A FOREST MANAGER'S GUIDE TO

Restoring Late-Successional Forest Structure

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INTRODUCTION

Interest in restoring and maintaining late-successional forest structure is increasing throughout the Northeast. There is growing recognition of the importance of maintaining late-successional forest stands on the landscape and restoring late-successional structural elements (e.g., large living and dead trees, large volumes of downed woody debris) within managed forests (Hagan and Whitman 2004). Currently, these forest types are found on only a small fraction of the landscape; however, late-successional forests were once the predominant cover type across much of this region. Efforts at late-successional conservation and restoration have been largely motivated by desires to protect and create habitat critical for sustaining native forest biodiversity as well as for maintaining the critical ecosystem services, such as carbon storage, that these systems historically provided.

The current age structure of most stands across the Northeast (< 100 years old) suggests that it will be at least another 50 to 100 years before many of our forests begin approaching late-successional forest conditions. Traditionally, approaches to restoring late-successional forests have primarily focused on "passive management strategies" in which reserve areas, often centered on existing late-successional forests, were delineated on the landscape and protected in perpetuity. Recently, more active approaches to restoring late-successional structure have been proposed that rely on deliberate stand manipulations designed to accelerate the development of late-successional forest characteristics (e.g., Jenkins et al. 2004; Keeton 2006).

DEVELOPING A LATE-SUCCESSIONAL FOREST MANAGEMENT FRAMEWORK

Because non-industrial private forests (NIPFs) make up the majority of forestland in the Northeast, the effectiveness of silvicultural techniques to restore late-successional structural elements will hinge on how socially and financially attractive they are to NIPF owners. Therefore, late-successional techniques must be flexible enough to appeal to a diversity of NIPF owners and be communicated to their foresters in a field-ready format. Given the national averages for NIPF parcel sizes (25 acres) and land tenure rates (26 years) (Butler 2008), these techniques must also consider landscape context and include estate planning recommendations. Based on a review of existing studies of late-successional forests in the Northeast (e.g., McGee et al. 1999, Keeton 2005), a set of management recommendations compatible with traditional forest management and scaled to NIPF ownerships was developed.

Due to the prevalence of northern hardwood forests within the region, these recommendations are geared toward northern hardwood forests managed using uneven-aged silvicultural techniques. However, late-successional structure can be recruited in other cover types in the Northeast that are likely to be managed with even-aged systems (e.g., shelterwood methods) by incorporating elements from the steps below. For example, species such as oak and pine can be regenerated while creating late-successional structure by moving toward the use of two-aged systems through the retention of legacy trees (Step 3). Ultimately, the goal of late-successional management is to recruit old-growth structure by diversifying tree ages and size classes and increasing the amount of cavity trees and large downed logs, all while meeting the landowner's objectives.

STEP ONE

Determine landowner objectives.

Determining a landowner's objectives will help to inform late-successional management decisions.

Because a diversity of objectives exists across NIPF owners, approaching late-successional restoration using a corresponding gradient of treatment options provides a flexible framework to address this range of objectives (Figure 1, page 4). The first step in implementing a late-successional restoration prescription involves determining where a landowner falls on this gradient. This will serve to inform subsequent steps dealing with the siting (Step 2) and intensity (Step 3) of late-successional management. Three general categories for landowner objectives related to restoring late-successional structure are

- Primary objective—restoring late-successional structure is the main focus;
- Complementary objective—restoring late-successional structure is one of several important objectives; and
- Related objective—restoring late-successional structure is of interest, but not as important as other objectives.

