Report of the Climate Forestry Committee: Recommendations for Climate-Oriented Forest Management Guidelines

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In June 2023, the Healey-Driscoll Administration launched the *Forests as Climate Solutions Initiative (Initiative)*, an effort that reflects the vital role of forests in addressing climate change and achieving the statutorily required limit of net zero greenhouse gas emissions (GHG) by 2050 set forth in the Global Warming Solutions Act as amended, and the Clean Energy and Climate Plans (CECP) the Executive Office of Energy and Environmental Affairs (EEA) has developed to implement that law. The CECPs developed by EEA address four sectors: buildings, electric power, transportation, and natural and working lands (NWL). The CECPs aim to reduce emissions and sequester carbon in forests and other natural lands through four primary strategies: (1) protect NWL to avoid land use conversion, (2) manage NWL to enhance carbon sequestration and resilience, (3) restore NWL from degraded conditions, and (4) utilize NWL products that store carbon and have lower emissions than alternatives. The *Initiative* will advance the CECP's Natural and Working Lands sector commitments, including conserving 40 percent of the Commonwealth's natural and working lands by 2050 and increasing the adoption of climate smart forest management practices. A key element of the *Initiative* is the development of climate-oriented forest management guidelines, based on the latest science, with the goals of increasing carbon storage and resilience to climate change. The guidelines, as applied to agency land management, will take a variety of forms including standards, protocols, procedures, manuals, and methods. They will also be used to inform the creation of incentives for other landowners to manage their forests with a climate change focus.

To develop recommendations for the climate-oriented forest management guidelines, EEA Secretary Rebecca Tepper appointed a 12-member group of distinguished scientific experts, who were convened as the Climate Forestry Committee (CFC). From June through November 2023 the CFC met eight times, both in person and virtually. They brought their knowledge and experience to intensive deliberations on climate change, carbon storage and sequestration, and passive and active management of forests. In addition, two public input sessions were held; combined attendance at these sessions was over 400 and 180 comments were received.

The CFC recommendations were informed by the complex dynamics of climate change and forests. Massachusetts forests currently store vast amounts of carbon and continue to sequester additional carbon each year. The challenge the CFC addressed is to retain, steward and grow these carbon stocks over time, while pursuing multiple forest land use objectives. Unsurprisingly, disturbing the forests of Massachusetts as little as possible and allowing forests to grow and age through passive management is generally the best approach for maximizing carbon, ecological integrity, and soil health. However, Massachusetts must manage forests for multiple purposes and benefits simultaneously.

It is important to note that CFC members wrestled with differing scientific findings and opinions as to how to optimize management of state forest lands held for multiple values and ecological, climate, cultural, social, and economic objectives. While they clearly agreed that state-owned forests are very important to achieving climate mitigation and adaptation goals, there were differences of opinion as to how to manage them for these purposes. The recommendations endeavor to faithfully characterize the degree of CFC support for each.

It is now up to the Healey-Driscoll Administration to implement these recommendations in service of *Forests as Climate Solutions* and CECP objectives. Actions to enhance forest management, conserve

additional forest land, expand reserves, and provide additional incentives to private landowners are expected to follow the issuance of this Report.

Report of the Climate Forestry Committee: Recommendation for Climate-Oriented Forest Management Guidelines is the product of Committee's work. It begins with an introduction that describes the *Initiative*, identifies the Climate Forestry Committee members, and articulates the charge they were given. It then provides background information on the climate change emergency that requires a strategic response across all sectors of the economy, and that is driving the Healey-Driscoll Administration and the Climate Forestry Committee. It also includes data on the forests of Massachusetts and offers context about their role in addressing climate change. Finally, as the CFC's work focused on state forest land management, it summarizes agency missions and provides data about these lands and active management projects since the early 2000s.

Recommendations for Climate Oriented Forest Management Guidelines:

The overall goal of the guidelines is to employ active and passive management strategies to keep our forest ecosystems and forest cover, to protect existing carbon stocks and sequestration capacity, and to recommend actions informed by the latest climate science that advance these objectives while also achieving other goals of the Commonwealth.

Throughout Committee discussions, members identified and discussed passive and active forest management strategies. Passive management being an intentional hands-off approach that allows forests to be shaped largely by natural processes and active management a set of strategic interventions to promote particular forest outcomes. CFC members generally preferred one approach or the other, mentioned here as it is evident in their recommendations, but they all recognized that forest management covers a broad range of approaches from passive to active, and that it is often appropriate to employ different strategies simultaneously across a landscape to achieve mutual complex goals. The overall recommendations of the CFC regarding application of their recommendations emphasize that:

- Active management typically reduces carbon stocks over the short term, a loss that must be carefully considered and minimized when evaluating projects that may advance other goals;
- Agencies should be more explicit and transparent regarding their land management objectives;
- Massachusetts landscape history should be considered when establishing goals;
- Flexibility is needed and agencies must be empowered to make considered decisions, informed by public input, that involve tradeoffs and simultaneously seek to achieve multiple goals; and
- Forests must be simultaneously managed for carbon sequestration and other benefits.

The Report organizes the Climate Forestry Committee recommendations into topical sections that provide strategic and project level guidance. The key content of each is summarized here.

Keep Forests as Forests: The Committee unanimously agreed that maintaining forest cover is essential, recognizing that every acre of forest lost to conversion represents a loss of stored carbon to the atmosphere as well as a loss of future carbon sequestration. The Committee strongly supported efforts to reduce land conversion, increase permanent land conservation, and enlarge forest reserves.

Forest Management for Habitat: Recognizing the significant carbon implications of current goals, especially for early successional habitat, the Committee recommended that as Executive Order 618 "Biodiversity Conservation in Massachusetts" is implemented, consideration be given to new goals that

place less emphasis on early successional habitat and more on late successional habitat. The Committee had differing perspectives on the value and proper application of passive to active techniques, but regardless of the approach, recommended that agencies be more explicit about their habitat goals, the rationale behind forest management projects, and their carbon and climate implications.

Ecological Disturbance: The Committee strongly agreed that ecological disturbances are an important and necessary aspect of forest ecosystems as they increase structural and compositional complexity and dead wood that are often lacking due to past land use. The Committee found no ecological rationale for salvage harvesting and noted that it usually represents a short term (10-20 year) carbon loss to the atmosphere in comparison to leaving the wood to decay. In most circumstances, it recommended foregoing salvage harvesting and leaving dead wood to realize the habitat quality and biodiversity benefits. The Committee also recommended the identification of salvage criteria and use of a flow chart to aid in deciding when, where, and to what degree salvage harvesting should occur.

Carbon Stocks and Sequestration: The Committee generally agreed that passive management confers greater increases in carbon stocks than active, and that allowing forests to grow and age is typically best to maximize carbon storage. The Committee strongly agreed that carbon storage is typically greatest in old forests and disproportionately in the largest trees, and that Massachusetts forests can continue to accumulate carbon for many decades if undisturbed. While there was some disagreement relative to the age at which forests sequester the most carbon, the Committee agreed that is not practical to manage for a narrow window of peak carbon sequestration, and that cutting older forest to create younger forests primarily to enhance the rate of carbon sequestration would be counterproductive. Recognizing that the Commonwealth has values and objectives beyond climate change for which it intends to actively manage forests, such as providing habitat for endangered species, the Committee recommended strategies to do so in a climate considerate manner. A few members argued that is critical to avoid the carbon loss that results from active management given the steep reduction in GHG emissions that must occur in coming decades.

Soils: The Committee strongly agreed on the importance of the carbon pool in soils. They concluded that the most important way to preserve soil carbon is to allow forests to mature naturally, and to employ practices that reduce forest soil disruption when harvesting. Updating the Forest Best Management Practices Manual to include climate considerations, requiring state projects to be exemplary, and implementing EEA's Healthy Soils Action Plan were among their recommendations.

Resilience: There was significant disagreement on the Committee regarding the ability and merit of active forest management to increase forest resilience or adapt forests to future conditions. While most of the Committee agreed that age and species diversity increase resilience at a landscape scale, there was significant disagreement as to whether the Commonwealth should actively manage to enhance diversity, and if so, under what circumstances. Some argued vociferously that nothing needs to be done to make forests more resilient. Others argued with equal intensity that active forest management that focuses on enhancing ecological integrity and function is important to increase forest resilience to climate change and other stressors by enhancing forest structure complexity and species diversity to help forests transition to future conditions and ensure that forests reliably sequester carbon and maintain stocks. Going forward, the CFC recommends that agencies be more specific and transparent when developing and proposing management actions by identifying the forest element or characteristic to be made more resilient, the disturbance to be addressed, and the way a proposed action improves

the situation. In addition, agencies should promote resilience when managing for other objectives and develop and use resilience metrics to evaluate and manage forests.

Pests and Pathogens and Invasive Plants: Pests, pathogens, and invasive plants are challenges that defy universal solutions due to their variety, the diversity of forest types and conditions, and other factors. Rarely is decisive intervention clearly warranted or is it obvious that nature should be left to run its course. In most circumstances, case-by-case judgement calls must be made. Recognizing this, the Committee recommended making intervention and treatment decisions in a systematic and transparent manner using referenced tools, frameworks, and protocols where possible and creating new ones where necessary. The CFC also suggested expanding the purview and expertise of the current Forest Reserve Science Advisory Committee, including to address outbreaks within reserves on land held by all three divisions. The Committee also offered strategies to avoid and limit outbreaks and encouraged enhanced monitoring of actively and passively managed forests to enable early detection and decision making. When trees are diseased or dead, the Committee recommended less salvaging; and that it occur only in extremely rare circumstances before tree mortality and infrequently thereafter.

Public Water Supply Management: As to public water supply management, the CFC was split on the role of active forest management, reflecting Committee members' overall perspective on active management and forest resilience. While limited tree harvesting was not found to be harmful to drinking water supplies, some suggested it not occur in order to secure as much carbon as possible, others cited enhanced resilience as a rationale for active management, and still others suggested limited wood production was a reasonable goal but unnecessary to protect the water supply or enhance resilience. Also, consistent with its advice to be more explicit and precise, particularly when managing for resilience, the Committee called on the Commonwealth to articulate its rationale for active forest management on Division of Water Supply Protection lands.

Wood Production: Committee opinion on wood production differed profoundly, both regarding the wood produced as a secondary benefit of harvesting on state lands and more broadly, whether more wood should be produced from Massachusetts forests of all ownerships. Some recommended that Massachusetts produce more of the wood it consumes and seek to utilize more harvested wood in long-lived products that store carbon and substitute for more emissions intensive materials. Others argued that our forests are better suited for removing and storing carbon and those elsewhere should produce wood to meet Massachusetts' needs.

Guideline Implementation: This section of the Report concludes with a proposal from the Committee on how to implement its guideline recommendations and related agency land management suggestions.

Cognizant that the Commonwealth will be reflecting on the Report recommendations, inviting public input, and responding with its approach to implementation, two means were suggested. First, selection of forest management projects and the application of specific techniques by agency land managers, with the affirmation of their respective Commissioner that the recommendations of the Committee are properly incorporated. Also, incorporation of the CFC's recommendations into new iterations of plans, such as the State Forest Action Plan, as they are produced. In addition, the Committee included references to a number of resources on climate-oriented forest management strategies that can be used to advance its recommendations.

As to agency land management recommendations, the Committee recognized that a key challenge agencies face is to accomplish their respective mission while prioritizing climate change mitigation and adaptation – something that requires carefully considered tradeoffs. To assist with this, the Committee recommended reviewing agency missions for consistency with *Forests as Climate Solutions* and other current policy priorities, clearly articulating management goals for the forests of Massachusetts, and directly and explicitly expressing the management intent of projects. For example, agencies manage a lot of their land passively and the CFC called on them to do so intentionally. The Committee also offered a number of recommendations for how to select locations and approaches for forest land management.

Supporting and Complementary Recommendations

While the Climate Forestry Committee focused on recommendations for climate-oriented forest management guidelines, inevitably, many related topics that complement the goals of the guidelines were discussed, and the Committee offered recommendations on them in its Report.

To begin, the Committee had many recommendations on three key *Forests as Climate Solutions Initiative* objectives, to keep forests intact via permanent conservation, to reduce conversion to other land uses, and to expand forest reserves. Regarding land conservation, the Committee recommended strategies and tools not only as to how to best conserve land for carbon sequestration and storage, but also to incorporate equity and environmental justice and other conservation goals such as ecological integrity and habitat connectivity. As to reserves, the CFC recommended that at least 10% of the forest in Massachusetts (of all ownerships) be managed as reserves and that reserves on state land be codified to ensure long-term passive management. The Committee also offered recommendations on how to select land for reserves to meet multiple management objectives, address inconsistent land uses in areas otherwise suitable as reserves, and handle existing reserves and the process used to designate them.

Regarding landowner and business incentives, highlights include a call for incentives to protect forest land and manage it passively, help landowners produce climate smart forest management plans, hire a consulting forester for private timber sales, and to recruit and train more consulting foresters. Forest data recommendations address creating more continuous forest inventory plots and collecting broader data on each plot more often, ongoing consultation with scientists, enhanced use of remote sensing and other modern technologies, research to compare reserves and actively managed land, and accounting for land management and project specific carbon emissions.

Finally, the Committee offered more than a dozen recommendations grouped under three other categories; Forestry Policy and Practices, Investment in State Agencies, and Communications and Collaboration. They address engagement with indigenous groups, enhanced and more transparent communication about forest management goals and projects, improved data collection, greater staff capacity, and expanded use of and augmented authority under current statutes – such use of Chapter 61 to better support passive management and use of reports submitted under a Forest Cutting Plan (Chapter 132) to improve reporting and tracking of forestry projects and their outcomes.

Conclusion

The CFC approached its work with a keen awareness of the growing threats of climate change and the crucial role forests play in reducing carbon in the atmosphere. They considered current and relevant science to work through critical choices to help the Commonwealth secure its carbon future and maintain the natural and societal benefits of its forests. They agreed that most importantly, forests must remain forests and support the Commonwealth in its plans to increase conservation land holdings as well as to prioritize climate change when managing state public lands and incentivize other forest landowners to do the same. They agreed that forests should be considered not only for their carbon stocks and sequestration, but for a full range of societal benefits, and that tradeoffs will be required to focus land management more directly on climate mitigation and adaptation. CFC members look to the state agencies to use the CFC recommendations to elevate climate and biodiversity to critical priority status even as they respect the past work of state agencies to protect public lands and steward forests through a combination of passive and active management strategies that balance the public's multiple needs and values.

INTRODUCTION

In June 2023, the Healey-Driscoll Administration launched the *Forests as Climate Solutions Initiative* (*Initiative*) recognizing the vital role forests play in helping the Commonwealth address climate change and realize net zero greenhouse gas (GHG) emissions by 2050.

The *Initiative* includes four related components:

1. **Forest Conservation (Keeping Forests as Forests) and Forest Reserves**: Accelerate the pace of permanent forest conservation and reduce conversion to other land uses; expand forest reserves, dedicated areas where natural processes play out with minimal human intervention and carbon storage is usually greatest;
2. **Climate-Oriented Forest Management Guidelines**: Develop forest management guidelines based on the latest science, to be applied to state lands and serve as a model for other owners;
3. **Landowner and Business Incentives**: Expand programs to support climate-oriented forest management and stewardship of private and municipally owned forests; support forest-based businesses; and
4. **Forest Data**: Enhance forest data resources, integrate the best science to inform management practices, and make information publicly available; increase transparency and public information relative to state forest management activities.

A Climate Forestry Committee (CFC or Committee) was convened to advise the Governor's Office of Climate Innovation and Resilience (Climate Office) and the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) on development of the climate-oriented forest management guidelines (guidelines). EEA presented the Committee with the following charge:

- Define goals and objectives of climate-oriented forestry for Massachusetts, including clarifying the range of objectives that should be considered relevant;
- Evaluate best practices for climate-oriented forestry and the science supporting them;
- Assess current climate-oriented practices and guidelines in place for state lands; and
- Develop a set of recommended climate-oriented forest management guidelines to be implemented through incorporation into land management plans and forestry activities for land managed by the Division of Fisheries and Wildlife and Department of Conservation and Recreation Division of State Parks and Recreation and Division of Water Supply Protection, as well as advanced through incentive programs for forestry on land held by others.

The following Climate Forestry Committee members were appointed by EEA Secretary Rebecca Tepper to provide recommendations on the guidelines:

- Richard Birdsey, Senior Scientist, Woodwell Climate Research Center
- Paul Catanzaro,* State Extension Forester & Professor, UMass Amherst
- Tony D'Amato,* Professor, Forestry Program Director, Univ. of Vermont
- David Foster, Former Harvard Forest Director; Professor, Harvard University
- Alexandra Kosiba,* Extension Assistant Professor of Forestry, Univ. of Vermont

- Meghan Graham MacLean, Lecturer of Quantitative Ecology, UMass Amherst
- Laura Marx, Climate Solutions Scientist, The Nature Conservancy
- William Moomaw, Professor Emeritus, International Environmental Policy, Fletcher School, Tufts University and Distinguished Visiting Scientist Woodwell Climate Research Center
- Todd Ontl, Climate Adaptation Specialist, U.S. Forest Service
- Christopher Riely,* Forester & Conservationist, Sweet Birch Consulting, LLC
- Jennifer Shakun,* Bioeconomy Initiative Director, New England Forestry Foundation
- Jonathan Thompson, Research Director & Senior Ecologist, Harvard University/Harvard Forest

  * Licensed/Certified Forester

This final report of the CFC is divided into three sections: Background; Recommendations for Climate Oriented Forest Management Guidelines; and Supporting and Complementary Recommendations. The Background section: 1) provides information about the global climate emergency and the role of forests in mitigating GHG emissions; 2) summarizes the Commonwealth's legal and regulatory framework; 3) reviews particular characteristic of Massachusetts' forests; and 4) describes the work of the CFC and the process by which its recommendations were developed. The Recommendations section proposes a range of climate-oriented strategies integrated into ten forest management objectives, along with suggestions for implementation. The Supporting Recommendations include CFC suggestions for the other *Initiative* components - Forest Conservation and Forest Reserves, Landowner and Business Incentives, and Forest Data, and for other aspects of state forest policy.

BACKGROUND

Global Climate Emergency

Climate change is an unprecedented global emergency that demands a strategic response with a vast array of tools. According to the Fifth National Climate Assessment released in November 2023, "present-day levels of GHG in the atmosphere are higher than at any time in at least the past 800,000 years, with most of these emissions occurring since 1970."[1] Earth has already experienced significant, rapid shifts in its global climate system. The ongoing and expected future impacts of increasing temperatures, altered precipitation patterns, extreme weather events, and sea level rise, have and will increasingly affect people and all other forms of life across the entire planet.[2] In Massachusetts, experts anticipate more intense severe weather events, more extreme summer heat, and elevated risks of both inland and

[1] USGCRP. 2023. Fifth National Climate Assessment. Crimmins, A.R. et al., Eds. U.S. Global Change Research Program. Washington, DC, USA.

