RESTORING OLD-GROWTH CHARACTERISTICS

to New England's *and* New York's Forests

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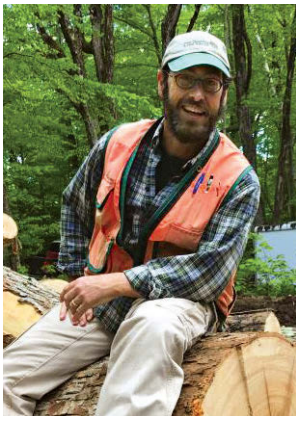

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WE DEDICATE this publication to our colleague, mentor, and friend David Kittredge, who was instrumental in motivating the original publication in this series, impressing upon us the importance of translating these concepts to the family-forest-owner-dominated landscapes of the Northeast.

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PAPER SOURCING

At the time this pamphlet went to press, printing on 100% recycled paper was prohibitively expensive. Rather than wait, we elected to proceed with printing to meet the immediate need of evidence-based guidance about managing for old-growth forest characteristics. Both the expense and lack of availability of the paper products we would have preferred certainly speak to the supply-chain challenges rippling across all sectors of the economy. However, these dynamics also underscore the critical need for investments in wood and paper product recycling infrastructure—as well as in local forest product industries. As we show in this pamphlet, applying ecological forest management principles and practices can not only help achieve a diversity of forest conditions—from young to old forest characteristics—but be entirely consistent with the very investments needed to ensure the availability of sustainably sourced and recycled wood and paper products.

Photo credits: (cover) Anthony D'Amato, (top left) Erica Housekeeper, (top middle) Dave Orwig, (top right) Anthony D'Amato
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The forests of New England and New York have long been recognized for providing myriad benefits, including clean air and water, wildlife habitat, recreational opportunities, and locally produced wood products. Increasingly, forests are being recognized as critical in addressing climate change, sparking even greater interest in our forests and stewardship strategies to conserve them. Maintaining this diversity of benefits necessitates a spectrum of stewardship strategies, ranging from intensive, active forest management to less intensive, passive approaches to forest stewardship. The forests of our past can help inform these forest stewardship strategies.

FORESTS DOMINATED about 90 percent of the region at the time of European settlement. In the nineteenth and early twentieth centuries, widespread land clearing for agriculture reduced forest cover to roughly 30 percent across much of the region. The last century and a half has witnessed an incredible rebound of our forests, which now occupy approximately 70 percent of the land base across New England and New York. However, even though our forests have grown back, there are few remaining examples of old-growth forests, which now occur on less than 0.1 percent of the region. Our current understanding of these remnant stands of old growth and historical accounts by foresters and ecologists tell us that these forests are quite different from the forests currently dominating our landscape. Since old growth is the condition that our forest species evolved with for thousands of years, maintaining old-growth characteristics within our forests restores missing pieces that will help ensure that our forests continue to sustain themselves and the many benefits we depend on.

We cannot re-create true old-growth forests; however, we have opportunities through both passive and active forest management to restore old-growth characteristics to our ecologically young forests. New England and New York have a diverse ownership pattern, which includes a plurality of forest owned by families and individuals, with substantial ownership by public agencies and other private entities, including conservation organizations and the forest industry. Therefore, restoring old-growth characteristics widely will take a diverse set of strategies that match the goals of these ownerships and that can be applied to each on a landscape scale.

This publication is intended for the many decision-makers of these diverse ownerships, including family forest owners, public and private foresters, land trusts, and municipal officials. The goal of this publication is to increase the amount of old-growth characteristics in the region by giving decision-makers the information they need to adopt old-growth restoration strategies in ways that complement their ownership goals, helping to sustain our native forests and their many benefits. This publication builds on earlier guides (D'Amato and Catanzaro 2007, 2009) and provides a description of the importance of old-growth characteristics, the differences between current

Regional Strategies to Conserve Forests, Young and Old

Permanently protecting the forests that form the natural "green infrastructure" of New England and New York is a priority of many agencies, organizations, and individuals. Most proposals guiding these efforts, such as *Vermont Conservation Design, Massachusetts Resilient Lands Initiative*, and *Wildlands and Woodlands*, recognize the value of protecting forests, using a variety of strategies, from wildland reserves to actively managed woodlands, to ensure that there are a range of forest conditions to support the diversity of biota, cultures, and livelihoods dependent on these forests. This includes designating areas to develop old-growth characteristics, as well as strategically creating young forests to provide habitat for declining wildlife species that depend on those conditions. A mix of strategies also helps to mitigate climate change, since young forests sequester (absorb from the atmosphere) carbon more rapidly and old forests store more carbon. Applying a variety of strategies will also increase forest resilience by creating diverse conditions across the landscape. Although the importance of wildlands has been acknowledged within these large-scale visioning efforts, there has been limited effort put toward the designation of these areas across the landscape. Applying strategies to restore old-growth characteristics on your land can not only help achieve your personal goals but also contribute to these regional efforts. In addition, family forest owners making formal long-term plans to ensure that their property remains forested into the future is crucial to the success of these regional efforts and benefits us all.

and old-growth forests, targets across New England and New York for old-growth characteristics, and management options for restoring these characteristics to our forests. In addition, this guide describes ways in which restoring old-growth characteristics complements efforts to adapt forests to global change, mitigate climate change through forest carbon, and promote biodiversity.

WHAT IS OLD GROWTH?

Old growth: forests that were never directly affected by intensive human land use, such as those implemented by Europeans. Old growth is a very rare condition in New England due to the extent and impacts of agriculture, logging, and other land uses beginning in the colonial era. Cultural practices, such as the use of prescribed fire by Indigenous peoples, certainly influenced the condition of historic forests, particularly near villages and other settlements, but are considered harmonious with the natural processes that were the primary driver of these forests.

Second growth: forests that established and grew following intensive human land use, such as agriculture or logging of the colonial era. Most of the forests currently found in our region are best described as second growth.

Old forests: a forest that contains a critical mass of characteristics associated with old-growth forests (see Table 3, page 20, for target levels). Although specific forest ages have been included in definitions of old forest, the ecological time frames over which old-growth characteristics develop vary considerably by forest type, disturbance history, and site fertility. As a result, conservation strategies should focus on restoring tractable characteristics associated with old growth versus relying solely on estimates of tree age.

WHY IS OLD GROWTH IMPORTANT?

Our current forests are much different from the forests our native plants and wildlife adapted with over thousands of years. Some plants, lichens, mosses, fungi, and invertebrate species are dependent on old-growth characteristics that are currently lacking or less abundant in our second-growth forests. Also, many species—particularly native birds, including some woodpeckers, warblers, and thrushes, as well as certain mammals, such as fishers and martens—have been shown to reach greater abundance in forests with old-growth characteristics, such as large trees with cavities and complex canopy structures. These abundant populations, called "source populations," are crucial for populating or repopulating surrounding habitats and are therefore central to the long-term viability of our native species.

In the context of climate change, it is widely recognized that although they do not sequester carbon as quickly as younger forests, old-growth forests store the greatest amount of carbon. As such, mitigating climate change requires increasing the representation of forests with old-growth characteristics and functions on some parts of the landscape, while encouraging a diversity of other forest age classes on others. Finally, forests with old-growth characteristics support cultural traditions, providing human wellness benefits and the opportunity for spiritual renewal. These human values, in addition to the tangible ecosystem services these forests provide (water storage and filtration, localized cooling/climate buffering), underscore the importance of these forests to our well-being and even survival.

Restoring these once common habitats is of central importance to conserving the full suite of our region's native plants and animals and maintaining key ecosystem services, like carbon storage and water filtration, now and into a highly uncertain future.

Photo credits: (p. 2) Bob Labrie, (above) Anthony D'Amato

As we grapple with the challenges posed by global change, including changing climate conditions and a proliferation of non-native insects and diseases, there is great uncertainty regarding what conditions might provide the opportunities for forests to adapt to these changes and sustain the many benefits we currently derive from them. Encouraging more of the forest structure and species composition found in old-growth forests helps us keep every piece of the puzzle that our forests naturally evolved with, undoubtedly conserving crucial adaptation pathways and refugia that may provide opportunities for species and processes to persist under changing conditions. Therefore, restoring these once common habitats is of central importance to conserving the full suite of our region's native plants and animals and maintaining key ecosystem services, like carbon storage and water filtration, now and into a highly uncertain future.

Forest structure:
the spatial arrangement (vertical and horizontal) of the living (trees, plants) and dead (cavity trees, downed logs) components of a forest. This includes the diversity and abundance of different tree sizes, ages, arrangements, canopy layers, standing and downed dead trees, and forest openings.

Forest composition:
the proportion of tree species within a forest.

OLD-GROWTH CHARACTERISTICS

Our region has a great diversity of forest types, ranging from the dominant oak-hickory forests in Connecticut and New York to the spruce-fir forests in northern Maine. Despite these differences in dominant species, there are common characteristics generally more abundant in old-growth forests, regardless of forest type. This section summarizes some of those key characteristics, which are often lacking in the second-growth forests you see today. The ecological functions of these characteristics and ways they can help a forest adapt to global change are presented in Table 1 (page 10).

Presence of large and old trees. The first characteristic that comes to many people's minds when thinking about old-growth forests is very big trees. It is common and understandable to relate a tree's size to its age. While in general, smaller trees are younger and larger trees are older, that's not always the case. A tree's height is related to the site's fertility: the more fertile the site, the taller the tree. A tree's diameter is more directly tied to how much space it's had to grow. Old-growth forests often have trees that are both large and old, though some old trees can have small diameters; for example, on lower fertility sites and in areas of frequent natural disturbance, the living trees may all be relatively young. It takes time (decades or centuries) for large trees to develop, and correspondingly, a common characteristic used to differentiate old-growth forests from second-growth forests is the abundance of large-diameter trees (e.g., in old-growth northern hardwood forests, 12–20 trees per acre, each with a diameter at breast height [DBH] of at least 20 inches; see Table 3, page 20). In many respects, the intensive periods of land use occurring across the region in the nineteenth and early twentieth centuries reset this large-tree developmental clock, with many forests now lacking trees of these dimensions.

