032,178	29	121,441	5%	
Medium	155,394	3,135,600	20	190,770	8%	
Small	16,288	123,273	8	21,559	1%	
Total	276,100	6,291,051	23	333,769	15%	Enrich. Plant
			Non-stocked			
Large	291	0	0	0	0%	
Medium	1,157	857	1	0	0%	
Small	1,785	0	0	0	0%	Plant
Non-stocked	10,006	55,304	6	2,124	0%	Plant
Total	13,239	56,160	4	2,124	0%	Plant
			10-10,000 Acre Landowner Total			
Large	1,457,043	87,074,157	60	908,027	40%	
Medium	1,689,290	70,257,825	42	586,101	26%	
Small	811,932	16,328,120	20	765,510	34%	
Non-stocked	10,006	55,304	6	2,124	0%	
Total	3,968,272	173,715,406	44	2,261,762	100%	

* FIA classification of the predominant (based on stocking) diameter class of live trees, where at least 10% of stand is forested. For large and medium classification, at least 50% of the stand is in large and medium trees, and classification is based on the highest proportion of those two size classes.

Large diameter: trees at least 11" diameter for hardwoods, 9" for softwood

Medium diameter: trees at least 5" in diameter but less than the large diameter trees

Small diameter: less than 5" in diameter trees

Non-stocked: less than 10% of stand is forested

^ dry biomass weight can be converted to carbon by multiplying the value by 0.5

2. Review available data for practice-based carbon programs throughout the United States.

With information provided by non-profit and University representatives, the Task Force considered the essential elements of carbon offsets, the history of carbon offset projects in Maine, and the general nature of voluntary and regulatory U.S. carbon markets. In particular, information on the following programs was reviewed and discussed: American Forest Foundation and The Nature Conservancy's Family Forest Carbon Program; FiniteCarbon's Core Carbon Program; SilviaTerra's Natural Capital Exchange; Vermont's Cold Hollow Carbon; Land Trust Alliance's Forest Carbon Offset Pilot Program; Maine's Forest Carbon for Commercial Landowners Project; Maine Mountain Collaborative's Exemplary Forestry Investment Fund; Northeast Wilderness Trust's Wild Carbon Program; Georgia's Sustainable Development Carbon Registry; and Nova Scotia's Forest Sustainability regulations. This analysis contributed to the specific recommendations contained in Sections #3 and #4 below, which identify a priority suite of climate-friendly forest management practices that could be adopted, and technical assistance and financial incentives that could be implemented, to maximize carbon sequestration and storage on Maine woodlands of 10-10,000 acres.

3. Identify a suite of climate-friendly forest management practices that improve carbon stocks and maintain current timber harvest levels.

As noted in Section #1 above, the 10-10,000 acre ownership range includes a very diverse group of landowners with significantly different levels of engagement with and management of their lands, including different harvesting practices. Though sufficient detail is lacking, the Task Force believes that significantly more harvesting occurs on ownerships of 1,000 acres and larger, and that smaller ownerships, particularly in the southern half of the state, are generally less likely to have been harvested in recent decades. The Task Force believes more active forest management on lands of 10-10,000 acres is an important strategy to achieve increased carbon sequestration and storage while maintaining harvest. Given this, the Task Force interprets the Executive Order directive of "maintaining current harvest levels" to mean "at a minimum," and that it is therefore necessary to 1) establish what the baseline harvest level is for logical acreage segmentations within this broad size class, and 2) identify practices that improve carbon stocks while maintaining or increasing harvest levels (at a broad scale, as opposed to on each specific parcel).

After reviewing the wide range of emerging voluntary forest carbon programs throughout the U.S., as described in Section #2 above, the Task Force concluded that consensus is building around the following forest practices having the greatest potential to achieve carbon benefits. Significantly more research is needed to understand the relative benefits associated with each practice as well as implementation costs. However, Maine's forest carbon program should focus on incentivizing a suite of forest practices, including:

Avoid Forest Conversion

- Avoid forestland loss/incentivize forest conservation (through conservation easements or fee purchases) to maintain forest ecosystem carbon and the potential for continued sequestration.

Enhance Forest Resiliency

- Manage competition from invasives, non-native tree species or species not suited to the site.
- If relying on natural regeneration, plan the harvest to regenerate the site quickly with desired species.
- When planting, select species well-suited to the site and a changing climate.
- Plan to reduce the risk of carbon losses from disturbances (e.g., wildfire, exotic and endemic insect infestations).

Conduct Intermediate Treatments

- Increase stocking in understocked stands.
- Conduct thinning in immature and/or overstocked stands to stimulate growth of the remaining trees and increase the yield of useful material from the stand (evaluate short-term carbon losses against longer-term forest and forest product carbon benefits):
  - Precommercially thin saplings and small poles.
  - Commercially thin (uniform thinnings or crop tree releases).
- Retain more carbon in thinnings (retain large-diameter live trees, snags, and species and age diversity).
- Focus investments in intensive silvicultural treatments on sites with high carbon value potential (superior soils, drainage, aspect).

Practice Sustainable Harvesting

- Seek to increase the proportion of harvested materials likely to be used in long-lived wood products.
- Manage partial harvests thoughtfully to retain quality trees and minimize stand damage and soil disturbance.
- Extend harvest cycles to grow larger trees that are more likely to be used in long-lived wood products.
- Utilize timber harvesting professionals, including licensed consulting foresters trained in climate-friendly harvesting practices.

Establish Forest Reserves

- Establish forest reserves on sites with high carbon density and in areas of special ecological value to allow the development of late-successional forest.

This suite of sustainable forest practices should be encouraged, promoted, and/or incentivized through existing voluntary state forest management programs to incorporate climate objectives into these programs. This includes the Forest Stewardship Program and the Open Space Current Use Taxation Program (see Section #6 below).

Efforts should be made to similarly implement these practices through U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) programs. To accomplish this, NRCS program funding needs to be increased, with programs achieving higher visibility and reaching a much broader cross-section of small woodland owners through targeted outreach and technical assistance. NRCS cost-share practices should be developed that are specifically aimed at increasing carbon sequestration and storage, and administrative requirements must be simplified in order for programs to appeal to small landowners. Toward this end, the NRCS

program should build off the successes of the NRCS Regional Conservation Partnership Program's efforts nationwide to simplify, streamline and supplement traditional NRCS approaches. Moving forward, this will require engagement with Maine's Congressional delegation, the Chief of the NRCS, the State Conservationist, landowners, and other stakeholders.

4. Identify a suite of financial incentives and technical assistance activities to increase carbon sequestration on woodland owners of 10 to 10,000 acres, and carbon sinking in wood products, through active forest management.

The Task Force recognizes that landowners within as broad an acreage category as 10-10,000 acres invariably exhibit a wide range of levels of engagement with their forests. Research on this population, largely comprised of family woodland owners, indicates that they can be reliably segmented according to their motivation for owning forestland. "Woodland Retreat Owners" make up 48% of this population, and care primarily about the beauty, nature, and recreational value of their woodland. "Working the Land Owners" (19%) value aesthetics and recreation, but are pragmatic in that they see the land as an economic asset as well. "Supplemental Income Owners" (14%) own land primarily for timber income and investment. And "Uninvolved Owners" (19%) tend not to care about their woodland, are most apt to be willing to sell their land, and are least likely to want to see it remain as woodland.[1]

Given this range in ownership motivations, it is important to provide technical assistance and financial incentives that are relevant to these varying types of landowners. Landowners first need to become meaningfully engaged in the management of their forests before they can take steps toward implementing carbon enhancing forest management practices. As a result, the Task Force recommends a two-pronged approach to developing a forest carbon program:

- Significantly increase technical assistance to woodland owners to reduce threats of conversion, and to rapidly expand the number of landowners adopting practices that increase carbon sequestration and storage; and
- Offer financial incentives to engaged landowners to implement carbon-enhancing forest management practices, including long-term agreements that can encourage practices that continue over time.

4a. Technical Assistance

Numerous studies over the years have found that family woodland owners place a high value on one-on-one access to state forestry agency professionals and licensed consulting foresters to walk their land with them and discuss their management alternatives. Engaging as many landowners as possible to work with knowledgeable forestry professionals can yield positive results with regard to carbon sequestration and storage on their woodlands. Dedicated boots-on-the-ground landowner education and engagement can make this happen.

Maine Forest Service (MFS) data show that providing dedicated, individualized guidance through MFS and licensed consulting foresters, coupled with practice and plan incentives, the potential number of landowners reached is substantial. In the late 1990's, due to an increase in

[1] Butler, B. et. al., *Understanding and Reaching Family Forest Landowners: Lessons from Social Marketing Research*, Society of American Foresters Journal of Forestry, Oct/Nov. 2007.

federal funding, 4,000 forest management plans were completed representing 500,000 acres of family woodlands. Today, due to federal funding reductions, MFS now provides cost-share assistance for landowners to engage consulting foresters to prepare 100 plans per year, representing approximately 7,600 acres. The exponential growth of real estate transfers over the past two years points to the significant need for increased and sustained landowner engagement in order to retain and increase forest carbon benefits.

