2.3 REGENERATION METHODS

BACKGROUND

Carefully designed regeneration practices help perpetuate desired tree species.

Regeneration refers to the seedlings and saplings that develop beneath a forest stand, in openings within a stand, or following the removal of a stand (grouping of trees similar in species, age and site). In younger stands with potentially valuable trees, the immediate goal may be to manage the existing trees for timber as described in 2.4 Managing for High-Quality Trees. If the stand is older or contains an abundance of poor-quality trees, the emphasis can shift to a regeneration harvest using the techniques described in this section.

Silviculture is the art and science of establishing and tending trees and forests. Controlling the composition, health, structure, and growth of forest stands to help meet the landowner's objectives lies at its foundation. Landowner objectives may include timber products, wildlife, aesthetics, recreation, or overall health and stability. Some owners may wish to develop a forest that appears completely natural or untouched. Landowner objectives play a predominant role when choosing a silvicultural approach.

Successful regeneration involves analyzing the condition of the existing trees, advanced regeneration and seed source, and the site capability, then choosing a harvest practice that will regenerate the species best meeting your objectives. Regeneration is one of the most important factors affecting the long-term value and productivity of a forest property.

Financial and Biological Maturity

The need for income, promoting wildlife habitat or creating special aesthetics are but a few reasons to regenerate a stand. Financial maturity is one indication of whether or not to harvest. A tree is financially mature when its rate of return becomes less than what other financial investments (such as stock or bonds) can yield. Trees growing on better sites become financially mature at larger diameters than the same species growing on average or poor sites, since they grow faster and are able to deliver a higher rate of return for a longer period. Likewise, poor-quality trees mature financially at much smaller sizes than high-quality ones. Approximate diameters for financially mature, high-quality trees are given below. Maturity varies depending on tree condition, site quality, and markets.

Except for short-lived species such as paper birch and balsam fir, financial maturity isn't highly correlated with biological maturity. Most tree species can live for decades or centuries past their financial maturity. Biological maturity occurs when a tree begins to decline. Biological maturity may trigger a regeneration harvest, but these older trees provide benefits described in other chapters. Approximate ages are listed below.

Financial Maturity by DBH and Biological Maturity by Age

Species	Financial Maturity (DBH) inches	Biological Maturity years
Sugar maple, white ash, yellow birch, red oak	18-24	150-200
Red maple, beech	14-18	120-150
Paper birch, aspen	12-14	80-100
White pine	18-24	150-200
Red spruce	12-16	200-300
Balsam fir	10-14	60-80
Hemlock	16-18	200-300

Site Capability

Analysis of site capability gives insight into which species are best adapted to grow on a particular site. Some general guidelines are:

Species	Preferred Site and Soil Conditions
White ash, sugar maple	Moderately well-drained and enriched fine-textured soils, especially with low acidity (higher pH soils)
Beech	Sandy tills, but common on a wide variety of soils
Red oak *	Sandy tills and outwash (where red oak may be poorly formed and defective)
White pine*	Outwash and, to a lesser extent, sandy tills
Yellow birch	Moderately well-drained, fine-textured soils; also on somewhat poorly drained pan soils in mixture with softwood
Red spruce, hemlock, balsam fir	Shallow pan soils and lakebed sediments often somewhat poorly drained; outwash; or shallow-to-bedrock
Paper birch, aspen, red maple	Adapted to a variety of soils, but often on sites that supported shade-tolerant softwoods.

** Currently found growing on a variety of soils due to agricultural history and generally difficult to regenerate on the better soils.*

New Hampshire soils are complex and highly variable, primarily due to their glacial origins. The Natural Resources Conservation Service (NRCS) categorizes site capability to correlate with county soil survey maps. Referred to as Important Forest Soil Groups, these categories can be used to evaluate the relative productivity of soils and better understand patterns of plant succession and the ways soil and site interactions influence management decisions. All soils are grouped into one of six categories. For a more complete treatment see the appendix. NRCS field offices can provide more information.

Site index is another way to categorize site quality. It is expressed as the height of a species at a given age, usually at age 50. The higher the site index, the taller the tree will grow in the given amount of time, and the better the site is for that species. A poor site for one species may be adequate for another. In New England, a site index of 45 or lower is poor, 55 to 65 is average, and 80 is excellent.

Tolerance

Shade tolerance, a species' ability to thrive and prosper depending on the amount of available light and competition from others, influences what will regenerate.