The life span of the long-lived tree species often found in old-growth forests (hemlock, sugar maple, red spruce, red oak) ranges from three hundred to more than four hundred years old. By comparison, our approximately one-hundred-year-old forests are ecologically young, which accounts for their lack of old-growth characteristics. Therefore, beyond their size, an important aspect of these old trees is their advanced age, which results in a high degree of tree-level complexity in terms of unique bark and branch patterns, which support a diversity of native

Old-Growth Forest

A. Gap in the forest created by a natural disturbance resulting in standing and downed deadwood. Increased light conditions will promote the release and establishment of young trees. These gap-scale events generate the spatial heterogeneity in tree densities and sizes that is a key characteristic of old-growth forests.

B. Large-diameter (20"+ DBH) standing dead tree (snag).

C. Large-diameter (20"+ DBH) overstory trees.

D. Seedlings and saplings from a previous gap create multiple canopy layers, variation in tree size and density, and species diversity.

insects that birds forage on as well as perching habitats. In addition, these old trees often contain pockets of decay that serve as important points for the formation of cavities (holes), which serve as homes for a wide range of wildlife. In short, old trees show their age!

Spatial variation in tree density and tree size. Although big trees are the first characteristic many associate with old-growth forests, this emphasis on large trees actually hides a key attribute of all old-growth ecosystems: a high degree of variability across the forest in terms of the size, age, and density of living and dead trees. This variability results from the long-term influence of natural disturbances, such as wind, insects, and disease, killing individual and groups of trees and creating a mosaic of canopy gaps and groups of different tree sizes and ages across the forest over time. This mosaic was likely reinforced in our fire-dependent ecosystems (e.g., pitch pine barrens and oak woodlands) by historic prescribed burning applied by Indigenous people, as well as more broadly across the landscape due to the influence of beaver activity prior to their widespread extirpation.

Abundant downed deadwood in various sizes and stages of decay. Natural tree death is an important ecological process, both in generating the openings in the forest canopy necessary for new trees to establish and in creating deadwood, which serves as critical habitats for many species and contributes to carbon storage, moisture retention, and soil protection. No attribute is more reflective of this long disturbance history than the high abundance of large downed logs found on the forest floor. It is estimated that old-growth forests often have at least two to four times the amount of dead downed wood on the forest floor than is typically found in second-growth forests.

A key characteristic of these downed logs is not just their abundance but also their range of decay. Downed logs are the consequence of periodic disturbances throughout time that killed trees in the forest, resulting in some logs that were recently killed and just beginning to decompose and others that are well-decomposed from disturbances decades ago. In addition, since there are often large trees in old-growth forests, the downed logs tend to be large in diameter, which makes them more resistant to decay. These attributes take decades to develop and thus are quite rare in our current forests. These downed logs provide habitat for organisms that break wood down, provide foraging opportunities for other species, and serve as "nurse logs" for tree species that regenerate well on decomposing wood, such as hemlock, red spruce, northern white cedar, and black and yellow birch. Forests are diverse habitats, often including streams, wetlands, and vernal pools for which dead logs contribute a critical habitat role. Finally, these logs provide key ecosystem functions, including storing and cycling nutrients and carbon and moderating hydrology by retaining moisture.

Large-diameter standing dead trees (snags). Although less abundant than downed logs, large-diameter standing dead trees—called "snags"—are also a common characteristic of old-growth forests. Snags serve a crucial role in providing foraging opportunities for birds (such as woodpeckers) that excavate the deadwood in search of insects. The holes that are created in the wood then serve as habitats for various birds and small mammals, with larger snags even supporting large

Photo credits: (p. 8) Anthony D'Amato, (p. 9) Alexandra Kosiba

mammals, such as fishers, martens, and black bears. The presence of these large snags reflects the long-term legacies of natural disturbance, as well as the fact that some trees are able to live out their natural life spans in these forests, making them quite large. Given that our current forests are lacking many large-diameter living trees because of their relatively young age, large snags are even more uncommon.

Multiple canopy layers. The diffuse light and deep shade you often encounter when visiting an old-growth forest are a testament to the many layers of leaves that sunlight filters through in these ecosystems. That filtering (and absorption) of light is the product of centuries of canopy development, which has allowed slow advancement of trees of different species into different heights beneath the main canopy over time. The resulting layers of foliage, often extending from the forest floor to treetops, creates a habitat-rich space that includes hiding and nesting cover close to the ground as well as travel and gleaning corridors for certain birds and other species that use the highly connected upper canopy layers. The multiple layers of vegetation also provide opportunities to store more carbon in the forest.

Regeneration. A key aspect of the previously described canopy layers worth singling out is the well-developed regeneration layer found in old growth. This layer is typically dominated by seedlings and saplings of shade-tolerant species that thrive in low light conditions—like hemlock, sugar maple, beech, red spruce, and balsam fir—and have established themselves over time, often on well-decomposed logs or the forest floor. The presence of this existing "advance regeneration" before a disturbance to the forest canopy provides a key mechanism by which old growth and all forests recover following a disturbance event. A disturbance that kills the overstory trees will allow the advance regeneration to grow into the main canopy and occupy the space vacated by the killed trees. Having established regeneration increases the resilience of the forest by ensuring that the next group of trees that will occupy the site is already in place when a natural disturbance kills the overstory trees.

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Plant communities. Few plant species only occur in old-growth forests; however, the abundance of dispersal-limited and sensitive species is often far greater in these forests given that it takes a long time for them to recover in areas cleared by historic land use, particularly agriculture. Examples of species occurring at greater abundance in older forests lacking past agricultural use include forest herbs, such as wild sarsaparilla, dwarf ginseng, wood sorrel, squirrel corn, and cucumber root, as well as lichens (like lungwort) and feather flat moss. Many of these species maintain their populations through either clonal growth or ant dispersal of seeds, making them quite sensitive to forest loss. Although you may find all these species in second-growth forests, they generally occur at much lower levels relative to old-growth forests. Similar dynamics are also observed with many fungal species, which either require a long period of time to develop extensive belowground networks in symbiotic associations with maturing and old trees, or are reliant on the large well-decomposed logs found in old-growth forests as substrates.

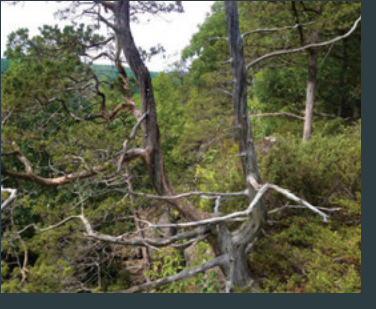
TABLE 1 **Common attributes associated with old-growth forests and linkages with key ecological functions and forest adaptation in the context of climate change and an increasing proliferation of non-native insects and diseases. General management strategies to restore and maintain these conditions in second-growth forests are also listed. Adapted from Keeton (2006); Bauhus, Puettmann, and Messier (2009); and D'Amato and Palik (2021).**

Old-Growth Attribute	Ecological Function	Adaptation Mechanism	Management Strategies
Presence of large and old trees	• Food, shelter, and breeding habitat for wildlife • Well-developed bark providing substrate for dispersal-limited taxa, such as lichens, lignicolous fungi, and mosses • Perch sites for raptors • Carbon storage	• Conservation of regeneration options and genetic diversity (seed sources)	• Crown thinning to accelerate large-tree growth • Legacy tree designation of long-lived species to allow individual trees to live out natural life span • Potentially focusing old forest work on high-quality sites, which provide high growth potential
Spatial variation in tree density and tree size	• Diversity of habitats (gaps, closed canopy areas) and functional niches for wildlife species • Microhabitats (light, temperature, moisture) supporting understory plant and regeneration development	• Reduced vulnerability to disturbance (spatial variability in wind risk, fuels, drought stress) • Multiple recovery and developmental pathways (regeneration in gaps, propagules from surviving mature trees)	• Regeneration methods that combine removal of individual trees and groups of canopy trees with retention of a high proportion of mature trees in the stand (single-tree and group selection [0.1- to 0.5-acre openings], irregular shelterwoods, variable-density thinning) • Under burning in fire-dependent ecosystems[1]
Abundant downed deadwood in various sizes and stages of decay	• Habitat for deadwood-dependent species • Microsites for regeneration of small-seeded tree species • Soil stabilization, nutrient cycling, and moisture retention • Carbon storage • Water/moisture storage	• Regeneration safe site for tree species during drought • Water storage and reduction in run-off during extreme events • Microrefugia for moisture-sensitive taxa, such as amphibians, during drought	• Felling and leaving larger-diameter trees, particularly through culling • Legacy tree designation to provide future deadwood inputs • Limiting or refraining from salvaging trees after disturbance
Multiple canopy layers	• Foraging and nesting habitat for breeding birds • Habitat for epiphytic lichens • Interception and storage of precipitation • Habitat for arboreal mammal species • Stable microclimates: moderate temperature swings (thermal buffering), reduce wind speeds, maintain higher minimum temps, and provide greater efficiency in absorbing/dissipating incoming solar energy	• Reduced vulnerability to disturbance (heterogeneity in wind risk and host sizes for insect pests) • Resilience to canopy disturbance (presence of advance regeneration) • Water storage via interception to buffer extreme precipitation events	• Regeneration methods that promote and maintain multi-age conditions (selection and irregular shelterwood methods) • Protection of advance regeneration during harvesting

[1] Fire-dependent ecosystems are those in which fire is an important driver of forest conditions and processes, including the establishment and reproduction of certain plant species. Although fire is a comparatively rare disturbance in New England and New York forests relative to other parts of the globe, several of our ecosystems, namely pitch pine barrens and oak woodlands, were historically shaped by natural fires and Indigenous burning practices. As such, restoration of old-growth conditions in these areas may include the use of prescribed fire to restore barren and woodland conditions and encourage the recruitment of certain plant species, including oak and pine.