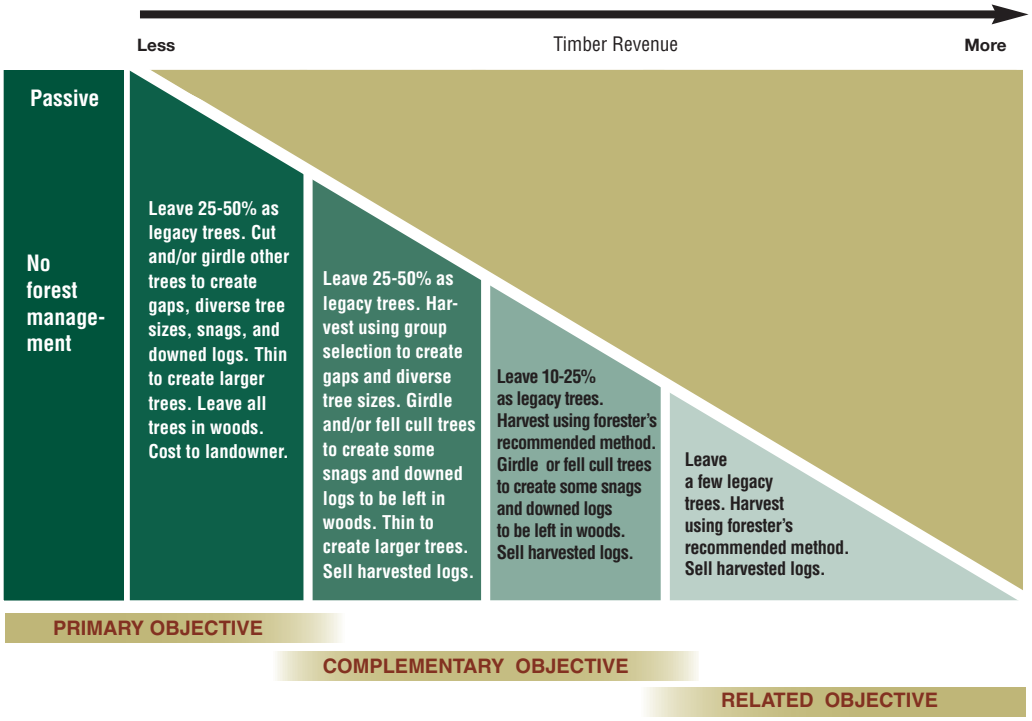
STEP TWO

Determine areas on property suitable for treatments.

Late-successional management should be sited based on the landowner's objectives, the ecological resources of the property, and the property's landscape context. In some cases (e.g., primary objective above), management will be implemented on the entire property, whereas landowners with a complementary objective (as described above) may want this approach applied only to specific sites within the ownership (e.g., a stand or areas within a stand). When deciding where to concentrate restoration management within a property, efforts should focus on the best growing sites where it is compatible with other landowner objectives. For example, more productive sites will increase the rate at which late-successional structures such as large trees develop; however, these areas may also represent opportunities to achieve other landowner objectives, such as timber production. This balance between ecological and financial objectives can be achieved based on where a landowner places him- or herself on the gradient of late-successional management (Figure 1, page 4).

Consider the property's landscape context when determining where to site late-successional management.

In addition, late-successional restoration should focus in areas of diverse environmental conditions as the property allows (e.g., both dry and wet sites, different stand types) to encourage diverse habitat conditions. Finally, consider the landscape context of the management and, where possible, place late-successional restoration management in close proximity to interior forest or large blocks of forest on nearby properties.



Late-Successional Restoration Gradient

Figure 1

A gradient in opportunities exists in the level of late-successional restoration practices that you might apply to your land. Multiple combinations of practices can be used to restore old-growth structure to your land, and even low levels of restoration practices can be used in areas primarily focused on maximizing timber revenue. Central to all these practices is the use of long-term planning and forest protection.

STEP THREE

Determine the number and location of legacy trees and patch reserves.

A significant difference between traditional forest management approaches and those aimed at late-successional restoration is the designation of permanent leave or legacy trees within harvest areas. These legacy trees serve as future old-growth structure as they are left to grow to very large sizes (> 25" DBH), develop into snags, and eventually fall over, becoming large downed logs. **Designating legacy trees is perhaps the single most important late-successional treatment.** Based on landowner objectives, determine the amount and configuration of legacy trees before marking trees to be removed. Recommendations based on the work of McGee et al. (1999) include the following:

- Primary objective—retain 25–50% of main canopy (dominant and co-dominant) trees
- Complementary objective—retain 10–25% of main canopy (dominant and co-dominant) trees
- Related objective—retain a few legacy trees per acre to 10% of main canopy (dominant and co-dominant) trees