The following actions include two key elements: on-the-ground capacity improvement and "cost-share" funding for carbon-friendly practices for landowners and loggers. They provide practical and relatively quickly implemented climate solutions, and provide stewardship progress for small woodland owners who otherwise have not been engaged in forest management. They also take steps towards preventing further annual loss of forestland.

Action items:

- Increase capacity within the Maine Forest Service by hiring a Forest Carbon Specialist (Senior Planner). This person, knowledgeable in forest carbon, will be a centralized source for forest carbon information for stakeholders and the general public. Duties would include, among other activities, developing training modules for landowners, loggers, and foresters on climate-friendly forest management practices, and potentially playing a role in a forest carbon program described in the Financial Incentives section directly below.

- Increase District Forester capacity within the Maine Forest Service. MFS currently has 10 District Foresters. This compares to past staffing levels of 18 Service Foresters, 4 Regional Foresters, 2 Watershed Foresters, and a Marketing and Utilization Forester. Increasing current forester staffing by 5 would allow for greater outreach to landowners. This number includes a Senior Planner position specializing in marketing and utilization to work with loggers, foresters, and landowners. The District Foresters would also receive training for consistent carbon messaging, building off learnings from Forest Opportunity Roadmap/Maine's (FOR/Maine's) small landowner engagement survey. They would serve as a clearinghouse for information and education and would provide on-the-ground statewide field visits, general advice, and educational services, including a social media presence and workshops on climate-friendly practices for all forestry sectors.

The above actions align with the Maine Climate Action Plan recommendation to, "Increase technical service provider capacity by 2024 to deliver data, expert guidance, and support for climate solutions to communities, farmers, loggers, and foresters at the Department of Agriculture, Conservation and Forestry, Maine Forest Service, Department of Inland Fisheries and Wildlife, Department of Marine Resources, and University of Maine." The Plan also states, "Increasing the number of field foresters at Maine Forest Service should support landowner and land-manager adoption of climate-friendly practices, as well as efforts to support good forest management practices."

- Provide adequate funding for the Maine Forest Service to market the benefits of implementing climate-beneficial forest stewardship practices, participating in carbon markets, and engaging qualified natural resource professionals.

- Consistent with the recommendations in Section #3 to make NRCS programs more accessible to small woodland owners, increase alignment with NRCS to implement forest carbon practice incentives. NRCS is exploring funding half a dedicated position to work with landowners to encourage participation in NRCS forestry programs. This will include identifying the list of EQIP practices that most closely align with the menu of forest practices listed in Section #3 above and working with NRCS to fund those practices at a meaningful level.

- Increase allotted amounts for the MFS WoodsWise program by $50,000 to $100,000 per year (this program provides cost-share to landowners to work with a licensed consulting forester to develop a management plan). This funding could possibly also support cost sharing for carbon-friendly practices and would include a carbon planning component to management plan incentives. This would also include working with NRCS for input and alignment of their CAP-106 plans (Conservation Activity Plans within EQIP) to include carbon planning.

- As part of the duties of the new MFS Marketing and Utilization Forester, support the creation of improved markets for low-grade wood through public and private business efforts.

- Maine agriculture may also have a significant interest in climate-based forest management practices. According to USDA's 2017 Census of Agriculture, 5,305 of Maine's 7,600 farms report have woodland as part of their land holdings. Agricultural producers reported owning 685,529 acres of woodland (52.4 percent of the total agricultural acres in Maine). Outreach and technical assistance for small woodlot owners should include Maine's agricultural producers.

- The USDA describes agroforestry as the integration of trees and shrubs into crop and animal farming systems to create environmental, economic, and social benefits. Agroforestry includes practices such as ally cropping, forest farming, and silvopasture, which facilitate agricultural production in a semi-forested or forested landscape, minimizing the need to remove trees for livestock and crop production. Farmers can implement agroforestry practices as a production and economic diversification strategy, generating income while protecting numerous ecological services present in forested landscapes, including ongoing carbon sequestration. Maine's Department of Agriculture, Conservation and Forestry's Bureau of Agriculture, Food and Rural Resources should look for opportunities to develop and promote resources to encourage farmers and woodland owners interested in agricultural production to consider agroforestry opportunities as an alternative to converting forested land to pasture or cropland.

Outcomes of these actions include:

- Given the current acreage covered by forest management plans, an increase in cost-share funding by $50,000/year could significantly increase the acreage impacted annually and include carbon inventories, expanding beyond timber resources to cover other forest characteristics, including forest biomass and ecosystem carbon content. The current acreage for which forest management plans are developed annually using the WoodsWISE program is approximately 7,600 acres and does not include a carbon inventory.

- Increased acreage treated with climate-friendly forest management practices that are not

economically feasible in today's markets, contingent upon NRCS investment in carbon-friendly practice incentive funding.

- Measurable increase in awareness and training of woodland owners, foresters, loggers, and the public about the benefits of climate-friendly forest management.

4b. Financial Incentives

The Task Force recognizes that there are many innovative voluntary carbon programs currently being developed by the private and non-profit sectors throughout the U.S, and that this landscape of program offerings is evolving and expanding rapidly. Diverse approaches to incentivize forest carbon sequestration are being piloted or otherwise tested. **The existence of this dynamic environment suggests that the State of Maine may be well served by working in partnership with one or more external entities to develop a voluntary credit-based and/or practice-oriented carbon program, tailored specifically to Maine's unique landowner demographics and land ownership patterns.**

The Task Force recommends that the Maine Forest Service:

- Facilitate the development and/or adoption of a program to enable small woodland owners to store more carbon on their forestlands while maintaining or increasing harvest levels, and invite parties interested in partnering with the State on such an effort to make themselves known

- Create an advisory committee to interview external entities expressing an interest to solicit their feedback on:

    - What the State role should be to increase landowner participation, and increase the value of any "offsets" created

    - Alternatives for funding such a program, noting advantages and disadvantages of recommended options

    - How such a program would be made available to landowners, including the program's structure and format

    - How carbon storage could be increased while maintaining harvest levels

    - How forest carbon measuring and monitoring would be conducted

    - How harvest levels could be maintained system-wide (not necessarily parcel by parcel)

    - How a program could be implemented to maximize its impact, including bridging between the current generation of older landowners and the younger generation who will be inheriting the land

- Convene structured discussions with potential partners to explore ideas for how such a program might be designed
- Select a partner (or partners) to work with in designing and establishing a program (or programs)

In this regard, the Maine Forest Service could, for example, work with the partner(s) selected to:

A. Define what business-as-usual management actually is for various ownership size subclasses (e.g., 10-100, 100-500, 500-1000, 1000+ acres) or geographic regions. This could be determined via a field survey of landowner practices over the last X years, could include both harvest and stand-tending activities, and could document harvest and residual stocking volumes.

B. Determine what outcomes are possible under different circumstances regarding increased stocking and harvest volumes given improved silviculture (e.g., thinning in the stands where growth rates on the most desirable trees could be enhanced, or another carbon-enhancing management practice identified in Section #3 above). This should result in predictions regarding outcomes, e.g., if practice W is implemented in circumstances X, it will result in Y for growth and Z for harvest.

C. Set a numeric target for additional tons of carbon storage by small woodland owners and document how this will be verified. Note: This target is likely to be only a portion of total potential as it will be influenced by program design.

D. Determine the manner of delivery of the program to landowners (agreements, contracts, other) and duration.

E. Determine what it would cost to implement the practices that would increase carbon storage (in the forest and in durable wood products) and substitution benefits.

F. Determine what it would cost to subsidize the productive use of small diameter and low-quality trees by mills.

G. **Conduct a detailed program design effort based on learnings from A.-F., identify the types of policy instruments that best target the kinds of landowners whose behavior can be changed cost-effectively, and detail how these would actually work in terms of permanence, leakage[2], reversal, monitoring, and verification.**

[2] Leakage occurs when interventions to reduce emissions or harvest in one area lead to an increase in emissions or harvest in another area.

This could result in a recommendation to focus on a narrower subset of small woodland owners (for example, those open to practice changes and who have lands where carbon stocks could be increased substantially through management that increases biomass while improving stocking). The program might also include:

- an element focused on wood processors to increase their use of small diameter materials, for instance, via practice-based incentives like those currently used in Nova Scotia;
- some variant of carbon offsets that addresses the transaction cost issue (perhaps through aggregation across smaller ownerships); and/or
- a focus on logging contractors to incentivize high-quality harvesting practices as this has a direct bearing on stand quality and ultimately on forest carbon storage capacity.

H. Secure funding from private parties (e.g., corporations with obligations to reduce emissions), federal or state programs, or other states, to implement a program to achieve the target for additional carbon storage while maintaining harvest. If funds are generated either in full or in part via payments for carbon offsets, the State should ensure that offsets issued meet an approved standard that includes third-party verification (ensuring that the offsets are real, additional[3], verifiable[4] and lasting), and are recorded in a registry. The State should also consider whether it will have standards for the purchasers of offsets, such as whether they are executing a plan to reduce their own emissions.

I. Authorize the private partner to implement the program by enrolling landowners, either paying landowners for practices or paying contractors directly to implement them on lands enrolled. In addition, the private partner could, depending on program design, act as a carbon broker, or distribute funds to forest products companies using wood that would not normally be part of their feed stocks (e.g., small diameter or low-value trees coming off the lands enrolled).

