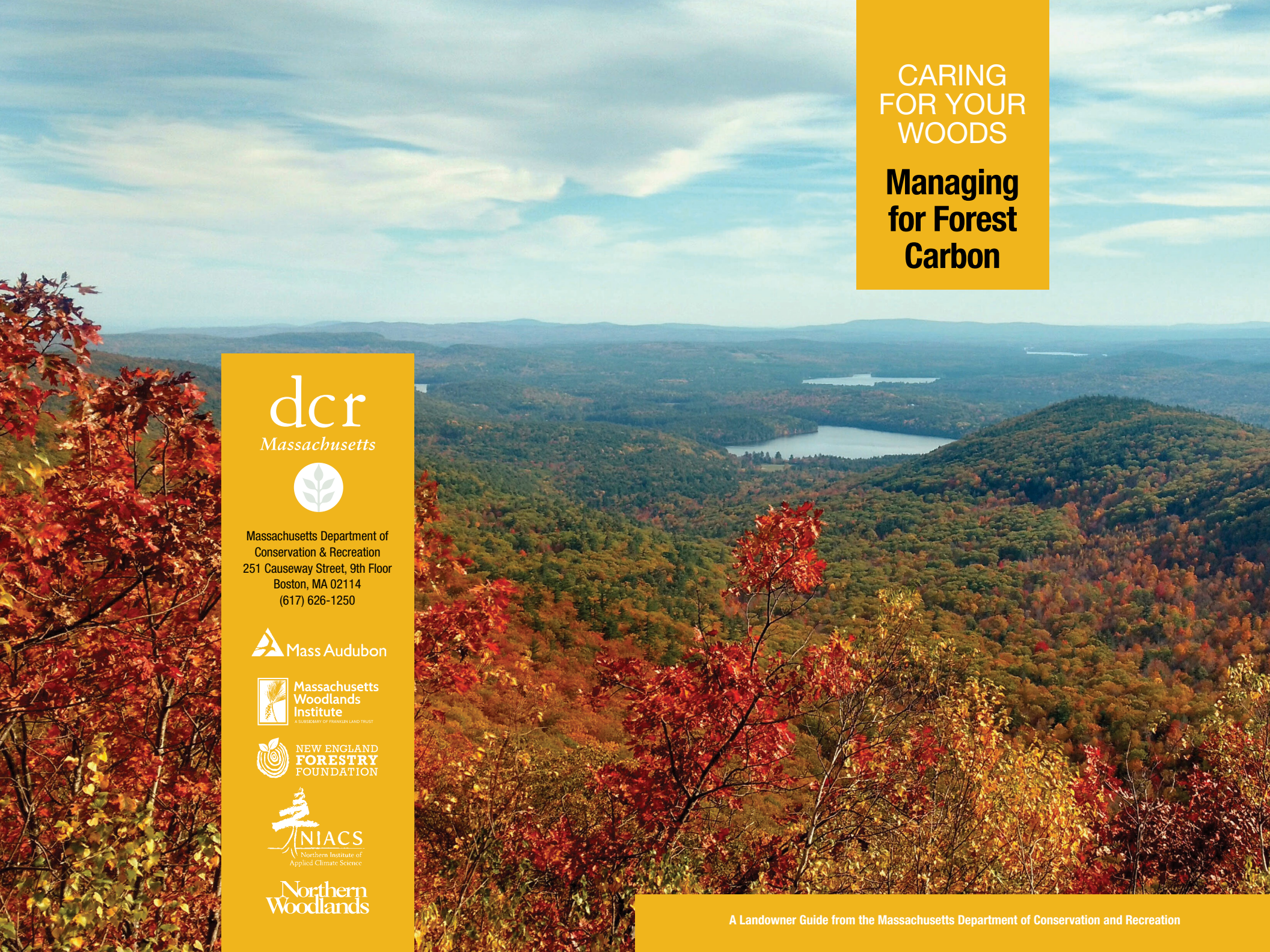

CARING FOR YOUR WOODS

Managing for Forest Carbon

dcr Massachusetts

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Mass Audubon

Massachusetts Woodlands Institute
A SUBSIDIARY OF FRANKLIN LAND TRUST

NEW ENGLAND FORESTRY FOUNDATION

NIACS
Northern Institute of Applied Climate Science

Northern Woodlands

A Landowner Guide from the Massachusetts Department of Conservation and Recreation