[2] IPCC Working Group 6. 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

coastal flooding, among other impacts on our health, communities, economy, infrastructure, and ecosystems.[3]

Forests are an essential component of the earth's operating system and will be affected by climate change as well as play a vital role in addressing its causes and adapting to its effects.[4] Globally, forests have the capacity to remove substantial amounts of carbon dioxide from the atmosphere, serving as partial mitigation for GHG emissions that cannot otherwise be eliminated.[5] This includes forests in Massachusetts, which currently store regionally significant quantities of carbon and can continue sequestering and storing substantially more,[6] with climate change potentially improving growing conditions through mid-century.[7] However, increasing occurrence of pests and pathogens, extreme weather, and other environmental stressors threatens to degrade forest health, according to the 2022 Massachusetts Climate Change Assessment,[8] while land conversion and deforestation could lead to additional carbon emissions.[9] Forests provide many benefits in addition to carbon sequestration and storage, including clean water and air, biodiversity-supporting habitat, local temperature regulation, recreational opportunities, and wood products. It is thus essential to protect and sustainably manage our forests in the face of climate-driven disruption and local and global environmental change to both mitigate GHG emissions and to continue to benefit from the broad range of other services forests provide.

Governing Legal and Policy Framework

The Global Warming Solutions Act (GWSA),[10] passed in 2008, requires economy wide GHG emissions reductions and obligates EEA to issue, every five years, a Clean Energy and Climate Plan. In 2021, An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy (2021 Climate Law) amended the GWSA and established the requirement for Massachusetts to adopt a statewide limit for 2050 that achieves at least net zero emissions by 2050; codified environmental justice criteria into law; and

---

[3] MA EOEEA. 2023. ResilientMass Plan: 2023 State Hazard Mitigation and Climate Adaptation Plan. Massachusetts Executive Office of Energy and Environmental Affairs.

[4] IPCC. 2023. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

[5] Mo, L. et al. 2023. Integrated Global Assessment of the Natural Forest Carbon Potential. *Nature*: 1–10.

[6] Meyer, S. R. et al. 2022. New England's Climate Imperative: Our Forests as a Natural Climate Solution. Highstead Foundation. Redding, Connecticut.

[7] Thompson, J. R., et al. 2020. Land Sector Report: A Technical Report of the Massachusetts 2050 Decarbonization Roadmap Study. Massachusetts Executive Office of Energy and Environmental Affairs.

[8] MA EOEEA. 2022. Massachusetts Climate Change Assessment. Massachusetts Executive Office of Energy and Environmental Affairs.

[9] Foster, D. R., et al. 2017. Wildlands and Woodlands, Farmlands and Communities: Broadening the Vision for New England. Harvard Forest Paper No. 33.

Olofsson, P. et al. 2016. Time Series Analysis of Satellite Data Reveals Continuous Deforestation of New England since the 1980s. *Environmental Research Letters* 11(6): 064002.

[10] Commonwealth of Massachusetts. 2008. An Act Establishing the Global Warming Solutions Act. Chapter 298 of the Acts of 2008.

required sector-based statewide[11] sublimits to be established. "Net zero" means a level of statewide GHG emissions that is equal in quantity to the amount of carbon dioxide or its equivalent that is removed from the atmosphere and stored annually by, or attributable to, the Commonwealth, and a reduction of GHG emissions by at least 85 percent relative to the 1990 baseline. The Clean Energy and Climate Plans for 2025 and 2030 (2025/2030 CECP)[12] and for 2050 (2050 CECP),[13] lay out a comprehensive suite of specific goals, strategies, policies, and regulatory actions to comply with these statutory requirements, including near-term and mid-century emissions reductions (Figure 1). These include changing how we heat homes, power vehicles, and supply the electric grid to phase out reliance on fossil fuels, as well as conserving and sequestering carbon on natural and working lands (NWL).[14]

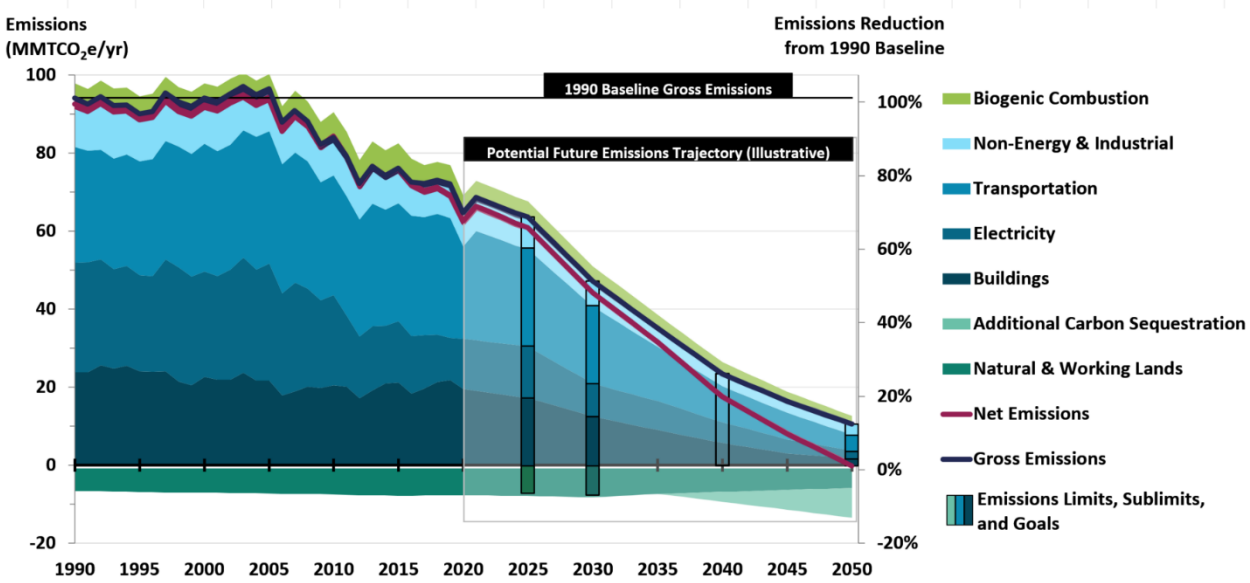

Figure 1: Massachusetts' pathway to achieving declining GHG targets, including an 85% reduction in 1990-level gross emissions and zero net emissions by 2050, as described in the 2050 CECP.[13]

NWL, particularly forests, are an important part of Massachusetts' approach to meeting its climate goals, and particularly in achieving net zero emissions in 2050, when NWL sequestration will be needed to help offset remaining GHG emissions from other sectors (Figure 11). Carbon sequestration from

[11] An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy, Chapter 8 of the Acts of 2021, Section 8.

[12] MA EOEEA. 2022. Massachusetts Clean Energy and Climate Plan for 2025 and 2030. Massachusetts Executive Office of Energy and Environmental Affairs.

[13] MA EOEEA. 2022. Massachusetts Clean Energy and Climate Plan for 2050. Massachusetts Executive Office of Energy and Environmental Affairs.

[14] Natural and working lands are defined by Massachusetts General Law Ch. 21N§1 as "lands within the commonwealth that: (i) are actively used by an agricultural owner or operator for an agricultural operation that includes, but is not limited to, active engagement in farming or ranching; (ii) produce forest products; (iii) consist of forests, grasslands, freshwater and riparian systems, wetlands, coastal and estuarine areas, watersheds, wildlands or wildlife habitats; or (iv) are used for recreational purposes, including parks, urban and community forests, trails or other similar open space land."

forests and other NWL contributes to offsetting residual emissions, and as the graph illustrates, is an essential component of meeting the 2050 net zero legislative mandate. However, future levels of NWL carbon sequestration are highly uncertain given ongoing environmental changes, including age-related decline in forest growth, regeneration challenges, ecological disturbances, land conversion, and climate change impacts.

The CECPs include plans to reduce emissions from and sequester carbon in forests and other NWL through four primary strategies: (1) protect NWL to avoid land use conversion, (2) manage NWL to enhance carbon sequestration and resilience, (3) restore NWL from degraded conditions, and (4) utilize NWL products that store carbon and have lower emissions than alternatives. The most important forest-related goals and actions in the 2025/2030 and 2050 CECPs include:

- Permanently protecting 30% of Massachusetts' land area by 2030, and 40% by 2050 (currently 27%) through a range of conservation programs and investment;
- Increasing the adoption of climate-smart forestry and healthy soils management practices through existing forest stewardships incentive programs and a new Forest Resilience Program;
- Increasing riparian and urban tree cover (an important strategy to reduce urban heat island effect, particularly in environmental justice communities) by over 16,000 acres by 2030 and over 64,000 acres by 2050, through expanded urban tree-planting and new riparian tree-planting programs; and
- Encouraging more efficient production and use of long-lived wood products harvested from local forests, including a Forest Viability Program that supports a more sustainable forest economy.

To achieve the Commonwealth's statutory emissions reductions mandates, forest policy must be established and forest management pursued on the basis of the most current science, taking into account the crucial role of our forests in mitigating emissions and providing health and many other benefits, and the ecological systems on which human survival depends.

Forest Management: The intentional application of a range of passive to active approaches to forest land aimed at reaching desired future conditions to achieve specific objectives (e.g., carbon sequestration, wildlife habitat, timber production, old-growth characteristics).

Massachusetts Forests

Massachusetts is one of the most highly forested states in the nation.

Overview

- Forests cover nearly 3 million acres, or about 56% of Massachusetts. These forests contain over 1.5 billion live trees.[15]

[15] USDA Forest Service. 2020. Forests of Massachusetts, 2019. Resource Update FS-239. Madison, WI: U.S. Department of Agriculture, Forest Service. 2p.

- Massachusetts' forest land is held and managed by a diverse set of landowners with varied interests.[15]
    - 64% of forests are privately owned by individuals, families, non-profit organizations, and businesses.
    - 17% of forests are held by state agencies on behalf of the public.
    - 16% of forests are held by municipalities.
    - 3% are held by the federal government.
- Between 2013 and 2019 Massachusetts experienced approximately 4,000 acres of net forest loss per year as a result of around 7,000 acres of deforestation and nearly 3,000 acres of reforestation and afforestation.[15]
- Further, detailed information on forests in the Commonwealth can be found in the Massachusetts 2020 State Forest Action Plan.

Land Use History[16]

- For more than ten thousand years, Massachusetts was mostly covered by mature and old-growth forests.
- What is now known as Massachusetts was first the home of indigenous people from many different tribes, and they have stewarded this landscape for thousands of years.
- With the arrival of European colonists in the 1600s and peaking after 1850, forests were cleared for agriculture.
- The shift of agriculture to the Midwest and transitions in Massachusetts' economy in the late 1800s led to a decline in farming and a major expansion of forest area on abandoned fields.
- New England is now the nation's most heavily forested region, even as the southern part of the region, including Massachusetts, is also among the most densely settled.
- Today's second growth forests have substantially different characteristics compared to the primary forests of the pre-colonial era, and face vastly different environmental conditions, including threats from development, invasive species, and other stressors.

[16] Foster, D. R., et al. 2017. Wildlands and Woodlands, Farmlands and Communities: Broadening the Vision for New England. Harvard Forest Paper No. 33.

Forest Carbon

- Forest ecosystems in Massachusetts currently contain carbon stocks equivalent to approximately 1.2 gigatons of carbon dioxide,[17] or the past 15 years of statewide GHG emissions.[18] The state's forests have among the highest carbon stocks per acre in New England (see Figure 2).[19]
    - Maintaining and growing overall forest carbon stocks, as has been occurring in Massachusetts (Figure 4), keeps carbon out of the atmosphere and contributes to mitigating climate change.
    - Carbon is stored in several forest ecosystems pools, including live biomass, dead organic matter, and soils, as well as in harvested wood products, landfills, etc. In Massachusetts forests, soils represent the largest, but slowest-growing pool, while live biomass is growing the most quickly (Figure 4).

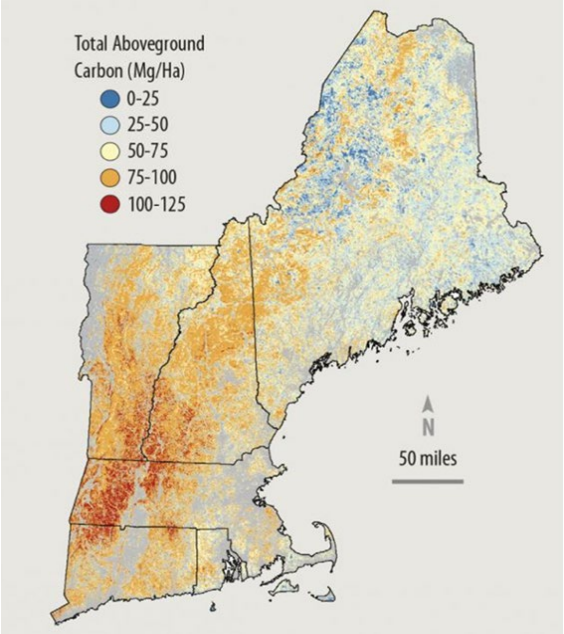

Figure 2: Forest carbon stocks across New England.[19]

[17] Walters, B.F., et al. 2023. Greenhouse Gas Emissions and Removals from Forest Land, Woodlands, and Urban Trees in the United States, 1990-2021: Estimates and Quantitative Uncertainty for Individual States, Regional Ownership Groups, and National Forest System Regions. U.S. Forest Service Research Data Archive.

[18] Calculation: Sum of statewide gross GHG emission, 2006-2020 = 1156 $MMTCO_2e$ ≈ 1200 $MMTCO_2e$ = 1.2 $GTCO_2e$. Massachusetts gross GHG emissions data from MassDEP. 2023. Appendix C: Massachusetts Annual Greenhouse Gas Emissions Inventory: 1990-2020, with Partial 2021 & 2022 Data. In *MassDEP Emissions Inventories* (accessed 11 December 2023). Massachusetts Department of Environmental Protection.

[19] Foster, D. R., et al. 2017. Wildlands and Woodlands, Farmlands and Communities: Broadening the Vision for New England. Harvard Forest Paper No. 33.

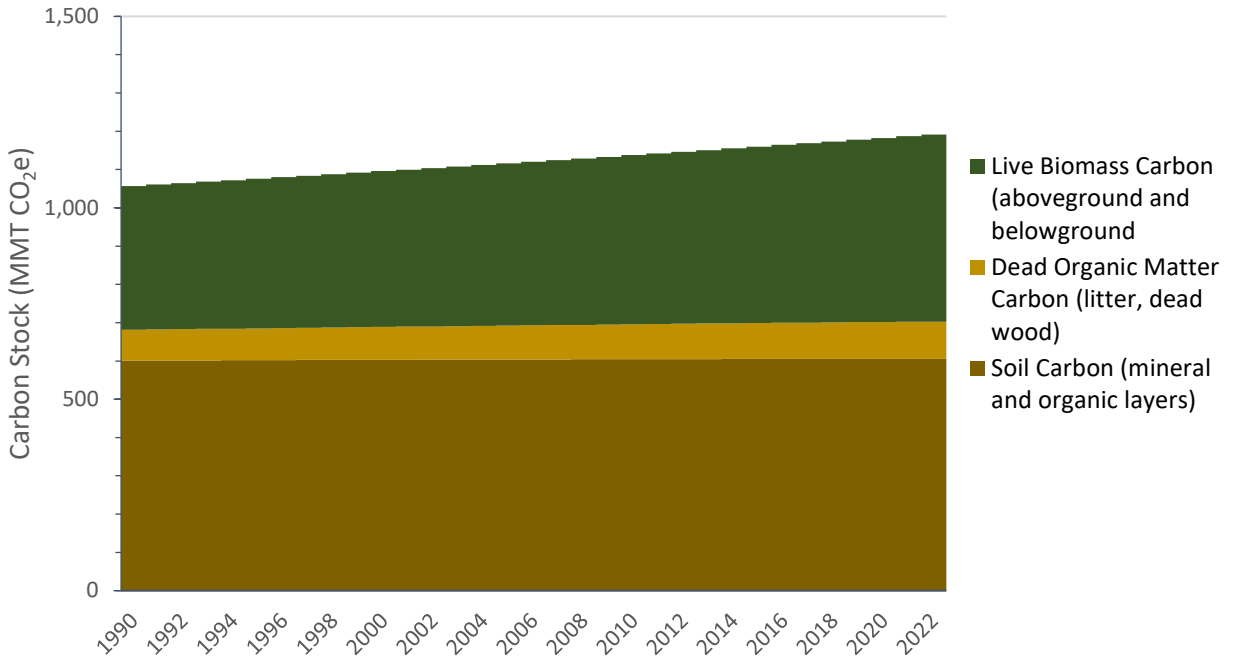

Figure 3: Estimated annual forest ecosystem carbon stocks in live biomass, dead organic matter, and soil pools in Massachusetts.[21]

- Massachusetts' forest ecosystems are estimated to be sequestering carbon at a rate of 4.5 $MMTCO_2e$ per year, as of 2021. Including sequestration in and emissions from settlement area[20] trees and forests, harvested wood products, and recently deforested and reforested or afforested land, total net sequestration is estimated at approximately 8 $MMTCO_2e$ per year (Figure 4).[21]
    - Net carbon sequestration from forest land uses is currently equivalent to just over 10% of statewide annual GHG emissions.[22]

---

[20] Settlements are areas of developed land use, including areas of forest and tree cover within urban areas or otherwise surrounded primarily by developed land uses See: EPA. 2023. Chapter 6. Land Use, Land-Use Change, and Forestry. In *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021*, Reports and Assessments, U.S. Environmental Protection Agency.

EPA (2022) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. U.S. Environmental Protection Agency, EPA 430-R-22-003. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020 | US EPA.

[21] Walters, B.F., et al. 2023. Greenhouse Gas Emissions and Removals from Forest Land, Woodlands, and Urban Trees in the United States, 1990-2021. Harvested wood product estimates from EPA. 2022. State Inventory and Projection Tool.

[22] Calculation: 8 $MMTCO_2e$/yr. net forest sequestration / 70.4 $MMTCO_2e$/yr. statewide gross GHG emissions (average of most recent 5 years reported) = 11.4%. This is equivalent to 8.6% of 1990 baseline gross emissions. Gross emissions data from: MassDEP. 2023. Appendix C: Massachusetts Annual Greenhouse Gas Emissions Inventory: 1990-2020, with Partial 2021 & 2022 Data. In *MassDEP Emissions Inventories* (accessed 11 December 2023). Massachusetts Department of Environmental Protection.

- Forest carbon sequestration had been increasing since 1990, though it appears to have recently plateaued, meaning carbon stocks are growing at a steady, but no longer accelerating, rate.