J. Through sampling and statistical analysis, accurately document the results of the program in terms of additional carbon stored and emissions avoided by substituting wood for other materials and harvest levels by comparison to business-as-usual management.

The possible approach articulated in A.-J. above is intended as initial guidance only, with the expectation that this could and likely would evolve as the concept is further refined.

[3] In this context, "additional" means the carbon benefit realized from a project would not otherwise have happened in the absence of the project.
[4] In this context, verifiable means that carbon offsets can be quantified, monitored, and verified by an accredited third-party actor through a standarized system.

5. Identify incentives for high-quality, on-the-ground performance by loggers and promote the use of low-impact harvesting equipment.

The Task Force recommends various actions that are intended to directly support logging contractors' ability to contribute to carbon benefits that will have positive outcomes for landowners. These include:

- The proposed Maine Forest Service Forest Carbon Specialist (Senior Planner) is envisioned as including loggers among its target stakeholders for technical assistance and training on climate-friendly management and harvesting practices.
- Support higher level on-the-ground performance to encourage climate-friendly timber harvesting with verifiable outcomes by promoting voluntary use of third-party certified harvesting companies**.** Third-party certification provides verification that high standards are being met at the point of harvest, by utilizing independent licensed consulting foresters as verifiers, ultimately providing a verification model for landowners that participate in a carbon program and utilize the services of timber harvesting companies.
- Provide financial cost-share resources for harvesting companies to become third-party certified in a similar manner as cost-share resources are provided by the State to landowners who create a forest management plan (i.e. the MFS WoodsWise program).
- Increase funding for the Direct Link (Clean Water State Revolving Fund) program and reassess the elements of the program so as to provide greater availability of reduced interest loans for equipment that will minimize soil compaction and disturbance of forest soils.
- Provide cost-share resources for landowners and contractors to purchase and implement carbon-enhancing best management forest practices (e.g., portable bridges, culvert pipes, grass seed, hay, skid trail regrading, road relocation, post harvest stabilization, corduroy, gravel, silt fencing).

Outcomes of these actions include:

- Currently, there are approximately 300 logging companies in Maine and just over one-third are third-party certified. Cost-share resources to support more companies becoming certified will increase landowner awareness and provide greater verification of climate-friendly harvesting practices.
- Significant increase in the use of trained loggers, logging equipment, and best management practices that promote climate-friendly harvesting practices.

6. Recommend updates to the Open Space Current Use Taxation program including in a manner that incentivizes climate-friendly land management practices.

The recommendations in this section represent the aspirations of the Task Force, which acknowledges that further dialogue with municipalities and other interests will be required to finalize a legislative approach.

Task Force members have prepared initial concepts for revision of the Open Space Current Use Tax program, and gathered initial feedback from representatives of Maine Revenue Services and the Maine Municipal Association. It then sought broader feedback on a draft during the public comment period. This section is not an attempt to provide complete or final language for update and revision of the program, but instead focuses on key program elements.

Priority Concepts:

- The Open Space program should be streamlined, with an added emphasis on climate benefit.
- The Open Space program should contribute to maintaining forestland and reducing forestland loss in the state. It is an important but underutilized option among Maine's current use tax programs.
- The Open Space Program should be made more efficient to increase value to the public, attract more landowner participation, and be easier to administer by municipalities, with reduced financial burden.
- The Open Space program should accommodate a wide range of potential land management practices, from intensive silviculture and production of forest products to development of old forest and maximizing carbon storage.
- The Open Space program should not create a fiscal burden for municipal budgets and will require state reimbursement (noting complexity in that municipalities may benefit from reduced costs of providing services when lands remain undeveloped and from increased revenue sharing as a result of reduced valuation).

Potential Program Revisions:

A. Provide state reimbursement to municipalities to reduce financial burden on municipalities, in acknowledgement of the broad public benefit of maintaining undeveloped lands. (Reimbursement could be based on the same formula used for state reimbursement under the Tree Growth Current Use Tax program or could use the tax rates for undeveloped acreage used by individual municipalities.)

B. Revise Open Space Program valuation reductions to:

- Increase the discount for "Ordinary" Open Space (which precludes development) in order to encourage greater participation in the Open Space program and emphasize its core

value of helping to keep land undeveloped. (The Task Force recommended an increase to 50% from the current 20%)

· Maintain the current discount of 25% for Public Access

· Create two new categories:

Wildlife Habitat Management: Consider a 20% discount for implementation of a wildlife enhancement practice. (Practices to be approved by the Maine Department of Inland Fisheries and Wildlife in alignment with the State Wildlife Action Plan or with mapped Beginning with Habitat features, with landowner attestation of practice implementation.)

AND

Carbon Management: Consider a 20% discount, with eligibility based on the following concepts:

Forested land (properties with 10 or more forested acres and greater than 70% forested) may qualify with any of the following options. Any qualifying property would automatically be considered to provide a public benefit and be eligible for enrollment in the Open Space program:

Adoption of a 10-year forest management plan signed by a licensed forester that includes strategies to increase forest carbon and considers carbon stored in forest products. (This is essentially the same requirement for the Tree Growth current use program eligibility, but the plan here can prioritize forest carbon.)

Implementation of a forest carbon practice approved by the Maine Forest Service, qualifying for the Carbon Management reduction for 10 years, with landowner attestation of practice implementation. (This option is intended to facilitate greater participation by owners of smaller properties.)

Properties with permanent ecological reserve restrictions shall qualify for the carbon management discount. (The recommended 20% discount is the same discount available in the current program, and ecological reserves have demonstrated benefits for carbon storage.)

Non-forested land (properties not qualifying as Forested Land, above) may qualify for 10 years based on implementation of carbon management practices approved by the Maine Department of Agriculture, Conservation, & Forestry, with landowner attestation of practice implementation. (Owners of non-forested lands may also have the option to: 1) choose the wildlife habitat management option, or 2) if eligible, participate in the Farmland Current Use program.)

▪ Maintain the current maximum discount of 95% (note that for forested acres, the current program limits the reduction to be no greater than that available through the Tree Growth Current Use program).

C. Streamline program to rely on % reductions and eliminate the alternative approach of individual discretionary assessment based on assumed impacts of enrollment on valuation. (This is intended to provide greater clarity and certainty for landowners interested in enrolling in the program, and to reduce complexity for assessors and municipalities.)

D. Allow any landowner to transfer their property from Tree Growth to Open Space without penalty for properties in Tree Growth prior to 2021.

7. Explore opportunities for partnerships with large, commercial forestland owners.

The Maine Climate Table, a nonpartisan effort to create a state-based model for climate initiatives, has been hosting convenings of commercial forestland owners since March, 2020, to explore whether large commercial forestland owners in Maine can store more carbon in the forest and in forest products while maintaining harvest rates. Its efforts to date, under a program titled Forest Carbon for Commercial Landowners (FCCL), have been focused on whether commercial forest could be managed to store more carbon without constraining, or, perhaps while even enhancing, a landowner's financial performance, and if so, using what specific "instruments" (e.g., the carbon offset market, tax policy, payments from corporations interested in securing carbon).

The Maine Forest Carbon Task Force acknowledges that this parallel process is exploring comparable issues to its own charge, though for a larger landowner size class, and with a more explicit focus on economic objectives. The Task Force recommends ongoing monitoring of FCCL's work and research outcomes, to potentially inform the design of a forest carbon program for family woodland owners as described in Section #4. At the same time, FCCL is not the only other process underway that is exploring the potential of large forest ownerships to sequester and store more carbon. The Task Force recommends tracking these other emerging efforts as well.

Clearly, the development of markets for low-quality timber, the importance of which is emphasized at the outset of this report, would benefit woodland owners of all sizes, including large commercial forestland owners. In addition, the recommended additional Maine Forest Service staff (Forest Carbon Specialist, Marketing and Utilization Forester, and District Foresters) would support all Maine forestland owners regardless of size. And the development of a forest carbon program as envisioned under Section #4 could conceivably result in a program that is accessible to large landowners as well.

8. Consider opportunities for Maine to participate in multi-state forest carbon initiatives.

The Co-chairs of the Task Force have been engaged in ongoing discussions with the Governor's Office of Policy Innovation and the Future, the U.S. Climate Alliance, and the States of Massachusetts, Vermont, and New York to identify opportunities and issues related to the initiation of a regional collaboration to increase investment in forest carbon sequestration and storage. To date, these discussions have focused on financing mechanisms that could support forest conservation and management at scales aligned with each state's greenhouse gas mitigation targets, and the infrastructure that would be necessary to support a regional carbon market, including offset protocols, a registry, and accounting frameworks. The Task Force supports the continuation of these discussions (including examination of the potential to expand the Regional Greenhouse Gas Initiative) that could advance a regional initiative that is complementary to or ultimately replaces individual state-based programs, assuming it proves the most efficient way of enabling Maine's forests to help achieve the state's greenhouse gas reduction goals.