Old-Growth Attribute	Ecological Function	Adaptation Mechanism	Management Strategies
Large-diameter standing dead trees (snags)	• Foraging and nesting habitat for breeding birds • Habitat for deadwood-dependent organisms • Roosting sites for bats • Carbon storage • Future source of downed logs	• Microrefugia for moisture-sensitive taxa during drought	• Legacy tree designation to allow for natural snag development, with priority given to existing cavity trees • Girdling of large-diameter trees • Prescribed fire in fire-dependent ecosystems
Regeneration	• Microhabitats (light, temperature, moisture) supporting understory plant and regeneration development • Hiding and nesting cover for bird species	• Reduced vulnerability to disturbance (spatial variability in wind risk, fuels, drought stress) • Multiple recovery and developmental pathways (regeneration in gaps, propagules from surviving mature trees)	• Regeneration methods that promote and maintain multi-age conditions (selection and irregular shelterwood methods) • Protection of advance regeneration during harvesting • Control of competing vegetation (e.g., invasive plants and beech thickets) • Control of deer and moose populations
Plant communities (understory plants, mosses, and lichens)	• Hiding and nesting cover for bird species • Food and energy sources for insects, including late-seral pollinators • Retention and cycling of nutrients	• Source populations for post-disturbance recovery	• Designation of reserve "patches" within stands where no harvesting occurs • Retention of canopy trees supporting an abundance of mosses and lichens

Atypical Old Growth



We largely associate old-growth forests with forest types and locations on the landscape where large and old trees and closed-canopy forest conditions can develop. Nevertheless, there are many other places, such as ridgetops and wetlands, where old-growth forests once existed. These areas are less likely to be actively managed to restore old-growth characteristics, but their protection through a passive approach is equally important to ensure that the full suite of old-growth forest communities once common across the region are restored and maintained. Examples of these "atypical" old-growth forests include dwarf pitch pine woodlands, cedar bluffs, black gum swamps, and black spruce bogs. In addition to these atypical old-growth communities, other old-growth ecosystems are better characterized as woodlands or barrens, which have far more open forest conditions than most of the forests predominating in our region. These lower-density conditions are often associated with site conditions (e.g., dry, nutrient-poor soils) and disturbance regimes (frequent low severity fires) that prevent the formation of dense forests. Given that natural fires rarely occur in our climate, burning by Indigenous communities for culturally significant wildlife and plant species was an important factor locally in maintaining many of these ecosystems, including pitch pine barrens and oak woodlands. As such, restoring old-growth conditions in places where these communities once predominated would benefit from an understanding of traditional cultural practices to guide the application of prescribed fire and other management techniques.

Photo credit: Liz Thompson

RESTORATION OF OLD-GROWTH CHARACTERISTICS

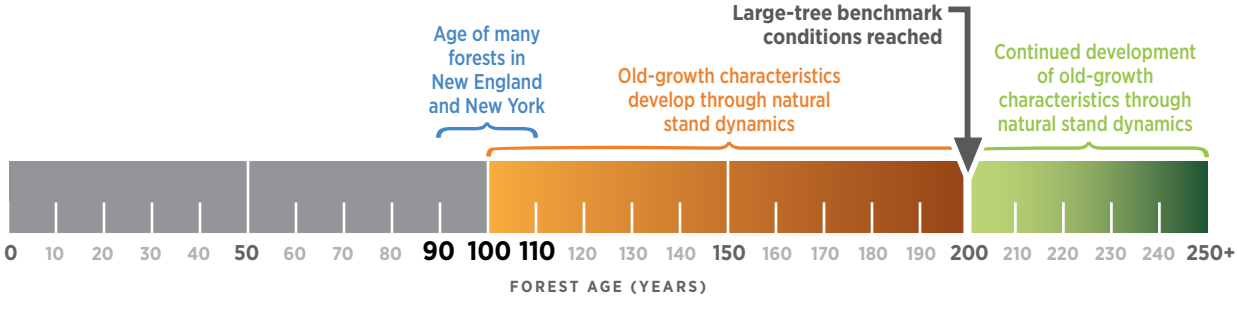
Old-growth characteristics can be restored to your woods through either passive or active management. Although there are landscape characteristics that may make one strategy more effective than the other, these approaches are highly complementary, and both are necessary across the landscape. In addition, the active management approach offers a gradient of strategies that can be used based on the landowner's interest in increasing the "old-growthness" of their forests while meeting other landowner goals (e.g., wildlife) and societal needs (e.g., locally produced wood products).

PASSIVE MANAGEMENT

This approach involves letting nature take its course and waiting for forest development and natural disturbances to create old-growth characteristics without any direct human intervention. Designating an area of your land as a reserve without active forest management does not mean old-growth characteristics will appear in those places overnight. Developing these conditions with a passive approach will often take over a century (see figure below) based on the current age of most forests in New England and New York and is influenced by the fertility of the site on which it is growing, past agricultural impacts on the soil from tilling and grazing, and the amount of natural disturbance to which the forest is exposed. In addition, the current condition of the forest will strongly influence the likelihood and rate of old-growth characteristics developing, as current forest conditions—such as the presence of dense forest plantations, abundant invasive plants, high deer densities, or beech bark disease—may inhibit the development of key old-growth characteristics (large living and dead trees, multiple canopy layers) and inhibit or reduce biodiversity, carbon storage and sequestration, and resilience to climate change. As such, achieving old growth via passive management isn't suited for every forest condition currently on the landscape.

As with old-growth systems, the key drivers creating old-growth characteristics with a passive approach are disturbance events, such as windstorms, ice storms and snowstorms, and insect and disease outbreaks. These events strongly influence forest structure and composition by creating gaps in the forest canopy, standing dead trees, pit-and-mound topography from blown-over trees, and downed logs on the forest floor. The progression and rate of change in passively managed areas is determined by the type, frequency, and intensity of natural disturbance. Since the most frequent disturbance events affect only single or small groups of trees, a passive approach will tend to favor tree species that are most competitive in shade, such as hemlock, beech, sugar maple, and

Passive Pathway to Old Forests



Adapted from Hagan and Whitman (2004)

Should I Salvage My Woods?

Developing old-growth characteristics, whether through a hands-off or an active approach, involves leaving dead and dying trees in the woods. After a disturbance such as a windstorm or an insect and pathogen outbreak, landowners are often interested in salvaging trees that have been knocked down or killed. While initially looking "messy," leaving these trees in the woods is critical to developing old-growth characteristics. In particular, natural disturbances serve as active assistance in the development of old-growth characteristics. These are the very processes and structures that are missing in our woods. With extreme weather events happening more frequently due to climate change and invasive insects—including the emerald ash borer, the spongy moth, the hemlock woolly adelgid, and beech leaf disease—now being found in many parts of the region, it is likely that the opportunity for salvage will only increase in the future. It is important to remember that these disturbances are generating key deadwood absent from most forests, canopy openings that allow for the establishment of regeneration, and complex young forest conditions necessary for many species of wildlife. As such, limiting salvage operations or deliberately leaving some disturbed areas unharvested during salvage operations will ensure the positive legacy of these events by making sure that key structural conditions are maintained.

red spruce. Because no trees are harvested with this approach, it will produce the most natural appearance and conditions in your woods in the long run (i.e., no cut stumps or skid trails and more deadwood remaining).

The passive approach to the restoration of old-growth characteristics will likely result in the greatest amount of carbon storage. As time goes by, trees get larger, more deadwood is added to the forest, and soils continue to increase as deadwood decomposes. The passive approach is therefore a good strategy for those interested in storing carbon that has already been removed from the atmosphere; however, landowners should recognize that forests dominated by low-vigor trees and invasive species may not accrue these carbon storage benefits at a similar level to natural and healthy stands.

Landowners interact with their land in a variety of ways. The ultimate goal of the passive approach is to let natural forest processes and disturbances develop the missing characteristics over time. Activities that allow these processes to be the primary driver are compatible with a passive approach. Hiking trails, controlling invasive species, removing a tree infested with an invasive insect, and even removing a few cords of wood per year for firewood can all be compatible with the passive approach.

Taking a passive approach to restoring old-growth characteristics will help meet the goals for increasing wildlands across the region. Since the time frame for developing old-growth characteristics is beyond that of a family forest owner, engaging in forest and estate planning is critical to achieving and sustaining old-growth characteristics in your woods.

Photo credit: Paul Catanzaro

ACTIVE MANAGEMENT

The second approach to restoring old-growth characteristics involves active management of the forest. Active management falls onto a gradient of intensities that can be tailored to specific goals and forest conditions. Carefully planned forest management provides an opportunity to accelerate the development of old-growth characteristics. An active approach can also be used not only to meet regeneration goals by creating the light conditions necessary for species that are most competitive in partial or even full sunlight (e.g., yellow birch, black cherry, white pine, and red oak), restoring aspects of the compositional complexity of old-growth forests, but also to benefit wildlife and increase forest resilience through diverse species composition. In addition, active management can provide young forest habitat for those species that depend on it, increase a forest's resilience to such challenges as invasive insects and wind events, and meet important needs for local wood products. Forest management provides an opportunity to mimic the processes historically shaping the diversity and conditions of our forests (i.e., natural disturbances), thus increasing the growth of remaining trees and speeding up the development of old-growth characteristics. Although it may sound counterintuitive, active management can restore old-growth structural characteristics and associated values and functions faster than the passive approach (see the timeline on page 15), since active management offers the opportunity to purposefully introduce the disturbances that result in a number of the old-growth characteristics.

Carefully planned forest management provides an opportunity to accelerate the development of old-growth characteristics.

Many of the forest stewardship practices used for meeting other landowner objectives are also excellent tools for restoring old-growth characteristics; however, it is critical for landowners to match these practices with the types of old-growth characteristics they hope to restore.

Restoring Large Trees, Multiple Canopy Layers, Regeneration, and Diverse Species

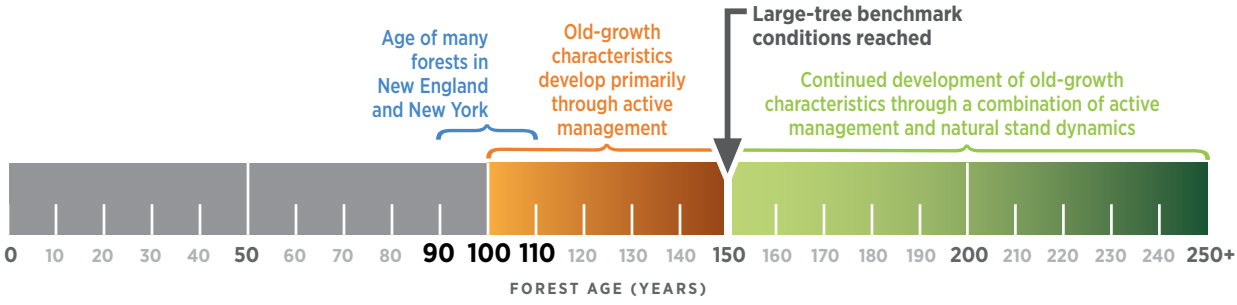
As with other management approaches, the tactics used for restoring old-growth conditions will vary based on the forest type and existing conditions, given that a guiding principle for active old-growth restoration is to emulate the natural developmental dynamics for that specific ecosystem through forest management. Nevertheless, a key action likely necessary for most New England and New York forests is enhancing age-class diversity and spatial complexity. This action is meant to address the largely even-aged (i.e., composed of trees all largely the same age due to past land use) and spatially uniform arrangement of trees in most current forests, which is very different from that of the old-growth forests.

