Section 3
Silvicultural Systems

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INTRODUCTION

Silvicultural systems are a planned series of treatments that are carried out during the entire life of a forest stand with the main objective of controlling the establishment, species composition, and growth of the stand. Successfully implemented treatments also have the potential to produce forest products at present, improve the quality and quantity of forest products in the future, and maintain or enhance a variety of wildlife habitats and recreational opportunities provided by the forest. Numerous factors will determine the nature of treatments and their intensity of application including site quality, quality of the existing forest and its growth potential, markets for forest products, management objectives, and financial constraints.

Silvicultural systems are named for the type of harvesting method used and are divided into two broad categories: uneven-aged systems and even-aged systems.

Uneven-aged forests contain trees of all ages and sizes that are intermixed throughout the site. Usually, there are at least three age classes present. Within managed stands, trees are usually grown continuously without a uniform rotation length until they reach a specified maximum diameter size. An exception occurs in stands being managed for old growth where it is desirable to retain some very large diameter trees. Basal area remains fairly constant except for fluctuations due to mortality or periodic selection harvests followed by ingrowth. The average height of the tallest trees also tends to remain constant over time and the growth protential of individual trees is related to crown vigor and position in the canopy. These stands are managed by maintaining a balance of trees in each of the diameter classes (i.e., basal area) from seedlings through to mature trees (OMNR 1998*a)*.

Even-aged forest stands are comprised of trees that are all within 20 years of the same age. Normally a population of trees of similar age or age class is managed according to the area and volume occupied by the specific age classes (i.e., stands), from their initial establishment to final harvest on a specified rotation cycle that can vary from 50 years to 200 years. A variety of silvicultural techniques is used in even-aged stands to control species composition and quality, and to accelerate the growth of crop-trees (OMNR 1998*a*).

Only shade-tolerant species (e.g., hard maple, beech) can be managed by strict uneven-aged methods (Daniel *et al.* 1979). Species with less shade tolerance (e.g., yellow birch, black cherry, red oak) are better managed and regenerated using even-aged methods, or a modification of the uneven-aged method allowing representation of small, even-aged patches within the uneven-aged stand (OMNR1998*a*).

3.1 DESCRIPTION OF MAJOR SILVICULTURAL SYSTEMS


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There are three major silvicultural systems with each one having some modifications:

1. Selection systems
2. Shelterwood systems
3. Clearcut systems

Selection systems are only applicable in uneven-aged stands while shelterwood and clearcut systems only apply to even-aged stands.

In most of southern Ontario, the selection system or a modification of it is the most commonly used silvicultural system. In some parts of southern Ontario where oak and/or pine forest cover types predominate, the shelterwood system is occasionally used. Use of the clearcut system is rare in this part of the province.

1. Selection systems

Selection systems favor trees that grow well in the shade (e.g., maple, beech, hemlock). While clearcutting and shelterwood systems create even-aged forests, the selection system creates or maintains uneven-aged forests containing trees of different ages and sizes. This system is designed to maintain permanent forest cover despite periodic partial-cuttings. At no time is the complete canopy removed. Instead trees are removed to obtain a target basal area, distributing the trees to be removed across all diameter classes, and never removing more than 1/3 of the pre-harvest basal area. To reach the target basal area and maintain the target basal area distribution over diameter classes, trees of lesser quality are removed first, either individually or in small groups, over the entire stand. Periodic harvests occur on a short cycle (8 to 25 years) and usually establish regeneration following each cut.

The proper selection of trees for harvest is a difficult task and requires considerable training. Forest managers must not only understand how trees grow in order to predict the ones that will do best over the long term, but they should also be able to identify markets for the eventual harvest as well as specific wildlife habitats and other values that should be protected. Usually density levels determine the amount of trees to be cut in each diameter class. Decisions to remove individual trees are based on characteristics reflecting their general health and quality including their vigor and presence of disease and decay; as well as their potential susceptibility to serious risks such as windthrow.

The selection system is best implemented on accessible, highly productive sites consisting mainly of hard maple and other shade-tolerant species.