Sugar maple, American beech, red spruce, hemlock, and balsam fir are shade-tolerant. They can survive under heavy shade, including shade from the species itself, although growth is usually more rapid in the open.

White ash, red oak, white pine, and yellow birch are intermediate and can survive under partial shade or in small openings. Red maple is intermediate to tolerant.

Paper birch and aspen are shade-intolerant and survive best with full sunlight. They are called pioneer or early successional species, because often they are the first to inhabit openings after a disturbance.

In the absence of advanced regeneration, tree tolerance provides guidance as to which species may regenerate from a given harvest technique.

2.3: Regeneration Methods

Advanced Regeneration

Seedlings or saplings established naturally without the influence of harvesting under a forest canopy are called advanced regeneration. Often it will determine what species will regenerate.

Some hardwoods such as beech and red maple are aggressive as advanced regeneration on certain sites. When crushed during timber harvesting, they sprout profusely. Other hardwoods aren't as aggressive and may sprout from small stumps but their survival and future in the stand is less certain.

Other species including most softwoods, may be persistent as advanced regeneration but may be eliminated from a stand from crushing if harvesting practices don't protect them. Most softwoods don't sprout. If advanced regeneration is destroyed during a timber harvest, new stems must start over from seed. Many softwood species are slow starters, giving hardwoods a head start.

Lack of advanced regeneration may provide opportunities to establish desired species suitable to the site. Measures may be taken to establish the desired species as advanced regeneration, or harvest practices may encourage regeneration at the time of harvest.

Seed Source

During all phases of management, it's important to maintain or increase a source of seed for the several species of most interest. The best seed producers are sawlog-sized trees with well-developed crowns. However, there is great variation among individual trees and seed crops vary greatly from year to year. If the desired species aren't present as advanced regeneration, harvest during the fall or winter of a good seed year. Most seeds fall within a couple hundred feet of the seed tree, but some seeds, notably red and white oak, may be moved (and eaten) by birds and small mammals such as squirrels. Both red and white oak are heavily consumed by wildlife.

Seeding Characteristics of Selected Trees

Species	Seeding Interval (good years)	Other Seeding Characteristics
Birches	1-2	wide dispersal on snow
Sugar maple	3-7	
Red maple	1-2	
Beech	2-5	occasional animal dispersal
White ash	2-5	most germination second year after dispersal
Red oak	3-5	two years to mature; look closely for small one-year acorns
White oak	3-5	one year to develop
White pine	3-10	two years to mature; look for one-year cones
Red spruce	3-8	
Eastern hemlock	2-4	

Regeneration Harvest Methods

Knowing landowner objectives, site capability, advanced regeneration and seed sources helps to choose an optimum regeneration harvest method. Regeneration practices are applied in even-aged stands at the end of the rotation when the stand is mature and ready for final harvest. In uneven-aged stands, regeneration takes place after every harvest cut. The methods described below cover a wide range of disturbance levels, some approximating natural disturbances:

Single tree selection

- Removes about ¼ to ⅓ of the trees singly or in small groups, leaving a range of tree sizes—roughly one-third to half the basal area in sawlog and the remainder in poletimber.
- Encourages tolerant species such as beech, sugar maple (on good sites), red maple, red spruce, balsam fir, and hemlock.
- Produces or perpetuates an uneven-aged stand (three or more age classes). If the tolerant understory that develops is undesirable (e.g. beech), choose a different system such as groups, patches or clearcuts.

Group selection

- Creates openings of ¼ to 2 acres centered on clumps of mature or defective trees.
- Regenerates intermediate shade-tolerant species such as white ash, yellow birch, red oak, and white pine.
- Harvested in larger groups (> ⅔ acre), it promotes aspen and paper birch.
- Produces a patchy, uneven-aged stand.
- Produces consistent timber flow when harvested in groups the equivalent of about 1 percent of the stand for each year between harvests. For example, for a 10-year entry period, about 10 percent of the stand is harvested in groups, as well as some trees between groups.
- Works well for stands with patches of large trees intermixed with patches of immature trees.

Shelterwood

- A flexible system ranging from high-density shelterwoods (removing about ⅓ of the basal area) to encourage tolerant regeneration to low-density shelterwoods (removing about ⅔ of the basal area) to encourage intermediate and some intolerant-species regeneration.
- A standard shelterwood harvest is followed by a removal harvest of the remaining overstory trees in 5 to10 years, producing an even-aged stand.
- In a deferred shelterwood, the overstory is left in place for perhaps several decades, resulting in a two-aged stand.