Our forests have always been important to us, but lately we are realizing how many benefits they provide to people. Whether hiking a path in the deep shade of soaring trees, marveling at the sight of spring wildflowers carpeting the forest floor, or relaxing to the melodies of forest songbirds, we feel refreshed and renewed in these special places. Lately, our forests have also been getting a lot of attention for another, almost miraculous property: their ability to capture and store carbon, which is among the most cost-effective and dependable ways to slow rising atmospheric carbon dioxide concentrations that cause climate change.

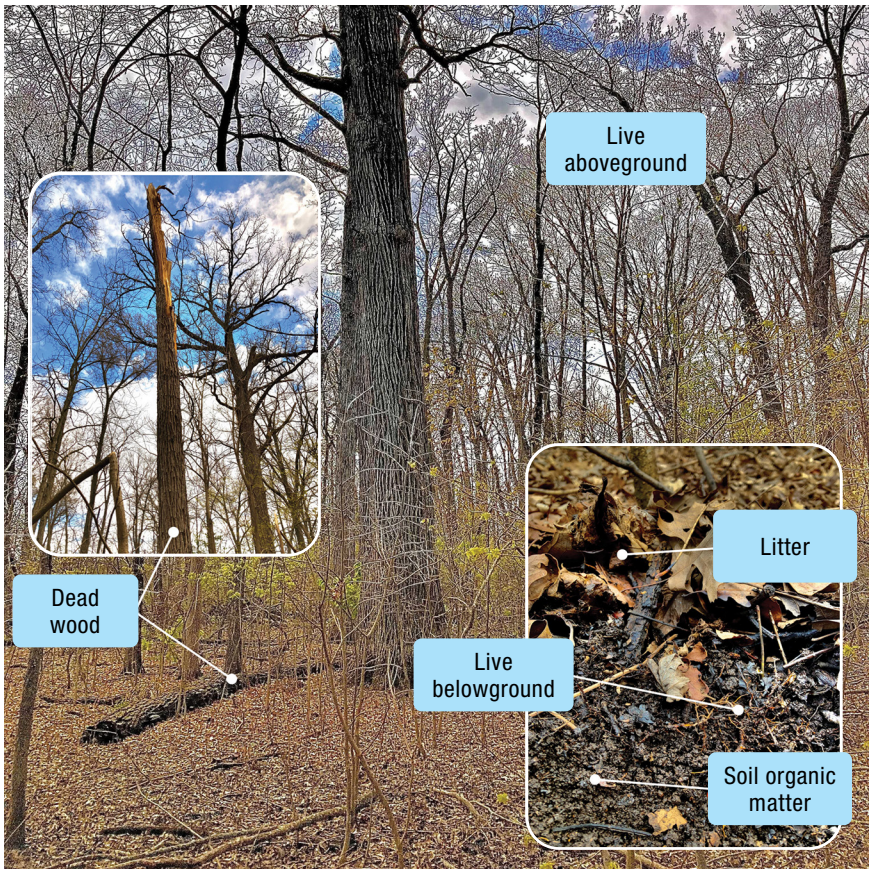
You probably don't own your forest because of the carbon it stores, but knowing that thoughtful management of your woods can provide the things you value – as well as being part of the solution for a changing climate – can be both inspiring and comforting. Considering management for carbon benefits can also give your land management planning decisions an added sense of purpose. If you and your family are interested, this booklet is designed to help you learn more and be ready to discuss your options for carbon management with your forester.

Litter and soil contribute to forest carbon stocks.

Downed logs take many decades to decay.

Why manage forests for carbon?

Increasing concentrations of greenhouse gases, particularly carbon dioxide (CO_2) from burning fossil fuels, are causing our climate to warm and change at rates never seen before. While society works to reduce these emissions, forests are one of our only cost-effective ways to lower atmospheric CO_2 that can be applied at large scales. This ability of forests to mitigate climate change comes from the ability of trees to take up (sequester) large amounts of CO_2 from the atmosphere. This carbon is then stored in living trees, soils, and dead wood (e.g. downed logs) in the forest.