When marking legacy trees, preferred tree species include those that are typically long lived and routinely reach 200–300 years of age, such as sugar maple, beech, white pine, hemlock, red oak, and white ash. In addition, priority should be given to larger individuals (> 15" DBH), mast producing species, as well as trees with existing dens or signs of wildlife use. Where possible, legacy trees—typically 6 to 20—should be aggregated to create circular patch reserves ranging in diameter from 75 to 120 feet to maintain interior forest conditions within harvested areas. Areas receiving priority for placement of patch reserves include areas containing existing late-successional structure (cavity trees, downed logs, windthrow), vernal pools, well-developed understory plant communities, or primary forests (i.e., forest stands never cleared for agriculture). Disperse individual legacy trees between the patch reserves to provide structural continuity (large trees, future snags, and downed logs) between patch reserves and surrounding forest areas that can serve as ecological "stepping stones" for slowly dispersed species (e.g., invertebrates, amphibians, certain wildflowers, lichens, and mosses). The combined canopy coverage of patch reserves and the individual dispersed legacy trees should meet the goals for the chosen objective listed above.

STEP FOUR

Designate legacy trees and patch reserves and document location.

Late-successional forest structure develops over multiple decades. It is therefore critically important to document late-seral restoration practices so that future landowners are aware of the restoration practices and their locations. Mark legacy trees and patch reserves in the field with paint or scribe marks and document their approximate location on a map or in a management plan.

STEP FIVE

Create gap sizes and determine placement.

Harvest gap with designated legacy trees.

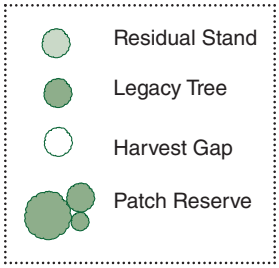
Creating harvest gaps provides for the development of diverse tree sizes and ages found in late-successional forest stands. Gaps also allow forest managers to meet regeneration goals necessary to meet other landowner objectives. The guidelines below are based on existing estimates of historic patterns of natural disturbance for the Northeast; however, forest managers will have to adjust these guidelines to meet regeneration goals (i.e., larger gaps to maintain mid-tolerant species) and account for local conditions such as deer browse, variable stocking levels, competing vegetation, and variability in historic size of natural disturbances (cf. Seymour et al. 2002).

Primary objective: Create gaps ranging in size from a single tree up to 1/4 to 1/3 acre to match patterns of historic disturbances of .5–2% of the canopy per year (Lorimer and White 2003, Seymour et al. 2002). Gaps should remove approximately 5–20% of the canopy in a 10-year cutting cycle, 7.5–30% of the canopy in a 15-year cutting cycle, and 10–40% of the canopy in a 20-year cutting cycle and be based on a forester's regeneration goals. Importantly, gap sizes and harvesting intensities should be varied over time to ensure a diversity of structures and regeneration conditions within the stand. Place gaps between patch reserves with three to seven legacy trees retained within each gap, depending on gap size and regeneration goals; the larger the gap, the more legacy trees that can be retained. Legacy trees can be aggregated or dispersed with placement along the edge of the gap or in the middle, depending on characteristics of desired regeneration.

Complementary objective: Implement uneven-aged management with gap sizes up to 1/4 to 1/3 acre (100 to 120 feet across) placed between patch reserves.

Related objective: Implement a forester's recommended silvicultural system. Designate patch reserves and dispersed legacy trees as described above.