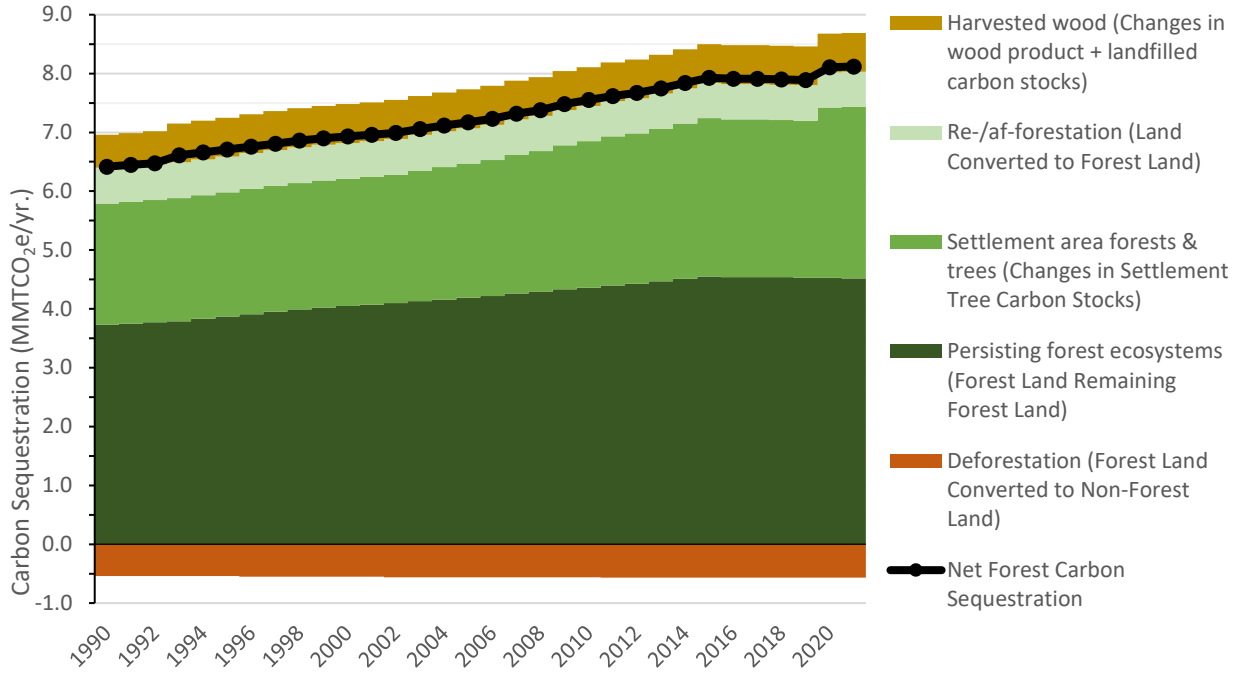

Figure 4: Estimate annual carbon sequestration and GHG emissions from Massachusetts forest land uses and land use conversion.[21]

- Most forests in Massachusetts can continue to accumulate carbon for decades to come, though uncertainty about major disturbances and other ecological processes (e.g., age-related decline in tree growth, climate change impacts, regeneration) makes it challenging to precisely quantify future potential carbon storage levels and sequestration rates.
    - Forest simulation modeling in Massachusetts' *2050 Decarbonization Roadmap Study* indicates that live biomass carbon in the state could increase by over one-third from 2020 to 2050 across a range of future scenarios, and that climate change is likely to create more favorable growing conditions, though the study did not include major disturbances like hurricanes that could be intensified by climate change.[23] An updated forest carbon modeling study is underway to examine outcomes under a broader range of disturbance, land use, and management scenarios. Specifically, it will consider anticipated effects of climate change, invasive insect pests, hurricanes, deforestation, and reforestation/afforestation.
    - If current levels of carbon sequestration on forests and other natural and working lands were to continue through midcentury, an outcome that is far from assured, total net

[23] Thompson, J. R., et al. 2020. Land Sector Report: A Technical Report of the Massachusetts 2050 Decarbonization Roadmap Study. Massachusetts Executive Office of Energy and Environmental Affairs.

carbon sequestration would offset around half the state's allowable residual GHG emissions in 2050, leaving a gap to reach net zero emissions (Figure 1, p.13).

State Forest Lands

Three EEA agency divisions hold and manage considerable amounts of forest land. Each agency and division is responsible for pursuing a specific mission[24]:

- Department of Conservation and Recreation (DCR) Division of State Parks and Recreation (DSPR): DCR's Management Forestry Program engages in stewardship activities and outreach, on state forests and parks, to support a range of ecosystem services that benefit the people of Massachusetts and beyond. These services include climate change mitigation, promotion of human health through improved air and water quality, forest health mitigation, conservation of biological diversity, quality forest recreation, and provision of local wood products.
- DCR Division of Water Supply Protection (DWSP): DCR's Division of Water Supply Protection protects forests and drinking water resources in perpetuity for future generations.
- Department of Fish & Game (DFG) Division of Fisheries & Wildlife (DFW, or MassWildlife): DFG's Division of Fisheries and Wildlife 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 as an integral part of natural ecosystems, and for people to enjoy.

Over the past two decades, limited active forest management (harvesting) has been conducted on agency-managed land in pursuit of their missions. Mortality data is not currently available for DFW land. See Table 1 and Figure 5.

- DCR DSPR holds over 280,000 acres of forest land and has harvested an average of 647 acres annually (0.23%) since 2006. Harvesting removed the equivalent of approximately 7% of growth from 2001 to 2020, while natural mortality claimed the equivalent of about 44% of growth.
- DCR DWSP holds over 96,000 acres of forest land and has harvested an average of 524 acres annually (0.54%) since 2006. Within the Quabbin and Ware River watersheds harvesting removed the equivalent of approximately 24% of growth from 2001 to 2020, while natural mortality claimed the equivalent of about 37% of growth over the same period. Harvest removal and mortality data is not currently available for the Wachusett and Sudbury watershed portions of DWSP land.
- DFG DFW holds over 143,000 acres of forest land and has harvested an average of 397 acres annually (0.30%) since 2006. Harvesting removed the equivalent of approximately 3% of growth from 2006 to 2020. Mortality data is not currently available for DFW land.

[24] Relevant statutory citations are including in Appendix D.

Table 1: Forest land area, harvesting, growth, and mortality estimates reported by agency, and for Massachusetts forests statewide.[25] For harvest volume and mortality estimates, data sources, methods, and covered time periods differ across agencies and comparisons across columns should be treated as rough approximations.

	DCR DSPR Forests	DCR DWSP Forests	DFG DFW Forests	Total State Forests	All Forests Statewide
Forest Area (acres)	280,196	96,751	143,294	520,241	2,986,657
Harvested Area					
annual average acres, 2006-2022	647	524	397	1,568	13,553 (2013-2019)
average annual % of forest, 2006-2022	0.23%	0.54%	0.28%	0.30%	0.45% (2013-2019)
Harvested Volume					
harvest removals as a % of gross growth	7.1% (2001-2020)	23.7%* (2001-2020)	2.8% (2006-2020)	data not available	12.1% (2013-2019)
Natural Mortality					
mortality as a % of gross growth	43.9% (2001-2020)	37.2* (2001-2020)	data not available	data not available	39.3% (2013-2019)

* Quabbin and Ware River watersheds only; data not available from Wachusett and Sudbury watersheds.

[25] Statewide forest estimates from USDA Forest Service. 2020. Forests of Massachusetts, 2019. Resource Update FS-239. Madison, WI: U.S. Department of Agriculture, Forest Service. 2p.

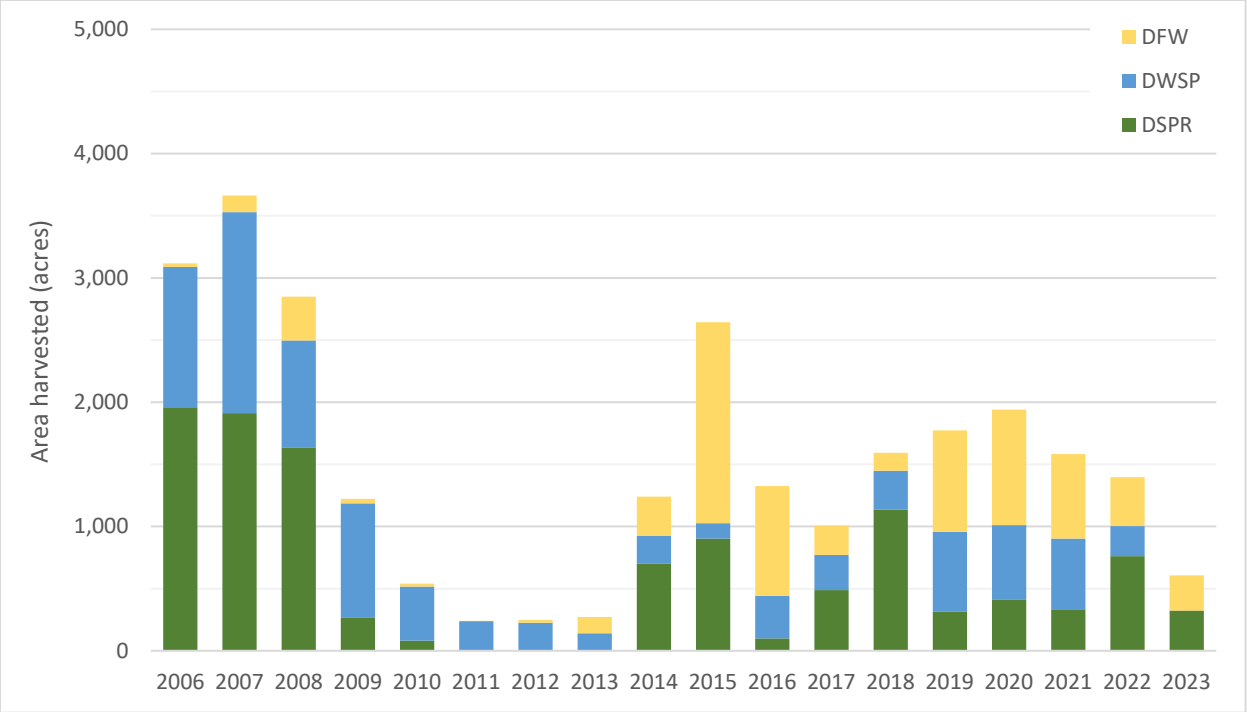

Figure 5: Reported annual harvested area for each division that owns & manages forest land. DFW & DSPR harvests are reported by fiscal year (through FY2023), while DWSP harvests are reported by calendar year (through 2022).

The Climate Forestry Committee

The Healey-Driscoll Administration convened the Climate Forestry Committee, a group of distinguished scientific experts listed above, to inform the development of climate-oriented management guidelines that increase forest carbon storage and resilience to climate change. The recommendations of the Committee evaluate and build on the science-based practices currently in place, and help the state ensure its forest land management decisions are prioritizing climate mitigation and resilience in line with the GWSA and 2021 Climate Law. The Executive Office of Energy and Environmental Affairs and its agencies will implement the guidelines by applying them to state forest management plans and projects and by incorporating them into incentives, educational outreach, and other engagement with private and municipal forest landowners.

CFC Process

Upon its establishment, the CFC held an introductory meeting in late June 2023, during which Committee members determined its organization, schedule, and general process. Just prior to its first meeting, each Committee member was individually interviewed and discussed their interests, concerns, and values related to the science of forest management and climate change as part of a situation assessment conducted by the facilitator. From September through November, the CFC held 7 additional meetings, 4 were in person with a few members participating virtually, and three were 2-hour virtual meetings. Stephanie Cooper, Undersecretary for Environment, and Kurt Gaertner, Assistant Secretary for Environmental Policy, convened and supported the CFC deliberations. Each meeting was professionally facilitated by Susan Podziba of Podziba Policy Mediation. After each meeting, the EEA Team and facilitator met with the CFC members who had been absent from the meeting to update them

on the Committee's deliberations and obtain their input on issues for integration into iterative drafts of the CFC Final Report.

All CFC members brought their scientific backgrounds and expertise to the discussions and shared their own and others' research papers, including recent scientific findings related to climate change and forests. Throughout its discussions, the CFC reviewed, sought, and shared information its members identified as relevant to its charge, including peer reviewed papers on aspects of climate change and forests generally and climate-oriented forest strategies, as well as a summary of existing climate-oriented forest management practices currently in use on state lands. Whereas CFC members generally agreed on the implications of climate change on forests and some key management strategies, members held different views about other aspects, particularly on the effectiveness and appropriateness of active management strategies.

After the CFC identified the need to learn more about the missions and current practices of the Division of State Parks and Recreation and Division of Water Supply Protection at the Department of Conservation and Recreation and the Division of Fisheries and Wildlife at the Department of Fish and Game, they invited the leadership from those three Divisions to discuss current management goals and approaches. The Division presentations and answers to CFC questions were considered highly useful and helped to inform the Committee's work.

At the end of the third meeting, and after CFC discussions clarified key areas that members agreed were important to include in the guidelines, several members volunteered to draft a framework for the report. At and between each subsequent meeting, all CFC members reviewed, commented on, contributed references to, discussed, and revised the draft document until it was finalized and approved. The EEA Team and facilitator provided drafting support throughout the process.

The Final CFC Report provides background context for the CFC's work and specific recommendations for climate-oriented forest management guidelines. The report documents where the CFC reached consensus and where members held divergent views. For example, consensus, "many," "some," and "few" are used as descriptors in an effort to accurately characterize support.

As indicated in its agreed upon organizational protocols, for areas where consensus could not be reached, the CFC members worked to clarify their differences, with the understanding that EEA will consider the CFC information and public input to make its final policy determinations. In addition, the CFC provided complementary recommendations, beyond its specified charge, regarding support for the state agencies that conduct forest management activities and other components of the *Forests as Climate Solutions Initiative*.

Public Input

EEA hosted two virtual public meetings, one at the outset of the CFC process on September 12th and another on November 14th as it neared its completion. Each meeting was well-attended, with 250 and 180 attendees, respectively. In addition, a guidelines@mass.gov email address was established, and comment input forms were utilized, to facilitate communication and receipt and posting of comments. Over 180 comments were received, including oral comments made at the meetings and written submissions (see Forests as Climate Solutions | Mass.gov).

The purpose of the first public meeting was to provide context and share information about the broader *Forests as Climate Solutions Initiative*, of which the CFC process is one part, and to seek general input

from the public as the CFC was delving into the substance of its work. EEA presented framing questions to guide public input, which focused on human roles in managing forests, forest reserves, and how to best respond to climate impacts on forests. Some CFC members attended this meeting, and EEA provided CFC members with the comments received, a recording of the meeting, and a thematic summary of the meeting.

The purpose of the second public meeting was to share content and themes reflecting the CFC deliberations, and to seek input for EEA's consideration when reviewing CFC recommendations. EEA provided an overview of key areas the CFC had identified for inclusion in the guidelines and presented a series of statements that reflected CFC discussions. Public meeting participants were provided with a survey that asked them to indicate their level of agreement with a series of statements and provide open-ended comments. The survey results and public comments solicited upon release of this report will be considered by EEA as it updates its approach to forest land management.

CFC RECOMMENDATIONS FOR CLIMATE-ORIENTED FOREST MANAGEMENT GUIDELINES

Introduction

The overall goal of the guidelines is to employ active and passive management strategies to maintain our forest ecosystems and forest cover, to protect existing carbon stocks and sequestration capacity, and to recommend actions informed by the latest climate science to ensure achievement of GWSA and 2021 Climate Law statutory requirements while also achieving other goals of the Commonwealth.

The CFC recommendations are organized into ten topical sections that provide general and project level guidance. Rather than develop a list of actions to take to manage for climate, the Committee elected to address the most common topic areas, considerations, and goals that forest landowners, managers, and state agencies consider, and examined those topics with a climate lens. For example, when planning for the creation, maintenance, or enhancement of wildlife habitat, one should consider these additional characteristics, strategies, and practices in light of climate. This reflects the CFC's recognition of climate change as a cross-cutting issue and the perspective that, in most cases, state managers should incorporate climate considerations into an existing decision-making process, rather than treating it as a separate issue. In line with this approach, each section includes recommendations to the Commonwealth for enhanced climate-oriented forest management, which is expected to be implemented through incorporation into forest land management plans and activities of the Divisions of Fisheries and Wildlife, State Parks and Recreation, and Water Supply Protection.

Throughout the Committee discussions, members identified and discussed passive and active forest management strategies. Passive management is an intentional hands-off approach that allows forests to be shaped largely by natural processes. Active management is a set of strategic interventions to promote particular forest outcomes. Although CFC members generally preferred one approach over another, they all recognized that there is a broad range of forest management intensities, activities, and techniques across a spectrum from passive to active, as depicted conceptually in the Continuum (Figure 6), and that it is often appropriate to employ different strategies simultaneously across a landscape to achieve mutual complex goals. Many of the topical sections of the recommendations reflect these multiple perspectives.

Application of Committee Recommendations:

- To achieve the statutory missions of the agencies[26], including protection of forests and wildlife, provision of quality recreation, production of local wood and provision of clean water and wildlife habitat, while also meeting statutory obligations to reduce carbon emissions, will require flexibility in application of the guidelines.
- The recommendations are intentionally general, to be considered and applied by state land managers as they utilize professional expertise to address specific circumstances.
    - Committee suggestions are not meant to be prescriptive, instead they are intended to allow managers to apply their knowledge and enable ongoing learning and adaptation.
    - Each forest stand is unique and is shaped by a number of characteristics, including its physiography and land use history. Each forest also sits within a particular landscape context that includes a combination of past and current land objectives and challenges (e.g., invasive pests and plants).
- The Committee recognizes that land managers will utilize a broad range of forest management strategies across a spectrum from passive to active. This includes a completely and decidedly hands-off approach as well as a variety of active management approaches.
- These recommendations are built on a foundation of existing forestry laws and policies, which help ensure that, where appropriate, active management of forests can be done sensitively and play an important role in mitigating climate change. These laws include the Forest Cutting and Wetlands Protection Acts and forester licensing.

[26] Relevant statutory citations are including in Appendix D.

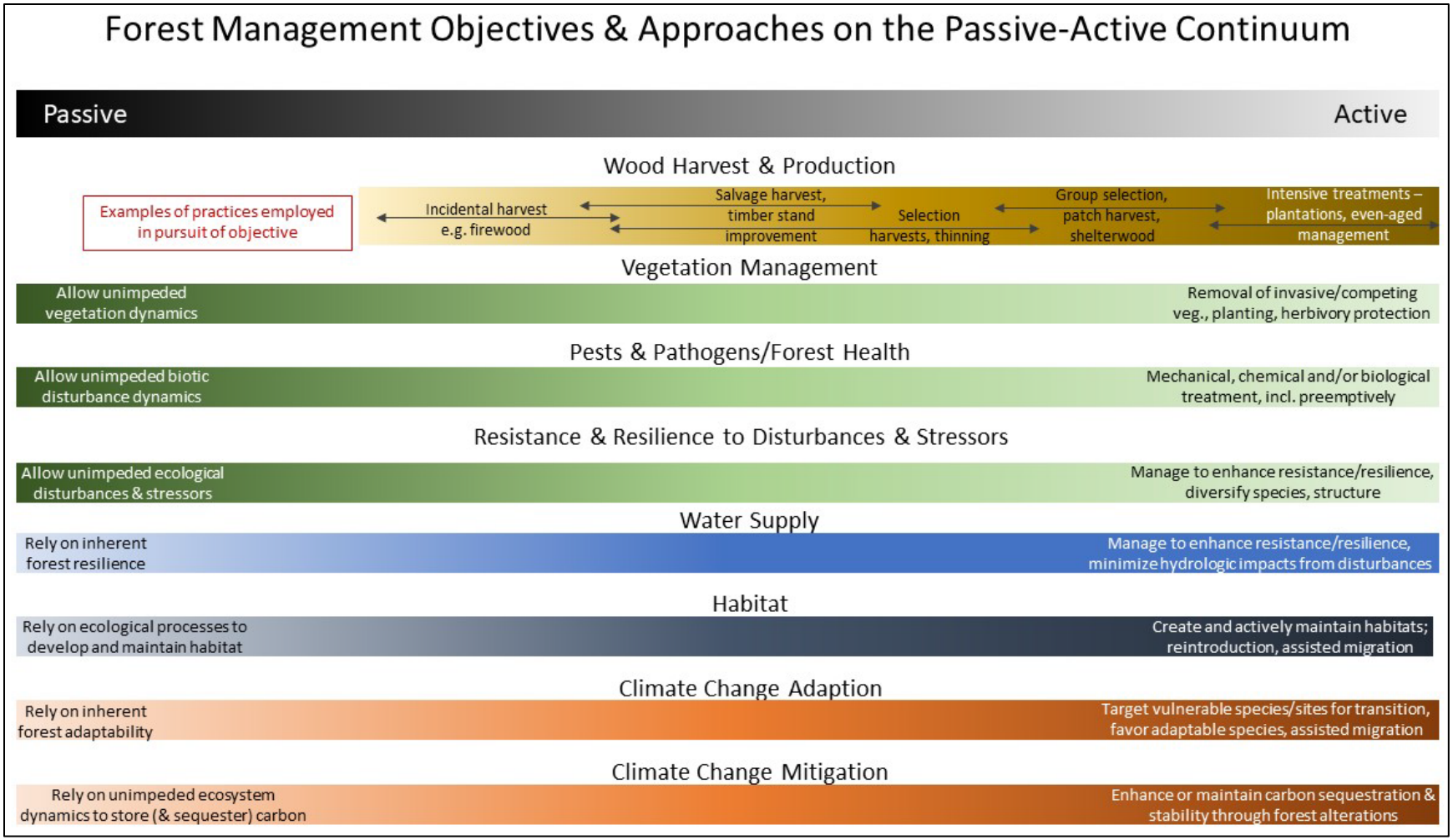

Figure 6: Forest management along a continuum from active to passive. Illustrative and meant to inform creation and implementation of updated forest management guidelines.