CARBON TERMINOLOGY

Climate change mitigation: Actions that reduce the amount of heat-trapping greenhouse gases, such as CO_2, in the atmosphere to minimize changes in the earth's climate. Actions can include reducing or avoiding emissions of greenhouse gases into the atmosphere, as well as removing greenhouse gases that are already present in the atmosphere.

Carbon sequestration: The process of plants using sunlight to capture CO_2 from the air and convert it into plant biomass, including wood, leaves, and roots.

Carbon storage: The amount of carbon retained within the forest in various types of biomass, referred to as pools. Forests are called "carbon sinks" when more carbon is coming in than leaving.

Carbon pools are different categories of biomass found within forests. Pools can be defined various ways, but generally include the following:

50%
Live aboveground
trees, shrubs, herbs, grasses
36 tons C/ac

10%
Live belowground
roots
7 tons C/ac

7%
Dead wood
standing dead trees, stumps, logs
5 tons C/ac

5%
Forest floor
leaves, small branches
4 tons C/ac

28%
Soil
mineral soils, including decaying organic matter
21 tons C/ac

Numbers indicate pool size (%) for an average oak-hickory forest in MA

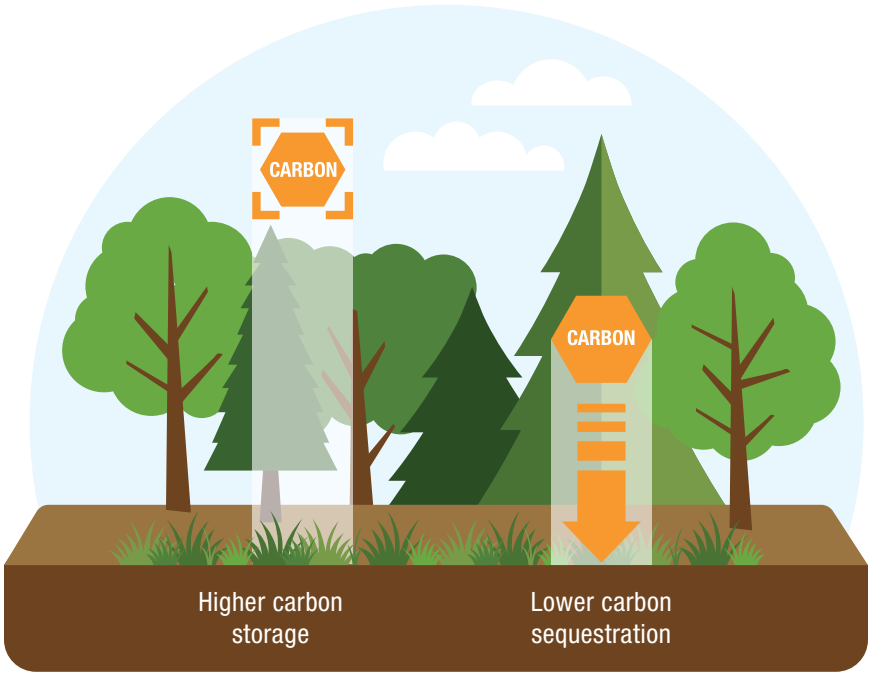
Data from USDA Forest Service, Forest Inventory and Analysis 2020.

What influences how much carbon is on my land?