Figure 2 Comparison of late-successional restoration treatments



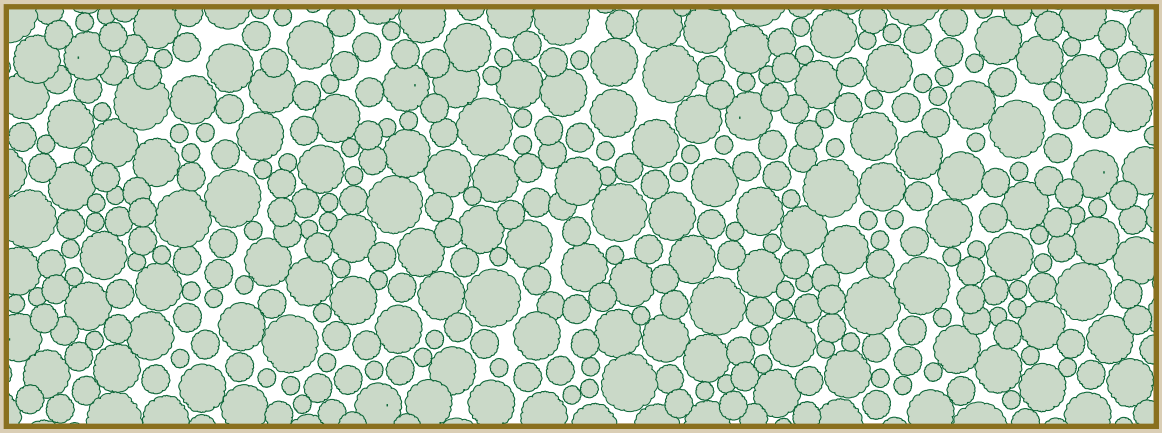


Figure 2a
Pre-harvest woodlot.

Figure 2a

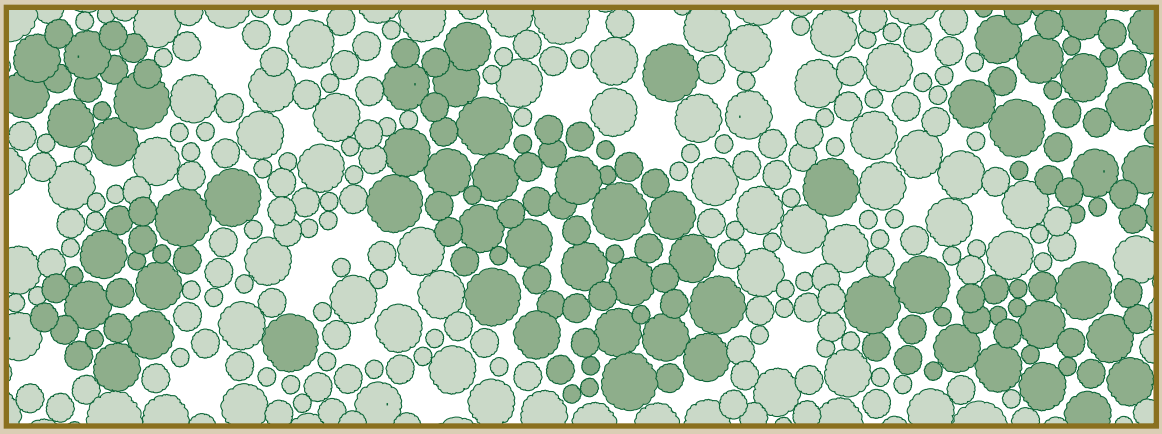


Figure 2b
Woodlot shown in Figure 2a (above) managed with late successional structure development as a primary objective. Legacy trees: ~ 50%. Regeneration: single-tree selection. Intermediate treatment: thinning.