9. Recommend a numeric goal or targets for increased carbon sequestration in Maine over time.

Maine's forests as a whole (i.e., including all landowner sizes and types) have sequestered an average of 9 million metric tons of carbon dioxide equivalent per year ($MtCO_2e/yr$) over the past decade (Bai et al., 2020; Domke et al., 2021). An additional 3 $MtCO_2e/yr$ has been sequestered on average in harvested wood products manufactured in the state (Bai et al., 2020; Daigneault and Frank, 2021). Combined, Maine's forest sector has been sequestering an average of 12 $MtCO_2e/yr$, equivalent to removing about 65% of the state's reported gross GHG emissions over the past decade (Figure 1).

The state's forest carbon sequestration values have been historically high over the past decade as well, averaging nearly double the amount of sequestration in the 1990s. There is no guarantee that the current levels will hold indefinitely into the future. Continuing to sequester carbon at similar levels is an ambitious goal that will play a significant part in helping Maine achieve its 2045 net-zero GHG emissions target, especially as the state continues to reduce its gross GHG emissions to 80% below 1990 levels by 2050.

The Task Force recognizes that there is a balance between achieving the goal of maintaining or increasing timber harvests to help grow the forest economy and accumulating carbon on the stump as well as minimizing carbon leakage. In addition, the Task Force also recognizes that the state's forests are vulnerable to future impacts from pests, disease, climate extremes, and wildfire, which could have a negative impact on the ability to sequester carbon.

It should be noted that forest soils represent a large carbon pool in forest ecosystems, often exceeding the sum of all other ecosystem components, including trees. However, total carbon stocks change slowly, and there is significant uncertainty about the effects of forest management and forest disturbance on these stocks and the rates of change for Maine forests. Changes can include loss, gain, no change, and combinations thereof at different time scales. For this reason, achieving better information in the future about soil carbon changes in Maine is a high priority, and sustainable forest practices should be a priority to preserve or enhance soil carbon. However, incorporating quantitative changes in soil carbon into a carbon program because of forest management or disturbance effects is not justifiable at this time.

Figure 1. Maine GHG emissions and forest sector carbon sequestration (Sources: DEP, 2020; Domke et al., 2021; Daigneault and Frank, 2021).

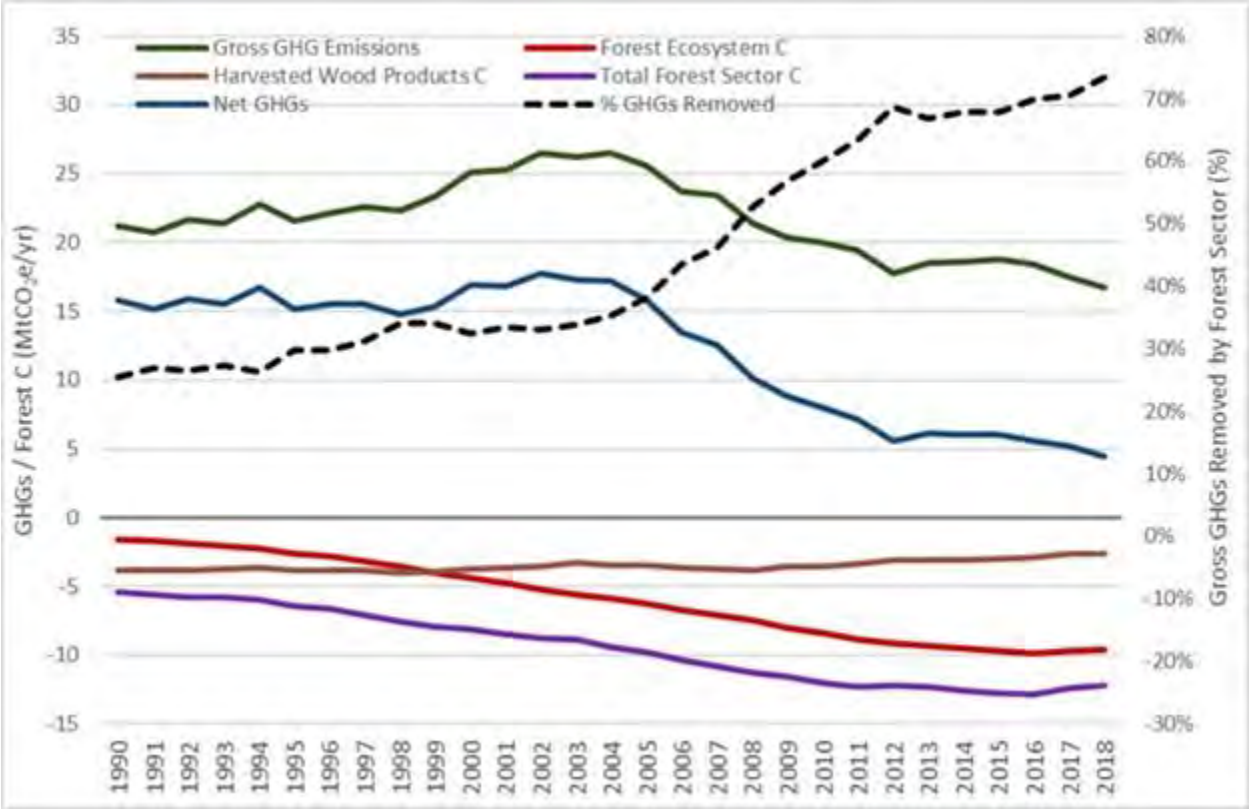
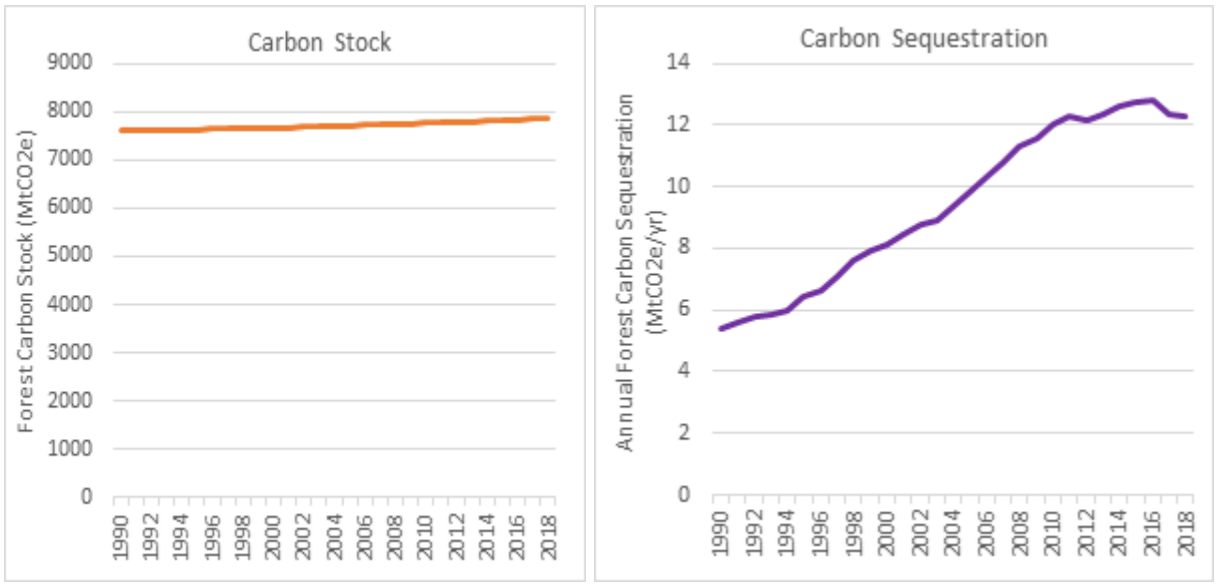


Figure 2. Maine Forest Sector Carbon Stock and Sequestration ($MtCO_2e$) (Source: Daigneault, 2021).



The Task Force recommends the following:

- **A statewide total forest sector carbon sequestration target of no less than 12 $MtCO_2e$/yr through 2045, maintaining the past decade's historically high carbon sequestration level.**

- **This forest sector target includes carbon sequestered in forest ecosystems (e.g., aboveground live, dead wood, soils, etc.) as well as harvested wood products.**

- **The target should be measured using a 5-year rolling average, recognizing the interannual variability in forest carbon sequestration that occurs in natural systems.**

- **The target should be re-evaluated by an advisory committee every 5 years as new data and knowledge about Maine's forests and harvested wood products become available, while retaining the goal of maintaining or increasing total carbon sequestration.**

The several million acres of Maine's small forestland owners (10 to 10,000 acre ownerships) can play an important role in helping Maine achieve the Task Force's recommended forest sector-wide target. Doing so will require investment in technical assistance and improved forest management. Any program needs to be able to demonstrate success and monitor progress over time with whatever metrics are used. Increasing the number of MFS district foresters by 50% will have a corresponding impact on the number of landowner contacts and forest management plans they assist with. Providing information and technical assistance for Maine forest owners to

improve management of Maine forests on a voluntary basis will enhance their ability to achieve landowner objectives while also enhancing rates of carbon sequestration over the next several decades. Forests managed based on the best available science will also be more resilient to stressors that include a changing climate, enhancing their ability to retain carbon that would otherwise be lost back to the atmosphere. Further, the state should utilize other mechanisms for developing forest management plans, such as the Tree Growth Tax and NRCS cost-share programs to increase carbon sequestration and storage through more targeted improvements in forest management.