General Recommendations

- Strategic application of the guidelines is important, especially in regard to the selection of specific locations to be subject to particular management approaches. The Committee recommends that all three agencies clearly designate more of their forests to be passively managed as reserves. Also, given limited time and resources, agencies should seek to maximize the beneficial impact of their forest management activities along the passive to active continuum by taking a landscape scale approach and prioritizing areas, which will have the greatest beneficial impact and odds of success.

- The Committee emphasized that active management that involves tree cutting typically reduces carbon stocks within forests, at least in the short term. This loss must be carefully considered and minimized by land managers and Division leadership when evaluating the benefits and consequences of potential projects that may advance other goals. A few argued that short term loss of carbon stocks is critical to consider, given the steep reductions in GHG emissions that must occur to avoid more dangerous levels of warming[27].
    - The history of the Massachusetts landscape[28] should be considered when establishing land management goals, because current forest cover is significantly altered and very different from that found centuries ago.
    - While a broad view is important to address the many state forests that serve multiple purposes, specialization of function and use in some places and situations is appropriate. For example, it will be appropriate to manage a forested campground differently from the larger forested land that surrounds it.
- The Committee recommends that agencies be more explicit and transparent regarding land management objectives. Agencies are encouraged to articulate habitat/land cover and other goals in their guiding plans, to acknowledge when those goals are taking precedence, to explain their choices to pursue specific forest management projects, and to articulate the rationale behind forestry prescriptions for individual projects within the context of their division's mission.
- The Committee recommends that, in general, when forest management is implemented, silviculture should mimic natural disturbance regimes historically associated with that local site and forest community (e.g., leave some large trees and downed wood).
- Commonwealth land managers and agency leadership must be empowered to make considered decisions, informed by public input, that involve tradeoffs and simultaneously seek to achieve multiple goals. For example, an action that does not yield the greatest short-term carbon storage may be appropriate because other goals are advanced, an action that yields the most

---

[27] IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, doi: 10.59327/IPCC/AR6-9789291691647

[28] Foster, D. R., et al. 2002. Wildlife dynamics in the changing New England landscape. *Journal of Biogeography* 29: 1337-1357.

short-term carbon storage may lead to other detrimental outcomes, or the pursuit of lower, but stable amounts of stored carbon may be more beneficial than pursuing maximum short-term carbon storage.

- The Committee agreed that Massachusetts forests should never be managed solely for carbon, rather, they should be simultaneously managed for multiple benefits including carbon sequestration. These goals are often compatible – biodiverse ecosystems, for example, are more resilient to the impacts of climate change. As shown in joint studies of The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC), the three crises of climate change, biodiversity loss, and declining human equity and well-being need to be addressed simultaneously to avoid unanticipated and inadvertent consequences:[29]
    - "Safeguarding biodiversity and ecosystems is fundamental to climate resilient development, in light of the threats climate change poses to them and their roles in adaptation and mitigation (very high confidence)." [30]
    - "A sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fiber or energy from the forest will generate the largest sustained mitigation benefit."[31]

Keep Forests as Forests

The Committee unanimously agreed that maintaining forest cover is essential.

Harvard Forest calculates that since 2010 Massachusetts has lost nearly 50,000 acres, or almost 4,000 acres per year, of forest to land conversion.[32] Every acre of forest lost to conversion represents a loss of stored carbon to the atmosphere as well as a loss of future carbon sequestration. The Committee strongly supported aspects of the *Forests as Climate Solutions Initiative*, discussed below, that seek to reduce forest land conversion and increase permanent forest conservation to protect stored carbon and the capacity to sequester more carbon, provide critical habitat, and realize the other benefits of forested land.

- Though forest land owned by the three Divisions is already protected under Article 97 of the Amendments to the Constitution of the Commonwealth, and its charge focused on management of this conserved land, the Committee was compelled to note that maintaining forests in forest use is a foundational strategy for both public and private forest land.

---

[29] Portner, H.O. et al. 2021. Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change. IPBES secretariat, Bonn, Germany.

[30] IPCC Working Group II. 2022. Summary for Policymakers. In *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

[31] IPCC Working Group III. Chapter 9: Forestry. In *Climate Change 2007: Mitigation of Climate Change*. Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

[32] Based on analysis conducted by Harvard Forest of U.S. Geological Survey Land Change Monitoring, Assessment, and Projection (LCMAP) land cover data products.

Forest Management for Habitat

Given the significant carbon implications of current goals, especially those of MassWildlife for early successional habitat, the Committee recommended that the state reconsider its existing goals and articulate new goals for a diversity of habitat types. Pursuant to Executive Order 618 "Biodiversity Conservation in Massachusetts," and recognizing GWSA and 2021 Climate Law requirements, and the 2050 CECP plan, which all require increasing carbon storage on Massachusetts lands, the CFC recommends establishing habitat goals that place less emphasis on early successional habitat and more emphasis on late successional habitat and the development of old-growth forest characteristics.

- The Committee recommends that MassWildlife reassess its current habitat goals for grasslands (1-2%), shrublands (8-9%), young forest (10-15%), full canopy forest that is between 30 and 120 years old (60%), and forest reserves and biologically mature forests that are over 120 years old (15%). Currently grasslands, shrublands, and young forest comprise 10-12% of MassWildlife land holdings, full canopy forest 75-80%, and mature forest about 10-12%.[33] Regarding new goals, the Committee recommends that greater consideration be given to carbon implications and the alignment of habitat management with carbon storage and sequestration goals. It also suggests that habitat goals be set across state agency land holdings and for all the natural land cover within Massachusetts in order to set priorities based on the most suitable land regardless of ownership and to consider carbon and other implications comprehensively.
    - Increase the goal for late successional and old-growth habitat, which is associated with carbon storage and is greatly underrepresented on the landscape compared to the historic amount.
        - Active management can employ silvicultural techniques that help to accelerate development of some old forest characteristics (e.g., snags and woody debris) and habitat in our currently maturing forests,[34] while a passive long-term approach allows natural processes to develop old growth forest characteristics over time.
        - The Committee has differing perspectives on the value and appropriate application of passive to active techniques, but regardless of which approach is used, the Committee recommends being more explicit about agency intentions and means of expanding habitat with old forest characteristics.
    - Reduce the goal for early successional habitat (e.g., grasslands, shrublands, young forests) given the current goal's carbon implications, which include foregoing the climate benefit of sequestration by continually maintaining land as grassland or another early successional habitat. DFW currently has goals for early successional habitat types

[33] Scanlon, J. and Hawthorne, B. 2019. Carbon and Conservation on MassWildlife Lands. *Massachusetts Wildlife*. 69(4): 2-13.

[34] D'Amato, A. and Catanzaro, P. 2022. Restoring Old-Growth Characteristics in New England's and New York's Forests. University of Massachusetts Amherst.

that are cumulatively up to 25% of Division land.[33] A goal closer to the current management rate is also more likely to be achieved, given limited time and resources.

- Assess the extent to which early successional habitat is or could be continuously created in all forested areas of the Commonwealth, including public and private lands, as a result of ecological disturbances (e.g., extreme weather events, disease, pest infestations), potentially intensified by climate change, as well as by other management efforts (e.g., energy or transportation corridors). Then determine how much more state forest land should be dedicated to early successional habitat. The proliferation of energy and transportation land uses and corridors and the shift away from the use of herbicides to maintain electrical transmission corridors has resulted in a great abundance of grassland, shrubland, and early successional forest that is actively maintained. Accounting for this large amount of habitat could reduce the need for early successional habitat on other forested land.
- Reduce cutting of maturing forests to create early successional habitats to realize species regeneration and habitat goals. Instead, designate recently harvested areas, including those cleared of plantations and areas disturbed by natural processes, as early successional habitat. This could reduce the number and area of additional early successional habitats required to meet the needs of the species they support.
- Retain early successional habitat, rather than allow it to mature only to create it elsewhere, where wildlife biologists indicate that this approach creates equivalent habitat.
    - Provide additional funding as this practice increases management cost.

- As discussed in the general recommendations, agencies are encouraged to be more explicit and transparent regarding land management objectives and their carbon and climate implications.
    - Articulate habitat/land cover and other goals in guiding plans, acknowledge when those goals are taking precedence, explain choices to pursue specific forest management projects, and articulate the rationale behind forestry prescriptions for individual projects.
- Consider the history of the Massachusetts landscape[35] when re-evaluating habitat goals, including whether the decline of early successional species is a natural consequence of forest recovery and succession from past forest clearance, and whether active management for these species and their habitats is warranted in the context of an overall emphasis on natural land cover and climate mitigation.

[35] Foster, D. R., et al. 2002. Wildlife dynamics in the changing New England landscape. *Journal of Biogeography* 29: 1337-1357.

Ecological Disturbance

The Committee strongly agreed that ecological disturbances, even when they are more frequent and intense due to human activity, are an important and necessary aspect of forest ecosystems as they serve to increase the structural and compositional complexity and dead wood that are often lacking in Massachusetts' forests because of the region's land-use history.[36]

Recognizing that a disturbed forest is still a forest, in most circumstances the Committee recommends that state land managers forego salvage harvesting and leave dead wood to realize the habitat quality and biodiversity benefits of increased structural diversity of the forest.[37] **The Committee also pointed out that disturbances help the agencies achieve their resilience goals insomuch as they diversify age classes and create opportunities for species establishment. In addition, areas of disturbance, particularly wind disturbance, may provide protection from herbivory and facilitate regeneration.**[38]

The Committee found that salvaging logging usually represents a short term (10-20 year) carbon loss to the atmosphere in comparison to leaving the wood to decay in the forest, that carbon benefits accrue only in limited circumstances,[39] **and that the practice may have negative effects on biodiversity.**[40]

- The Committee was deeply skeptical of pre-salvage harvesting (removal before trees are affected by a pest or pathogen) and the notion that it is ecologically beneficial and indicated that it could only be justified in very narrow circumstances, such as trees causing a public safety hazard or a rapid response to a novel detrimental species occurrence (e.g., Asian Long-Horned Beetle, Southern Pine Beetle).[41]
- The Committee was more supportive of evaluating post-salvage harvesting (removal of trees after they are infested or dead) on a case-by-case basis. However, they agreed that salvage of trees after a disturbance should not be the primary impetus for a timber harvest. Rather, post-

---

[36] Foster, D. R., et al. 1997. Forest response to disturbance and anthropogenic stress. Rethinking the 1938 Hurricane and the impact of physical disturbance vs. chemical and climate stress on forest ecosystems. *BioScience* 47: 437-445

[37] Thorn, S. et al. 2018. Impacts of Salvage Logging on Biodiversity: A Meta-Analysis. *Journal of Applied Ecology* 55(1): 279–89.

[38] Grisez, T. J. 1960. Slash Helps Protect Seedlings from Deer Browsing. *Journal of Forestry* 58:385–387.
Hunn, J. 2007. Retention of Logging Debris to Reduce Deer Browsing and Promote Forest Regeneration. Bachelor's Thesis, College of Agriculture and Life Sciences, Department of Natural Resources, Cornell University, Ithaca, NY.
Smit, C. et al. 2012. Coarse woody debris facilitates oak recruitment in Białowieża Primeval Forest, Poland. Forest Ecology and Management. 284: 133–141.

[39] Gunn, J. S., et al. Forest carbon resilience of eastern spruce budworm (Choristoneura fumiferana) salvage harvesting in the Northeastern United States. *Frontiers in Forests and Global Change* 3: 14.

[40] Thorn, S. et al. 2018. Impacts of salvage logging on biodiversity: A meta-analysis. *Journal of Applied Ecology*, 55(1): 279-289.

[41] Foster, D. R., and Orwig, D. A. 2006. Pre-emptive and salvage harvesting of New England forests: when doing nothing is a viable alternative. *Conservation Biology* 20: 959-970.

salvage harvesting should only occur under limited circumstances such as when a harvest was already planned and it makes sense to harvest while there is still value, or where there is a clear public safety or access issue that necessitates harvesting (i.e., in the event of a fire the dead trees would present a hazardous condition, in which case prompt action to remove timber while it has commercial value is prudent in order to avoid incurring unnecessary costs). The Committee recommends identifying overall or agency specific salvaging criteria (for example, it might make sense to manage differently if the disturbance impact is at the edge of state land abutting private land or in the middle of a large state-owned landscape), and the creation of a decision-making flow chart to aid land managers in deciding when, where, and to what degree salvage harvesting is warranted.

    - Regarding flow chart creation see *Does Salvage Logging Mitigate Subsequent Forest Disturbances?,*[42] recognizing that there are multiple considerations that should be incorporated into the chart beyond how the salvage operation affects the ecology of the forest, such as the size and quality of the timber to be recovered and whether it makes sense to capture that value and carbon.

- The Committee found no ecological rationale for salvage harvesting on public land. Some on the Committee found salvage harvesting appropriate when there is a clear carbon benefit or an opportunity to produce local wood and reduce harvest elsewhere. Others argued there could be no carbon benefit.
- The Committee acknowledged that there are important differences between public and private ownership, and that more leeway regarding salvage harvesting is appropriate on private land.
- Several members of the Committee argued that state lands should play an important role in efforts to preserve species (e.g., ash) in the landscape. They stated that it is important for state land managers to consider forgoing pre-salvage harvesting to allow individual trees with natural genetic immunity or resistance to survive and continue the existence of these species. In addition, that disturbances diversify forests, often without the additional impacts and carbon loss associated with harvesting.

Carbon Stocks & Sequestration

The Committee strongly agreed that carbon storage is typically greatest in old forests and disproportionately in the largest trees, and that Massachusetts forests can continue to accumulate additional carbon for many decades if undisturbed, thus underscoring the importance of forest reserves for protection of carbon storage.

There was some disagreement on the Committee relative to the age at which forests sequester the most carbon. While it was accepted that younger to middle aged forests sequester carbon at a higher rate than older forest, Committee members did not agree on the specific age range at which sequestration is maximized. Regardless, the Committee agreed that is not practical to manage for a narrow window of peak carbon sequestration.

---

[42] Leverkus, A. B. et. al. 2021. Does Salvage Logging Mitigate Subsequent Forest Disturbances? *Forest Ecology and Management* 481: 118721.

- The Committee generally agreed that passive management would confer greater increases in carbon stocks compared with active management.[43] That is, allowing forests to grow and age through passive management is typically the best approach for maximizing carbon storage. However, there may be exceptions to this, and the CFC recognizes that the Commonwealth has additional values and objectives, such as the creation of early successional habitat for biodiversity or managing for wood production, that warrant more active forms of management.
    - Middle-aged forests that predominate in the Eastern U.S. have attained about half of their maximum carbon stocks, and most could continue to accumulate carbon for many decades or even centuries in the absence of harvesting and major disturbance.[44]
    - Reserves in the northeast have greater or similar carbon stocks and rates of sequestration than environmentally comparable forests that are protected from conversion but open to active management.[45]
    - Not all passively managed forests will reach their carbon potential. For example, those that experience multiple stressors (e.g., disturbances, invasive species that limit regeneration) are unlikely to store as much carbon as they otherwise could, and can be expected to have varying future ecosystem and forest carbon dynamics.
- The Committee opposes deliberate removal of older forest to create younger forests primarily for the purpose of enhancing annual carbon sequestration. Doing so would be counterproductive, as it would release more forest carbon to the atmosphere than would be removed by enhanced sequestration over a meaningful timeframe.
    - Active forest management and ecological disturbances have complex long-term climate implications. Both lead to tree mortality, reducing carbon stocks and elevating emissions in the short term, particularly for harvested biomass that is not converted into long-lived wood products. Harvesting and disturbance of mature forests will also typically lead to increased carbon sequestration rates as forests recover.
- Active forest management as currently practiced in Massachusetts plays a relatively small role in determining future forest carbon accumulation.

---

[43] Faison et al. 2023. Adaptation and Mitigation Capacity of Wildland Forests in the Northeastern United States." *Forest Ecology and Management* 544: 121145

Nunery J. S. and Keeton, W. S. 2010. Forest carbon storage in the northeastern United States: Net effects of harvesting frequency, post-harvest retention, and wood products. *Forest Ecology and Management* 259: 1363-1375.

Thompson, J. R., et al. 2020. Land Sector Report: A Technical Report of the Massachusetts 2050 Decarbonization Roadmap Study. Massachusetts Executive Office of Energy and Environmental Affairs.

[44] Birdsey et al. 2023. Middle-Aged Forests in the Eastern U.S. Have Significant Climate Mitigation Potential. *Forest Ecology and Management* 548: 121373.

[45] Faison et al. 2023. Adaptation and Mitigation Capacity of Wildland Forests in the Northeastern United States." *Forest Ecology and Management* 544: 121145.

Miller et al. 2016. National Parks in the Eastern United States Harbor Important Older Forest Structure Compared with Matrix Forests. *Ecosphere* 7(7): e01404.

- Harvesting activity in Massachusetts is estimated to reduce statewide carbon storage by about 10% between 2020 and 2050, based on current harvest intensities and accounting for enhanced forest growth and harvested wood carbon emissions and storage in wood products.[46]
- Massachusetts forests are growing and sequestering carbon in biomass at about four times the rate of harvest.[47] The rate of harvest removals on most state forest lands is lower relative to that of state as a whole (see Table 1 and Figure 5). Given that state forests comprise about 17% of forests statewide, the role of active management on state lands is proportionately limited.
- Some on the Committee also pointed to active management for long-lived, carbon-storing wood products as an important climate change mitigation strategy, given society's need for less GHG emissions-intensive materials (see Wood Production below).

- Most on the Committee agree that it is important to maintain a forest landscape with diverse age and size classes of trees, which may sustain both storage and sequestration benefits over the long-term.
- When forests are actively managed, the Committee recommends adopting ecological principles, including:
  - Looking for and pursuing opportunities to develop and perpetuate old forest characteristics (i.e., large, old trees, accumulations of downed woody materials, standing dead trees, multi-layered canopies) that will help maintain carbon storage in areas outside of reserves.
  - Retaining some trees on site, particularly large mature ones, while meeting species regeneration goals by using multi-aged silvicultural systems.
- The Committee recommends a mix of forest management approaches across the landscape to account for uncertainties in future conditions and ecosystem responses (e.g., degree to which tree species ranges will shift) and to mitigate risks from climate change, such as more frequent and severe disturbances.