Forest management techniques that create gaps in the canopy can be used to increase large

TABLE 2 **Decadal development of large-tree densities in a northern hardwood forest actively managed for old-growth characteristics. Numbers represent percentage of large-tree benchmark densities (lower and upper range) being achieved each decade in a forest receiving 2–3 crown thinnings to accelerate large-tree growth over a 50-year period. Assumed diameter growth of large trees is based on Nyland et al. (1993) and Singer and Lorimer (1997) and were applied to average stand conditions in New England and New York based on USDA Forest Service Forest Inventory and Analysis data. The time needed to reach the large-tree target will depend on stand conditions and site quality.**

	Percentage of the large-tree target reached over time through active management (2–3 crown thinnings) starting from current forest conditions					
Density of large trees (DBH >20")	Average Current Condition	10 years	20 years	30 years	40 years	50 years
12 trees per acre (lower bound of large trees)	8%	15%	45%	75%	105%	165%
20 trees per acre (upper bound of large trees)	5%	10%	25%	45%	65%	100%

Active Pathway to Old Forests



trees, create multiple canopy layers, and establish regeneration. In particular, implementing regeneration harvests that create the growing space necessary for establishing seedlings and allowing the development of advance regeneration into the main canopy while retaining a large proportion of the forest in mature trees will help restore these old-growth characteristics. Examples of these silvicultural systems include single-tree and group selection, irregular shelterwood, and variable density thinning.

These regeneration methods can be designed to create canopy gaps that emulate those frequently created by natural disturbances (0.1–0.5 acres), although larger openings (1–3 acres) with legacy tree retention (see next section) can also be created to emulate historic landscape scale disturbances, like microbursts. Openings of this size can favor shade mid-tolerant (e.g., oak and pine) and shade-intolerant (e.g., black cherry, tulip poplar, and bigtooth aspen) species, which are most competitive with higher levels of light. Creating this range of openings in the canopy is critical in accommodating common old-growth canopy species, such as yellow birch and white pine, which require greater levels of light than do shade-tolerant species. Although much of the focus of restoring old-growth characteristics is placed on the structural attributes found in old growth, restoration strategies should also consider the future species composition of the forest as well. Regenerating diverse species can not only help achieve landowner goals but also increase forest resilience at the landscape level by diversifying the types of species found across the forest. This diversity makes forests less vulnerable to such challenges as invasive insects and diseases, which focus on particular species, and increases the variety of functional traits present (e.g., species drought and heat tolerance), providing multiple ways for the forest to respond to future climate change.

When implementing this type of harvest, allocate 10 to 20 percent of the area in your forest to openings to establish regeneration. This number of openings emulates average natural disturbance rates if applied every ten to twenty years and provides the opportunity for future entries to create a mosaic of old-forest conditions over time. Similarly, skipping a comparable area in your forest (10%–20%) and designating them as "patch reserves"—a group of legacy trees in your woods dedicated to developing old-growth structure—will contribute to forest-wide goals of restoring the heterogeneity of tree densities found in old growth.

Restoring Large and Old Trees and Deadwood

A key element of active management for old growth is identifying and retaining trees to live out their natural life span in the woods. These trees, often referred to as "legacy" trees, are in the main canopy and are left to serve as future sources of old-growth structure. Unlike trees that are left following traditional timber harvests to grow larger and be harvested in the future, legacy trees are never removed from the woods. Instead, these trees are left to grow larger and die—providing standing dead trees for habitat—and eventually fall over, providing different habitat value as a large downed log on the forest floor. Due to their age, legacy trees can

Legacy tree:
a tree purposefully left in the forest to grow large, grow old, and die, creating old-growth characteristics often lacking, such as large living trees and deadwood.

Patch reserve:
a group of legacy trees. Also referred to as a "skip," since active forest management practices are skipped in that part of the forest.

also have greater levels of genetic variation than younger trees in a second growth forest owing to genetic changes in vegetative cells that accumulate as a tree ages, which is important for our forests as they face an increasing number of challenges in the future.

Depending on your objectives, individual legacy trees can be dispersed throughout your land or retained in small groups as patch reserves. In the selection of legacy trees and patch reserve locations, preference should be given to trees in your woods that already contain important habitat features, such as cavities and dens, or patches of your woods containing ecologically sensitive features, like a well-developed population of forest herbs or highly decayed deadwood. Likewise, reserving large canopy trees with wide crowns will allow for faster development of large-diameter trees on your property. Finally, selecting long-lived species for legacy trees, such as sugar maple, red spruce, yellow birch, red and white oak, white cedar, and white pine, can ensure that these old-growth characteristics are present on your land for future generations.

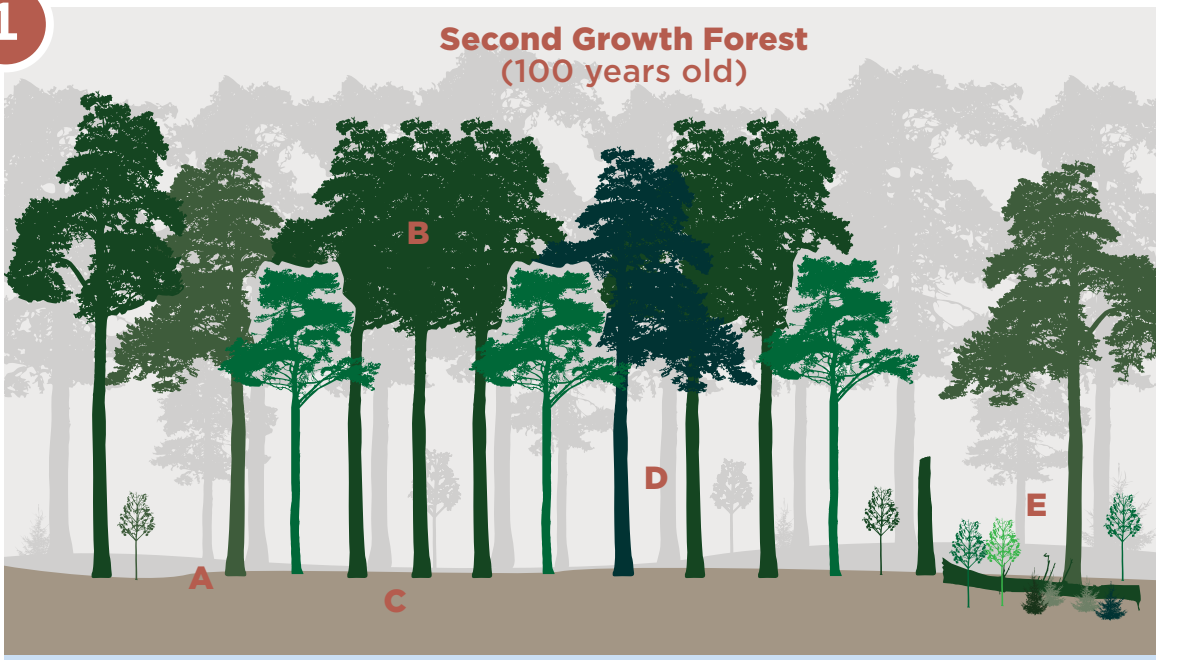
The number of legacy trees left will depend on your landowner goals. If old-growth restoration is your primary objective, then leaving 25 to 50 percent of your canopy trees as legacies and patch reserves will ensure that an old-growth structure will develop over time. If fewer trees are left, it will take longer for the structure to develop. However, leaving even just a few legacy trees per acre can provide old-growth characteristics missing from most woodlots.

While the retention of legacy trees provides for restoration of the large-tree structures currently lacking in most forests, there are opportunities to accelerate the development of these structures on your land through active forest management techniques. Specifically, the time frame it takes to restore large living trees can be shortened by removing competing trees directly adjacent to the largest vigorous trees. This increases resources available for their growth and can shorten the time necessary to reach large diameters (>20" DBH; see Table 2, page 14) by several decades. Similarly, large standing dead trees can be created through girdling large-size trees, and the number and volume of downed logs can be enhanced by felling and leaving these trees on the ground. These deadwood-creation activities can complement traditional forest management by concentrating on canopy trees not desirable for commercial purposes (often termed "unacceptable growing stock"), thus improving the growth of residual trees to meet complementary landowner objectives. Focusing these large-tree management activities between openings and patch reserves (also called "skips") will enhance the heterogeneity in forest structural conditions found on your land and provide a distributed source of future large deadwood. Table 3 (page 20) provides information on potential targets to guide these and other active restoration practices on your land.

Photo credit: Anthony D'Amato

Example restoration of old-growth characteristics using the active management approach

1



A. Very few large standing or downed deadwood.

B. Uniform main canopy without multiple canopy layers. Little variation in tree size and density.

C. Very little regeneration.

D. Few large-diameter trees.

E. The development of some old-growth characteristics (deadwood, multiple canopy layers, regeneration, increased variation in tree size and density) from natural disturbance.

2

A. Creation of a ¼–½-acre gap to diversify the canopy layers, establish regeneration, and increase variation in tree size and density.