The relative advantages and disadvantages of the selection systems are compared to those of the shelterwood and clearcutting systems in **Tables 3.1.1** and **3.1.2**.

Modifications to the selection system

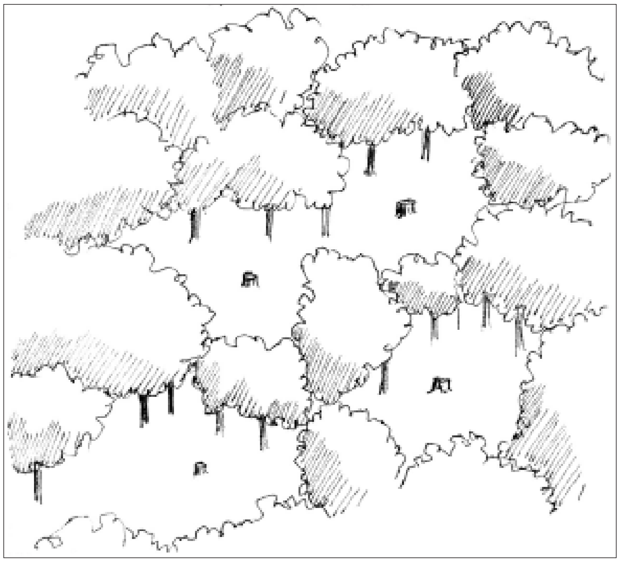

Figure 3.1.1: Aerial view of canopy following single-tree selection harvest showing canopy openings following removal of marked trees.

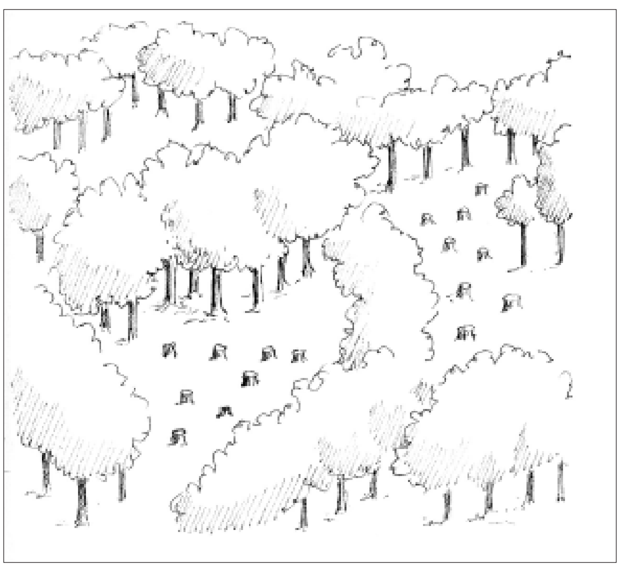

Figure 3.1.2: Aerial view of canopy following group selection harvest showing canopy openings following removal of groups of marked trees.

Single-tree selection

This variation is only used with shade-tolerant species. Single trees are cut and the subsequent regeneration that occupies the remaining growing space is thinned over time to eventually produce another single mature tree. Thinning can occur by deliberate tree removal and/or through natural mortality or self-thinning.

Group selection

This variation removes trees in small groups and thus opens the canopy up more than single-tree selection. It is best used to encourage regeneration of mid-tolerant species such as yellow birch, red oak, white ash, and occasionally the more intolerant black cherry. The goal is to maintain these species within an uneven-aged stand by developing a staged mosaic of even-aged patches that are periodically regenerated in various cutting cycles (OMNR 1998*a*).

This variation could be minor in nature (e.g., by creating an occasional opening to encourage mid-tolerant species), or major, for example, where several group openings are created or when single-tree selection is used in conjunction with it, to remove trees between the group openings. Considerable skill is required to locate the group openings.

2. Shelterwood systems

The shelterwood system involves the gradual removal of the entire stand through a series of partial-cuttings and usually results in an even-aged stand. Normally regeneration is natural but artificial regeneration methods may also be used on some sites to supplement natural regeneration or to shift forest species composition to a more desired condition.