Soils

The Committee strongly agreed on the importance of the soil carbon pool, which is underappreciated and often larger than the amount of carbon found in living biomass. They concluded that the most important way to preserve soil carbon (and advance related climate and environmental objectives) is to allow forests to mature naturally, and when harvesting, employ practices that reduce the disruption of forest soils and the complex biodiversity of fungi and other organisms that inhabit them.

---

[46] Thompson, J. R., et al. 2020. Land Sector Report: A Technical Report of the Massachusetts 2050 Decarbonization Roadmap Study. Massachusetts Executive Office of Energy and Environmental Affairs.

[47] US Forest Service. 2020. Forests of Massachusetts, 2019. Resource Update FS-239. Madison, WI: U.S. Department of Agriculture, Forest Service. 2p.

The Committee recommends that the Commonwealth:

- Add climate considerations to the current Massachusetts Forestry Best Management Practices Manual.
    - For example, active forest management projects should be planned with consideration of more frequent storms, increased water flow, higher temperatures, and other climate change impacts in mind (e.g., use timber bridges, install bigger culverts, employ methods to help maintain proper moisture and temperature in the forest.)
- Incorporate recommended Best Management Practices (BMPs) from the BMP Manual into agency standard operating procedures as required elements, to the maximum extent feasible, and document project compliance.
    - Planning, bidding, and execution of state forest management projects should exceed regulatory performance standards, and the agencies should be funded and staffed accordingly.
- Limit the number of forest roads and skid trails and close out and restore legacy roads and trails to reduce soil damage from harvesting, recreation, and increasingly intense precipitation events.[48]
- Implement the Healthy Soils Action Plan, including recommendations to expand best management practices that emphasize soil health and carbon informed management, incentivize the use of matting and timber bridging in forest harvesting where appropriate to protect vulnerable soils, and assist landowners and communities in protecting and managing carbon-rich land.
    - Several review papers and meta-analyses document the effect of forest management on soil carbon.[49] The Committee suggests that these be considered in the process of updating the Forestry BMPs.

Resilience

There was significant disagreement on the Committee regarding the ability and merit of active forest management to increase forest resilience or adapt forests to future conditions.

[48] Catanzaro, P.F., et al. 2013. Massachusetts forestry best management practices manual. University of Massachusetts, Cooperative Extension Landowner Outreach Pamphlet, 52 pp.

[49] Mayer et al. 2020. Tamm Review: Influence of Forest Management Activities on Soil Organic Carbon Stocks: A Knowledge Synthesis. *Forest Ecology and Management* 466: 118127.
Nave et al. 2010. Harvest Impacts on Soil Carbon Storage in Temperate Forests. *Forest Ecology and Management* 259(5): 857–66.
Nave et al. 2019. Effects of Land Use and Forest Management on Soil Carbon in the Ecoregions of Maryland and Adjacent Eastern United States. *Forest Ecology and Management* 448: 34–47.

Some argued vociferously that the long history of forest change and recovery from historic changes in climate and natural and human disturbances indicate that little or nothing needs to be done to make forests more resilient.

Others on the Committee argued with equal intensity that although our forests have shown themselves to be remarkably resilient over the past 10,000 years, they face a number of stressors which can decrease resilience, many of which are novel, including the growing impact of climate change.[50] They were concerned about the ability of forests to provide the wide diversity of ecosystem benefits that the Commonwealth relies on now and in the future when stressed by the impacts of climate change and other challenges, such as invasive pests, pathogens, and extreme weather events. In the view of these Committee members, active forest management that focuses on enhancing ecological integrity and function can provide opportunities to increase forest resilience to climate change and other stressors by enhancing the complexity of forest structure and diversifying species composition to increase resilience, maintain forest cover, help forests transition to future conditions that sustain societal expectations of ecosystem services,[51] and potentially reduce large swings in carbon from disturbances.

Resilience: "The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential functions, identity and structure." IPCC AR6 Working Group 2 Glossary p. 2920.

Factors influencing the perspectives of Committee members on this topic were the type and extent of disturbance, challenges associated with increasing resilience to a meaningful degree on a landscape scale, the site-specific nature of appropriate action, whether and how social dimensions of resilience are factored into evaluations of ecosystem dynamics, and the evaluation timeframe.

- While most of the Committee agreed that age and species diversity increase resilience at a landscape scale, there was significant disagreement as to whether the Commonwealth should actively manage to enhance diversity, and if so, under what circumstances.
- Massachusetts' forests are primarily second growth, having regrown following widespread land clearing for agriculture. This, along with past logging impacts (e.g., "high grading"), has resulted in forest conditions that are markedly altered from the pre-colonial condition, including relatively young developmental stages, altered species composition, degraded and homogenized soils, reduced structural complexity, reduced amounts of dead trees and dead logs on the ground, and overall landscape forest homogenization, often decoupled from local climatic gradients.[52]

---

[50] Forzieri, G. et al. 2022. Emerging signals of declining forest resilience under climate change. Nature, 608(7923), pp.534-539.

[51] Seidl, R., et al. 2016. Searching for resilience: addressing the impacts of changing disturbance regimes on forest ecosystem services. *Journal of Applied Ecology* 53:120-129.

[52] Thompson, J. R., et al. 2013. Four Centuries of Change in Northeastern United States Forests. *PLoS ONE* 8:e72540.
Foster, D. R., et al. 1998. Land-Use History as Long-Term Broad-Scale Disturbance: Regional Forest Dynamics in Central New England. *Ecosystems* 1:96-119

- Forests now face stressors such as invasive plant species, pests, and pathogens, coupled with the effects of climate change – which is occurring at a pace much faster than past change to which forests have responded.
- Those skeptical of active management took the position that Massachusetts' forests have demonstrated inherent resilience to substantial environmental change in recent centuries,[53] and that the impacts of intervention, including carbon emissions and the potential introduction of invasive organisms, for uncertain outcomes are not worthwhile for resilience purposes alone. From this perspective natural disturbances, including those augmented by human activity, will continually increase the structural, compositional, and functional diversity of forests over time. They disagreed with the premise of the argument for active management, and pointed out that actions taken now represent certain loss of carbon with no guarantee that any resilience gained will be beneficial.
- Active management proponents argued that:
    - While the regrowth of the forests of Massachusetts over the past century has been remarkable, the past is not necessarily prologue. That, taken together, existing forest conditions and the pace at which change is occurring may limit the ability of some forests to respond to the many challenges they face within the timeframe of decades or a century. Although a passive approach that does not involve human intervention will likely allow forests return to a similar ecological function over a long period of time, [54] we need them to respond more quickly if we want them to provide needed and desired ecosystem services in a meaningful timeframe;[55]
    - A thoughtful, science-based, ecologically informed, landscape approach to management is an appropriate tool to use to enhance resilience, accommodate inevitable disturbances, restore degraded ecosystem functions, and transition highly stressed and vulnerable forests by promoting species more acclimated to expected climate conditions and diversifying species threatened by invasive pests;[56]
    - Where forests lack structural or species diversity, silvicultural treatments that mimic natural disturbances can be effective in adding structural complexity and diversifying

---

[53] Foster, D. R., and Aber, J. D. 2004. *Forests in Time: The Environmental Consequences of 1,000 Years of Change in New England*. New Haven: Yale University Press.
Foster, D. R. et al. 1997. Forest response to disturbance and anthropogenic stress. Rethinking the 1938 Hurricane and the impact of physical disturbance vs. chemical and climate stress on forest ecosystems. *BioScience* 47: 437-445.

[54] Liang, Y et al. 2018. How disturbance, competition, and dispersal interact to prevent tree range boundaries from keeping pace with climate change. Global Change Biology, 24(1), pp.e335-e351.

[55] Miller, K.M. and McGill, B.J., 2019. Compounding human stressors cause major regeneration debt in over half of eastern US forests. *Journal of Applied Ecology* 56(6) 1355-1366.

[56] Mina, M. et al., 2022. Managing for the unexpected: Building resilient forest landscapes to cope with global change. *Global Change Biology* 28(14): 4323-4341.

forests in strategic landscape locations, as a complement to naturally occurring disturbances;[57] and

- Under certain circumstances active management may be warranted to help ensure that forests reliably sequester carbon and maintain stocks, thus providing a more steady and resilient carbon benefit, and offer habitat and other forest benefits that are less vulnerable to losses from stressors.[58]

- Some on the Committee also emphasized the importance of more holistically addressing adaptation, as adaptation options can range from accepting changes without intervention to engaging in active management to transition forests from a current less adapted state to one better suited to future conditions. Included in this broader adaptation framework is recognition of forests as complex adaptive systems where heterogeneity in species, functional, and structural conditions contribute to ecosystem resilience. As such, management actions that increase species and functional diversity, as well as structural complexity are expected to increase adaptive capacity and resilience relative to forests with lower levels of these attributes.[59] Some on the Committee indicated that in their opinion, transition should only be an option when active management is happening for other reasons, and there is a plethora of evidence that there is either regeneration failure already happening in that location or strong evidence that it would. Adaptation Actions for Resistance, Resilience, and Transformation[60] is a resource on this topic.

- As to state agencies:

  - Recognizing that resilience is often cited by agencies as a rationale for active forest management projects, the Committee suggested greater specificity, meaning avoidance of references to and pursuit of forest resilience in an open and undefined way. For example, identification of the forest function or characteristic that is to be made more resilient, the disturbance that is to be addressed, and the way a proposed action improves the situation. To address this suggestion, agencies could more clearly articulate their resilience goals and how their actions will advance them in guiding documents and forest management project prescriptions. This includes articulating desirable future conditions in relation to levels of ecosystem services and abundance of

---

[57] Anderson-Teixeira, K. J., et al. 2013. Altered dynamics of forest recovery under a changing climate. *Global Change Biology* 19:2001-2021.

[58] Messier, C., et al, 2019. The functional complex network approach to foster forest resilience to global changes. Forest Ecosystems, 6(1):1-16.

[59] Mori, A. S., et al. 2013. Response diversity determines the resilience of ecosystems to environmental change. *Biological Reviews* 88(2):349-364.
Filotas, E. et al. 2014. Viewing forests through the lens of complex systems science. *Ecosphere* 5:art1.
Messier, C. et al. 2019. The functional complex network approach to foster forest resilience to global changes. *Forest Ecosystems* 6:21.

[60] Evans, A. et al. 2022. Adaptation Actions for Resistance, Resilience, and Transformation. Massachusetts Ecosystem Climate Adaptation Network and Northeast Regional Invasive Species & Climate Change Management Network.

species populations to acknowledge these actions are tied to ecological and social resilience.

  - Responding to the lack of consensus on a broad approach to managing for resilience, many on the Committee encouraged agencies to concentrate their efforts on promoting resilience when managing for other objectives, rather than as a primary objective.
  - The Committee recommended that agencies develop metrics to evaluate their holdings for vulnerability, use them in the selection of sites and approaches for management, and assess the effectiveness of these approaches in addressing vulnerabilities.
  - Some on the Committee suggested that agencies pursue active forest management to enhance resilience in areas where multiple risk factors are present and where risks of becoming a net carbon emission source are high, for example, lack of forest diversity and presence of an invasive pest or public safety risk. There was Committee consensus that plantations should be converted to more compositionally diverse forests via harvesting, and some also supported adaptive management of other stands with several risk factors, such as a dense stand of diseased trees that would represent a fire risk to nearby development.

- There was some agreement on the Committee that some current forest conditions, such as plantation monocultures, many compositionally and structurally simple second-growth stands, forests heavily infested with non-native invasive plants, or those lacking plants in the understory due to heavy deer browsing, may not exhibit the same level of resilience as forests with a higher degree of ecological integrity and absence of invasives.
- Another concern of some on the Committee was compromised regeneration. Absent active management to address excessive deer browse and invasive plant species crowding out seedlings of native tree species, there was apprehension about future forest composition and resilience.
- The Committee found that there is an important role for further study and discussion on this topic, including the timeframes and metrics being used to quantify resilience (i.e., is it important to address the resilience of the conditions society may desire from forests in the near-term, or to address long-term resilience of ecological processes that may include difficult state transitions and thresholds that are potentially less desirable from a short-term and human standpoint?). Other important considerations include the role of experimentation, trials, and evaluation of resilience and adaptation strategies (an activity undertaken by other states on public land).

Pests and Pathogens

The Committee strongly agreed that pests and pathogens can exert a wide range of impacts on forests and, in extreme situations, can quickly change the structure and composition of a forest. This may result in reduced uptake and even significant, but protracted, emissions of carbon from decaying trees to the atmosphere. The Committee further agreed that quick action, including cutting and chipping/burning of significant numbers of trees may be warranted in a very limited number of situations. These include the novel infestation of an invasive pest (for example, the first detection on

the east coast of the U.S.), the appearance of a clearly controllable insect such as Asian Longhorn Beetle, or the infestation of a species where management is known to be able to alter the trajectory of a pest's impact, such as Southern Pine Beetle.

The Committee agreed that pre-salvage harvesting is not a climate-smart forestry strategy in more common situations where a pest has long been present and forestry techniques have not proven to significantly alter the rate of spread or impact of the pest. However, actions to diversify species composition can help reduce the impacts of an invasive pest or pathogen. Recognizing that circumstances are rapidly evolving, and decisions must be made on a case-by-case basis, the Committee recommended use of the Rapid Response for Invasive Species: Framework for Response developed and used by the New York Department of Environmental Conservation.

- The Committee found that it is necessary to evaluate each circumstance individually. In regard to forest reserves, where potential intervention takes on greater significance and treatment must be weighed against the intent to manage land passively, the Committee recommended that the Commonwealth consider expanding the purview of the existing Forest Reserves Science Advisory Committee (FRSAC) to land across the three Divisions, and that agency staff work with the FRSAC to document, expand upon, and make available decision protocols for the benefit of all forest landowners. The work of that committee could benefit from the considerable expertise on reserve and wilderness management developed by many federal agencies and national experts.[61]
    - Evaluate the nature of the invasive pest or pathogen, the tree species impacted, the stage of the invasion, and the likelihood of successful intervention.
    - *Wildlands of New England* is a useful resource for management decisions about pests and pathogens within reserves (see especially invasive species section, p.39).
- Avoid pre-salvage harvesting except for specific cases of early detection and rapid response (i.e., in the case of novel invasives that have the potential to have large impacts, that can be controlled, and when an early response may be necessary to limit larger losses).
- Make efforts to maintain genetic pools and diversity of threatened species on the landscape.
    - As pathogens and pests damage species such as beech, hemlock, and ash, avoid harvesting before signs of disease or invasive pests appear to allow individual trees with immunity or resistance to survive and continue the existence of these species.
- Consult with the Massachusetts Department of Agricultural Resources regarding additional actions to limit the introduction or sale of nursery stock known or likely to carry invasive pests or pathogens.

---

[61] Landres, P.C. et al. 2008. Keeping it wild: An interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. General Technical Report RMRS-GTR-212. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO.
Landres, P.C. et al. 2015. Keeping it wild 2: An updated interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. General Technical Report RMRS-GTR-340. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO.

- Consider Tree-Smart Trade recommendations.

Invasive Plants

There was strong agreement on the importance of controlling the establishment and spread of a limited number of invasive plants, particularly climbing vines that can kill mature trees and those impacting regeneration. Also, because active forest management projects risk the establishment and spread of invasive plants due to inadvertent transport of seeds and the favorable conditions that result (greater light, soil scarification, and reduced competition) agencies need to select, conduct, and monitor their projects very carefully.

The Committee recommends that the Commonwealth:

- Address invasive plants before and after active forest management to address concern about the spread or population increase of invasive species;
- Prioritize intervention and treatment based on the invasives curve;[62]
    - Focus treatment on initial infestations and areas with over 30% invasive plant cover, a level associated with regeneration failure,[63] as the invasive vegetation prevents tree seedlings from reaching the sapling class, ultimately impacting forest vigor and carbon stocking and sequestration;
    - *Wildlands of New England* has some guidance on the management of invasive plants within reserves.
- Require, whenever feasible, an invasive plant inventory and control plan when active forest management is performed and integrate this work into timber harvests using 'in-kind services' when bidding state jobs.
    - Provide additional funding for state projects and grants to others to enhance feasibility.
- Monitor recently managed areas for invasive species and include a requirement for quantified reporting (e.g., 99% controlled), and immediate management of invasives, potentially for multiple years, if detected.
- Monitor and assess passively managed forest land (e.g., reserves) for invasive plants.
- Offer additional training and support for management of invasive species.
- Develop long-term guidelines for invasive plant management that address what to do when control is no longer an option.
- Utilize chemical treatments only where necessary after review of recommendations from the *Invasive Plant Management Chemical Fact Sheet* produced by the Nature Conservancy of

[62] US Forest Service. 2005. Invasive Plant Environmental Impact Statement. U.S. Department of Agriculture.

[63] Marx, L.M. et al. 2021. Healthy Forests for Our Future: A Management Guide to Increase Carbon Storage in Northeast Forests. The Nature Conservancy and Northern Institute of Applied Climate Science, pp. 1-40.

Vermont and consistent with the *U.S. Department of Agriculture Animal and Plant Health Inspection Service Treatment Manual*.[64]

- Take further actions to limit the introduction or sale of non-native plant species (e.g., species listed in nearby/southern states as invasive).
    - Modify state agency procurements and establish best management practices to lead by example when landscaping or restoring sites.

Public Water Supply Management

The importance of forests to water resources was uniformly recognized by Committee members. Rather than delve into the many ways in which forests and retaining forest land cover are critical, the Committee focused its discussion of water resources directly on the role of forest management in stewardship of water supplies.

The Committee was split on the role of active forest management in helping DCR's Division of Water Supply Protection steward watershed forests to act as a filter that helps provide abundant clean water. The split reflected Committee members' overall perspective on active management and forest resilience.

- The Committee understands that the Division is managing for greater forest diversity and increased structural heterogeneity to enhance resilience and avoid significant changes in forest cover from disturbance events which could potentially impact water quality.
- Some on the Committee assert that producing consistent clean water over the long-term in the face of climate change and other forest threats is best ensured by forests with complex structure and diverse, well-adapted species. They argue that complex structure slows down water, reducing its energy to carry sediment and giving time for water filtration and that forests of diverse species and age help to avoid the loss of many trees at once due to a disturbance. Also, that while a passive approach can achieve these conditions, they support active management to accelerate the creation of desired conditions and strategically selecting areas within the watershed to apply practices that increase complexity and diversity.[65]
- Other Committee members argued that abundant ecosystem science shows that there is no reason for the Division to actively manage forest land to produce clean water.[66] They argue that forest development and natural disturbances will lead to increasingly diverse structure to these forests and that the benefit of future old-growth forests is great. While agreeing that limited wood production can occur without adverse impact on the provision of abundant clean water, they prefer that this, rather than "resilience" be the stated management objective. A few also

[64] USDA. Animal and Plant Health Inspection Service. 2016. Treatment Manual. U.S Department of Agriculture.

[65] DWSP Science and Technical Advisory Committee. 2012 Review of the Massachusetts DWSP Watershed Forestry Program.
Water Research Foundation and EPA, 2009. Utility Guidance for Mitigating Catastrophic Vegetative Change in Watersheds.