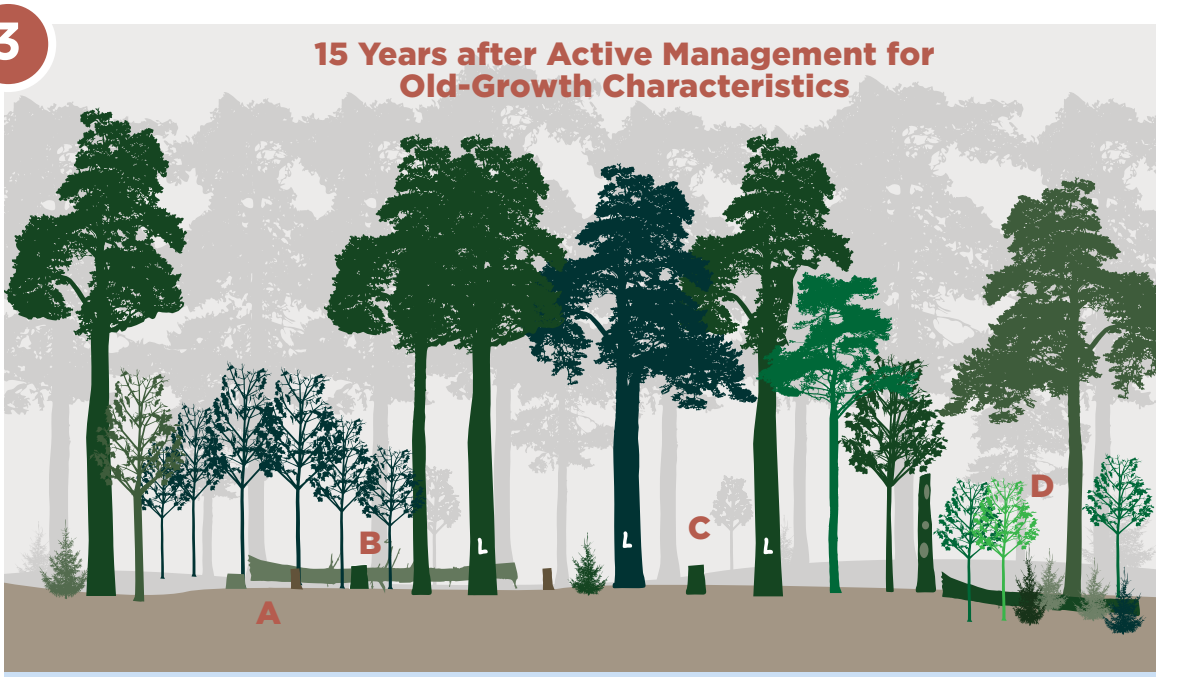
B. Intentionally leaving a large tree on the ground to increase downed deadwood.

C. Thin trees to increase their growth rates, speeding up the development of large-diameter trees.

D. Creation of a patch reserve in an area with existing old-growth characteristics to serve as a foundation on which to build.

3

15 Years after Active Management for Old-Growth Characteristics



A. Gap is filled with saplings of diverse species from the increased light availability, widening the variation in tree size, density, and composition.

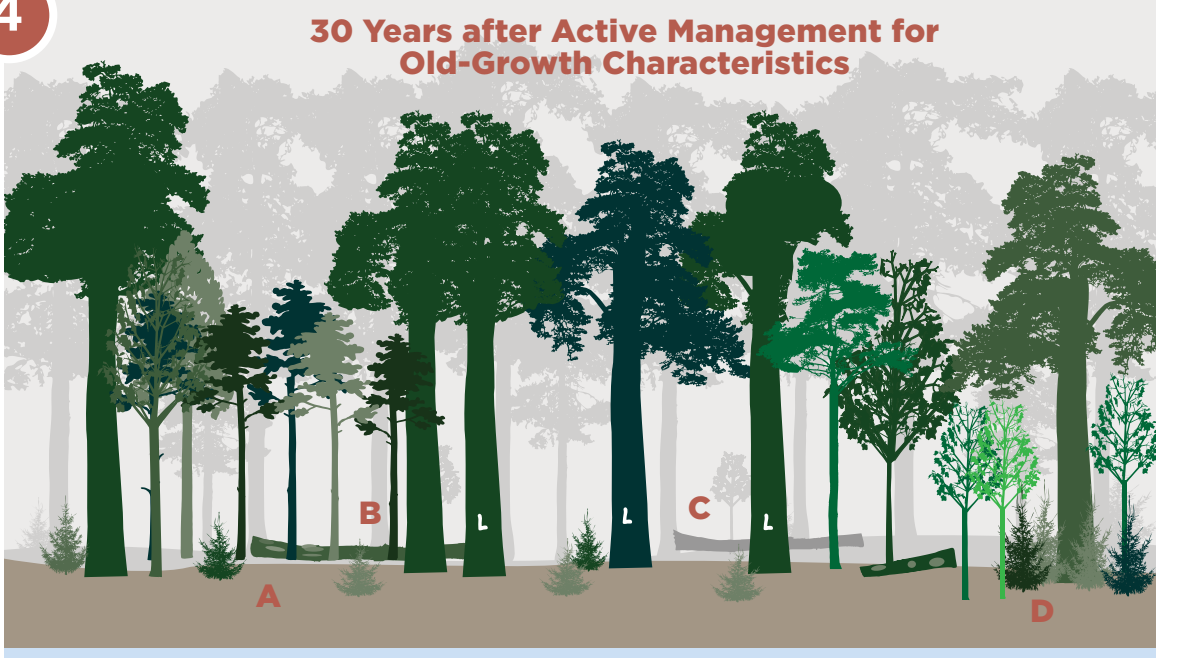
B. Downed deadwood has begun to decompose.

C. Residual trees, now marked with an "L" (legacy tree) to show that they will remain in the forest to live out their natural life span, have increased in size from the thinning.

D. The patch reserve continues to develop.

4

30 Years after Active Management for Old-Growth Characteristics



A. Young trees continue to grow.

B. Downed deadwood continues to decompose.

C. Residual trees continue to increase in size from the thinning.

D. Trees within the patch reserve continue to develop, contributing to the variation in tree size and density across the stand. The snag falls and now serves as downed deadwood.

TABLE 3 Forest structural benchmarks for restoring stand structural conditions that approach those found in common old-growth forest types in New England and New York. Targets are based on values in studies of existing old-growth northern hardwood, northern hardwood–spruce mixed woods, oak–central hardwood, oak-pine-hemlock, and spruce-fir stands. Values are meant to represent long-term goals, as few contemporary forests contain these conditions. If engaged in active old-growth restoration, these targets should be considered in conjunction with regeneration harvests (selection and irregular shelterwood methods, variable density thinning) that introduce spatial heterogeneity in tree densities across a stand and restore aspects of structural and compositional complexity. Subscripts "p" and "c" indicate benchmark values for downed deadwood structural targets for ownerships on which restoration of old-growth structural characteristics is either a primary or a complementary objective. In the latter case, other objectives (e.g., harvest of trees for local wood) may limit the total number of large trees that can be left on-site. Values for downed wood targets assume that a low level of downed deadwood is currently present on-site. Snag recommendations assume that large-diameter (>20" DBH) legacy trees are used to meet long-term snag/cavity tree basal area targets; however, old-growth forests generally contain a wider range of snag diameters.

Old-Growth Attribute	Benchmark	Management Approach
Large live trees	**Northern hardwood (NHW):** 12–20 trees >20" DBH per acre **Northern hardwood–spruce mixed woods (MW):** 11–21 trees >20" DBH per acre **Oak–central hardwood (CHW):** 4–18 trees >20" DBH per acre **Oak-pine-hemlock (OPH):** 3–35 trees >20" DBH per acre **Spruce-fir (SF):** 10–35 trees >20" DBH per acre	Sizes can be attained through passive (i.e., letting trees grow) or active (i.e., crown thinning around legacy trees) approaches. For active approaches, applying crown thinning around 40–60 trees per acre provides the density of large trees to account for natural mortality and supplies candidate trees for snag and downed log creation and future commercial removals.
Abundant downed logs in various stages of decay and across a range of diameters	**NHW_p:** 7–9 cords (cds)/acre (16–20 trees 20" DBH per acre) **NHW_c:** 3–5 cds/acre (8–10 trees 20" DBH per acre) **MW_p:** 7–11 cds/acre (11–16 trees 20" DBH per acre) **MW_c:** 4–6 cds/acre (6–9 trees 20" DBH per acre) **CHW_p:** 3–8 cds/acre (5–14 trees 20" DBH per acre) **CHW_c:** 2–4 cds/acre (3–7 trees 20" DBH per acre) **OPH_p:** 7–15 cds/acre (9–20 trees 20" DBH per acre) **OPH_c:** 4–9 cds/acre (5–12 trees 20" DBH per acre) **SF_p:** 8–12 cds/acre (11–17 trees 20" DBH per acre) **SF_c:** 3–7 cds/acre (8–10 trees 20" DBH per acre)	Reach target through natural mortality of legacy trees and snag falls. If stand is far below target, consider increasing the number by felling trees >20" DBH and leaving them on the ground. Felled trees can concentrate on unacceptable growing stock (UGS). Typical large-diameter snag fall rates: ~40%–60% of northern hardwood, oak, pine, hemlock, and spruce snags fall during the first decade after tree death. Snag fall rates may be higher for snags that have been created through girdling, as well as for smaller-diameter stems.
Presence of standing dead trees	**NHW:** 15–25 ft^2/acre (8–12 trees >20" DBH per acre) **MW:** 17–43 ft^2/acre (8–12 trees >20" DBH per acre) **CHW:** 8–15 ft^2/acre (4–7 trees >20" DBH per acre) **OPH:** 4–55 ft^2/acre (2–16 trees >20" DBH per acre) **SF:** 15–45 ft^2/acre (7–12 trees >20" DBH per acre)	Target can be met through natural mortality of legacy trees. If stand is far below target, consider girdling trees >20" DBH. Girdled trees can concentrate on UGS.