The Task Force also conducted a preliminary analysis using secondary data sources to estimate the carbon sequestration potential if Maine's small woodland owners implemented a mix of the recommended practices (Appendix A). The preliminary analysis identified a number of key uncertainties, including the total ownership area, landowner participation, current distribution of practices, harvest, and carbon leakage impacts, and mitigation potential for each of the recommended management practices. As a result, the Task Force was unable to provide a specific numerical target for this specific ownership type.

Appendix A

Preliminary Analysis of Maine's Small Landowner Forest Carbon Mitigation Potential

(Note: The information which follows is the best available on this topic but is considered preliminary. Efforts are already underway to refine it.)

Methodology

A literature review was conducted of nearly a dozen studies examining management implications on forest carbon in the Northeastern U.S. to produce estimates of the carbon sequestration potential if Maine's "best guess" estimate of 6.9 million acres of small woodland owners implemented the recommended practices (see Table A-1). The collective findings – which are considered a rough approximation due to data limitations – indicate that implementing various forest management practices could result in a mean/median sequestration rate of about 0.25-0.5 tCO_2e per acre per year (Figure A-1). Using these studies and other relevant sources, carbon sequestration and cost estimates were approximated by practice (see below) and by overarching practice categories (Table A-1).

The Task Force's ***15 recommended practices*** (Table A-1) were synthesized into five overarching forest carbon management categories or goals (Table A-2), and average costs and sequestration rates were reported. The 5 categories were grouped by similarity according to:

- Secondary benefits (e.g., habitat preservation, increasing value of standing timber, transition to old growth)
- Likelihood of implementation by small woodland owners (i.e., participation)
- Land scale applicability (6.9 million acres for management versus 5,150 acres/yr for avoided conversion)

The aggregate potential for implementing these practices was then estimated by proportioning out each of the practice categories. This analysis took a conservative approach by assuming that none of the practice groups could be jointly implemented, while in some cases (e.g., enhanced forest resiliency and intermediate treatments), more than one recommendation could be done on the same forest area.

This preliminary analysis has several uncertainties and limitations due to variability across studies and data used to derive the estimates for Maine's small landowners:

- **Methodologies.** The studies used for this assessment used a mix of data, models, and methodologies to quantify the impacts of varying management on forest carbon sequestration. This included FIA, remote sensing, Forest Vegetation Simulator (FVS), LANDIS, and stand and landscape-level bookkeeping models.

- **Study area and time length**. Each study had a unique study area (966 to 17.6 million acres) and length of time (20-160 years) over which it estimated changes in forest carbon. The study-specific estimates were normalized by converting forest carbon metrics to a per acre per year basis.

- **Biophysical v. socio-economic impacts.** All studies assessed the biophysical and carbon impacts of different practices, but less so the socio-economic effects. These include costs associated with changes in management or the opportunity costs from changes in harvest revenue. Cost estimates were utilized from other studies or calculated as a rough estimate based on other sources like NRCS.

- **Carbon stocks and fluxes.** Each study measured a unique set of forest carbon stocks (e.g., aboveground, soil) While all looked at aboveground growing stock, others also examined storage in harvested wood products and substitution of more GHG-intensive products such as steel and concrete. To account for this, outliers were removed, particularly those with high values due to product substitution.

- **Baselines/Business as Usual**. All sequestration estimates were based on comparing the effect of a given practice on the study-specific baseline. This can vary based on when and what data were collected and the study assumptions about future stand growth, wood product demand, etc.

- **Harvest and carbon leakage effects**. Many data sources used for this analysis did not report changes in harvest levels or the associated carbon leakage effects that could occur should harvests decline relative to the baseline. Any management practice that results in a reduction in harvest is likely to result in increased timber harvests and carbon emitted outside of the study area. This effect would reduce the overall amount of carbon sequestration from some of the practices considered (e.g., set-asides).

- **Climate impacts**. Most studies assumed a constant climate that reflected historical trends in forest growth and yield. Changes in future climate conditions have differing levels of impact across different forest compositions and age classes impacting management decisions. For example, a large increase in climate variability has a larger impact on unmanaged forestland than an actively managed forest.

- **Natural disturbance regimes**. As with climate, most studies did not explicitly account for a potential change in the frequency or impact of natural disturbances over time.

Despite the noted uncertainties, there is some confidence in the mean-level estimates that are presented in Table A-1. More details on the references used, data collected, and how estimates vary across study and practice can be found here:

https://umainesystem-my.sharepoint.com/:x:/g/personal/adam_daigneault_maine_edu/ESVrH-RDnzBFuqUD984vq1QBqbcm0B4iEqOLH-UPl2n8Ow?e=HVL4Ej

Figure A-1. Histogram of carbon sequestration estimates ($tCO_2e/ac/yr$). relative to baseline for all management practices (n=98)

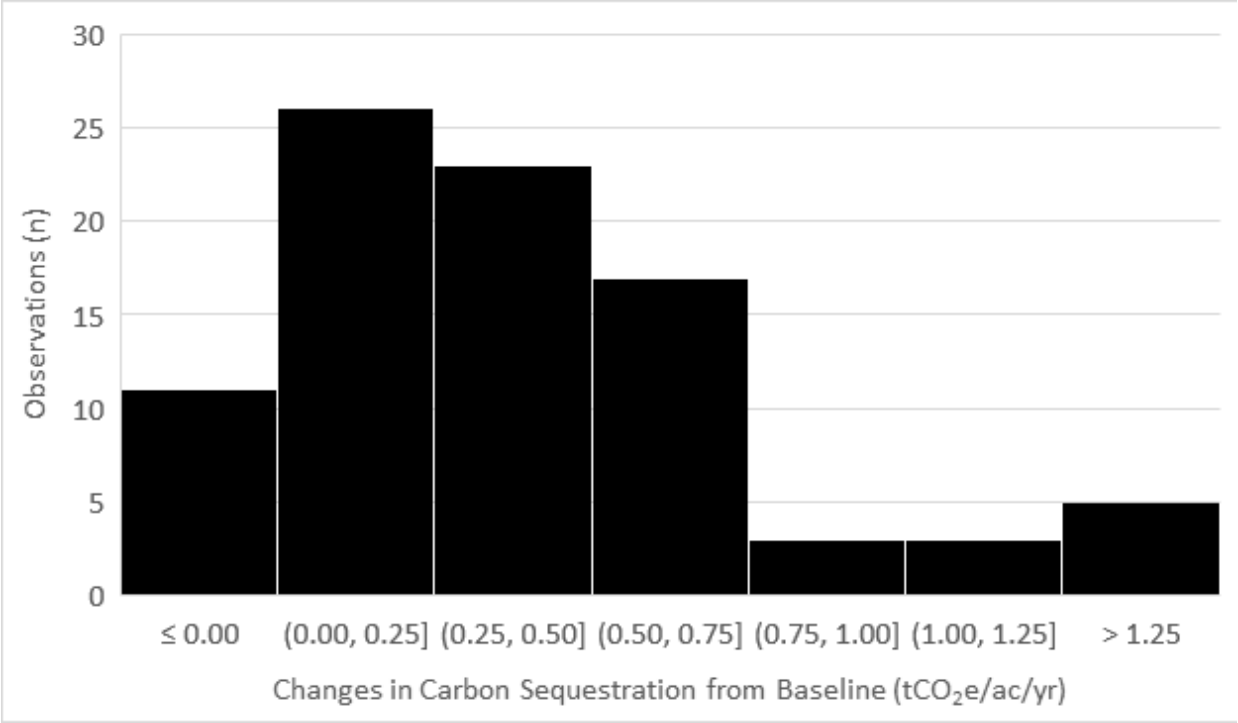


Table A-1. Preliminary Analysis of Quantified Impacts of Forest Carbon Task Force Recommended Practices and Metrics

#	***Recommended Practice***	*Annual Forest C Seq ($tCO_2e/ac/yr$)*	*Break-even C Price ($/tCO₂e)*	*Cost ($/ac)*	*Annualized Cost ($/ac/yr)*	*NRCS Scenario*	*C Seq Source*	*C Price Source*
	Avoided Forest Conversion							
1	Avoid forestland loss/incentivize forest conservation (through conservation easements or fee purchases) to maintain forest ecosystem carbon and the potential for continued sequestration	212	$17.00	$3,604	$256	N/A	1	1
	Enhanced Forest Resiliency							
2	When planting, select species well-suited to the site and a changing climate.	0.46	$18.40	$546	$39	N/A	2,7	1,7
3	If relying on natural regeneration, plan the harvest to regenerate the site quickly with desired species.	0.19	$6.11	$453	$32	Competition Control	6	5,6

4	Manage competition from invasive and undesirable tree species.	0.49	$9.41	$240-630	$31	Brush management (chemical or mechanical)	2,4	1,4,5
5	Plan to reduce the risk of carbon losses from disturbances (e.g. wildfire, exotic and endemic insect infestations)	0.15	$16.00	$947	$67	Forest slash treatment	1	1, 5
Intermediate Treatments								
6	Retain more carbon in thinnings (retain large-diameter live trees, snags, and species and age diversity).	0.49	$9.41	$640	$45	Thinning for wildlife and forest health	2,4	4, 5
7	Pre-commercially thin saplings and small poles	0.49	$13.69	$640	$45	Pre-commercial thinning	2,4	4, 5
8	Commercially thin (uniform thinnings or crop tree releases)	0.49	$9.41	$440	$31	Crop/mast tree release	2,4	4,5,6
9	Increase stocking in understocked stands	0.60	$17.40	$804	$57	hardwood hand planting	7,8,9	4,5