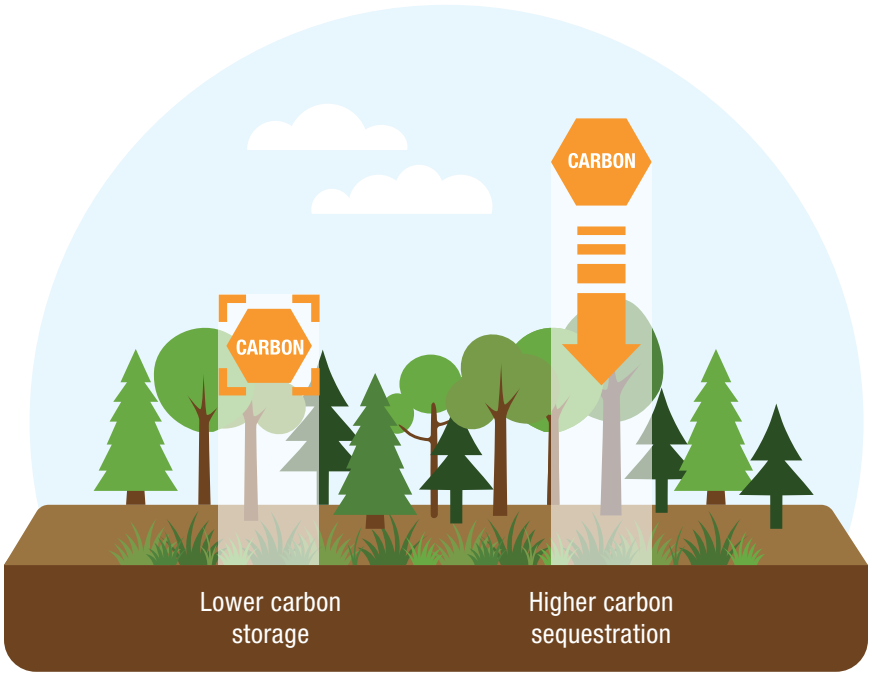
The benefits of your forest from sequestration and storage of carbon may be very different from your neighbor's land right across the road. Many factors combine to determine how much carbon is on your land, and how much there could be in the future.

Age of the forest: As forests get older, they typically store more carbon. The accumulation of greater biomass in trees and the continual transfer of biomass into other pools, such as the buildup of dead wood when trees die or lose branches, means older forests store more and more carbon as they age. The turnover of leaves in deciduous trees and the death of fine roots belowground also contribute to carbon pools on the forest floor and in soil.

Although younger forests with smaller trees store much less carbon compared to older stands, young forests can grow very quickly and so often sequester carbon at higher rates compared to older forests. Carbon sequestration rates begin declining after the forest canopy closes, typically after the forest stand is 30-70 years old, due to higher tree mortality and competition between trees for light, nutrients and water. As older stands become dominated by fewer large-diameter trees, more trees in the stand become shaded, reducing their growth. This can lower the overall sequestration rate of the forest. It is important to recognize this generalization about growth rates only applies across stands of forest and does not indicate growth rates of individual trees. Because a dominant canopy tree in an older stand can have less competition for light, water, and nutrients, it may maintain very high carbon sequestration rates while the smaller non-dominant trees have reduced growth rates.



Mature forest



Young forest

Past management: Your forest's past may play a large role in the total amount of carbon stored, where it is stored, and the potential to sequester more carbon in the future. Was your land once farmed and the forest has since grown back? Has there been a more recent history of harvesting? The type of past management and when it occurred can influence nearly every aspect of your forest, from the age of the trees, the species present and their relative abundance in your woods, to the amount of carbon stored as dead wood, in soils, or on the forest floor. Whatever your land's history, the current conditions that result from it will likely determine what the options are for managing for carbon mitigation into the future. Working with a professional forester will help identify these opportunities.

Soils: Soils represent one of the biggest carbon pools in forests. But not all soils are created equal in terms of their capacity to store carbon, or their risk of losing carbon due to disturbance.

- Wet sites often have high soil carbon, whereas soils on sandy or drought-prone sites such as ridgetops typically have low carbon levels.
- Soils on steep slopes or next to streams are more prone to erosion and subsequent carbon loss than others.
- Water-saturated soil or places with heavy, clay soils are prone to compaction with long-term impacts on forest vegetation growth and carbon.

Places with high soil carbon or greater potential impact from disturbance should be prioritized for protection or implementation of forestry best management practices to minimize carbon losses.

Messy can be good for carbon: Greater amounts of dead wood in the form of standing dead trees and downed logs are important elements of forest structure that enhance carbon storage. Dead wood decomposes slowly, holding on to carbon for many decades or longer, while releasing nutrients back to the forest to enhance the growth of trees.

The importance of diversity: Forests with greater diversity of tree species and vertical canopy structure (layering of vegetation) often have higher carbon storage compared to less diverse forests of a similar age. Stands with a variety of tree sizes and heights, including abundant understory, mid-canopy, and overstory trees, have more biomass per acre of forest. Stands with greater tree species diversity are also often able to maintain higher carbon densities. For example, forests with a greater number of species adapted to different light levels allow for greater layering of vegetation that may result in higher carbon density.