SITING OLD-GROWTH RESTORATION AREAS: WHERE AND WHEN

Where

You may choose to implement old-growth management and restoration, whether passive or active, in all of your woods or only a portion. Restoring old-growth characteristics to a variety of sites with soils ranging from wet to dry will help provide a diversity of old-growth characteristics and conditions. When considering where on your land to develop old-growth characteristics, it is most effective to identify and enhance old-growth structural characteristics already present in your woods. These areas might include large amounts of downed logs due to a windstorm, or a group of large trees containing woodpecker cavities. Focusing the passive approach on areas of high ecological or cultural value (e.g., cedar swamps, ridgetops, vernal pools, spring ephemerals, and medicinal plants) provides the added benefit of protecting these important resources. Identifying and documenting areas of your forest with existing old-growth characteristics and those with special ecological or cultural value is a key first step of both active and passive strategies. Establishing a patch reserve around existing old-growth characteristics will enhance their value as old-growth habitat by providing contiguous forest dedicated to developing additional old-growth features. In addition, designating patch reserves in an area with high environmental variation (e.g., topography, moisture, and soil productivity) will help restore the natural variation in forest types once found across the landscape.

When considering where on your land to develop old-growth structure, it is most effective to identify and enhance old-growth structural characteristics already present in your woods.

Another consideration in siting your old-growth efforts is directing them to areas of your land in which management for old-growth features will develop fastest. These areas would include those of the highest site quality in which the restoration of structures, such as large living and dead trees, would occur most rapidly. Site quality is a way to describe the fertility of a site and is determined by the amount of available water and nutrients for plant growth. High-productivity sites will grow big trees faster than will low-productivity sites. Old-growth structure (big trees, large standing dead trees, and large downed logs) will develop faster on high-productivity sites. If you are a landowner, work with a professional forester to understand your options based on the ecological conditions across your land and to balance your objectives. To find a qualified forester working in your town, see the “Additional Resources” section.

While leaving a scattering of legacy trees across your forest will certainly contribute to the restoration of old-growth characteristics, the larger the area dedicated to either the passive or the active approach (or both!), the better. A minimum area of approximately ten acres in landscapes that are mostly forested is recommended, as an area of this size will provide enough forest for the development of environmental conditions and characteristics that are different from the forests around it, which are stewarded in more traditional ways. However, the minimum size is greatly affected by the landscape within which the forest lies. The more isolated a property is within a non-forest matrix, the larger the area should be.

When

Certainly, there is a regional and global urgency to increase the amount of forests with old-growth characteristics as quickly as possible given their biodiverse value, potential as natural climate solutions, and other important functions; however, not every area on your land or in a region is suitable for immediate action. The timing for when you decide to apply old-growth restoration treatments will depend on the condition of your forest as well as the overall timeline for your stewardship.

Forest Condition

Older forests that have had time to grow larger trees and are more developmentally advanced due to decades of disturbances already contain some old-growth characteristics. Such forests are excellent candidates for implementing both passive and active strategies, as they will likely serve to speed up the restoration of the range of complexity associated with old-growth forests. Depending on your ownership, this may be all of your forest or only certain areas due to its past land-use history. If you own multiple parcels, identifying areas within your ownership that are at this point in their development will help you identify candidate locations for the active management approach.

Timing of Landowner Decisions

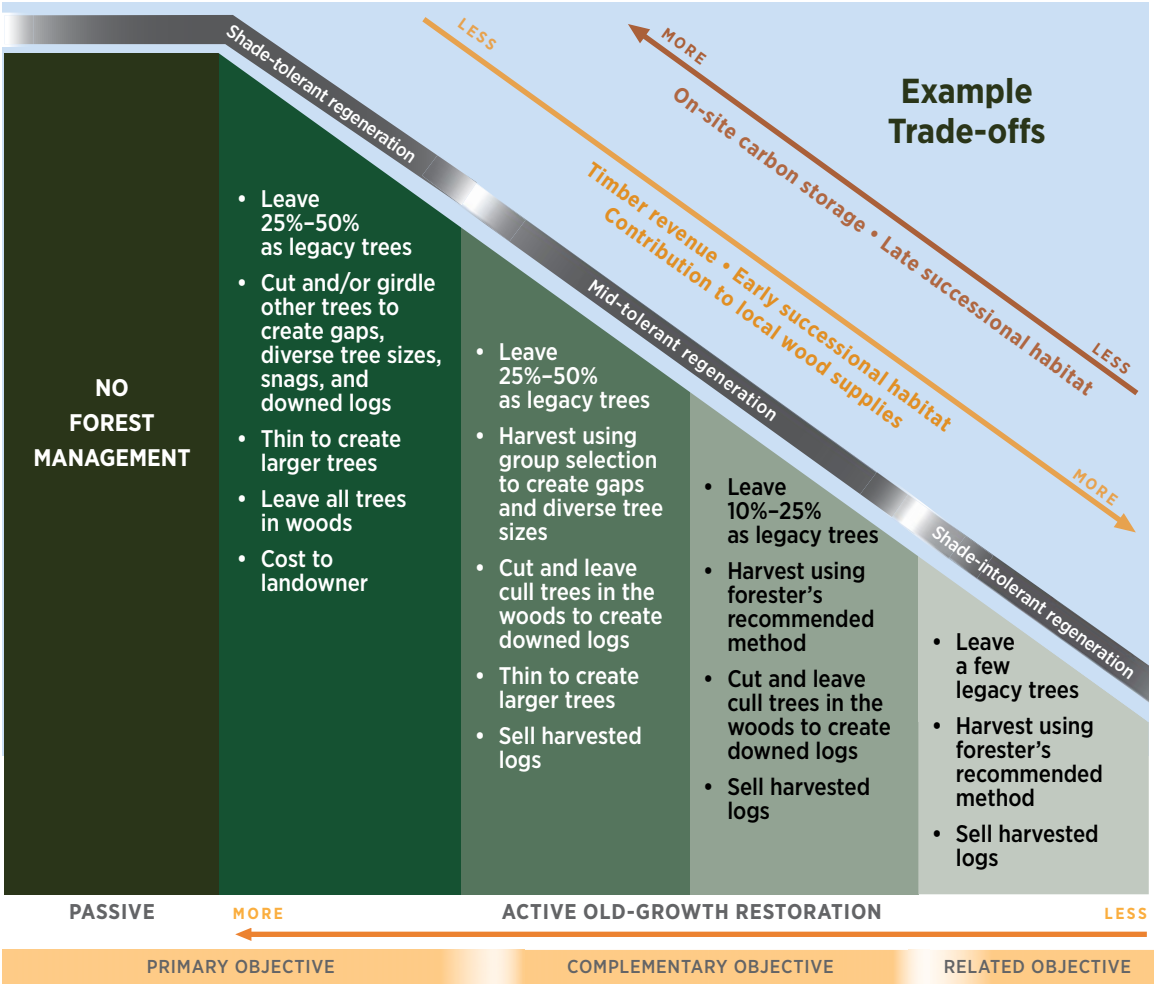
Forest management decisions aren't always triggered by what's going on in the woods. Often they are triggered by decisions a family forest owner needs to make about their land or a need or an opportunity in a community or organization. Therefore, when circumstances have triggered a decision about the way in which your forest is going to be stewarded—planning a timber harvest, developing a forest management plan—it is a good time to consider the ways in which restoring old-growth characteristics may contribute to your goals. Since developing these characteristics takes decades, family forest owners should pair these conversations with those about the future ownership and use of the land. Formal conservation-based estate planning to ensure that your land remains forested after you are gone provides the opportunity for future old-growth restoration treatments in those areas. See the "Additional Resources" section to contact a local land trust.

GRADIENT OF OLD-GROWTH RESTORATION PRACTICES

There is no one specific "old-growth condition" to aim for as an objective and therefore no one way to create it. Instead, it is more valuable to consider increasing the amount of old-growth characteristics in your woods in a way that matches your objectives. While applying the entire set of old-growth restoration practices to your property may be the quickest and most effective way to restore old-growthness back into your forest, this approach may interfere with other management goals, such as creation of early successional habitat and production of sustainable and renewable forest products. It is important to recognize that a gradient of old-growth restoration practices is available for you to apply to your land. This gradient ranges from implementing a single practice, such as retaining a few legacy trees or felling low-quality canopy trees, to employing combinations of practices. Choosing the level of restoration intensity that is consistent with your other management goals is critical. If you are only interested in applying a single practice, the designation of legacy trees on your property will provide for the greatest number of old-growth characteristics (e.g., large old trees, future snags, and logs).

Photo credit: Paul Catanzaro

Gradient of old-growth restoration strategies



The gradient of restoration treatments can also include a one-time active management approach to "flip the system" followed by a passive approach. Some forests may benefit from this onetime "set it and forget it" active approach to move the forest toward a successional trajectory that will enable natural processes to take over. For example, a plantation of non-native species could have a regeneration harvest to initiate a stand of native species before a passive approach is taken, or a stand of diseased beech with a beech understory could be regenerated to diversify the species composition and allow for the establishment of vigorous trees that will better meet the structural old-growth characteristics.

It is also not necessary to choose one approach for your whole property or, if you own multiple properties, all your properties. A mixed approach can be a great way to meet your overall personal or organizational goals—for example, taking a passive approach in one stand of your property and an active approach in others. At the landscape level, we need both types of strategies to meet our societal goals. Therefore, whichever strategy or combination of strategies you choose will contribute in meaningful ways.

Restoring Old Growth within a Current Use Program

Current use tax programs recognize the many benefits that family forest owners provide to the public by reducing property taxes in exchange for a commitment to keep their land in its "current forest use" and, in many cases, to manage the land according to a state-approved forest management plan. Because restoring old-growth characteristics can include a mix of active and passive approaches, there may be opportunities for these management strategies to be compatible with the current use program in your state. For more information about the current use program in your state and opportunities to incorporate strategies to restore old-growth characteristics, see the "Additional Resources" section to find contact information for your local state service or county forester.

IMPORTANCE OF A LANDSCAPE PERSPECTIVE

Another important consideration in planning for old-growth restoration is how your land fits into the surrounding landscape. Like most management objectives, an excellent way to increase the functioning of the areas containing old-growth restoration treatments is to implement these strategies in landscapes where other landowners, both public and private, are doing similar management. Even if multiple landowners in a landscape each implemented just a small amount of old-growth restoration strategies, it would add up by providing stepping-stones across the landscape for animal and plant species to move. Consider coordinating your management activities with adjacent landowners to increase the size and effectiveness of those areas serving to replicate old-growth conditions on the landscape. If the property lies within a forest matrix, a smaller area dedicated to these strategies can contribute to the landscape, but if the land around your forest has been converted to residential development, then dedicating a larger area to these strategies is recommended.