[66] Shannon, P. D. et al. 2019. Adaptation strategies and approaches for forested watersheds. *Climate Services*. 13: 51-64.

argued that active management should not occur at all given the carbon density of land managed by Watershed Division around the Quabbin Reservoir (see Figure 2) and the need to sequester and store more carbon to address climate change.

    - In very narrow circumstances, for example where plantations of red pine or other maladapted species were planted, those advocating for passive management in water supply lands recognized that active management may be warranted.

- The Committee recommends that the Commonwealth articulate its rationale for active forest management, particularly regarding the Quabbin Watershed, given perceived lack of clarity over time and in representations by different responsible entities. The Division acknowledged to the Committee that active forest management is not necessary to maintain an abundant and clean water supply. However, the Division also asserted that long-term stewardship of a healthy forest is critical to support the forest filter that provides a low-cost natural solution to clean water. The Committee also reviewed and considered previously stated positions of the Division (e.g., the DCR Watershed Protection Plan) and a written comment letter submitted by the Massachusetts Water Resources Authority (available here).

- While the preceding paragraphs concern the management of specific state watershed lands, the Committee recognized that similar considerations regarding selection of an appropriate management approach will need to be weighed by other water suppliers on a case-by-case basis.

Wood Production

As a component of active management for habitat, water supply, recreation, and other objectives, wood production occurs on land held by the three Divisions.

Regarding wood production:

- Some Committee members called for the establishment of a goal to produce a higher percentage of the wood products consumed in Massachusetts within the Commonwealth, while staying well below the rate of forest growth, siting significant emissions associated with importing wood from other regions of the United States and other parts of the world. They argued that given the level of wood consumption in Massachusetts, it is ethically important to produce wood products for local consumption to help address the significant gap between the Commonwealth's wood product use and in-state production.

- A few strongly disagreed, viewing the moral imperative to address the climate emergency as superseding consideration of additional local harvest of timber. They argued that Massachusetts' forests are better suited for removing and storing carbon, and other forests across the nation and around the world are better suited for producing forest products. They point out that Massachusetts forests are of an age and composition that is capable of accumulating large amounts of carbon out of the atmosphere in the critical decades between

now and 2050 and beyond. In addition, they note that from a regional perspective, harvesting is the largest total source of emissions from forests relative to other disturbances.[67]

- Those who supported meeting more of our demand for wood products in-state advanced these perspectives:
    - Massachusetts uses a lot of wood and currently harvests the equivalent of about 6% of our use.[68] Thus, while Massachusetts residents benefit from many wood products, the impacts of wood production are mostly outside state boundaries and function to reduce carbon stocks and otherwise impact the environment where the timber harvest takes place.
    - More than 94% of the wood used in Massachusetts is harvested and processed elsewhere, pushing the impacts to the environment and people in those locations, under what are often less stringent environmental standards, given the applicability of the Massachusetts Wetlands Protection Act and Forest Cutting Practices Acts. When wood is harvested elsewhere the intended carbon benefit of not harvesting in Massachusetts is negated. The emissions happen, just in a different place, and they are potentially higher given the carbon cost of shipping wood from across the country and beyond.
    - The Committee supported, first and foremost, societal reduction of resource consumption through efficiency, as well as the judicious use of wood and bio-based products to replace more GHG intensive materials.
    - Wood production on state lands has greater environmental planning and oversight by multiple natural resource professionals. Also, because it is not pursued for financial benefit and does not have the economic drivers applicable to private projects, state projects can afford to implement the highest and best strategies. Some on the Committee emphasized the importance of exemplary forestry on state land and the ability for state harvests to serve as demonstration sites, sources of innovation, locations for the introduction of new techniques and equipment, and as an opportunity for research on forestry practices for wood production.
- The State Parks and Recreation Division has timber production as part of its statutory mission, the Divisions of Water Supply Protection and Fisheries and Wildlife do not. All three divisions produce wood when managing for other objectives. A few on the Committee called for an end to harvesting on watershed lands and a reduction elsewhere, given climate goals. Others view Division management as an opportunity to practice well planned and executed timber

[67] Harris, N. L. et al. 2016. Attribution of Net Carbon Change by Disturbance Type across Forest Lands of the Conterminous United States. *Carbon Balance and Management* 11(1): 24.

[68] Perschel et al. 2014. Chapter 12: Grow as Much as We Use. In *New England Forests: The Path to Sustainability*, New England Forestry Foundation.

harvesting while also contributing to resilience objectives, addressing invasive species, restoring streams, etc. (a few members of the Committee object to the resilience premise).

- Some Committee members also pointed out that carbon-storing harvested wood products can be part of a broad range of low-emission solutions needed to satisfy society's material demand. Better utilization of harvested wood through retention or recycling, is among the climate mitigation strategies being pursued in the Commonwealth[69] and globally.[70]
    - Mass timber (short for massive timber) a building system that uses layers of wood bonded together to create structural elements, can reduce GHG emissions by substituting for more emissions-intensive building materials, like steel and concrete, and other innovative wood products, such as wood fiber insulation, can utilize wood residues that would otherwise decompose quickly and emit stored carbon.
    - A critical cautionary note is that increasing the use of long-lived wood products and substituting them for other materials will not necessarily increase stored carbon or reduce net emissions if harvest volume is increased.[71]
    - Some on the Committee also called for more impartial research on the carbon implications of substituting wood for other materials.

Guideline Implementation

The Committee recognized and supported the Healey-Driscoll Administration's intent to implement the forest management guidelines in two ways. First, by putting them into practice right away through the selection and application of forest management techniques based on the guidelines by state land managers, with the review and approval of their respective Commissioner to affirm that the proposed approach reflects the revised guidelines. Next, in the form of standards, protocols, procedures, manuals, and the like and incorporation over time as new iterations of plans and guiding documents are produced (e.g., State Forest Action Plan, DWSP 2017 Land Management Plan, Landscape Designations for DCR Parks and Forests, DCR Resource Management Planning, and DFW State Wildlife Action Plan).

As the process of reviewing forest management projects resumes and agencies look to implement the new forest management guidelines, the Committee recommended that state land managers select and employ specific forestry practices and techniques to apply the guidelines from existing materials as outlined in Appendix A: Climate-Oriented Forest Management Strategies. This will enable the Commonwealth to pursue climate-oriented forest management while it determines what other more specific materials and approaches might be warranted. The Appendix provides three tables of techniques. The first, Combined Climate-Smart Practices List, features 14 techniques intended to advance climate smart forestry in

[69] MA EOEEA. 2022. Massachusetts Clean Energy and Climate Plan for 2025 and 2030. Massachusetts Executive Office of Energy and Environmental Affairs.

[70] Johnston, C. M. T., and V. C. Radeloff. 2019. Global Mitigation Potential of Carbon Stored in Harvested Wood Products. *Proceedings of the National Academy of Sciences* 116(29): 14526–31.

[71] Nunery J. S. and Keeton, W. S. 2010. Forest carbon storage in the northeastern United States: Net effects of harvesting frequency, post-harvest retention, and wood products. *Forest Ecology and Management* 259: 1363-1375.

Massachusetts. The second, from Climate Change Tools and Approaches for Land Managers, is focused on climate change adaptation strategies. The final table, which replicates the "Menu of Adaptation Strategies and Approaches for Carbon Management" from Forest Management for Carbon Sequestration and Climate Adaptation, lists strategies that advance both climate change adaptation and mitigation. Regarding resumption of project review and approval, some on the Committee recommended that "paused" forest management projects move ahead as designed, without returning to the planning stage for further evaluation. It was also pointed out that these projects could be utilized as a means of perfecting the process of applying the revised guidelines before entirely new projects are introduced.

Agency Land Management Recommendations

The challenge for the state divisions is to accomplish their respective missions while also prioritizing climate change mitigation and adaptation, biodiversity, and human well-being. The charge given the Climate Forestry Committee and their management guideline recommendations assist the divisions in meeting this challenge.

CFC recommendations related to the overall missions and land management of the Divisions of Drinking Water Supply Protection, Fisheries and Wildlife, and State Parks and Recreation:

- Review agency missions for consistency with *Forests as Climate Solutions* and other current policy issues, challenges, and opportunities, and pursue important updates (e.g., explicitly add climate change).
    - Ensure that agency goals and responsibilities include stewarding forests and other ecosystems, protecting and restoring biodiversity of all kinds, and assuring environmental equity and justice.
- Set management goals considering the forests of Massachusetts in their entirety recognizing that forest land managed by state agencies does not exist in isolation.
    - State forests are inexorably linked to the surrounding landscape, and decisions made regarding state forest management, along the passive to active management continuum, require system-level understanding of their socio-ecological impacts outside the state forests' boundaries.
    - State-owned forests are uniquely large relative to private parcels, and often include ecological communities not found on other land holdings, such as white pine stands in Mohawk Trail State Forest and the primary forest remnants in Mt. Greylock Reservation.
- Convey management intent directly and explicitly and ensure consistency with actual practice.
    - Agencies manage a lot of their land passively; they should do so intentionally and state that. Use the *Forests as Climate Solutions Initiative* as an opportunity to express, pursue, and achieve biodiversity, carbon storage, wood production, and other desired goals explicitly through careful planning and long-term monitoring.
    - Calculate and address any gap between management goals and the amount and type of forest management performed.
- Shift forest management by the Division of State Parks and Recreation from a property and project-based approach to one focused on the critical and unique landscape position and role

Division lands play. While doing so, look for opportunities to clearly communicate the connection between mission and land management, recognizing that the very broad mission of the Division can make it difficult for stakeholders to understand the specific application of land management priorities.

    - Consider producing more local wood, especially for long-lived products, through deliberate and carefully considered forest management on woodlands that are managed by DCR's Division of State Parks and Recreation, consistent with that Division's current mission (and as a co-benefit of other land management by the Divisions). This would meet some of the Commonwealth's wood product demand. However, some on the Committee object to wood production on state land and do not support this recommendation.

- Prioritize for active management forest stands that have simplified structure and low species diversity, especially plantations that are in poor health. Seek to enhance structural complexity and propagate diverse species well-adapted to the site and predicted future conditions.
    - Maximize the impact of limited staff and funding by analyzing agency land holding for these stands and prioritizing work accordingly.
- Develop, on an annual basis for each management forestry region, a list of its top priority stands for management and the areas recommended for treatment that provides a clear and science-based justification and explanation of its tie to the agency mission and goals of the *Forests as Climate Solutions Initiative*.
- Increase forest diversity and/or regeneration in areas in need of restoration (e.g., former forest plantations or areas severely impacted by invasive species).

SUPPORTING AND COMPLEMENTARY RECOMMENDATIONS

The deliberations of the Climate Forestry Committee led to considerable discussion of related topics beyond the originally envisioned charge of the Committee to develop and enhance a set of recommended climate-oriented forest management guidelines. The Committee deemed these issues important enough to include in this report in the form of recommendations intended to support and complement the goals of the climate-oriented forest management guidelines. Many of these recommendations intersect to varying degrees with the other branches of the *Forests as Climate Solutions Initiative* (Forest Conservation and Reserves, Landowner and Business Incentives, Forest Data), in addition to other topics (Forestry Policies and Practices, Investment in State Agencies, Communication and Collaboration) and the Committee's recommendations are organized accordingly.

Forest Conservation and Forest Reserves

The Committee had many recommendations directly related to a primary objective of the *Forests as Climate Solutions Initiative*, to keep forests intact by accelerating the pace of permanent conservation and reducing conversion to other land uses. In addition, the CFC had many ideas related to another *Initiative* objective, expansion of forest reserves, areas where no active forest management is intended and nature takes its course, for carbon sequestration and storage, habitat, and other benefits. Details on Commonwealth implementation of these aspects of the *Initiative*, provided as

context for the Committee's recommendations, can be found in Appendix C: Summary of *Forests as Climate Solutions Initiative* Branches**.**

CFC recommendations to Reduce Forest Conversion and Increase Conservation:

- Conserve and manage forest land from a landscape and statewide perspective. Embrace ecological principles that emphasize landscape continuity and ecological integrity. Maintain and promote connectivity, advance complementary land management on adjoining parcels, and recognize that coordination across large areas (in both management and conservation) can lead to better long-term outcomes.
    - Protect significant forest areas in western Massachusetts to help create a large uninterrupted corridor of protected forest extending from Pennsylvania to Canada.
    - Acquire land that represents the variety of forest types across the Commonwealth.
    - Buffer reserves by acquiring land around them to facilitate complementary neighboring ownerships and land management.
    - Conserve forest blocks that connect existing reserves.
- Consider a property's ability to store high amounts of carbon over long time periods, for example, nutrient rich sites with low disturbance histories.
- Protect forest cores as depicted in BioMap (the most intact forests of Massachusetts, those least impacted by development and essential for animals and plants dependent on remote habitat).
    - The Committee noted, however, that forest core characteristics vary considerably, and they should be handled accordingly (e.g., pine barrens vs. northern hardwoods).
- Incorporate into land acquisition criteria preference for land that can advance climate change mitigation and adaptation alongside other priorities and forest benefits such as recreation/public access to nature, water quality, stormwater retention/flood prevention, ecological restoration, soil health, etc.
    - Apply environmental justice criteria and seek to increase access to protected lands for marginalized communities.[72]
- Increase the Commonwealth's 2050 land conservation goal from 40% to 50% of Massachusetts to be consistent with what the IPCC has called for.
- Complete, where not already in place, district management plans to help prioritize annual work plans and inform land acquisition. These plans should consider the agency land in the context of the surrounding landscape and seek to integrate agency management approaches with those of other landscape partners, including other agencies, municipalities, conservation organizations, and private forest owners.

[72]Sims K., et al. 2022. Environmental Justice Criteria for New Land Protection Can Inform Efforts to Address Disparities in Access to Nearby Open Space. *Environmental Research Letters* 17(6): 064014.

- Recognize, when conserving land, making landscape designations, and managing land that stands on each property can be in different places on the continuum of active and passive management and act accordingly.
- Reduce unnecessary forest land conversion via collaboration across state agencies and complementary polices, infrastructure investments, and other actions (e.g., solar facilities, powerlines, highways, housing, or other development).
    - Forest conversion on any given acre results in more carbon loss than harvesting on average, is more permanent, and also results in the loss of all other forest benefits.

CFC recommendations Regarding Forest Reserves:

- Advance reserve expansion as part of an integrated approach to land management that includes suitability of different parcels for carbon storage, habitat, active forest management for wood production, and other benefits. Holding a diversity of forests in both reserves and active management (with redundancy) would allow the Commonwealth to be most adaptive to future conditions.
- Expand the number and size of reserves, potentially to 10% of Massachusetts forests conserved and managed as reserves, a level consistent with the Wildlands, Woodlands, Farmlands, and Communities goal.
    - Some Committee members suggested 30%, citing IPCC recommendations regarding climate and biodiversity.[73]
- Codify reserves on state land to provide a higher level of protection than the administrative designation that currently applies.
    - While Article 97 of the Amendments to the Constitution of the Commonwealth and the Public Lands Preservation Act protect land from conversion, timber harvesting and other types of active management within reserves are currently only precluded by administrative designation.
    - Some members of the Committee suggest that most conserved land be managed to remain in a natural state as the IPCC has called for (i.e., consistent with at least a U.S. Fish and Wildlife Service GAP 2 designation - essentially a reserve).
- Utilize, with appropriate updates to reflect circumstances unique to the other Divisions, the terminology, process, and criteria that DCR's Division of State Parks and Recreation followed pursuant to its Landscape Designations for DCR Parks and Forests: Selection Criteria and Management Guidelines to explore the identification of additional reserves.
    - When updating the criteria carefully consider designating actively managed properties, such as Myles Standish and Manuel Correllus state forests, separately from other reserves due to the level of active management used to maintain them.

[73] IPCC Working Group II. 2022. Summary for Policymakers. In *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

- The Committee found the process that originally designated the current reserves on land managed by DCR's Division of State Parks and Recreation to be very effective. It believes the current designations should remain in place (with the possible exception of the two more actively managed reserves as noted above).
- As before, designate and manage some of the most biologically productive forests as reserves to prioritize carbon accumulation (and realize other important objectives like the provision of mature forest habitat) and others as parklands and woodlands.

- Consider the existing density of carbon on the landscape as part of an effort to designate reserves that will "maintain the ecological integrity and biodiversity that will accumulate and store the most carbon."[74]
- The CFC recognizes that establishing reserves advances multiple land management objectives including carbon sequestration and provision of old growth forest habitat.
- Designate reserves based on intent to manage passively going forward, not just the current condition of land. This approach would be consistent with that of the major Wilderness areas on National Forests and other wildlands in New England.[75]
- Exclude or carve out developed areas (buildings, roads, etc.) within forested properties otherwise appropriate for reserve designation. This would also be consistent with practices on Federal Wilderness Areas and other wildlands.
- Seek to designate reserves throughout the Commonwealth under multiple ownerships and across difference contexts (e.g., from small reserves in exurban landscapes to large reserves in more rural regions), recognizing that there are equity considerations, including` benefits to designating reserves close to population centers, and ecological value even in small reserves.
- Expand the existing Forest Reserves Scientific Advisory Committee, convened by DCR's Division of State Parks & Recreation, with appropriate updates to reflect a broader mission, to inform critical management decisions across reserves on land held by all three divisions.
- Recognize and consider leakage into the surrounding landscape or more broadly. Eliminating harvesting within forested areas newly designated as reserves will allow carbon stocks to increase over time but may not necessarily change the amount of forest harvesting occurring elsewhere, given continued consumption of wood products by the Commonwealth, and thus may not result in any significant emissions reduction.

---

[74] IPCC Working Group 6. 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Sixth Assessment Report of the Intergovernmental Panel on Climate Change

[75] Foster, D. et al. 2023. *Wildlands in New England: Past, Present, and Future*. Harvard Forest, Northeast Wilderness Trust, Highstead Foundation.

Landowner and Business Incentives

The Climate Forestry Committee had several recommendations related to the *Forests as Climate Solutions Initiative* component to expand incentives and programs to protect private and municipally owned forests, encourage landowners to manage their property using passive and active climate-oriented forest management techniques, and help forest centered businesses improve their technology and business practices. Details on Commonwealth implementation of this aspect of the *Initiative*, provided as context for the Committee's recommendations, can be found in Appendix C: Summary of *Forests as Climate Solutions Initiative* Branches**.**

CFC recommendations to the Commonwealth Regarding Incentives:

- Allocate additional funding to support the Climate Forestry work that is underway and to expand the Forest Climate Resilience Program to incentivize climate-smart forest practices beyond municipal land in the Woodlands Partnership of Northwest Massachusetts region.
- Enhance efforts to make landowners aware of and in some cases assist them in accessing non-state sources of funding for climate-smart forestry practices such as appropriate Environmental Quality Incentives Program practices from the USDA Natural Resources Conservation Service, credible carbon market incentives, and the New England Forestry Foundation's Pooled Timber Income Fund.
- Provide incentives to:
    - Encourage private landowners to protect their forest land (e.g., raise the Conservation Land Tax Credit cap, help with conservation planning and transaction costs).
    - Persuade forest landowners to pursue passive management to keep their forests growing.
    - Adopt recommended management practices from the Massachusetts Forestry Best Management Practices Manual and otherwise assist with environmentally beneficial practices, including those that address on-the-ground realities of climate change, such as sites that no longer freeze, high intensity rain events, and invasive plants (e.g., power washing of equipment between private jobs).
    - Reduce wood harvesting and processing emissions, including those from machinery, where a cost benefit analysis shows value and research on sources of harvest emissions indicates that alternative technologies can lower emissions.
    - Implement practices in the forest that will lead to the production of more local, durable wood products to help meet the wood needs of Commonwealth residents.
        - Climate oriented-forest management must be complemented by a viable wood products industry that reduces carbon loss by increasing local production while also providing more reliable supply chains and economic benefits to landowners and communities.
    - Increase the stocking of poorly stocked private forests to store carbon and achieve their full potential to produce wood volume and larger trees for long-lived wood products.
    - Use a forester on private timber sales.
    - Address labor shortages by encouraging new timber harvesters and consulting foresters.