While greater species and structural diversity impact carbon *storage*, they can also support higher rates of carbon *sequestration* in forests. For example, when trees that grow well in shade are below a canopy of trees that need direct sunlight, efficient use of sunlight is enhanced and the ability to sequester carbon is greater.

Forest type: Total stored carbon, and the percentage across various carbon pools, can vary significantly based on the type of forest on your land. While an average oak-hickory forest stores 73 metric tons of carbon per acre, a typical northern hardwoods stand can contain 26% more carbon (92 tons/acre).

Dead wood left after a harvest, as shown at Norcross Wildlife Sanctuary, maintains carbon storage.

Forest carbon slows climate change, but climate change impacts forest carbon

Although forest carbon is a critical climate solution, climate change is also impacting forests and their ability to sequester and store carbon. While warming temperatures mean longer growing seasons and more time for trees to photosynthesize and grow, there are a host of risks from climate change and other stressors that may impact your forest's health, and with it, the capacity to sequester or store carbon. Changes in temperature and precipitation patterns can jeopardize both the existing carbon stored in your forest, as well as the ability to sequester additional carbon in the future.

Active management and productive soils contribute to diverse, mature forest at J. Harry Rich State Forest in Groton.

A first step in planning for carbon management on your property should be to talk with your forester to understand how your woods may be vulnerable to climate change and other stressors, and what you can do about it. The risks, and the various management options to adapt your forest to changing conditions, may be unique to your property. Protecting the functions of your forest by safeguarding soils and water and reducing the impacts of stressors such as invasive plants and insect pests are essential steps to ensuring your forest remains a carbon sink into the future. Taking proactive steps to align your forest to future conditions by improving the health of the forest or through intentional changes in its composition or structure may enhance future carbon sequestration. For more information on how climate change may affect your forests and how to adapt, see *Caring for Your Woods: Adapting to Changing Conditions*.

Deciding how – and where – to manage your forest for carbon

While there are many factors that determine the carbon storage and sequestration abilities of your forest, the carbon mitigation value of your land in the future depends on the forest management planning decisions you make now. Identifying achievable carbon management actions that align with your other goals for your woodland is often a good place to start. A property map highlighting key features, tree stands, or areas of focus can help.

If wildlife is an interest, you may consider the habitat requirements of the species for which you most want to manage. For wildlife that use mature forests, management to retain high forest cover and large trees emphasizes carbon storage. If providing habitat for a greater diversity of wildlife species is a goal, look for options that enhance the complexity of forest stands by creating small openings within older stands to balance sequestration and storage. If your forest management plan already supports the main values you seek, you might simply be looking for opportunities to incorporate changes that enhance carbon benefits.

Sometimes there are tradeoffs between carbon and other goals. If timber production is important, your forester will work with you to manage for forest health and increased productivity to ensure future harvests. This can provide carbon benefits from sequestration in young, vigorously growing trees while the wood harvested stores carbon in long-lived products, like lumber for building houses or furniture. However, it may be important to recognize that removal of trees for timber reduces carbon storage in the near term in these stands. Keeping non-forested areas for fields, crops or raising livestock may be at odds with forest carbon goals and these areas may be excluded from carbon management planning.

Whether it is a desire to act on climate change or the co-benefits realized in conjunction with other goals, management for carbon may take on an elevated importance for some landowners. For those who prioritize carbon benefits, there are many options suitable for a variety of site conditions to consider.

ASSESSING MARKET OPPORTUNITIES

Have you wondered if you can be paid for your forest's carbon? If you have heard of carbon credits, the answer is probably yes. A carbon credit is one metric ton of CO_2 (or an equivalent amount of greenhouse gas) removed from the atmosphere through sequestration or not emitted due to emissions reductions. Carbon credits must be verified by an independent contractor for a landowner to be paid. Due to the expense of verification, a carbon offsets project often must cover thousands of acres – larger than the majority of forest properties owned by families and individuals – in order to be financially viable. The recognition of this challenge has led to efforts to take innovative approaches to forest carbon projects. These efforts overcome the barriers of high verification costs and identify carbon-beneficial management practices – along with eligibility requirements – so that landowners can choose from a set of practices that fit their site conditions. For more information, see the Resources page at the back of this guide.