The series of partial-cuttings allows natural regeneration to develop in the stand over time while existing trees are being removed. The new regeneration is protected from excess sun, heat, and moisture until it is well established because the existing trees are removed in stages. The final overstory removal cut is completed when regeneration has met specific targets for size and density. Initial thinning begins with the smaller, shorter trees. The largest and healthiest trees are also usually the best seed trees and are kept in the stand until the final removal.

Under the shelterwood system, the overstory trees are removed in a series of two to four cuts and each cut is done for specific reasons:

- The *preparatory cut* permits the crown expansion of the remaining trees to increase their potential for seed production. Depending on crown size, this cut may not be necessary. This cut also removes undesired species and trees of low quality.
- The *regeneration* or *seeding cut* improves conditions for seedling establishment by spacing the best quality trees with large crowns, increasing seed production from good parent trees, and allowing more sunlight to reach the forest floor. It also permits any necessary site preparation (e.g., soil scarification). This cut is best conducted in or just before a good seed year. Note that it is erroneous to refer to any harvesting with any other system or bad forestry practice as a "regeneration cut"; this term applies specifically to the shelterwood silviculture system.
- The *removal cut(s)* removes the residual stand in one or more operations once the established seedlings, known as advanced regeneration, meet specific size standards.

The relative advantages and disadvantages of the shelterwood systems are compared to those of the selection and clearcutting systems in **Tables 3.1.1** and **3.1.2**.

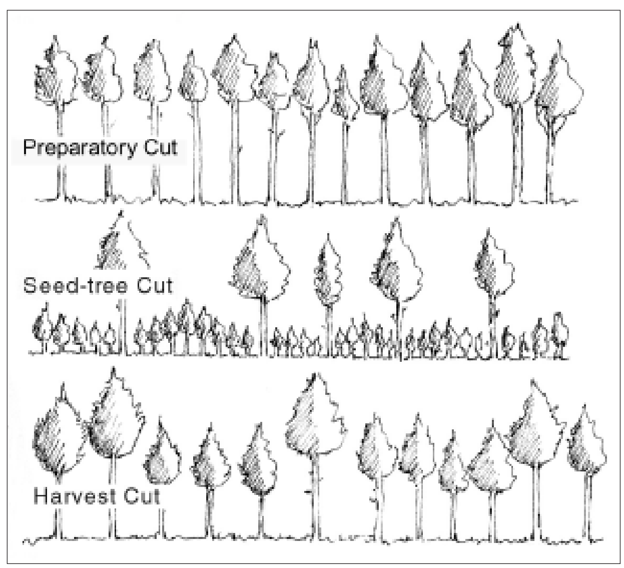

Figure 3.1.3: Diagramatic representation of a typical stand after each cut in a three-cut shelterwood.

Modifications to the shelterwood system

Uniform shelterwood

This modification is used to periodically and uniformly open the canopy throughout the entire stand, and is most applicable where site or seedbed protection is essential and aesthetic appearance is important. Established targets for crown closure are used to control the distribution of residual trees.

Strip shelterwood

Usually, the forest stand is cut in strips, starting on one side with a seeding cut on the first strip. After a few years, a removal cut is made on the first strip and the next strip receives a seeding cut. A few years later, a final cut is done on the first strip, a removal cut on the second strip, and a seeding cut on the third strip. Over time, a series of cuttings progresses strip by strip across the stand (Smith 1986).

Group shelterwood

This modification applies the shelterwood system to areas of up to few hectares in size. Complete canopy removal in the gap does not occur until preparatory and seeding cuts and tending or other cultural treatments have established good advanced regeneration.

3. Clearcut systems

The clearcut system is used to regenerate an even-aged forest stand (i.e., all trees are within approximately 20 years of the same age). All or most of the existing forest is removed from the area in one operation. Clearcutting is usually done in blocks, strips, or patches but can be modified to suit local stand and site conditions.