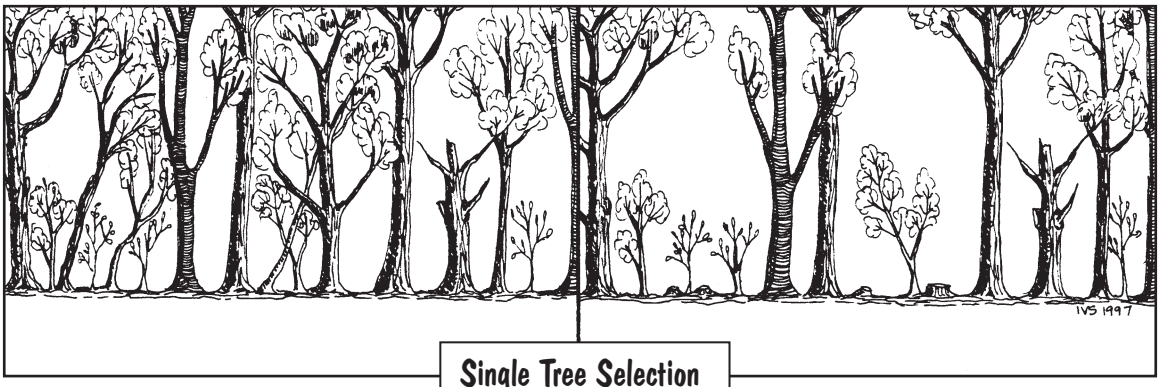
Clearcut

- Removes all trees (above 2 inches DBH). If necessary, unmerchantable stems may be removed by a followup noncommercial operation.
- Commonly about 5 acres or larger. Smaller openings (2 to 5 acres) are often called patch cuts.
- Results in early successional (intolerant) regeneration including paper birch, aspen, pin cherry, and *Rubus* species together with intermediate and tolerant species.
- Useful in mature, overmature, and defective stands and stands subject to windthrow, or to produce early successional wildlife habitat.
- Not generally effective for softwood regeneration unless advanced regeneration is present (sometimes called a natural shelterwood or overstory removal).
- The retention of uncut groups of trees can improve the appearance and provide diversity.

Strip cut

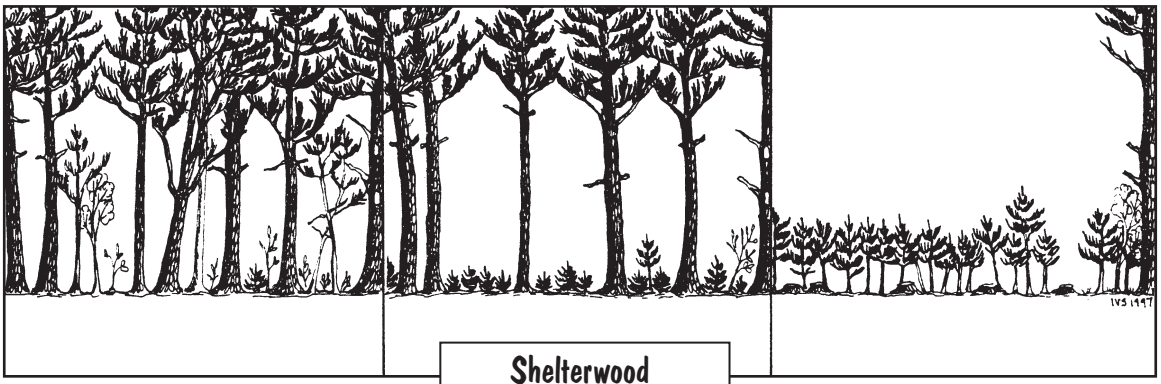
- All trees are removed in strips ranging from perhaps 25 to 100 feet wide.
- A progressive strip cutting leaves three to four uncut strips, which are harvested at intervals over a rotation.