Taking action for forest carbon

There are many different options available for stewarding the health of your forest while enhancing carbon sequestration or storage. Finding what is the right approach for you will depend on many factors: the goals you have for your land, the conditions on your property – including the age, species composition, and health of your forest – as well as the risks of changing conditions to the current plant communities in your woodlands. Working with a professional forester allows you to create a plan that meets the needs of your unique situation and interests.

The carbon implications of every forest management action can be considered: does this practice accelerate carbon sequestration? Or is the amount of carbon stored enhanced by avoiding losses of carbon from disturbance? These considerations also shed light on the expected time frame for carbon benefits. Some actions – such as retaining large canopy trees during management activities – produce immediate carbon benefits, while others such as planting trees or reducing damage from deer may take years to decades to generate significant carbon benefits. Landowners may choose to implement multiple carbon management practices within their plan in order to balance benefits to sequestration and storage and provide both short- and long-term carbon benefits.

Given the important role of management in determining your forest's carbon future, landowners may consider implementing various forest carbon strategies:

Continue to let your forest grow: Allowing your forest to keep growing rather than cutting trees seems like a sure-fire way to manage for more carbon. If your woodlands are experiencing forest health issues or have high vulnerability to stressors or climate impacts, such as insect pests or drought mortality, not intervening to remove unhealthy trees may elevate risks of widespread carbon loss or die-off. However, if your forest is healthy and considered to have low vulnerability to climate impacts and stressors, letting your forest grow may provide significant carbon benefits. This may involve delaying a planned harvest for a period of time to allow trees to get bigger, or may entail designating a portion of your property as a protected forest reserve.

Balancing harvest and carbon: Whether for habitat, timber revenue, or improving forest health, harvesting portions of a property may be needed to meet the goals of some landowners. Work with your forester to divide your property into management units to meet all of your management objectives, and consider spacing out activities over time. Consider expanding buffers around wetlands or riparian zones, or minimizing roads or trails to protect soils. Areas considered low risk for carbon loss can be targeted for maintaining carbon stocks, while areas at greater risk are prime areas for early successional habitat and carbon sequestration. Your forester can help you find the right balance for your property and goals.

Enhancing buffers around sensitive areas such as riparian zones preserves more carbon.

Removing invasive species and other competing vegetation: Invasives can degrade our native plant communities and even destroy habitat, and they can also be bad for forest carbon. Removing undesirable vegetation that competes with trees for water, nutrients, or light can have both short- and long-term carbon benefits. This strategy increases carbon sequestration by improving tree growth and survival of desired young understory trees. Removing invasive vines that have infested mature trees can help maintain existing carbon stocks by reducing tree mortality. Competing vegetation can be invasive species, although a few native species such as grapevine, hay-scented fern, striped maple, or beech sprouts can significantly impede growth or survival of mature trees.

Protecting small trees from herbivory: A concern for the future of your forest should include a recognition of the importance of young trees – which represent the next generation of trees in your woodland. Many forests in Massachusetts have a noticeable lack of young trees because deer feed on them. Protecting the young trees in your forest by using tree tubes, fencing, or the strategic placement of tree tops following a harvest, can reduce deer browsing to give the next generation of trees a chance to grow tall enough to be out of harm's way. Coordinating with neighbors to control local deer populations through hunting can be effective at reducing impacts and giving the young trees a fighting chance for survival.

Creating new forests: If forests are one of our best ways to mitigate carbon emissions, then it makes sense that having more forests will increase that benefit. Reforestation of appropriate non-forested sites on your property takes time and work,

Acorns take root, starting a new generation for the forest.

but the transformation that takes place from planting trees or letting them establish on their own – both in carbon sequestration, as well as a host of other benefits – is a legacy worth the effort.

Enhancing species and structural diversity: Snags, downed logs, and coarse woody debris aren't just dead weight, but can be critical for reaching your carbon goals. These components of your forest provide structural elements that are important for both enriching the habitat for wildlife, as well as packing more carbon into your forest. Actions that enhance the diversity of tree species in your forest, such as enrichment planting or harvest practices to encourage the growth of species that are uncommon in your woods can enhance the resilience, and the future carbon sequestration, of your forest.