Regeneration is from one or more of the following sources:
- release of established seedlings
- sprouts from stumps or roots
- seeds existing in the soil seed bank or from mature trees in neighboring stands
- planting of tree seeds or seedlings

This system can result in forest stands with a variety of species; both intolerant and tolerant species may become established in clearcuts. Generally clearcutting is best suited for the management of species that are intolerant of shade (e.g., poplars, white birch, black cherry). These species tend to have the lightest seeds, grow fastest in open conditions, quickly establish themselves and then predominate on the site.

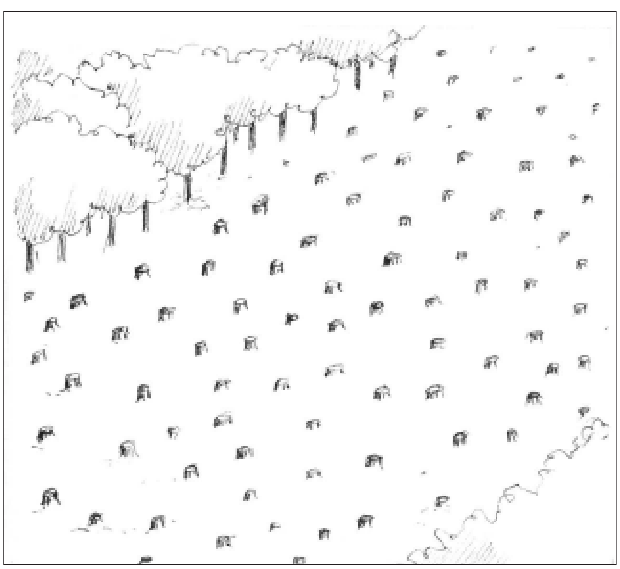

Figure 3.1.4: Aerial view of forest following patch clearcut harvest.

Cutover size is critical if natural regeneration from seeds is anticipated. Forest managers must be aware of average seed dispersal distances of target species and the longevity of seeds in the soil seed bank (**Appendix B**).

Although the clearcut system may be appropriate for regenerating some forest cover types, there are few locations in southern Ontario where the resultant negative aesthetics and potentially detrimental environmental conditions would be acceptable. Therefore extreme caution, careful planning, and consultation with experts should occur before applying the clearcut system or any modification of it. Most forest cover types in southern Ontario should not be managed with the clearcut silvicultural system.

The relative advantages and disadvantages of clearcut systems are compared to those of the selection and shelterwood systems in **Tables 3.1.1** and **3.1.2**.

Modifications to the clearcut system

Seed tree method

Using the seed tree method, all trees are cut, except a small number of isolated or groups of trees that will provide a natural seed source for the site over the regeneration period. This system often requires site preparation and either manual or chemical tending to ensure success.

Selected seed trees must be windfirm and able to survive for several years in the open environment that follows a clearcut. They must also have large crowns capable of abundant seed production. The number of seed trees needed varies according to the target species, the amount of seed produced, average tree and seedling survival rates, and the size and weight of the seed.

The advantages and disadvantages of this method are similar to those of the clearcut system in general. The main advantage is that the seed trees provide a source of seed in the clearcut area for many years after harvesting. Also the remaining trees provide more structural diversity than is found in the unmodified clearcut system. However, the seed tree method of regeneration is essentially inappropriate for maintenance of local gene pools of many forest tree species since there would be insufficient seed trees left to maintain genetic diversity (Gordon 1994). If the stand is isolated (e.g., not within pollination distance from other stands), this method can lead to greatly reduced genetic diversity within the stand (Buchert *et al.* 1997). Also, on many sites, competition from poplar, birch, and raspberries often severely limits regeneration success with this modification.

The success of this method usually depends on the provision of an adequate number of seed trees and their fecundity, as well as proper site preparation following the harvest.

Patch clearcut

This modification is most suitable for use in stands of variable composition, found on broken and irregular terrain. Patch size and shape can be modified to accommodate the site and stand variability and it will often reflect the predominant mosaic in the original forest. Some patch clearcuts create more edge than more regular-shaped clearcuts and therefore may encourage some wildlife species and discourage others.

Progressive strip

The area to be clearcut is first divided into strips and then adjacent strips are cut in sequential order. This method is most applicable for use on relatively flat, uniform terrain, or where forest stand conditions are fairly homogeneous.

