Cornell University Cooperative Extension

Forest Connect

Supporting Sustainable Management of Private Woodlands

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Assessing the success of hardwood regeneration

Peter Smallidge, NYS Extension Forester and Director, Arnot Teaching and Research Forest, Department of Natural Resources, Cornell University Cooperative Extension, Ithaca, NY 14853. Contact Peter at pjs23@cornell.edu, or (607) 592-3640. Visit his website www.ForestConnect.info, and webinar archives at www.youtube.com/ForestConnect.

Brett Chedzoy is the South-Central Regional Extension Forester for Cornell Cooperative Extension and Manager, Arnot Teaching and Research Forest. CCE Schuyler, Montour Falls, NY. 14891. (607) 742-3657

For four decades or more interest in sustainable and "regenerative" forestry has been of primary interest to many people and organizations. Because all trees eventually die and society needs forests to be replaced, the question of successful regeneration is essential and central to that discussion.

At the beginning of scientific forestry in the late 1800's, research priorities focused on describing the remaining forests or establishing new forests on cutover lands or abandoned agricultural lands. As the science progressed and landscapes changed, attention began shifting to management practices that would manipulate an existing forest and ensure its replacement. By the latter half of the 20th century, considerable research was documenting regeneration failures, often associated with deer browsing impact on forest regeneration. The USFS Northern Research Station and many others immersed themselves in resolving the need to regenerate eastern forests. In 2013, the New York Forest Owners Association, in partnership with other organizations and institutions, committed itself to the Restore New York Woodlands initiative (Figure 1) that recognizes NY's maturing forest and several barriers to regeneration.

Figure 1. The Restore New York Woodlands initiative was developed to highlight the need for attention to the barriers of forest regeneration given the maturity and aging of forests in New York.

Defining Terms

The purpose of replacing the current community of trees, "the forest", with the next forest is to ensure that the services and benefits from the forest are sustained (Figure 2). These services and benefits are tangible and intangible (e.g., wildlife habitat, timber, clean water, aesthetic vistas). Usually the entire forest isn't replaced at one time, but rather management units within the forest called

"stands" are incrementally replaced. A "stand" is comparable to a farmer's field with a high similarity of species, sizes and ages within a field/stand that distinguish it from other fields/stands. The full suite of services and benefits are possible only when a stand is adequately stocked. Stocking refers to occupancy of a stand with trees such that the available sunlight is fully utilized by the canopy of the trees' crowns. The number of trees to achieve adequate or full stocking depends on tree size. Therefore, a stand is regenerated when there is adequate stocking of desirable species. The term "regenerated" should be reserved for stands that have adequate stocking of seedlings of desired or acceptable species with adequate vigor and quality that are taller than the reach of deer.

Figure 2. The full array of benefits that forests provide depend on full stocking of desirable trees and plants. For example full stocking ensures cooler stream temperatures, higher dissolved oxygen for aquatic organisms and fish, and reduced potential for erosion.

The task of regenerating a stand is not trivial. Several barriers complicate the process of regeneration, including excessive browsing by deer (Figure 3), which amplify shading by interfering vegetation, and past management practices that deplete tree spe-cies diversity, productivity, seed supply and site conditions. Because owners and foresters know the goal is to replace the current stand with the next stand of similar or better quality, many people are inclined to favorably focus on the presence of a few seedlings or sapling of desirable species. In some cases, the number of desirable seedling and sapling stems per acre, the stocking, may be insufficient to create a fully stocked new stand.

On several occasions woodlot owners and foresters have pointed to isolated seedlings of desirable, or even marginally acceptable, species and used terms such as "regenerating" or "getting some seedlings." In some cases, the stems they identified were heavily browsed by deer and not likely or soon to be a functional seedling or sap-ling. While these seedlings are pleasant to see, they do not constitute successful regeneration. It is better to recognize a problem and seek a solution than it is to refer to a failed effort with euphemisms that obscure the need for additional action.

Figure 3. Most desirable species, including this white oak, can suffer significantly reduced growth after browsing. The impact of deer browse is pervasive in most northeastern forests. Browsing can eliminate desirable tree and herbaceous plants, and cause cascading negative impacts through encroachment of interfering and invasive species.

Stand Development

Regeneration is a process that is part of the development of a stand. A stand might be young, or have young areas if it is uneven-aged, but the young trees and the young stand change through time. Stand development is the description of how the trees and vegetation change through time. The events and circumstances at the beginning and the end of stand develop-ment are particularly important to stand regeneration.