Taking a landscape perspective is not only important in regard to restoring old-growth characteristics but critical to the overall resilience of our forests.

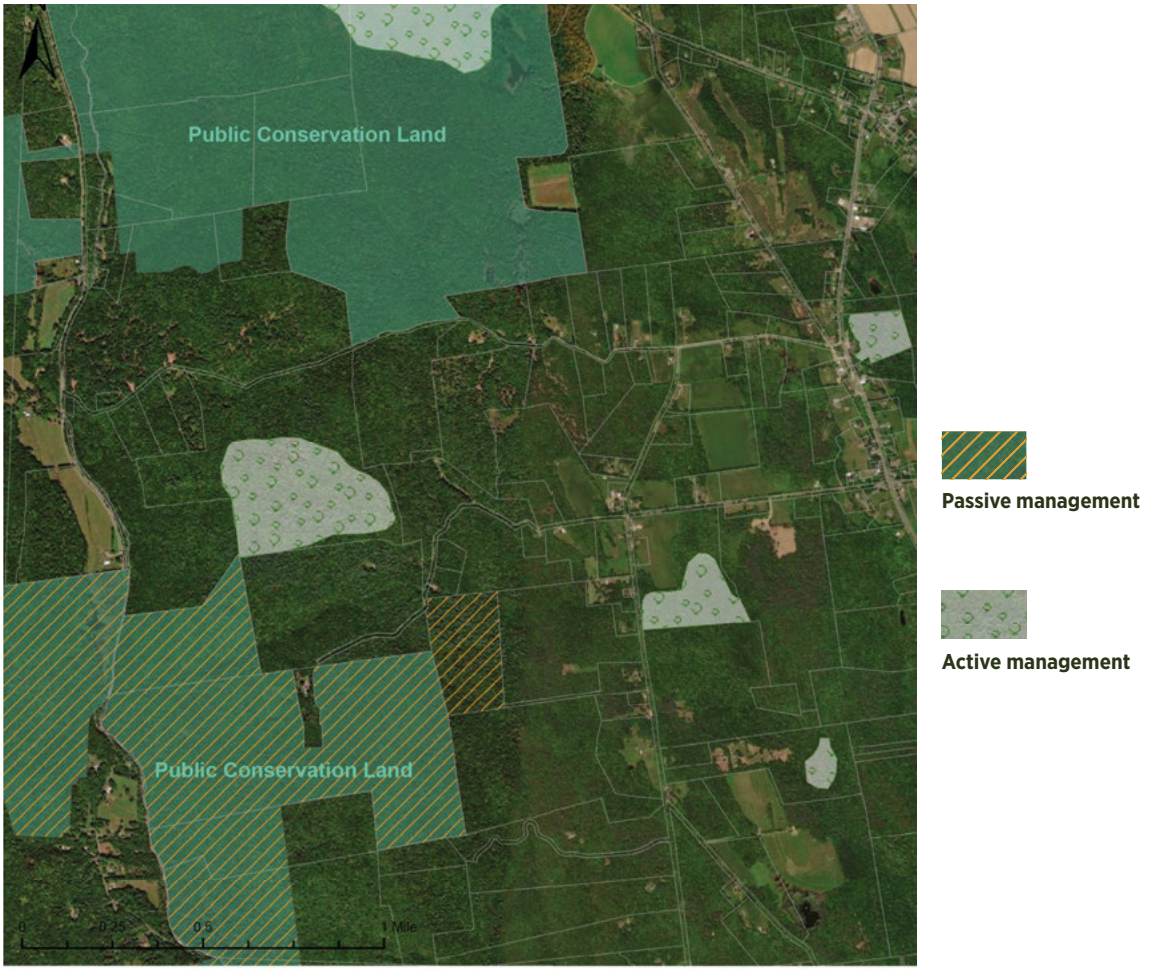
Though it is natural to focus attention on property-level considerations, since that's the scale on which most landowners are making decisions, taking a landscape perspective is not only important in regard to restoring old-growth characteristics but critical to the overall resilience of our forests. Natural disturbances don't start and stop at property boundaries. Landscapes with a diversity of species composition and forest structure will help ensure that our forests can adapt to such challenges as climate change and invasive insects. Because of our land-use history, many landscapes in New England are composed of forests with homogeneous species and structure. Encouraging the restoration of old-growth

Photo credit: Anthony D'Amato

forest characteristics through the passive or active approach (or both) will help to create diversity at the landscape level that will increase the resilience of our forests.

Ultimately we need both passive and active approaches on the landscape. The passive approach provides ecological benefits that the active approach cannot, such as maximizing carbon storage. Likewise, it's important to acknowledge the importance of areas where forests are managed with a greater emphasis on young forest habitat for species in decline or wood production to provide local resources to meet our societal demands, instead of looking to other regions or other parts of the world for our wood and other forest product needs. These approaches complement each other across the landscape by providing for landowner goals and heterogeneity while contributing to an increase in old-growth characteristics where this is a goal. Whichever approach(es) meet your needs, keeping your forest in forest use will help provide immense public value and support myriad plants and animals, especially in the face of global change.

Example landscape-level implementation of passive and active strategies to restore old-growth characteristics



Each ownership and both passive and active restoration strategies play an important role in helping to achieve a critical mass of old-growth characteristics across the landscape. The map illustrates an example of how both passive and active approaches can be applied across a mixed-ownership landscape. These approaches should be viewed as complementary, restoring important missing elements and serving as stepping-stones for species to move and migrate. Approximately 12% of the area has been designated as passive management, consistent with regional visions for wildland conditions.

GIS work: Lina Clifford

Using conservation-based estate planning tools such as conservation easements is an excellent way to ensure that your woods will stay forested long enough to develop the old-growth characteristics you desire.

LONG-TERM PLANNING

Developing old-growth characteristics takes a commitment to forest continuity and stewardship—that is, leaving your land forested and intentionally leaving more trees in the forest. Even with active management, old-growth characteristics take decades or longer to develop, requiring the need for long-term planning, both within the forest and, in the case of family forest owners, out of the forest through conservation-based estate planning.

Within the Forest

Within-forest planning is necessary to document your stewardship approach and intention over the long-term. Legacy trees and patch reserves should be clearly designated (e.g., marking legacy trees with an "L" and patch reserve boundaries with paint) and described both on paper (e.g., a map, forest management plan, or baseline documentation report) and in digital form (e.g., photos and GPS locations of legacy trees and areas being managed for old growth). Long-term forest management planning can ensure that future decisions about your woods will not disrupt the development of old-growth structure in areas that have been dedicated to restoring old-growth characteristics.

Conservation-Based Estate Planning

It is very important to recognize that the development of old-growth structure will depend on what happens to your land once it is passed on. If your forest won't be there in 100 years, what you do now won't matter. Therefore, talking to your heirs and using conservation-based estate planning tools such as conservation easements are excellent ways to ensure that your woods will stay forested long enough to develop the old-growth characteristics you desire. Conservation easements (CEs)—known as conservation restrictions in some states—are permanent legal agreements that allow some land uses (e.g., forest management, agriculture, recreation, and sometimes limited development) and not others (e.g., development or mining). In partnership with a conservation organization, CEs can be tailored to an individual landowner's objectives and can be written to allow the development of old-growth structure both passively (through a "forever wild" easement) and actively (allowing forest management). There are both public conservation organizations (such as wildlife and natural resource state agencies) as well as private conservation organizations (such as land trusts) that work with landowners on the permanent conservation of their land. Some conservation organizations focus more heavily on passive strategies and others on active approaches, but many do both. Finding a conservation organization or forester that shares your goals and vision for the land is critical. For more information on conservation tools or to find a land trust working in your town, refer to the "Additional Resources" section at the end of this publication. Talking to other landowners who have permanently conserved their land is a great way to hear from those with firsthand experience.

GETTING STARTED

Family Forest Owners

Evaluating how developing old-growth characteristics fits with your other goals is a great start. Working with a forester to evaluate your land, its landscape context, and your options for developing old-growth characteristics is an excellent way to develop the appropriate management options and move forward. Contacting your local land trust or public conservation agency to find out your land conservation options is another important step. To find a forester or land trust working in your town, look at the "Additional Resources" section at the end of this publication.

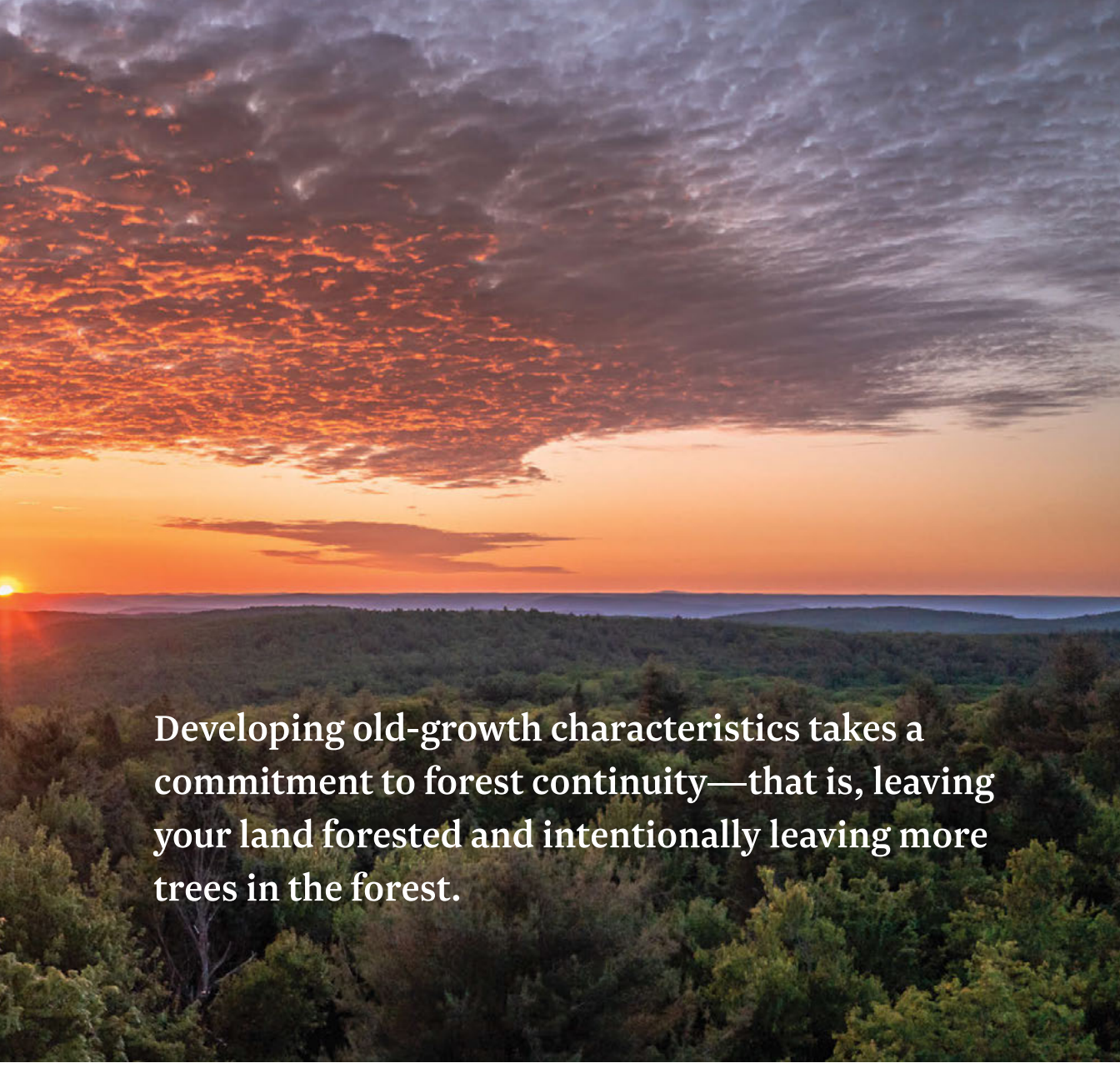
Public and Private Conservation Organizations