10	Focus investments in intensive silvicultural treatments on sites with high carbon value potential (superior soils, drainage, aspect).	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Sustainable Harvesting							
11	Extend harvest cycle to grow larger trees thatare more likely to be used in long-lived wood products.	0.51	$9.86	N/A	N/A	N/A	1, 2	1
12	Seek to increase the proportion of harvested materials likely to be used in long-lived wood products.	0.51	$9.86	N/A	N/A	N/A	1,2	1
13	Manage partial harvests thoughtfully to retain quality trees and minimize stand damage	0.04	N/A	N/A	N/A	N/A	6	N/A
14	Utilize timber harvesting professionals, including licensed consulting foresters trained in climate-friendly harvesting practices	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Establish Forest Reserves							

15	Establish forest reserves on high carbon density and special ecological value sites to allow the development of late-successional forest.	0.64	$12.14	N/A	N/A	N/A	1,2,3	1

Notes: Carbon (C) Seq: Mean annual amount of forest carbon sequestration above baseline practice. Break-even C price: value on a ton per CO_2e basis that the mean landowner would need to be paid to be indifferent between their baseline practice and the recommended practice. Cost: initial cost on a per acre basis that the mean landowner would face to implement the recommended practice. Annualized cost: Total annual cost of implementing recommended practice over 25 years using a discount rate of 5%. NRCS Scenario: Natural Resource Conservation Service scenario most aligned with recommended practice.

Sources: 1. Daigneault et al (2021); 2. Dugan et al. (2021); 3. Gunn and Bucholtz (2018); 4. Russell-Roy et al (2014); 5. NRCS (2021); 6. Nunnery and Keaton (2009); 7. Cook-Patton et al. (2020); 8. NEFF (2020); 9. Hoover and Heath (2011)

Table A-2. Aggregate Impacts of Forest Carbon Task Force Recommended Practices

Forest Carbon Practice Category	Max Acres (per year)*	Mean Annual Sequestration (tCO_2e/ac/yr)	Break-even cost ($/$tCO_2e$)	Recommended Practice (based on Table A-1 practice numbers)
A. Avoided Forest Conversion	5,150	212	$17	#1
B. Enhanced Forest Resiliency	6,900,000	0.32	$12	#2-5
C. Intermediate Treatments	6,900,000	0.52	$12	#6-10
D. Sustainable Harvesting	6,900,000	0.35	$10	#11-14
E. Establish Forest Reserves	6,900,000	0.64	$12	#15

* 6.9 million acres based on preliminary analysis 'best guess' in Table 1. Subject to revision as more data becomes available.

Descriptions of each of the five categories and how it relates to the specific 15 recommendations set forth by the Task Force are included below.

A. Avoided Forest Conversion (Forest Practice #1)

Identified as a critical management strategy of the Task Force, this practice seeks to incentivize landowners to maintain Maine's forests as forests. Between 2001 and 2016, land in Maine was converted from forests to development or other uses at a rate of 5,150 acres per year (Homer et. al., 2020). By ***avoiding forestland conversion (#1)*** of at-risk forestland and incentivizing forest conservation through conservation easements or fee purchases, forest ecosystems maintain carbon stocks on the margin of 5,150 acres per year, equating to 212 tons of avoided carbon dioxide emissions per acre per year. Other benefits of this practice include increased wildlife and habitat preservation, in addition to supporting Maine's forest economy.

B. **Enhance Forest Resiliency (Forest Practices #2-5)**

Forest resilience ensures forest health and longevity for future generations so Maine's forests can continue sequestering carbon. The Task Force's recommends ***selecting species well-suited to the site and a changing climate (#2),*** thereby expanding the carbon holding potential on an adaptive forest landscape. Other recommendations that serve as strategies to enhance forest resiliency include: ***assisting post-harvest sites for resilient forest regeneration (#3)***, ***managing for competitive undesirable and invasive species (#4)***, and ***reducing carbon losses from destructive disturbances (#5)*** such as wildfire, exotic and endemic insect damage, and ice damage. These strategies enhance carbon storage by managing forest health, resulting in bigger, stronger trees that increase the quality and value of standing timber. Woodland owners are more likely to adopt these resilience strategies with technical and financial support.

C. **Intermediate Treatments (Forest Practices #6-10)**

Intermediate treatments maximize forest carbon sequestration while reinforcing forest structure and composition. The task force recommends conducting thinning in immature and/or overstocked stands to stimulate growth of the remaining trees and increase the yield of useful material from the stand (i.e., evaluate short-term carbon losses against longer-term forest and forest product carbon benefits). These practices include ***retaining large diameter trees, snags, and species and age diversity (#6),*** and ***pre-commercial thinning (#7), commercial thinning (#8)***. Thinning practices remove unwanted or poor-quality vegetation, shrubs, and saplings around the healthiest trees, therefore maximizing the growth rates and increasing the amount of carbon available on the stand. Intermediate treatments also include a variety of silvicultural prescriptions and planting fast-growing or understocked species to ***increase forest stocking in understocked stands (#9).*** These treatments should ***steer investment to sites with high carbon value potential (#10),*** including superior soils, draining, etc. Landowners and foresters should select specific intermediate treatments with specific goals in mind, such as restoring or maintaining wildlife habitats, diversifying forest species and composition, increasing the health of the forest, and enhancing the aesthetic of the woodlot. Much of the success of small woodland owners implementing these practices is dependent on the strength and presence of low-grade markets for forest thinning residuals. Without these markets, financial support and cost-sharing services are crucial.

D. **Sustainable Harvesting (Forest Practices #11-14)**

Implementing sustainable harvest practices ensure minimal disturbance while enhancing the longevity of the forest ecosystem. Landowners should consider ***extending or delaying harvest cycles (#11)*** beyond 50 years to allow trees to grow larger, increasing the likelihood that more harvest material will be used in long-lived wood products. Likewise, ***increasing the proportion of harvested materials likely to be used in long-lived wood products (#12)*** reduces carbon

emissions in comparison to carbon-intensive products like concrete and steel**.** Encouraging ***partial harvesting practices (#13),*** as opposed to high grading, sustains the health of the forest and furthers its regeneration, especially if residual stand damage is minimized. As recommended by the Task Force, all aforementioned sustainable harvesting practices should be performed by ***timber harvesting professionals, including licensed consulting foresters trained in climate-friendly harvesting practices (#14)***. Woodland owners are likely to implement sustainable harvesting practices with additional technical and financial support.

E. **Establish Forest Reserves (Forest Practice #15)**

The Task Force recommends ***expanding the amount of forestland in reserves (#15)***, especially on sites with high carbon density and in areas of special ecological value. It is important to note that carbon-efficient areas are those forests with a high carbon density and may have old growth characteristics or sustain critical wildlife habitat. Additionally, forestland under reserves should be allowed to mature to a late-successional forest to store as much carbon as possible. Forest set-asides promote the transition to old-growth forests while maintaining ecosystem services such as: habitat conservation; soil health and nutrient cycling; water quality; and cultural/spiritual social values. Forest set-asides require low-intensity, passive management, and therefore, many small woodland owners are likely to adopt this management strategy.

Total mitigation potential by participation rate

The metrics presented in Table A-2 can be used to estimate the forest C sequestration and potential from the Task Force's "best guess" of Maine's 6.9 million acres of small forestland owners (see Table 1) based on the level of participation, assuming that this entire area currently follows baseline management practices (Figure A-2). Figure A-3 shows the mitigation potential by specific forest practice grouping (A-E) and participation rates (0-100%). Note: option A (avoided conversion) can be exclusive of options B-E, while implementing option E (establish reserves) would likely eliminate implementing B-D. Further, B-D could be potentially implemented jointly on some forestland. For simplicity, Figure A-3 was developed based on the conservative assumption that option A could be fully implemented with a 100% participation rate, while a full participation rate would result in landowners implementing 30% each of B, C, and D (90% in aggregate), and 10% of landowners implementing E. As a result, the estimate is that if all of Maine's small forestland owners participated in a forest carbon sequestration program, about 4 $MtCO_2e$/yr of additional forest carbon could be accrued annually, costing upwards of $54 mil/yr. This estimated cost is the equivalent of \$13.50/tCO_2e.

Figure A-2. Preliminary rough approximation of Maine's small landowner carbon sequestration potential and total cost of implementing a combination of enhanced forest resiliency, intermediate treatments, sustainable harvesting, and establishing forest reserves across different participation rates. (100% = 6.9 million acres).