As a stand approaches maturity, whether financial or biological maturity, and the owner works with a forester to make plans for replacing the stand there are several conditions necessary to attain. These conditions require time and often a sequence of operations, and thus regeneration is a process. Planning for the next stand requires a source of new propagules, usually naturally produced seed from mature trees growing in or near the stand. As a last resort for failed natural regeneration seedlings may need to be planted. The seeds need a seedbed that is conducive to germination. The new germinates need adequate but not excessive sunlight in an environment with favorable moisture and temperature conditions. Finally, a sufficient number of seedlings need to survive mice, deer, pathogens and other mortality agents so that their continuing growth allows for the young trees to form a closed canopy and develop straight, limb-free stems.

Figure 4. Most desirable species, including this northern red oak, can suffer significantly reduced growth after browsing. The impact of deer browse is pervasive in most northeastern forests. Browsing can eliminate desirable tree and herbaceous plants, and cause cascading negative impacts through encroachment of interfering and invasive species.

In many northeastern woodlands, harvesting or other disturbances create openings in the canopy of a mature forest that allows sunlight to the forest floor. That sunlight stimulates the germination of seeds and growth of seedlings (Figure 4). If the harvest was planned and thoughtful, the trees available to produce seed are of desirable species and form. Once seedlings attain sufficient height and number (more on that later), and they are sufficiently robust to withstand the change in temperature and humidity, the overstory is removed during one or more additional harvests.

An important ecological theory to consider in the regeneration process is called "initial floristic composition", which is a well-documented explanation for how forests initiate and develop following disturbances. This theory was presented by F. Egler in 1954, and importantly states that the majority of plants that are initially present and eventually dominate are established before or shortly after the disturbance event or harvest. What this means for stand regeneration and development is that if the harvest area does not include an adequate number of desirable species within a few years, those species are not likely to establish without an additional disturbance. It is possible for a stand that was subject to a harvest or disturbance to become dominated by undesirable species that exclude or suppress desirable species.

Young stands need an adequate number of seedlings per acre to allow for the formation of high quality stems and to optimize growth per acre. The young forest will have many thousands of stems per acre (Figure 5). As that forest develops, the trees compete for sunlight and some die. For each increase of one inch of diameter, approximately 20% of the stems must die. This is the basis for thinning; many trees will ultimately die and preemptive selective mortality will ensure the desired trees have sufficient sunlight to thrive.

Not every harvest needs to regenerate an adequate stocking of seedlings as the replacement of the current forest. Thinning, timber stand improvement (TSI),

and similar "cultural treatments" are done to improve the quality of the current stand and not to create the next stand. To the extent the treatments increase sunlight to the forest floor, there will be some vegetative response. That response is typically the establishment of seedlings of desirable and undesirable species. However, if deer browse the desirable species, then the height growth and survival of the undesirable species are favored. As a result, the undesirable species overtop the desirable species, and the undesirable species will dominate the sapling layer. If this happens, subsequent treatments will be needed to correct the condition.