Regeneration Harvest Methods

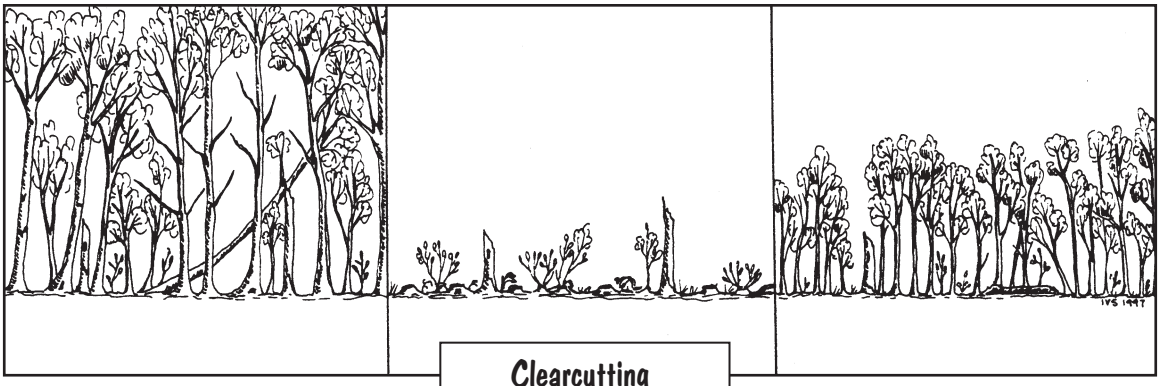


Single Tree Selection

Group Selection



Shelterwood



Clearcutting

- Strip cutting (especially without snow cover) provides maximum ground disturbance and is useful for removing unwanted advance regeneration or other undesirable vegetation.
- A strip shelterwood consists of a clearcut strip and an adjacent strip harvested by shelterwood methods. During the next entry the shelterwood strip is harvested by overstory removal and another adjacent strip is shelterwood-harvested, etc., until the cycle is complete and ready to be repeated.

Overstory removal

- Removal of the larger overstory trees to release advanced regeneration—removing overstory trees in the absence of advanced regeneration isn't truly an overstory removal.

Natural disturbance and natural process silviculture

- Natural disturbance silviculture approximates natural disturbances from windthrow, disease, and natural mortality. Trees are harvested, sometimes in small groups, when they approach biological maturity and begin to decline. The system resembles small group or individual tree selection and creates an abundance of large, old trees, dead woody material, and shade-tolerant regeneration.
- Natural process silviculture is concerned with maintaining ecological processes: natural succession, nutrient cycling, woody-material production, forest-floor maintenance and development, multiple-age and size-classes development, and minimal aesthetic impacts.

Practices Not Recommended

- Diameter limit removes all trees above a fixed diameter. It is considered a poor practice unless accompanied by precautions such as varying the diameter limit by species, removing poor growing stock, releasing acceptable regeneration, and controlling residual basal area.
- High grading removes the most valuable trees, usually the largest. It causes a progressive decline in stand value.
- Liquidation completely removes all merchantable trees, usually without measures to protect the site or provide for future harvests. It may be associated with a land-use change.

OBJECTIVE

Select a harvest practice that regenerates desired species rapidly and economically, consistent with landowner objectives and site capability.

CONSIDERATIONS

- Natural regeneration in New Hampshire is prolific due to favorable conditions of climate, soil, and native species. Natural regeneration is usually the best option, although seeding or planting may be useful to meet certain objectives.
- Predation and browsing may impact regeneration success or necessitate revision of the management objective or harvest method. Examples include predation on acorns and other seeds from small mammals, deer, turkeys, and insects; browsing from moose, deer, and rabbits; and defoliation of understory white pine by gypsy moth.
- The success of regeneration practices can be clearly evaluated only 5 to 10 years after the regeneration is well established. There are no hard-and-fast rules that will result in successful regeneration of the desired species every time.
- Some common trees and shrubs may out-compete more valuable commercial trees. Hobblebush, striped maple, ferns, and beech-sucker growth are common, competitive, noncommercial species.