- Offer education incentives, perhaps in the form of a loan forgiveness program, for forestry students willing to work as consulting foresters in Massachusetts for at least 5 years.
    - We rely on consulting foresters to work with forest landowners and encourage their adoption of climate-smart forestry practices. A lack of them is limiting opportunities to assist forest landowners who own most of our forests.

Forest Data

As part of the *Forests as Climate Solutions Initiative,* the Commonwealth has committed to integrate and make public the best science, research, and management practices and to provide detailed information on state forestry activities to increase transparency and enhance public knowledge. The Committee had several related recommendations. Details on Commonwealth implementation of this aspect of the *Initiative*, provided as context for the Committee's recommendations, can be found in **Appendix C**: Summary of *Forests as Climate Solutions Initiative* Branches**.**

CFC Recommendations to the Commonwealth regarding Data:

- Communicate on a regular basis with climate, forest ecosystem, and other scientists to stay informed about best practices for climate and forest land management.
- Establish Continuous Forest Inventory plots on newly acquired and DFW land and enhance the type and frequency of data collected from existing plots on DCR land.
- Incorporate modern technology and data analysis to augment and enhance traditional inventories and assessment methodologies.
    - Utilize remote sensing to monitor annual changes across all forest locations, in combination with ground truthing.
- Account separately for the effects of different types of land management (e.g., harvesting) and natural factors on carbon stocks and accumulation rates, including both emission and sequestration, to facilitate better attribution of the impacts of different factors to specific drivers.
- Evaluate the merits of calculating and sharing estimates of emissions associated with forest management projects.
    - Some on the Committee recommend that estimates of emissions at the time of harvest associated with management projects on state forest land be calculated and published by agencies. Others argued that this would be either so simplistic (e.g., done with a lookup table) that it would be of little benefit or if it accounts for all necessary aspects of emissions (e.g., carbon storage in wood products and operations emissions) it would be so complex as to be unrealistic to produce for each project. Also, some stated that doing so would be counterproductive and obfuscate the broader and longer-term effects of forest management on carbon cycling and ecosystem services. They argued that any reporting of emissions associated with forest management should include the potential

for long-term, post-harvest carbon sequestration and storage, including in wood products.
        - Communication of such information should acknowledge that some carbon loss is expected in pursuit of diverse management objectives, and that emissions associated with management on state forest land are small relative to emissions from buildings, vehicles, and other sources.

    - Overall monitoring of carbon in forests is conducted as part of the Commonwealth's GHG inventory. Some on the Committee called for specific ongoing monitoring of carbon associated with harvesting using remote sensing.
        - The current ability to monitor carbon remotely is limited, but state agencies should stay current with evolving science for doing so and consider effective applications as new technologies and strategies emerge.

- Analyze reserves as benchmarks against which to measure the productivity and resilience of actively managed forests on public and private lands.
- Evaluate life cycle carbon emissions of forest practices and products relative to other materials and processes and publish findings for Massachusetts forests.[76]
- Provide:
    - Forest cutting plans and derived data to enhance transparency and enable research and policy development;
    - Reports and other documentation of the outcomes of management projects to increase public awareness of the care and oversight exercised, document contractor compliance with approved plans, and publicize successful realization of project objectives; and
    - Generally agreed upon science to guide forest management by agencies and others.
        - Collect and publish data on carbon in soils and effective management thereof.
- Enhance the analytical capacity for measuring and monitoring soil health in Massachusetts, and research on ongoing changes to forest soils from climate change, as called for in the Healthy Soils Action Plan.

Forestry Policy and Practices

Massachusetts has one of the most advanced sets of forestry policies and laws in the country. The CFC identified many existing state regulations, policies, and programs that acknowledge the importance of forests; set goals for forest conservation, soil and water health, endangered species protection, carbon sequestration, and other objectives; address forestry related practices; and seek to achieve the established goals.

[76] Howard et al. 2021. Wood product carbon substitution benefits: a critical review of assumptions. *Carbon Balance and Management* 16(9): 1-11.

The Committee acknowledges that its recommendations rely and build upon existing foundational regulatory, procurement, and other authorities and procedures. It also recommends reexamining aspects of this framework. The Committee recommends exploring opportunities, including seeking legislative authority where needed, to better employ existing tools, including the following, to address climate change mitigation and resilience:

- Forester licensing, which requires documentation of continuing education (M.G.L. c. 132, Section 47 through 50)
    - Fund and expand continuing education for state and private foresters.
    - Promote Northeast Institute for Applied Climate Science training and other offerings that address the latest climate science.
- The Forest Cutting Practices Act (M.G.L. c. 132) that requires the application of forestry best management practices and includes Natural Heritage and Endangered Species Program review.
    - Utilize the final report required by Ch. 132 as a means of ensuring and documenting compliance with relevant forestry regulations and cutting plan requirements.
    - Incorporate, perhaps via new legislation, climate considerations into Ch. 132 and empower DCR Service Foresters charged with overseeing timber harvesting conducted under forest cutting plans by providing them enhanced enforcement authority.
- Agency procurements and resulting contracts for forest management projects
    - Explore opportunities to utilize requirements for state projects to enhance forest and natural resource protection (e.g., soil health) outcomes on state land and to facilitate the adoption and use of new less damaging machinery and techniques elsewhere.
- Current Use Taxation
    - Investigate ways for Chapter 61 to support passive management and potentially the creation of reserves on private lands.

Investment in State Agencies

The Committee recognizes that much is expected of our forests and the agencies that manage them, justifying additional actions and investments to assist with their proper stewardship.

CFC Recommendations to the Commonwealth:

- Fund expanded data collection to better monitor forests and forest management (e.g., the difference between forest reserves and woodlands in their relative accumulation of carbon, provision of habitat, etc.) by reducing the inventory interval and expanding what is measured by Continuous Forest Inventory plots to include factors like deadwood and soils.
- Augment staff training to ensure land managers remain current with evolving knowledge.
- Increase overall staff capacity in order to do more, to be more proactive, and to work more regionally and collaboratively.

- Provide funding to enable staff to further publicize existing resources that will benefit many forest landowners and advance climate change mitigation and resilience like Healthy Forests for our Future: A Management Guide to Increase Carbon Storage in Northeast Forests, Caring for Your Woods: Managing for Forest Carbon, The Forest Climate Resilience Program Fact Sheet, and The Combined Climate-Smart Practices List, and to augment them with new material as needed.
- Equip state land managers with sufficient direction as to the intent of the new guidelines, and a clear process to apply them, while allowing staff flexibility to apply their expertise.

Communication and Collaboration

Effective communication and transparent decision making are important.

CFC Recommendations to the Commonwealth:

- Enhance communication efforts and resources and transparency about forest management.
- Explore ways to provide clarity for managers and the public as to applicable, informative, and relevant science and regarding misinformation and the misapplication of data.
- Enhance the ability of each agency to respond to and interact with the public, including environmental justice populations, to help avoid actions driven disproportionately by a small number of vocal advocates with special interests, often from well-resourced communities, which could lead to disparate outcomes and EJ inequities.
- Communicate forestry decisions within the context of both agency goals and climate priorities, making specific connections between each project and realization of these goals.
    - Enhance the explanation as to why a project location was selected.
- Engage indigenous groups directly and proactively regarding aboriginal hunting, fishing, trapping, and gathering rights, other cultural use rights, and other matters pertaining to the stewardship of land by the divisions.

CONCLUSIONS

CFC members expressed deep concerns about the known and unknown impacts of climate change on the planet and on forests. Most have devoted their professional lives to understanding and working in forests, and they willingly volunteered their time and expertise to assist the Commonwealth in its innovative efforts to achieve net zero GHG emissions by 2050, which will likely to contribute to national models.

The CFC approached its work with a keen awareness of the growing threats of climate change and the crucial role forests play in reducing carbon in the atmosphere. They considered current and relevant science to work through critical choices to help the Commonwealth to secure its carbon future and maintain the natural and societal benefits of its forests. Ultimately, the Committee recognized that the complexity of forest landscapes, unique aspects of particular forest stands, impacts of natural disturbances, and societal benefits of forests suggest choices along a continuum of passive to active forest management strategies.

They agreed that most importantly, forests must remain forests and support the Commonwealth in its plans to increase conservation land holdings as well as to manage state public lands for climate and incentivize the same for other forest landowners. They agreed that forests should be considered not only for their carbon stocks, but for a full range of societal benefits, and that tradeoffs will be required to focus land management more directly on climate mitigation and adaptation.

CFC members look to the state agencies to use the CFC recommendations to elevate climate and biodiversity to critical priority status even as they respect the past work of state agencies to protect public lands and steward forests through a combination of passive and active management strategies that balance the public's multiple needs and values.

Throughout its deliberation, the Committee discussed, debated, and deliberated across a range of differing personal and scientific opinions, perspectives, and interpretations. They did so with great passion and with continuous acknowledgement that science needs to further evolve to provide greater clarity on the benefits of particular actions, that forests will survive on their own, but humans need the benefits forests provide, and that the uncertainties of climate change impacts will continue to challenge and humble them as scientists and foresters.

APPENDICES

Appendix A: Climate-Oriented Forest Management Strategies

To consider and implement the management guidelines and the recommendations of the Climate Forestry Committee it will be necessary for state land managers to select and apply, with the approval of agency leadership, appropriate forest land management techniques. To facilitate this three Tables follow that list forestry techniques that are derived from linked and cited sources.

The first is a list of 14 Climate Smart Practices that a group, including several Climate Forestry Committee members and staff from the Division of Fisheries and Wildlife, the Department of Conservation and Recreation, Mass Audubon, and the Nature Conservancy, developed by narrowing down nationally relevant techniques, such as those in other two tables, to those most appropriate for Massachusetts. This list is practical, actionable, and in use by agencies as the basis for DCR's carbon management booklets (e.g., Caring for your Woods: Managing for Forest Carbon) and the Forest Climate Resilience Program. Of the three lists of techniques, this one most closely matches the philosophy and recommendations of the Climate Forestry Committee.

The second table, a list of climate change adaptation oriented forest management strategies, is currently utilized by forest managers at the DCR Division of State Parks and Recreation, DCR Division of Water Supply Protection, and the DFG Division of Fisheries and Wildlife. The third is a more recently published list of strategies and approaches that aligns adaptation techniques, such as those listed in the adaptation table, with techniques to mitigate climate change by managing for forest carbon. These tables are from publications that undertook a review of forest science that was national in scope, and they are intended to assist land managers across the United States. Each contains content not directly relevant to Massachusetts, and indeed both list some techniques that directly conflict with the advice of the Committee. However, they are widely used, and the publication associated with each table provides useful detail on those techniques that are pertinent to forest land management in Massachusetts. As to techniques that conflict with the recommendations it has made, the Climate Forestry Committee understands that the selection and justification of forest management projects by state land managers is an inherent part of project review and approval, and any inconsistencies would need to be validated.

Other notable resources for state land managers to consider when selecting techniques to apply the guidelines are Managing Forests for Climate Change, Adaptive Silviculture for Climate Change: A National Experiment in Manager-Scientist Partnership to Apply an Adaptation Framework, Healthy Forests for our Future, and Managing Forests for Carbon in Massachusetts.

Going forward, it is the expectation of the Committee that state land managers will continue to selectively utilize techniques from the adaptation table, and transition to or incorporate techniques from the others, as an initial approach to addressing the Committee's recommendations as finalized in the new forest management guidelines. The important work to systematically develop more specialized means of strategically applying the guidelines to selecting locations and forest management techniques is the important work that the Commonwealth will be responsible for after issuance of this Report.

The 14 forest management practices below come from two sets of meetings of landowners, foresters, academics, loggers, land trusts, state and federal agency staff, and regional planners in New England in 2020-2021.

Climate-smart practices have carbon benefits (across varying time frames) and help forests adapt to climate change. In the second two columns are indications of the primary focus of each practice (carbon or adaptation).

A = Practices from the Massachusetts Forest Climate Resilience Program pilot, designed to help forests adapt to climate change. Practice development was led by Massachusetts Audubon and the Northern Institute of Applied Science, along with many stakeholders.

C = Practices from the Natural Climate Solutions Accelerator grant project in Massachusetts and Vermont, designed to increase forest carbon stock within 20 years. Practice development was led by The Nature Conservancy and the Northern Institute of Applied Science, along with many stakeholders.

Management Practice	C	A	Short Description
Keeping the Forests We Have			
Avoid forest loss	C	A	Reduce or eliminate the conversion of forest to non-forest use since forestlands contain more carbon than most other land use types and keeping land in natural forest cover maintains the ability of landscapes to adapt to changing conditions.
Respond to disturbance		A	Respond to a major disturbance to the forest by using one or more of the below practices to aid in post-disturbance recovery where ecosystem services and forest condition have been highly degraded.
Growing New Forests and Trees			
Reforest (Create new forests)	C	A	Through seeding, stocking, or natural reforestation, create forest with a diversity of tree species in an area that used to be but is not currently forest. Use climate-informed species that are suitable to the location. Expected to be used with invasive species control and deer protection when needed.
Green developed areas (Plant trees along streets and in yards)	C	A	Plant trees in urban and residential areas to add carbon stock as trees grow, and provide many local benefits to air quality, stormwater management, and human health and well-being. Use climate-informed species that are suitable to the location. Expected to be used with invasive species control and deer protection when needed.
Plant trees to increase forest stocking (Underplant climate-adapted trees)	C	A	Enrichment or supplemental planting in forests to support climate adaptation. Use climate-informed species that are suitable to the location. Expected to be used with invasive species control and deer protection when needed.
Intentional Passive Management			
Establish forest reserves (Protect	C	A	Intentional passive management (with exceptions for invasive removals or novel outbreaks of forest pests and pathogens) to maintain ecological, carbon, and other benefits. Reserves can be established on all or a portion of a forest. This practice is not appropriate everywhere, and may be most

rare and sensitive sites)			appropriate on sites with high carbon density and low vulnerability to climate change impacts (carbon), or unique or sensitive sites, which may include locations that contain at-risk species, sensitive ecosystems (e.g., vernal pools or riparian areas), or potential climate refugia (adaptation). Maintaining these areas preserves that adaptive capacity of these systems and may support landscape-level adaptation.
Increase time between harvests **(Extend cutting cycles)**	C		Wait longer between harvests to grow larger trees that are more likely to be used in long-lived wood products. For example, this may take the form of delaying a harvest in your current 10-year management plan until the next 10-year plan.
Reduce Stressors			
Climate-informed forest access and forestry operations		A	Reduce impacts to hydrology, soils, and nutrient cycling associated with shorter winters, extreme precipitation events, and other climate changes, by following best management practices updated for dealing with these conditions.
Remove invasive vegetation **(Remove and control non-native and competing vegetation)**	C	A	Remove heavy infestations of invasive plants that compete with regeneration or reduce growth of existing trees, either pre- or post-harvest, or both. May include the use of herbicides and/or mechanical cutting of invasive plants, and treatment over several years. Control of competing vegetation may be needed to maintain ecosystem functions as well as facilitate regeneration of forests along desired trajectories.
Protect seedlings and saplings from deer browse (Protect regeneration from deer and moose browsing)	C	A	Reduce over-browsing and protect regeneration from animal damage. Practices may include use of tree shelters or exclusion fencing. Protecting desired vegetation from browse may be needed to maintain ecosystem functions as well as facilitate regeneration of forests along desired trajectories.
Active management			
Create gaps to promote regeneration	C		Balance creation of gaps to promote regeneration with retention of existing carbon stocks when forests are undergoing harvests. For example, retain a minimum number of large-diameter live trees, snags (see NEFF's Exemplary Forestry standards), and live-but-dying trees (future snags), and limit gap creation to no more than 20% of the parcel.
Retain more carbon in a thinning	C		Limit the removal of trees in thinnings to retain large-diameter live trees, snags, and species diversity. For example, set aside between 25-50% of the stand as unharvested (retention) areas, and thin to partway between the A and B lines on a stocking chart, maintaining tree diameter.
Enhance adaptive capacity in forests (Resilience)		A	This practice is designed to improve the health and function of the current native forest vegetation in response to climate change. Silvicultural activities under this practice are designed to (1) reduce the impact from current and future stressors and disturbances, (2) diversify forest conditions to increase the capacity for adaptive responses, and (3) promote future-adapted regeneration of the current native plant community when forest regeneration (i.e., initiation of a new age cohort) is a desired outcome.
Facilitate forest transition to better		A	This practice is designed to facilitate transitions in forest communities toward assemblages that are expected to be better adapted to future conditions and

match future conditions (Transition)			support anticipatory adaptation where climate change is expected to exceed the capacity of the existing forest community to cope with climate change impacts and associated stressors (e.g., highly vulnerable or impacted systems).

USFS Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers

Introduction: Forests across the United States are expected to undergo numerous changes in response to the changing climate. This second edition of the Forest Adaptation Resources provides a collection of resources designed to help forest managers incorporate climate change considerations into management and devise adaptation tactics. It was developed as part of the Climate Change Response Framework and reflects the expertise, creativity, and feedback of dozens of direct contributors and hundreds of users of the first edition over the last several years. Six interrelated chapters include: (1) a description of the overarching Climate Change Response Framework, which generated these resources; (2) a brief guide to help forest managers judge or initiate vulnerability assessments; (3) a "menu" of adaptation strategies and approaches that are directly relevant to forests of the Northeast and upper Midwest; (4) a second menu of adaptation strategies and approaches oriented to urban forests; (5) a workbook process with step-by-step instructions to assist land managers in developing on-the-ground climate adaptation tactics that address their management objectives; and (6) five real-world examples of how these resources have been used to develop adaptation tactics. The ideas, tools, and resources presented in the different chapters are intended to inform and support existing decision-making processes of multiple organizations with diverse management goals.

EXISTING AGENCY Climate Change Adaptation Oriented Management Strategies	
Strategy 1: Sustain fundamental ecological functions.	
1.1	Reduce impacts to soils and nutrient cycling.
1.2	Maintain or restore hydrology.
1.3	Maintain or restore riparian areas.
1.4	Reduce competition for moisture, nutrients, and light.
1.5	Promote carbon sequestration or storage in soils and forest biomass.
1.6	Restore or maintain fire in fire-adapted ecosystems.
1.7	Avoid stream crossings or use appropriate BMPs when crossings are necessary to reduce impact.
1.8	Protect and buffer wetlands and vernal pools using recommendations outlined in the CLMP and established BMPs to minimize disturbance.
Strategy 2: Reduce the impact of biological stressors.	
2.1	Maintain or improve the ability of forests to resist pests and pathogens.
2.2	Prevent the introduction and establishment of invasive plant species and remove existing invasive species.
2.3	Manage herbivory to promote regeneration of desired species.
2.4	Enhance conditions of internal roads, repair and/or upgrade culverts.
Strategy 3: Reduce the risk and long-term impacts of severe disturbances	
3.1	Alter forest structure or composition to reduce risk or severity of wildfire.
3.2	Establish fuel breaks to slow the spread of catastrophic fire.
3.3(a)	Alter forest structure (age classes) to reduce severity or extent of potential damage.
3.3(b)	Alter forest structure to reduce severity or extent of wind and ice damage.