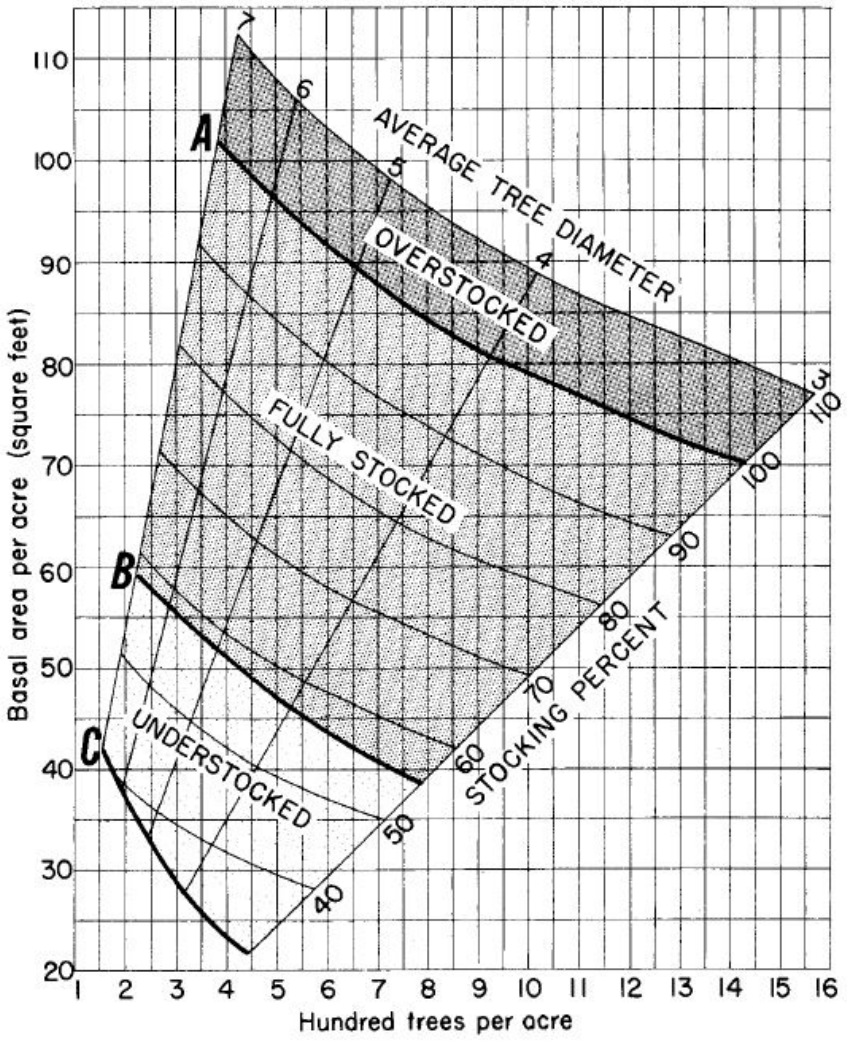

Figure 5. A stocking chart for upland oak habitats illustrates that a fully stocked stand with average stem diameter equal to 5 inches has 650 stems per acre, and 500 when it grows to an average of 6 inches. This is a 23% reduction in stem density with a one inch increase in average stem diameter. Stocking charts are also available for northern hardwood forests. Figure adapted from S.F. Gingrich. 1971. USFS Research Paper NE-195. Available at https://www.nrs.fs.fed.us/pubs/8318

Regeneration Success by the Numbers

Numerical targets can help define when a stand is regenerated. Think backwards in time from a mature stand which is fully stocked when it has several hundred trees per acre to a young stand with thousands or more seedlings and saplings per acre. Because of the mortality that happens during stand development, there needs to be a large initial number of seedlings for full stocking; the actual number depends on the size and species of the seedlings. USFS research scientists have developed seedling density thresholds that are associated with successful regeneration of northern hardwood forests (i.e., maple, beech, birch, ash, basswood, etc.), Allegheny hardwoods (i.e., northern hardwood plus significant numbers of black cherry), and oak dominated forests.

Prior to harvesting, there are seedling density thresholds suggested by the USFS that guide the prescription. Assessment of these thresholds requires a deliberate inventory. The inventory data is used to assess if there is adequate stocking of advance regeneration and other stand attributes (details at https://www.nrs.fs.fed.us/tools/silvah/). Recommendations to assess seedling density relative to the threshold involves an inventory with approximately 4 plots for every 3 acres, each with a 6-foot radius (Figure 6). The stand is also assessed for deer impact and the abundance of different types of interfering vegetation. Stands with higher deer impact have higher seedling thresholds, and a consistent presence

Figure 5. Basal bark treatments can be completed during the growing season to avoid the potential negative impacts of over-spray onto desired species.

of interfering vegetation presumes treatment for its control. Taller seedlings are counted twice. A simple walk through a section of the woods is not sufficient to assess seedling abundance and whether the stand is ready for regeneration. The seedling density threshold requires 70% of the plots to be "stocked." A plot in a stand with a deer impact rating of 3 (i.e., moderate) is stocked if it has 20 or more black cherry seedlings (equal to 7,700 per acre) or 50 seedlings of other desirable hardwoods (equal to 19,257 per acre). The oak threshold density per plot is between the thresholds for cherry and other hardwoods and depends on oak seedling size. For a deer impact rating of 4 (i.e., high), the number of seedlings necessary to classify the plot as "stocked" increases by 25% to 100% depending on species. The prescription for cutting, fencing, waiting, herbicides, etc. depends on stand maturity, overstory conditions, whether 70% of the regeneration inventory plots are stocked, the frequency of plots with interfering vegetation, and other factors.

After a harvest, continued inventory is necessary to judge if the stand has successfully regenerated. Inventory usually begins 2 years after the conclusion of the harvest. The ultimate measure of successful regeneration is if 70% of the 6-foot radius plots have at least two stems of desirable or acceptable species that are at least 5 feet tall; this amounts to an average minimum of 540 desirable stems > 5 ft tall per acre.

Forest regeneration is a process with many obstacles. Work with a good forester and invest in an appropriate inventory to measure your potential and your success. If the harvest wasn't successful, determine what needs to change and work towards success. Management prescriptions that include a reference to "hope" likely need additional thought and effort.

Literature Cited

Egler, F. 1954. Vegetation science concepts I. Initial floristic composition, a factor in old-field vegetation development. Vegetatio 4(6):412 – 417.

For additional information on woodland management go to:
www.ForestConnect.com & www.CornellForestConnect.ning.com

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