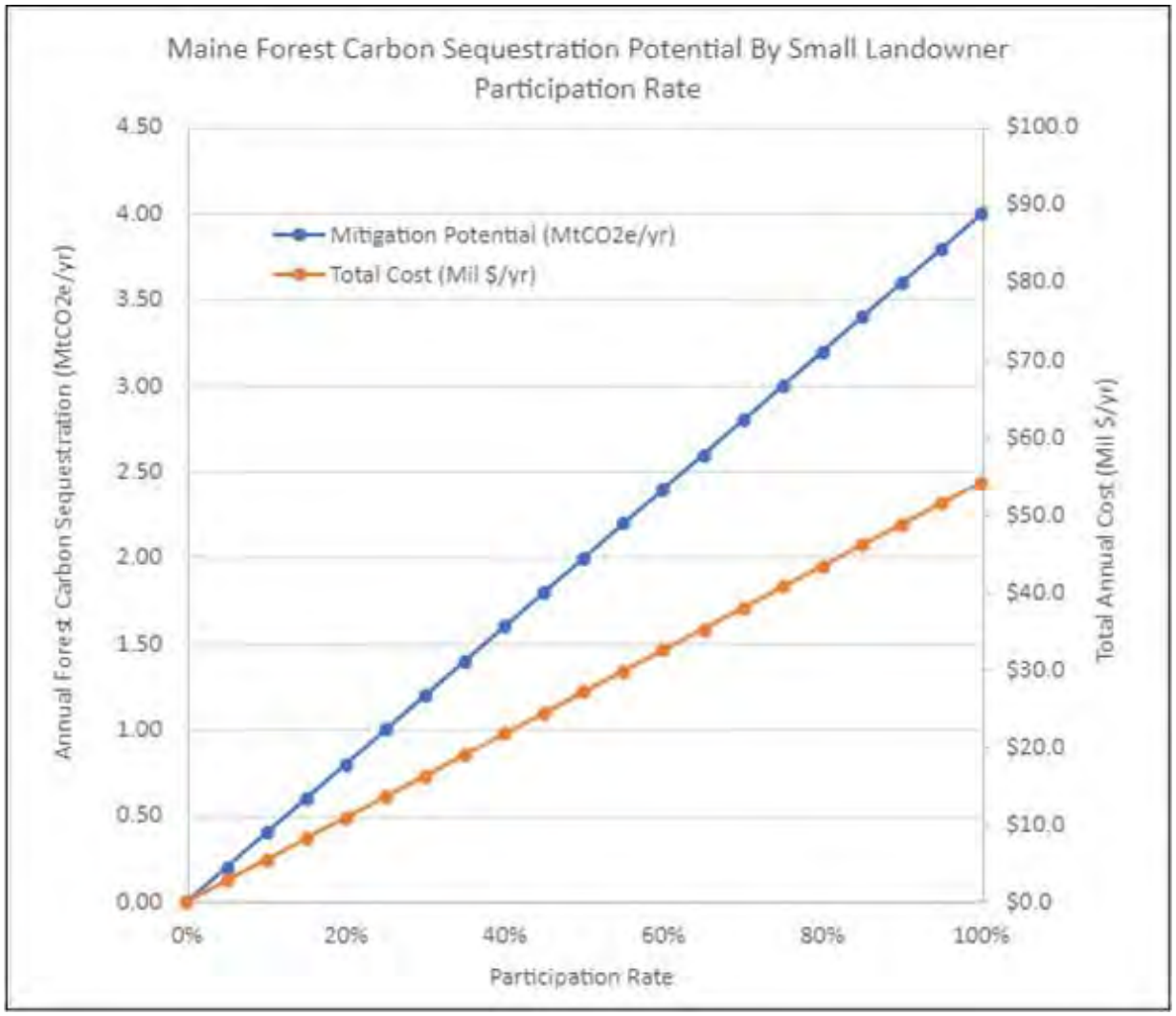
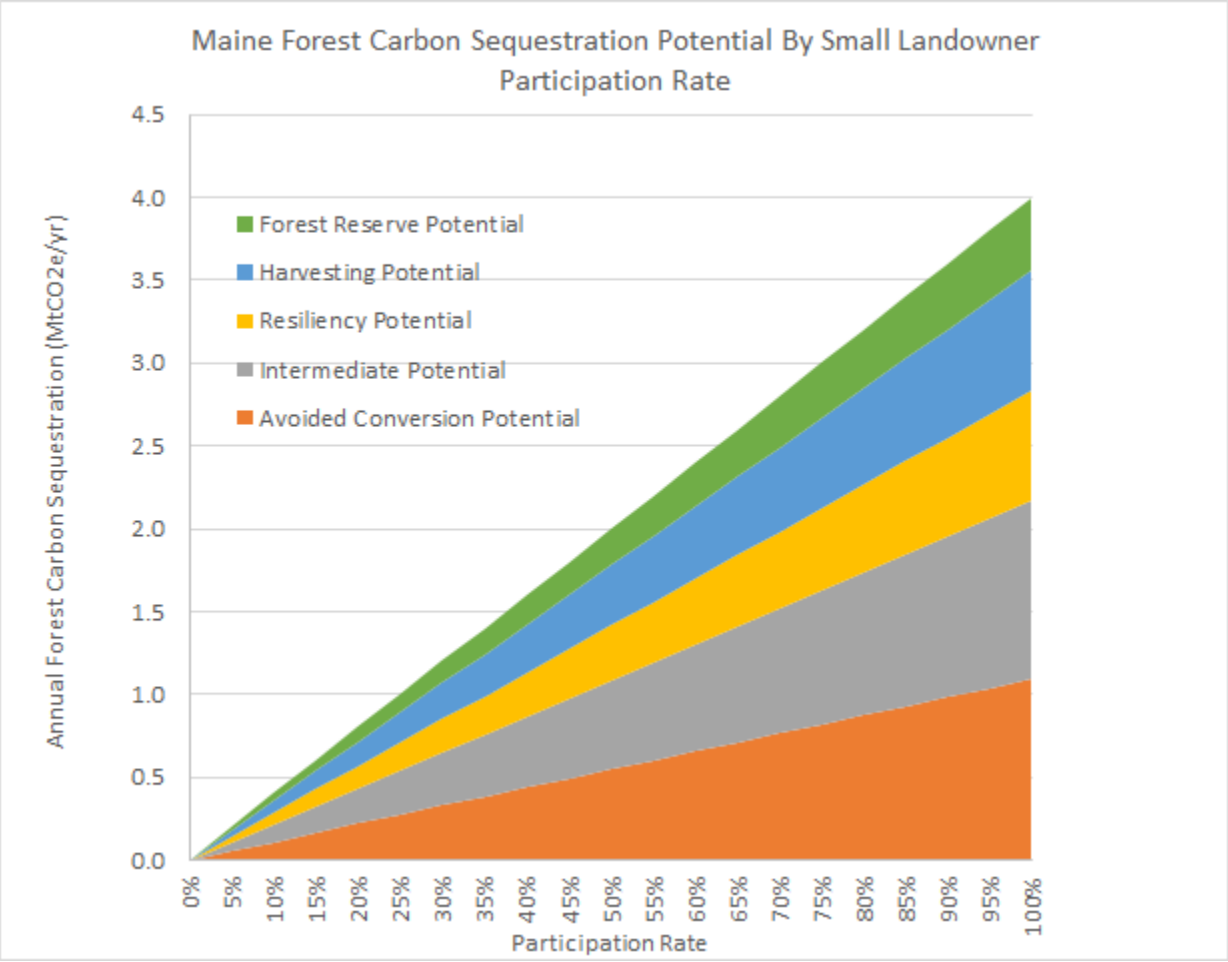


Figure A-3. Preliminary rough approximation of Maine's small landowner annual carbon sequestration potential across different practice groupings and participation rates. (100% = 6.9 million acres).



For comparison, the 2004 climate action plan evaluated the mitigation potential for 10 forest management practices if they were implemented across the entire state (DEP, 2004). That report noted that implementing individual practices could increase forest carbon sequestration by 72,300 to 531,700 tCO_2e/yr. If all practices were jointly implemented, then the 2004 analysis estimated that Maine's forests could sequester an additional 2.4 million tCO_2e/yr over the baseline. This figure is close to the above estimate if about 60% of Maine's small landowners participated in a forest carbon sequestration program.

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Appendix B

Acres, Harvest Levels, and Carbon Storage within 10-10,000-acre Ownerships

To examine the question of how many acres, how much volume/biomass is harvested, and how much live aboveground carbon is standing on small woodland ownerships (10-10,000 acres) in Maine three resources were examined: 1) The National Woodland Owner Survey (NWOS, Butler et al. 2021); 2) The MFS Silvicultural and Landowner Reports; and 3) The USFS FIA Database in conjunction with a digital map ownership product purchased from a private source that uses public tax lot data to assign ownerships. This appendix provides additional details on each of those data sources and assumptions behind the estimates listed in the main report.

National Woodland Ownership Survey (NWOS) Data

According to the National Woodland Owner Survey (NWOS), family ownerships (10+ acres) represent 4.7 million acres or 29% of the private land base (Butler et al., 2021). The NWOS reports that 345,000 out of the 4.7 million acres are in holdings greater than 5,000 acres. If so, 27% could be considered an extreme low-end estimate, and that accounting for small corporate ownerships could raise this estimate considerably. Using the USFS digital map product (DMP) in conjunction with FIA data on all small private ownerships (family and corporate), this figure increased to 43% where ownership was known. However, the DMP that was used in the process likely needs to be refined (see FIA DMP section below).