RECOMMENDED PRACTICES

- ✓ Determine the species to regenerate, based on landowner objectives, site capability, the presence or absence of advanced regeneration, and biological and economic risks.
- ✓ Choose a regeneration method based on the general guidelines below:

Species	Harvest Method
Beech, sugar maple, red spruce*, balsam fir*, hemlock*	Single tree/small group selection (< ¼ acre) or narrow strips (< 50 feet wide)
White ash, yellow birch, red oak, white pine	Group selection (¼-2 acres) or medium strips (50-100 feet wide)
Aspen, paper birch	Group selection (> ⅔-2 acres) or medium strips (50-100 feet wide)
Red oak, white pine, red spruce, balsam fir, hemlock	Shelterwood (natural or planned)**
Aspen, paper birch, yellow birch	Clearcut or wide strips (> 100 feet)

** On wet and shallow soils, windthrow can be a problem if using single tree selection.*
***A natural shelterwood is a removal cut where advanced regeneration is present.*

- ✓ Plan for the following special features when regenerating the species listed below:

Species	Special Feature
Red oak, white pine, red spruce, hemlock, balsam fir, sugar maple	Advanced regeneration important
Red oak, white pine	Important to bury the seed through harvesting activity or site preparation
Aspen, beech	Sprout from roots of trees present in the stand
Red maple, red oak	Prolific sprouters from stumps of poletimber or small sawlog trees
Sugar maple, red oak, red maple, yellow birch	Browsed heavily by deer
Paper birch, aspen	Short-lived species that typify early succession with pin cherry and *Rubus* sp.

- ✓ Regenerate oak on better sites by encouraging small stump-sprouts by fall and winter harvesting or shelterwood cutting during the fall and winter of a good seed year (coupled with special treatment to bury the seed).
- ✓ Reduce unwanted shade-tolerant advanced regeneration through groups, clearcuts and heavy harvesting to convert the stand to earlier-successional species.
- ✓ Where there is an undesirable understory of beech or other species, harvest in snow-free seasons to reduce the understory and provide a scarified seedbed.
- ✓ Where there is a minimal undesirable understory with overstory beech, harvest in the winter to minimize beech-suckering, unless scarification is required for regeneration of desired species.
- ✓ Reserve clean beech trees that show resistance to beech bark disease. Lightly harvest nearby to encourage resistant root suckers.

- ✓ Regenerate hemlock by releasing patches of advanced regeneration in the winter. To encourage advanced regeneration, apply very light harvests coupled with ground disturbance during late fall of a good seed year.
- ✓ In areas subject to heavy deer browsing (over 10 to 15 deer per square mile), use larger patches or clearcuts or regenerate species such as black birch or softwoods, or spot-plant with spruce or white pine.
- ✓ Invasives (e.g. European buckthorn) may almost completely inhibit desired regeneration, especially in areas with intense deer browsing. Try patch or clearcuts, making sure there are adequate nearby seed sources, or obtain professional advice on chemical control.
- ✓ Evaluate advanced regeneration by recording the species of the dominant (tallest) seedlings and saplings in a series of small circular plots about 3.7 feet radius (1/1000 acre). Advanced regeneration is adequate if 50 percent of the plots are stocked. Percent of stocked plots by species approximates predicted species composition following harvest.
- ✓ Retain snags and patches of mature live trees for wildlife habitat.
- ✓ Consider the aesthetic impact of the proposed harvest using the visual quality protection techniques described in 3.2 Logging Aesthetics.
- ✓ When clearcutting, give consideration to the landscape in which the cut occurs as part of an overall forest management strategy to maintain a sustainable balance of forest structures, age classes, and habitats across the landscape. Separate clearcuts by a manageable stand of at least the width of the area being harvested. Avoid the following areas:
  - Slopes > 35%.
  - Thin organic soils on top of bedrock ("duff soils") and soils classified in NRCS soil surveys as having severe erosion hazard.
  - Riparian management zones—except for specific wildlife management purposes.
  - In or around seeps, or vernal pools.
  - In highly visible or aesthetically sensitive areas.

CROSS REFERENCES

2.2 Forest Structure; 2.4 Managing for High-Quality Trees; 3.1 Timber Harvesting Systems; 3.2 Logging Aesthetics; 3.5 Soil Productivity; 4.1 Water Quality; 4.2 Wetlands; 4.3 Forest Management in Riparian Areas; 5.4 Logging Damage; 6.1 Mast; 6.2 Cavity Trees, Dens and Snags; 6.3 Dead and Down Woody Material; 6.7 Aspen Management; 7.2 Seeps; 7.3 Vernal Pools; Appendix: Important Forest Soils Group.

ADDITIONAL INFORMATION

Beattie, M., C. Thompson, and L. Levine. 1993. *Working with Your Woodland: A Landowner's Guide (2nd ed.)*. University of New England Press, Hanover, N.H. 279 pp.

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