3.4	Design forest management that mimics a natural disturbance.
3.5(a)	Promote restoration after a disturbance.
3.5(b)	Promptly revegetate sites after disturbance.
3.6	Salvage dead or damaged trees.
Strategy 4: Maintain or create refugia.	
4.1	Prioritize and maintain unique sites.
4.2(a)	Prioritize and maintain sensitive or at-risk species or communities.
4.2(b)	Promote and maintain at-risk species habitat.
4.3	Establish artificial reserves for at-risk and displaced species.
Strategy 5: Maintain and enhance species and habitat diversity.	
5.1(a)	Promote diverse age classes.
5.1(b)	Manage for a suite of stand age classes to increase temporal and structural diversity.
5.2	Maintain and restore diversity of native species.
5.3	Retain biological legacies at the species or stand level.
5.4	Establish reserves to maintain ecosystem diversity.
5.5 (4.1b?)	Prioritize and maintain Natural Communities as defined by the NHESP.
5.6	Manage or restore DWSP-defined Focus Areas or DFW/NHESP-defined Key Sites for specific types of rare habitat.
Strategy 6: Increase ecosystem redundancy across the landscape.	
6.1	Manage similar stand types over a range of sites and conditions.
6.2	Expand the boundaries of reserves to increase diversity.
6.3	Manage the forest at the landscape/watershed-level.
Strategy 7: Promote landscape connectivity.	
7.1(a)	Reduce landscape fragmentation.
7.1(b)	Reduce forest or stand fragmentation.
7.2(a)	Maintain and create habitat corridors through reforestation or restoration.
7.2(b)	Maintain and create forest/habitat corridors through management or stand retention.
Strategy 8: Maintain and enhance genetic diversity.	
8.1(a)	Use seeds, germplasm, and other genetic material from across a greater geographic range.
8.1(b)	Use plantings and other native stock from across their native range to establish regeneration.
8.2	Favor existing genotypes that are better adapted to future conditions.
Strategy 9: Facilitate community adjustments through species transitions.	
9.1	Favor or restore native species that are expected to be adapted to future conditions.
9.2	Establish or encourage new mixes of native species.
9.3	Guide changes in species composition at early stages of stand development.
9.4	Protect future-adapted seedlings and saplings.
9.5(a)	Disfavor species that are distinctly maladapted.
9.5(b)	Target species for harvest that are predicted to be distinctly maladapted to future conditions.
9.6	Manage for species and genotypes with wide moisture and temperature tolerances.
9.7	Introduce species that are expected to be adapted to future conditions.
9.8	Move at-risk species to locations that are expected to provide habitat.
Strategy 10: Realign ecosystems after disturbance.	
10.1	Promptly revegetate sites after disturbance. (also 3.5)

10.2	Allow for areas of natural regeneration to test for future-adapted species.
10.3	Realign significantly disrupted ecosystems to meet expected future conditions.

Practitioners Menu of Adaptation Strategies & Approaches for Forest Carbon Management

Abstract: The importance of forests for sequestering carbon has created widespread interest among land managers for identifying actions that maintain or enhance carbon storage in forests. Managing for forest carbon under changing climatic conditions underscores a need for resources that help identify adaptation actions that align with carbon management. We developed the Forest Carbon Management Menu to help translate broad carbon management concepts into actionable tactics that help managers reduce risk from expected climate impacts in order to meet desired management goals. We describe examples of real-world forest-management planning projects that integrate climate change information with this resource to identify actions that simultaneously benefit forest carbon along with other project goals. These examples highlight that the inclusion of information on climate vulnerability, considering the implications of management actions over extended timescales, and identifying co-benefits for other management goals can reveal important synergies in managing for carbon and climate adaptation.

Practitioner's Menu of Adaptation Strategies and Approaches for Forest Carbon Management	
Strategy 1: Maintain or increase extent of forest ecosystems	
1.1	Avoid forest conversion to non-forest land uses
1.2	Reforest lands that have been deforested and afforest suitable lands
1.3	Increase the extent of forest cover within urban areas
1.4	Increase or implement agroforestry practices
Strategy 2: Sustain fundamental ecological functions	
2.1	Reduce impacts to soils and nutrient cycling
2.2	Maintain or restore hydrology
2.3	Prevent the introduction and establishment of invasive plant species & remove existing invasives
2.4	Maintain or improve the ability of forests to resist pests and pathogens
2.5	Reduce competition for moisture, nutrients, and light
Strategy 3: Reduce carbon losses from natural disturbance, including wildfire	
3.1	Restore or maintain fire in fire-adapted ecosystems
3.2	Establish natural or artificial fuelbreaks to slow the spread of catastrophic fire
3.3	Alter forest structure or composition to reduce the risk, severity, or extent of wildfire
3.4	Reduce the risk of tree mortality from biological or climatic stressors in fire-prone systems
3.5	Alter forest structure to reduce the risk, severity, or extent of wind and ice damage
Strategy 4: Enhance forest recovery following disturbance	
4.1	Promptly revegetate sites after disturbance
4.2	Restore disturbed sites with a diversity of species that are adapted to future conditions
4.3	Protect future-adapted seedlings and saplings
4.4	Guide species composition at early stages of development to meet expected future conditions
Strategy 5: Prioritize management of locations that provide high carbon value across the landscape	
5.1	Prioritize low vulnerability sites for maintaining or enhancing carbon stocks
5.2	Establish reserves on sites with high carbon density
Strategy 6: Maintain or enhance existing carbon stocks while retaining forest character	

6.1	Increase structural complexity through retention of biological legacies in living & dead wood
6.2	Increase stocking on well-stocked or understocked forest lands
6.3	Increase harvest frequency or intensity due to greater risk of tree mortality
6.4	Disfavor species that are distinctly maladapted
6.5	Manage for existing species and genotypes with wide moisture & temperature tolerances
6.6	Promote species and structural diversity to enhance carbon capture and storage efficiency
6.7	Use seeds, germplasm, and other genetic material from across a greater geographic range
Strategy 7: Enhance or maintain sequestration capacity through significant forest alterations	
7.1	Favor existing species or genotypes that are better adapted to future conditions
7.2	Alter forest composition or structure to maximize carbon stocks
7.3	Promote species with enhanced carbon density in woody biomass

Appendix B: Glossary

https://www.mass.gov/doc/clean-energy-and-climate-plan-for-2025-and-2030/download**Afforestation:** The establishment of forest trees by planting or seeding an area not previously forested.

Best Management Practice (BMP): A method that has been determined to be the most effective and practical means of achieving an objective. In the context of forestry and water quality, these are practices like installing waterbars to divert water off skid trails or seeding landings to help stabilize bare soil; and may have the force of law or regulation in meeting clean water and wetlands protection goals.

Canopy: The upper level of a forest, consisting of branches and leaves of taller trees. A canopy is complete (or has 100 percent cover) if the ground is completely hidden when viewed from above the trees.

Carbon Sequestration: The removal by plants of carbon dioxide from the atmosphere, and storage of it plants and soil.

Current Use Programs: In Massachusetts, Chapters 61 for forestlands, 61A for agricultural land and 61B for recreational land give preferential property tax treatment to landowners who maintain their property as open space for timber production, agriculture, or recreation, respectively.

Early Successional Habitat: The condition of forest vegetation and habitat, in terms of species composition and structure, that is found in the early seral or successional stages of forest development. This habitat is made up predominantly of grasses, forbs, saplings, and shrubs, and provides an environment for a diversity of birds, mammals, plants, and invertebrates.

Ecosystem Services: Benefits provided by ecological resources and processes. These services can be broken into four broad categories: provisioning, regulating, supporting and cultural.

Emissions Limits: The level which GHG emissions in Massachusetts cannot exceed, pursuant to the GWSA and 2021 Climate Act.

Forest: A biological community dominated by trees and other woody plants.

Greenhouse Gas (GHG): A gas, such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), different types of hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF6), that traps heat in the atmosphere, like the glass in a greenhouse, and causes the average global air temperature to rise, thus changing weather patterns globally.

Herbivory: The feeding on living plant parts by animals, is a key ecosystem process that has widely recognized effects on primary production and on vegetation structure and composition. The effect of herbivory depends on herbivore feeding type and intensity.

Late Successional Habitat: The condition of forest vegetation and habitat, in terms of species composition and structure, that is found in maturing and later seral or successional stages of forest development. This habitat includes maturing trees of different size and age classes, multi-layered canopies including canopy gaps, increased amounts of standing and down woody materials, and provides an environment for a diversity of birds, mammals, plants, and invertebrates.

Leakage: The effects of policies that result in a displacement of the environmental impact, thereby counteracting the intended effects of the initial policies.[77] As defined by the Massachusetts Legislature, the offset of a reduction in emissions of GHG within the Commonwealth by an increase in emissions of GHG outside the Commonwealth.[78]

Management, active: The process of planning and implementing practices for the stewardship and use of forests to meet specific environmental, economic, social, and cultural objectives

Management, passive: an intentional hands-off approach that allows forests to be shaped largely by natural processes.

MMTCO2e: Million metric tons of carbon dioxide equivalent – This is a measure of how much GHG is emitted into our atmosphere. An emission of 1 MMTCO2e is equivalent to burning 112,523,911 gallons of gasoline.

Natural and Working Lands: Lands within the commonwealth that: (i) are actively used by an agricultural owner or operator for an agricultural operation that includes, but is not limited to, active engagement in farming or ranching; (ii) produce forest products; (iii) consist of forests, grasslands, freshwater and riparian systems, wetlands, coastal and estuarine areas, watersheds, wildlands or wildlife habitats; or (iv) are used for recreational purposes, including parks, urban and community forests, trails or other similar open space land.[79]

Old Growth Forest: Forests that approximate the structure, composition, and functions of native forests prior to European settlement. They vary by forest type, but generally include more large trees, canopy layers, standing snags, native species, and dead organic matter than do young or intensively managed forests.

Old Growth Characteristics: Characteristics that are generally **more** abundant in old-growth forests include:

- Presence of large (>20" diameter) and old trees
- Spatial variation in tree density and size
- Large-diameter standing dead trees
- Large downed logs in various stages of decay
- Multiple canopy layers
- Understory plant communities
- Regeneration[80]

Plantations: Forest stands established simultaneously through the planting of trees of similar, often non-native, species.

---

[77] **https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Annex-I.pdf**

[78] MGL CH21N section 1

[79] MGL CH21N section 1

[80] **MassWoods - https://masswoods.org/caring-your-land/restoring-old-growth-characteristics**

Post-Salvage Harvesting: Removal of trees after they are infested or dead to recover any remaining value.

Pre-Salvage Harvesting: The removal of dead, damaged, or diseased trees with the intent of recovering value prior to deterioration. [Note: in this document, pre-salvage harvesting is discussed in the context of addressing pests and pathogens].

Regeneration: The replacement of one forest stand by another as a result of natural seeding, sprouting, planting, or other methods; also, young trees which will develop into the future forest.

Reserves: Reserves are forest areas that are permanently protected and managed through passive approaches to allow natural processes to predominate and determine ecosystem structure, function, and composition with an absolute minimal amount of human impact.[81]

DCR's Landscape Designations for State Parks and Forests defines reserves as follows: large contiguous blocks of high-value ecosystems. These are areas where the dominant ecosystem service objectives will be biodiversity maintenance, nutrient cycling and soil formation, and long-term carbon sequestration. Forest management will generally consist of letting natural processes take their course, although under specific circumstances, more active management might be permitted. [82]

Resilience: Resilience is "the capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential functions, identity and structure."[83]

Silviculture: The theory and practice of controlling forest establishment, composition, structure, and growth; applied forest ecology; the art and science of producing and tending a forest.

Soil Scarification: Mechanical disruption of the forest floor, including small vegetation, and the duff and litter layers, to expose bare mineral soil, to facilitate the germination and survival of seeds of certain tree species.

Stand: A spatially continuous group of trees and associated vegetation having similar structures and growing under similar soil and climatic conditions.

Stocking: The amount of anything in a given area relative to some predefined standard; often expressed as a percent and using trees per acre, basal area, or volume as units; and sometimes as a unitless index based on long-term research of stands across a range of ages and histories.

Except where specified otherwise, the definitions listed in this Glossary were drawn from EEA agency resources including the following sources:

Glossary of Technical Terms for Forestry Operations

[81] Wildlands in New England (Foster et al. 2023)

[82] Landscape Designations for State Parks and Forests

[83] IPCC AR6 Working Group 2 Glossary p. 2920.

Glossary of Forestry Terms for Landowners

Glossary of Forestry Terms

2025/30 Clean Energy and Climate Plan

Appendix C: Summary of *Forests as Climate Solutions Initiative* Branches

As context for Climate Forestry Committee recommendations that pertain to each of them, this section provides a summary of the Commonwealth's intentions regarding each of the other components of the *Forests as Climate Solutions Initiative*: Keeping Forests as Forests, Forest Reserves, Forest Landowner and Business Incentives, and Forest Data.

Keeping Forests as Forests

Keep forests intact by accelerating the pace of permanent conservation and reducing conversion to other land uses.

Key actions the Commonwealth is taking to realize this objective include:

- Affirming and providing the resources to realize the Clean Energy and Climate Plans' objective of protecting 30% of Massachusetts lands by 2030 and 40% by 2050, much of that land to be forested (which entails doubling the recent pace of land protection).
    - Enhancing EEA land conservation and land use programs
    - Partnering with landowners, land trusts, and municipalities
    - Pursuing complementary policies to avoid conversion of forest land (e.g., siting of solar, housing, and other development)
- Setting, and committing to attaining, goals for:
    - Conserving forest land (currently ~35% of forest land is protected); and
    - Reducing the forest land conversion rate (e.g., by 2030 reduce the conversion rate by 50%, which would entail going from approximately 4000 acres per year to 2000 over seven years).
- Implementing the Resilient Lands Initiative, a Plan that guides land conservation and land use related efforts of the state and other entities, with a focus on policies, programs, and investments that protect forests and improve land use, seeking to reduce and be more strategic about where forest loss occurs.

Forest Reserves

Expansion of forest reserves, areas where no active forest management is intended and nature takes its course, for carbon sequestration and storage, habitat, and other benefits.

To advance this objective, the Commonwealth is providing additional land conservation funding and focusing time, attention, and resources on increasing the amount of state and other forest land designated as forest reserves. Currently less than 4% of the state is in a reserve status[84]

Key actions the Commonwealth is taking to expand the amount of land held in reserves include:

[84] Foster, D. et al. 2023. *Wildlands in New England: Past, Present, and Future*. Harvard Forest, Northeast Wilderness Trust, Highstead Foundation.

- Setting and committing to realization of a goal for a percentage of forest land, potentially encompassing conserved land owned by the state and other entities, to be held as reserves;
- Seeking permanent designation of reserves, e.g., by statute;
- Increasing land conservation funding and targeting investments at creating and enlarging reserves with the best prospect for long term carbon sequestration and other benefits; and
- Working with land trusts & municipalities to establish reserves on their holdings and across land held by multiple owners.

Forest Landowner and Business Incentives

Expand incentives and programs to protect private and municipally owned forests, encourage landowners to manage their property using passive and active climate-oriented forest management techniques, and help forest centered businesses improve their technology and business practices.

Key actions the Commonwealth is taking to advance this aspect of the *Initiative* include:

- Providing financial incentives for climate-oriented active and passive forest management;
- Supporting local markets and infrastructure for durable wood products from sustainably harvested wood;
- Offering incentives to promote practices in the woods and at the sawmill that reduce carbon loss and environmental impact and increase competitiveness; and
- Funding measures to increase the percentage of harvested wood used for long lived products.

Forest Data

Integrate and make public the best science, research, and management practices and provide detailed information on state forestry activities to increase transparency and enhance public knowledge.

To advance this objective, the Commonwealth will acquire more field data, continue to systematically integrate research into conservation and management practices and provide additional information to the public. Specifically, the Commonwealth will work to:

- Collect and provide more field data about forests, carbon sequestration and storage, and the use of harvested wood;
- Better integrate research to inform forest goals and policies for climate mitigation (including the Forest Carbon Study presently underway);
- Develop a web-based dashboard sharing information about forest status and trends;
- For active management on state lands:
    - Complete and issue post project reports demonstrating compliance with forest management objectives; and]
    - Contract for periodic independent review of forest management projects.

Appendix D: Agency Relevant Statutory Citations

DSPR

Article 97 of the Articles of Amendment to the Constitution of the Commonwealth of Massachusetts (1972): "The people shall have the right to clean air and water, freedom from excessive and unnecessary noise, and the natural, scenic, historic, and aesthetic 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."

M.G.L. Chapter 21, Section 2F (2003): "Said management plans shall include guidelines for the operation and land stewardship of the aforementioned reservations, parks and forests, shall provide for the protection and stewardship of natural and cultural resources and shall ensure consistency between recreation, resource protection, and sustainable forest management."

M.G.L. Chapter 132, Section 31 (State Forests) (enacted 1914 and revised 2003): "[The State Forester] shall reforest and develop such lands, and may, subject to the approval of the Commissioner, make all reasonable regulations which in his opinion will tend to increase the public enjoyment and benefit therefrom and to protect and conserve the water supplies of the commonwealth."

M.G.L. Chapter 132, Section 40 (enacted 1943 and revised 1983): "It is hereby declared that the public welfare requires the rehabilitation, maintenance, and protection of forest lands for the purpose of conserving water, preventing floods and soil erosion, improving the conditions for wildlife and recreation, protecting and improving air and water quality, and providing a continuing and increasing supply of forest products for public consumption, farm use, and for the wood-using industries of the commonwealth."

DWSP

M.G.L. Chapter 737, Section 7: "The commissioner, or his designee, shall annually prepare a plan detailing forestry activities, logging or lumbering activities, proposed plantings and the like which are to be undertaken for the next following year, which plan shall be open to inspection by the public."

M.G.L. Chapter 737, Section 8: "Lumbering or logging operations shall be permitted within the district to the extent and for the purpose of maintaining and conserving its forests in a healthful state of natural ecological balance consistent with reservoir and watershed purposes…"

DFW

M.G.L. Chapter 131, Section 2C: "The fund, subject to appropriation, shall be used only as follows: …(7) for acquisition and maintenance of wildlife sanctuaries and fish and wildlife management areas …(9) for maintaining sources of food for game birds…(12) for the management, inventory, preservation, protection, perpetuation, and enhancement of nongame wildlife and endangered species in the commonwealth"

M.G.L. Chapter 131, Section 35D: Natural Heritage and Endangered Species Fund "...All revenues credited under this section shall remain in said Natural Heritage and Endangered Species Fund: to acquire by purchase, lease, easement or license land or interests therein critical to nongame wildlife and endangered species for the multiple purposes of protecting and enhancing nongame wildlife and encouraging compatible wildlife uses; to manage, inventory, preserve, protect, perpetuate, and enhance nongame wildlife in the commonwealth"

M.G.L. Chapter 131, Section 4 (16): Powers of director "enter into such contracts as the director, in consultation with the commissioner, deems necessary or appropriate in order to fulfill the responsibilities and mandates of the agency, including, but not limited to, contracts for the cutting and sale of timber on lands managed by the division, and shall deposit monies received from such contracts into the Inland Fisheries and Game Fund pursuant to section 2C..."