Figure 2b

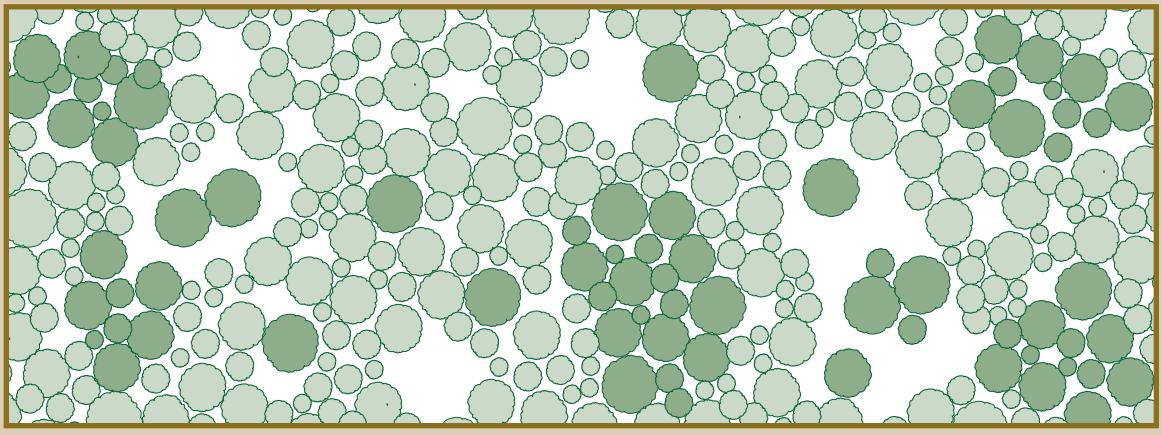


Figure 2c
Woodlot shown in Figure 2a (above) managed with late successional structure development as a complementary objective. Legacy trees: ~ 25%. Regeneration: single-tree and small group (1/4 acre) selection. Intermediate treatment: thinning.

Figure 2c

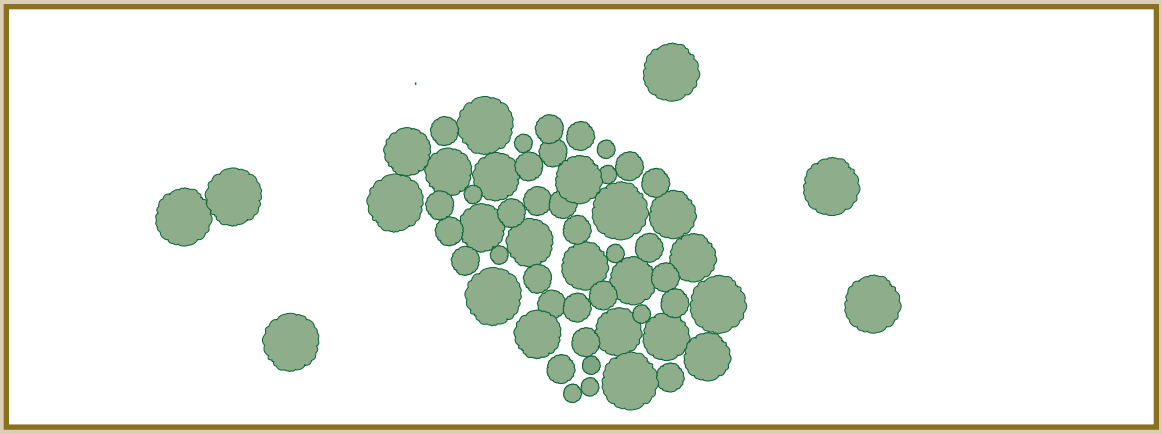


Figure 2d
Woodlot shown in Figure 2a (above) managed to regenerate species of intermediate shade tolerance while recruiting late-successional structure through the creation of a two-aged stand.

Figure 2d

STEP SIX

Tend stand through intermediate treatments.

Thinning a stand can accelerate the development of late-successional structure while also helping to meet other landowner objectives.

While Step 5 addresses the regeneration goals of the harvest, tending the stand between gaps through intermediate treatments, such as thinning, can provide opportunities for both creating late-successional structure as well as meeting other landowner goals. Important late-successional structures currently missing from most forests in the Northeast include very large trees (25"–30" DBH), large standing dead trees, and large downed logs. While the retention of legacy trees will provide for this structure in the future, there are opportunities to accelerate the development of this structure through traditional forest management techniques. Specifically, to increase the number of very large trees, thin the stand by removing competing, low-quality trees adjacent to the largest, vigorous trees. Large standing dead trees can be created through girdling medium- to large-sized trees. Girdling can be concentrated on unacceptable growing stock. Increasing the number and volume of downed logs can be accomplished by felling and leaving on the ground selected medium- to large-sized trees, including unacceptable growing stock. These intermediate treatments can complement traditional forest management by concentrating them on unacceptable growing stock, thus improving the growth of residual trees to meet complementary landowner objectives. The amount of intermediate treatments implemented should be guided by landowner goals. Table 1 (see page 8) provides information on late-successional structural targets

STEP SEVEN

Conduct land conservation based estate planning.