Determining where your organization falls on the old-growth restoration gradient will help you determine target percentages for restoration. Identifying and documenting areas of your forest with existing old-growth characteristics and those with special ecological and cultural value will help you identify specific area(s) in your forest to focus on and build off of to reach your overall target percentages. Decide the approach(es)—active or passive or both—that best meet your organization's goals and fit the conditions of your forest and its landscape context. If using an active approach, choose regeneration harvests that will meet your structural and species composition goals.

Photo credit: Norm Eggert

CONCLUSIONS

- Old-growth forests were the predominant natural forest condition that prevailed for thousands of years before extensive human impact, providing many key cultural, spiritual, and ecological values, including habitat for native biodiversity and ecosystem services like carbon storage and water filtration.
- Old-growth forests are increasingly rare in the region.
- Management strategies exist for restoring many of the important forest conditions found in old-growth forests. These strategies can involve either passive or active management approaches.



Developing old-growth characteristics takes a commitment to forest continuity—that is, leaving your land forested and intentionally leaving more trees in the forest.

- Old-growth restoration strategies can be implemented in a variety of intensities, stages, and combinations to fit within your overall landowner objectives.
- Even applying a single old-growth restoration treatment, such as designating and maintaining legacy trees, can make a considerable difference in restoring these habitat types to our forested landscapes. The benefits of these practices can be increased in a landscape by working across boundaries with neighbors.
- Beyond biodiversity benefits, the conditions found in forests managed for old growth provide many pathways for adaptation in the face of global change, in addition to forest carbon benefits.
- Long-term forest planning with the help of a forester will allow you to ensure that your landowner objectives are met.
- Conservation-based estate planning tools such as conservation easements (restrictions) are critical for ensuring the successful, enduring restoration of old-growth forest habitat by making sure your woods remain as forest into the future.

Photo credit: Bob Labrie

ADDITIONAL RESOURCES

Restoring Old-Growth Characteristics: publications, webinar recordings, scientific papers
masswoods.org/old-growth

Forest Carbon: An Essential Natural Solution for Climate Change
masswoods.org/carbon

Increasing Forest Resiliency for an Uncertain Future
masswoods.org/resiliency

Wildlands, Woodlands, Farmlands & Communities
wildlandsandwoodlands.org

CONNECTICUT

CT Department of Energy and Environmental Protection (DEEP), Forestry
portal.ct.gov/DEEP/Forestry

Service Foresters for Connecticut Landowners
portal.ct.gov/DEEP/Forestry/Landowner-Assistance/Technical-Assistance-and-Service-Forestry-Support-for-CT-Landowners

Find a Consulting Forester
portal.ct.gov/DEEP/Forestry/Service-Forestry-in-CT

UConn Extension
ctforestry.uconn.edu

Planning the Future of Your Land
ctconservation.org/conserve-land

Find a Land Trust
ctconservation.org/findalandtrust

MAINE

Department of Agriculture, Conservation and Forestry, Maine Forest Service
maine.gov/dacf/mfs

District Foresters for Maine Landowners
maine.gov/dacf/mfs/policy_management/district_foresters.html

Woodland Owners Resources Page
maine.gov/dacf/mfs/woodland_owners.html

Find a Consulting Forester
maine.gov/dacf/mfs/policy_management/selecting_a_consulting_forester.html

University of Maine Extension Service
extension.umaine.edu/woodland

Planning the Future of Your Land
forest.umaine.edu/legacy

Find a Land Trust
mltn.org/trusts

MASSACHUSETTS

UMass Extension, MassWoods
masswoods.org

Massachusetts Department of Conservation and Recreation, Bureau of Forest Fire Control and Forestry
mass.gov/orgs/bureau-of-forest-fire-control-and-forestry

Service Foresters for Massachusetts Landowners
mass.gov/service-details/service-forestry

Find a Consulting Forester
masswoods.org/professionals

Planning the Future of Your Land
https://masswoods.org/legacy

Find a Land Trust
masswoods.org/professionals

NEW HAMPSHIRE

New Hampshire Division of Forests and Lands
nh.gov/nhdfl

County Foresters for New Hampshire Landowners, UNH Extension
extension.unh.edu/countyforesters

Find a Consulting Forester
extension.unh.edu/resource/directory-licensed-foresters

UNH Extension Service
extension.unh.edu/natural-resources/forests-trees

Planning the Future of Your Land
extension.unh.edu/resource/protecting-your-legacy-new-hampshire-landowners-guide-conservation-based-estate-planning

Find a Land Trust
nhltc.org/find-land-trust

NEW YORK

New York Department of Environmental Conservation, Division of Lands and Forests
dec.ny.gov/lands/309.html

DEC Stewardship Foresters for New York Landowners
dec.ny.gov/lands/97398.html

Find a Consulting Forester
dec.ny.gov/lands/5230.html

Cornell Extension, ForestConnect
blogs.cornell.edu/cceforestconnect

Find a Land Trust
findalandtrust.org

RHODE ISLAND

Rhode Island Department of Environmental Management (DEM), Forest Environment
dem.ri.gov/programs/forestry

Service Foresters for Rhode Island Landowners
dem.ri.gov/programs/forestry/stewardship/index.php

University of Rhode Island Extension, Rhode Island Woods
rhodeislandwoods.uri.edu

Planning the Future of Your Land
web.uri.edu/rhodeislandwoods/legacy

Find a Land Trust
rilandtrusts.org/landTrusts.htm

VERMONT

Vermont Department of Forests, Parks and Recreation
fpr.vermont.gov/forests

County Foresters for Vermont Landowners
fpr.vermont.gov/forest/list-vermont-county-foresters

Find a Consulting Forester
fpr.vermont.gov/forest/managing-your-woodlands/working-professional

University of Vermont Extension, Our Vermont Woods
ourvermontwoods.org

Planning the Future of Your Land
ourvermontwoods.org/legacy

Find a Land Trust
findalandtrust.org

Vermont Conservation Design
vtfishandwildlife.com/conserve/vermont-conservation-design

REFERENCES

Bauhus, J., K. Puettmann, and C. Messier. 2009. "Silviculture for Old-Growth Attributes." *Forest Ecology and Management* 258, no. 4: 525–37.

Catanzaro, P. F., and A. W. D'Amato. 2019. *Forest Carbon: An Essential Natural Solution for Climate Change.* Amherst: University of Massachusetts.

D'Amato, A. W., and P. F. Catanzaro. 2007. *Restoring Old-Growth Characteristics*. Amherst: University of Massachusetts.

D'Amato, A. W., and P. F. Catanzaro. 2009. *A Forest Manager's Guide to Restoring Late-Successional Forest Structure*. Amherst: University of Massachusetts.

D'Amato, A. W., and B. J. Palik. 2021. "Building on the Last 'New' Thing: Exploring the Compatibility of Ecological and Adaptation Silviculture." *Canadian Journal of Forest Research* 51, no. 2: 172–80.

Foster, D. R., B. M. Donahue, D. B. Kittredge, K. F. Lambert, M. L. Hunter, B. R. Hall, L. C. Irland, R. J. Lilieholm, D. A. Orwig, A. W. D'Amato, E. A. Colburn, J. R. Thompson, J. N. Levitt, A. M. Ellison, W. S. Keeton, J. D. Aber, C. V. Cogbill, C. T. Driscoll, T. J. Fahey, and C. M. Hart. 2010. "Wildlands and Woodlands: A Vision for the New England Landscape." Harvard Forest Paper no. 30, Harvard Forest, Harvard University.

Keeton, W. S. 2006. "Managing for Late-Successional/Old-Growth Characteristics in Northern Hardwood-Conifer Forests." *Forest Ecology and Management*, no. 235: 129–42.

Palik, B. J., A. W. D'Amato, J. F. Franklin, and K. N. Johnson. 2020. *Ecological Silviculture: Foundations and Applications*. Long Grove, IL: Waveland Press.

Tyrrell, L. E., G. J. Nowacki, T. R. Crow, D. S. Buckley, E. A. Nauertz, J. L. Rollinger, and J. C. Zasada. 1994. *Information about Old Growth for Selected Forest Type Groups in the Eastern United States*. General Technical Report NC-197, USDA Forest Service, North Central Forest Experiment Station.

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Since old growth is the condition that our forest species evolved with for thousands of years, maintaining old-growth characteristics within our forests restores missing pieces that will help ensure that our forests continue to sustain themselves and the many benefits we depend on.