Creating gaps can increase species and age class diversity in your forest.

Retaining more carbon when harvesting: If you've ever stood below a gnarled giant with wide-spreading branches in a forest, likely a legacy from before our forests were cleared for agriculture, you may understand the importance of these large old trees. Retaining large-diameter trees, especially those in good health, can greatly increase the stored carbon in stands being harvested for forest regeneration. Similarly, designation of legacy trees in declining condition for habitat and as future dead wood provides similar benefits, along with the retention of snags, downed logs, and other course woody debris.

Thinning to enhance growth of dominant healthy trees: Thinning stands is a common practice to enhance the growth and survival of the remaining trees, and this is especially important as our climate changes and droughts increase in frequency, intensity, or duration. Thinning removes surrounding trees to reduce competition and potential forest health impacts into the future. By retaining the largest trees in this type of treatment, the maximum carbon benefit can be realized, from both the carbon remaining in the stand as well as the additional carbon sequestered as the remaining trees grow faster.

Thinning forest stands helps remaining trees grow faster.

Resources

The following resources can help you learn more about issues related to caring for your forest.

MASSACHUSETTS DEPARTMENT OF CONSERVATION AND RECREATION
The Department of Conservation and Recreation's Bureau of Forestry leads in delivering carbon benefits on state lands for future generations. Through balanced forest management strategies, we create resilient forests that will fight climate change for the benefit of all Commonwealth residents.
www.mass.gov/info-details/managing-our-forests-for-carbon-benefits

NORTHERN INSTITUTE OF APPLIED CLIMATE SCIENCE (NIACS)
Forest management actions are often necessary to support forest carbon goals, especially given climate change impacts on forests. Adaptation strategies and approaches can help landowners understand and select from a variety of climate-informed management actions that support carbon mitigation.
https://forestadaptation.org/focus/forest-carbon-management

MASSWOODS
Forest landowners and others who help to steward forests can have a significant impact on climate change through their land-use decisions. These decisions can impact the important role forests play in providing a natural solution to climate change.
https://masswoods.org/caring-your-land/forest-carbon

Old-growth forests typically store large quantities of carbon, yet are now one of the rarest habitats in our region. There are a range of opportunities to increase old-growth structure in your woods in a way that matches your forest objectives.
www.masswoods.org/caring-your-land/restoring-old-growth-characteristics

NEW ENGLAND FORESTRY FOUNDATION (NEFF)
NEFF's Exemplary Forestry standards are designed to accomplish three goals: enhance the role forests play to mitigate climate change, improve wildlife habitat and grow more and better-quality wood.
www.newenglandforestry.org/learn/initiatives/exemplary-forestry

USDA FOREST SERVICE
The Climate Change Resource Center features brief summaries of specific topics in natural resource sciences and management related to climate change.

Agroforestry:
www.fs.usda.gov/ccrc/topics/agroforestry

Forest Management:
https://www.fs.usda.gov/ccrc/topics/forest-mgmt-carbon-benefits

Forest Soil Carbon:
www.fs.usda.gov/ccrc/topics/forest-soil-carbon

The long-term capacity of forests to sequester carbon depends in large part on their health, productivity, resilience, and ability to adapt to changing conditions. This report provides information for considering carbon as one of many objectives for land management activities.
www.fs.fed.us/research/publications/gtr/gtr_wo95.pdf

THE NATURE CONSERVANCY
Forests filter our drinking water, provide homes for wildlife and improve our health. Forests also fight climate change in many ways.
www.nature.org/content/dam/tnc/nature/en/photos/MAForestCarbonFactsheet.jpg

FAMILY FOREST CARBON PROGRAM
This program pays woodland owners to carry out specific activities on their land that enhance wildlife habitat and water quality, while increasing the carbon stored on the landscape.
www.familyforestcarbon.org

MASS AUDUBON
Forest Carbon Market Solutions: A Guide for Massachusetts Municipalities provides an overview of current forest carbon market opportunities for municipalities and other interested landowners.
www.massaudubon.org/climateforestry

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