Land conversion is the most pressing issue facing late-successional forests, and forests in general, in the Northeast. When working with an NIPF owner, encourage him or her to complete an estate plan and investigate land conservation options with a local land trust or public conservation agency. Land conservation tools that allow forest management, such as conservation restrictions (i.e., conservation easements), will ensure that the NIPF owner's land will stay forested long enough to develop late-successional structure, as well as many other private and public benefits. To find a land trust in Massachusetts, visit **http://MassWoods.net**. To find a land trust in another state, visit **http://www.ltanet.org/findlandtrust/.**

STRUCTURAL TARGETS FOR RESTORATION

Over time, late-successional structure will develop through the growth and mortality of legacy trees as well as through active forest management. Table 1, below, presents target thresholds for landowners with the primary objective of recruiting structural conditions that approach those found in old-growth forests in the region. Landowners for whom late-successional management is a complementary or related objective will likely cultivate structural attributes below these benchmarks. Nonetheless, even small amounts of late-successional structure embedded into a larger landscape are important and can have critical cumulative effects.

Table 1

Forest structural benchmarks for NIPF owners interested in restoring stand structural conditions that approach those found in old-growth forests in the Northeast region. Targets are based on values found in studies of existing old-growth northern hardwood–hemlock stands.

Structure	Benchmark	Suggested approach
Snags	20 snags > 15" DBH per acre or 25 ft²/acre	Target can be met through natural mortality of legacy trees. If stand is far below target, consider girdling trees > 15" DBH. Girdled trees can concentrate on unacceptable growing stock (UGS).
Downed Logs	*Primary objective:* 10–12 cords*/acre or 40–45 trees > 15" DBH per acre *Complementary objective:* 5–10 cords/acre or 20–40 trees > 15" DBH per acre	Reach target through natural mortality of legacy trees and falling snags. If stand is far below target, consider increasing the number by felling trees > 15" DBH and leaving them on the ground. Felled trees can concentrate on UGS. Typical snag fall rates: ~30% of northern hardwood snags and ~40% of hemlock snags fall per decade. Snag fall rates may be higher for snags that have been created through girdling.
Live Trees	Live trees 20 trees > 20" DBH per acre 15 trees > 25" DBH per acre	Sizes can be attained through passive (i.e., letting them grow) or active (i.e., crown thinning around legacy trees) approaches. Removals from crown thinning can concentrate on unacceptable growing stock, where possible.

*1 cord = 128 cu. ft.

SUMMARY

Late-successional forests provide many important ecological and socioeconomic values and active approaches to restoring these systems represent an important tool for ensuring their future presence on the landscapes of the Northeast. Maintaining late-successional forests and their many public benefits will necessitate developing a matrix of public and private land that is permanently protected, with both reserves and complementary, well-managed forests (Foster et al. 2005). Late-successional management on NIPF land can help create a matrix of structural elements that can provide significant benefits toward biodiversity, carbon sequestration, and the movement of species in response to climate change and can complement other late-successional efforts across the landscape (e.g., forest reserves on public or conservation land).

The above framework provides a flexible, field-ready approach for incorporating elements of late-successional management into traditional forest management at intensities that suit landowner objectives. These same techniques can be implemented on public or conservation land. Importantly, weaving even modest amounts of late-successional management into traditional forestry will have an important cumulative effect at the landscape level. The use of these approaches, in combination with land protection tools such as conservation restrictions (i.e., conservation easements), will ensure that these ecologically and historically significant forests return to and remain important components of the landscapes of the Northeast.

ADDITIONAL INFORMATION

MassWoods—The UMass Forest Conservation program website: http://www.masswoods.net

- Read additional information on restoring late-successional or old-growth characteristics.
- Find a forester or land trust working in your town in Massachusetts.
- Learn about estate planning and land conservation tools, including conservation restrictions (i.e., conservation easements).

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