Table 3.1.1: Comparison of advantages of the selection, shelterwood and clearcutting systems.

Selection systems	Shelterwood systems	Clearcut systems
Ecological • emulates small-scale forest disturbances such as windthrow, natural mortality, and isolated insect and disease events that kill single trees or groups of trees • only system that provides or retains habitat for forest interior bird species • maintains forest cover and often creates numerous vegetation layers that are important to many plant and animal species • permanent canopy cover protects the site from wind, desiccation by sunlight thereby reducing risk of fire hazard and erosion by water Forest Management • presence of a permanent source of seed for natural regeneration • well-suited to the management of shade-tolerant species • provides the best way to obtain high-quality sawlogs or veneer logs of some species (e.g., hard maple) Economic • not nearly as expensive as clearcutting and replanting • less expensive than shelterwood systems if site preparation and planting are required due to inadequate natural regeneration • continual availability of high-quality forest products can lead to a steady income Social • maintains good aesthetic quality	Ecological • emulates medium-scale disturbances such as low intensity fires, or small-scale blowdowns (e.g., understory burns that occurred naturally in pine- and oak-dominated forests) Forest Management • natural reproduction is more certain than it is with clearcut systems and likely to be more uniformly established, due to a uniformly distributed seed source, although many white pine stands still require supplemental planting because of difficulties in coordinating regeneration cuts with good seed years • the rotation period is shortened since trees are established and growing before the old stand is completely removed • the partial canopy cover protects the site and new regeneration from weather extremes such as hot, dry conditions, or heavy rain • can encourage moderately shade-tolerant species and somewhat discourage shade-intolerant species by controlling the amount of canopy and therefore sunlight infiltration on the site Social • aesthetic quality of site is better than it is with clearcut systems	Ecological • emulates large-scale disturbances such as widespread fire, insect and disease outbreaks, and blowdowns that create or perpetuate early successional forest stands Forest Management • easiest system to learn and use • harvest operations are all done at once • no residual stand to protect in harvest except where there is advanced regeneration • well-suited to management of shade-intolerant species that require full sunlight

Table 3.1.2: Comparison of disadvantages of the selection, shelterwood and clearcutting systems.

Selection systems	Shelterwood systems	Clearcut systems
Forest Management • requires considerable training and supervision to properly implement • requires a larger area to meet volume needs • high risk of damage after cutting to both site (e.g., rutting) and residual stand if harvesting operations are not done properly and/or at the right time of year • will not regenerate intolerant species • high level of crown closure will discourage regeneration of mid-tolerant species Economic • requires a good market to accept hardwood pulpwood and fuelwood since a disproportionate amount of low-quality products usually need to be removed during the early cuts	Ecological • dramatically alters much wildlife habitat, especially for species requiring high canopy conditions Forest Management • greater technical skill is required to design the overall system for site preparation and harvest operations to accommodate residual trees, and to mark trees for removal and seed production • need to protect residual trees and minimize logging damage to regeneration during preliminary cuts • slash provides a source of fuel for fire that could potentially damage new regeneration Economic • need a market for the low-quality material that is usually cut first • multiple harvests can be expensive and immediate logging costs are higher than for clearcut systems	Ecological • possible reduction of genetic and species diversity of site • wildlife habitat is drastically altered and most species that were highly dependent on the stand before harvest will be replaced by other species asssociated with early successional habitats • site preparation for artificial or natural regeneration can damage soil structure • openings make the site more vulnerable to soil erosion and desiccation • on some sites, may result in changes to the water table (e.g., usually causing a rise in its level) Forest Management • hot, dry conditions in large openings can hinder establishment of regeneration • large amount of slash on ground after harvest can be a potential fire hazard • relying on natural regeneration is rarely successful unless intolerant hardwoods such as white birch and poplar are the desired species • stands will not produce marketable wood products for a long time • competition from non-crop competing vegetation may be intense Economic • may require high investment in site preparation, artificial regeneration, and tending Social • often unpopular with the public because of poor aesthetic appearance of site after clearcut