Forest Inventory and Analysis (FIA) & Digital Map Product (DMP)

Additional insight was gleaned using a combination of data sources. A digital map product (DMP) provided landowner data for a given parcel and parcel size. This layer was combined with the National Land Cover Database (NLCD) Tree Canopy Cover (TCC) map to assign land cover status (forested or non-forested) to the DMP. Acreages were summed by unique owners to assign an ownership size class to each parcel. Each FIA plot was assigned an ownership size class using the spatial intersect tool. The 2019 evaluation of the USFS-FIA database (i.e., the complement of data collected from FIA plots inventoried between 2015 and 2019; 2010 and 2019 for removals) was used to estimate area, aboveground biomass, and harvest removals. For more technical details, please see the USFS Spatial Data Services response to MFS Data Request section.

A key issue that emerged is that the DMP was ‘incomplete’ (e.g., many parcels did not have ownership information – particularly in Central Maine); as such ownership size class attributes could not be calculated for all of Maine’s forest area. This problem stems in part from incomplete tax lot records and maps. A brief examination of some of the data in the DMP

suggested that some large ownerships were contributing to a significant volume of unknown acres. It is also possible that some of the known ownerships may have additional parcels that were not being picked up (i.e., were unknown) and summing the knowns with the unknowns could move these into the larger size class. In addition, some ownerships names may have been entered incorrectly or inconsistently. Both of these items would lead to an overestimate of the acres in the 10-10,000 acre ownership size class (e.g. a parcel of 9,000 acres owned by John Smith might not have been merged with a parcel owned by either J. Smith or unknown of 1,001 acres). Lastly, it was noted that some FIA plots ownership class codes did not align with the DMP assessment.

Due to the quality of this dataset, the Task Force presented ranges of values (see Table 1), where the low-end estimate assumes all unknown parcels belong to large landowners and the high-end estimate assumes that all unknown parcels belong to small woodland owners. For the private forests in Maine, the 10 to 10,000 acres size class likely represents at least 24%, and certainly less than 68% of the forested acres; at least 27% and certainly less than 69% of the live aboveground carbon; and at least 24%, but certainly not more than 66% of the harvest removals. The best guesses of 43% of the acreage; 46% of the carbon; and 43% of the harvest removals would assume that (1) the proportion of small acres in the known category holds for unknown, and (2) it is unlikely that unknown parcels would add to smaller ownerships to move them into the larger ownership class.

Considering that FIA data are collected on a 5-year cycle, it is important to recognize that an ownership may have been harvested and transitioned between ownership size classes between “time 1” and “time 2” when calculating removals. The DMP only has data for time 2 (the most recent sample year). As such, the FIA-DMP removal estimates would include cases where a parcel was in a larger ownership at time 1 and smaller ownership class at time 2 but not the alternative. This would suggest that less harvest would actually be coming off of small woodland ownerships. Again, the high proportion of unclassified parcels in the DMP leaves us uncertain of the actual estimate. It may be possible to reduce this uncertainty in the near future by using other ownership layers to help clarify some of the gaps in the DMP, by identifying where the large (over 10,000 acres) ownerships are.

Table B-1. Acreage, aboveground biomass (inventory and annual removals); merchantable biomass (inventory and removals), and merchantable bole volume (inventory) using FIA data and DMP[1]

Landowner size class (acres)	Forest Area (acres)	Aboveground Biomass Live Stock (dry tons)	Aboveground Biomass Removal (dry tons/yr)	Net Merchantable Biomass (dry tons)	Net Merchantable Biomass Removals (dry tons/yr)	Net Merchantable Bole Volume (dry tons)
0-10 acres	384,406	26,115,505	235,969	18,782,787	164,756	1,047,649,490
10-100 acres	1,497,263	72,856,845	1,019,777	49,305,553	774,712	2,912,962,393
100-1000 acres	1,378,871	60,469,585	1,214,833	39,443,893	862,732	2,367,142,812
1000-5000 acres	512,545	20,052,331	430,755	12,719,236	317,659	774,755,465
5000-10000 acres	554,273	20,087,672	403,551	11,661,761	280,263	734,555,991
10000+ acres	4,877,217	174,317,030	4,178,557	101,561,777	2,979,036	6,324,457,697
10-10000 acres (known) subtotal	**3,942,952**	**173,466,433**	**3,068,916**	**113,130,443**	**2,235,366**	**6,789,416,661**
Total known landowner size	9,204,575	373,898,968	7,483,442	233,475,007	5,379,158	14,161,523,848
Unknown landowner size	**6,921,742**	**269,423,972**	**5,123,411**	**167,245,233**	**3,716,509**	**10,272,498,660**
Total known & unknown size	**16,126,317**	**643,322,940**	**12,606,853**	**400,720,240**	**9,095,667**	**24,434,022,508**

[1] Disclaimer pertaining to FIA summary data completed as part of the MFS data request described in the "MFS Data Request: Forest Metrics by Landowner Size Class and Private Landowner Class" (supplemental document available on request):

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Inventory & Analysis program (FIA) in all written or oral disclosures containing/or using the FS DATA.

MFS Landowner Report

The MFS landowner survey records data on volume (or tonnage) and acres harvested by ownership size class. In 2018, 3.8 million green tons were reported harvested on 138,001 acres. Since stumpage estimates are only reported on a subset of sales, this number was adjusted based on the total acres harvested as reported in the silvicultural report resulting in 9.3 million green tons. Two problems remain with these data: 1) Ownership holdings are reported in the following classes 1-100; 101-1,000; 1,001-100,000 and 100,000+ which does not allow for direct estimate of acres in holdings of 10-10,000 acres and 2) the total tonnage reported on the landowner report is nearly 30% less than that on the wood processor report. Using FIA data, the percentage of harvest in the 1-10 acre class was estimated to be no more than 3% of the total statewide harvest. Estimates of harvest would then range from 26% (10-1,000 acres) to 37% (10-100,000 acres) reflecting the harvest adjusted by silvicultural acres alone to 35 (10-1,000 acres) up to 48% (10-100,000 acres) after adjusting harvest up to reflect the harvest reported in the wood processor reports.

Table B-2. MFS harvest volume and acre estimates based on stumpage, silvicultural, and wood processor report data.

AcreageClass	Stumpage Acres Reporting	Stumpage Volumed Reported	Silv. Acres Reported	Volume Adjusted by Silvicultural Report Acres	10-100 acre class corrected using FIA data	Volume Adjusted to Match Wood Processor Report	Percent of Harvest on a wood processor report basis	Percent of Harvest on a stumpage basis
1 to 10 acres	24,751	758,994	51,140	1,568,215	266,597	359,095	2	3
10-100 acres					1,301,618	1,753,229	10	14
101 to 1,000 acres	30,056	890,998	65,983	1,956,017	1,956,017	2,634,678	16	21
1,001 to 100,000 acres	26,032	717,649	48,135	1,326,998	1,326,998	1,787,415	11	14
100,000 + acres	57,162	1,426,991	177,988	4,443,304	4,443,304	5,984,956	61	48
Totals	138,001	3,794,633	343,247	9,294,534	9,294,534	12,519,373	100	100

FIA Definitions Supporting Table 2 (Burrill et al. 2021)

FIA Stand-size class code: Table 2 of the main report includes references to stand-size and growing-stock classification categories that are based on FIA definitions listed in Burrill et al. (2021) and based on Asner et. al. (2001). Stocking is an expression of stand density that may be expressed in absolute terms, such as basal area per acre, volume per acre, number of trees per acre, or in relative terms, as a percent of some previously defined standard. The FIA stand-size class is based on the dominant (based on stocking) diameter class of live trees in a measured plot, which is defined in section 2.5.20. The FIA all live stocking code description indicates the stocking condition by all live trees, including seedlings (section 2.5.37), while the FIA

growing-stock stocking code description indicates the stocking of the condition of only the growing-stock trees and seedlings, as defined in section 2.5.36 (Table B-3).

Table B-3. FIA growing-stock stocking description

Code	Description
1	Overstocked (density of a stand of average maximum competition >100%)
2	Fully stocked (60 - 99% density of a stand of average maximum competition)
3	Medium stocked (35 - 59% density of a stand of average maximum competition)
4	Poorly stocked (10 - 34% density of a stand of average maximum competition)
5	Nonstocked (0 - 9% density of a stand of average maximum competition)

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Appendix C

Abbreviations

CAP - Conservation Activity Plans within NRCS/EQIP

DMP - digital map product

EQIP - USDA NRCS Environmental Quality Incentive Program

FIA - USDA Forest Service Forest Inventory and Analysis Program data

FOR/Maine - Forest Opportunity Roadmap/Maine

GHG - greenhouse gas

LANDIS - Landscape Disturbance and Succession Model

MFS - Maine Forest Service

MMTC - million metric tons of carbon

MtCO2e - million tons carbon dioxide equivalent

NGO - non-governmental organization

NRCS - USDA Natural Resource Conservation Service

NWOA - National Woodland Owners Association

NWOS - National Woodland Owners Survey

USDA - U.S. Department of Agriculture