6.2 UPLAND OAKS


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Introduction

Upland oak forests, as defined in this guide, are comprised of at least 50 % oak and hickory species. A variety of other tree species such as poplar, white pine, black cherry, white ash, sugar maple, red maple, ironwood, basswood, beech, and eastern red cedar may also occur in these forests but normally do not form a dominant component. Forest types dominated by black oak are found mainly in Site Region 7E. Also upland forests in this site region may contain Carolinian species such as sassafras, chinquapin oak, and tulip tree that are more characteristic of the deciduous forests of some parts of the northern United States.

Upland oak forest canopies are usually more open than those of the tolerant hardwood forests, with canopy closure ranging from 60 to 75 %. Soils are often shallow and droughty. Drainage varies but often ranges from rapid (DR 2) to moderately well-drained (DR 4). Site moisture regimes commonly range from dry (MR 0) to fresh (MR 1,2,3).

Stands with a composition of slightly less than 50 % oak and/or hickory species can still be managed under the proposed silvicultural systems described in this section, but lower species composition percentages (e.g., less than 30 % oak species) can be managed as individual trees dictate (i.e., when oak is encountered in sufficient quantity, it can be managed).

Forests dominated by oak species are most common in southwestern Ontario. The ELC for southern Ontario describes four Ecosite (Lee *et al.* 1998) that correspond to upland oak forests in which oak species comprise the dominant component. These ecosites are briefly described below.

Dry-fresh oak deciduous forest ecosite (FOD1)

This ecosite is typically found on sands and coarse loams or on sites with shallow soils (e.g., less than 30 cm deep). Gley is not found in these soils. Mottles, if they occur, are located below 60 cm. Frequently this forest ecosite is found on upper to mid-slope and tableland topographic positions.

In general, the vegetation of this ecosite is adapted to tolerate well-drained, droughty soils; direct sunlight; and periodic disturbance (e.g., fire). Oak species exhibit several such adaptations including the ability to develop deep root systems and resprout from suckers, and a relatively thick, fire-resistant bark.

The ELC for southern Ontario describes four forest types for this ecosite. One of them, the dry-fresh black oak deciduous forest type, is dominated by black oak, growing in association with eastern red cedar, poplar species, and black cherry, and is considered rare in southern Ontario. It is most common in Site Region 7E. Another, the dry-fresh mixed oak deciduous forest type, is also considered rare in southern Ontario. It is characterized by having more than two codominant oak species (e.g., red, white, black, bur, or chinquapin oak), and is also more

common in Site Region 7E, but also occurs on the Frontenac Axis in southeastern Ontario, and sporadically on dry ridges throughout Site Region 6E. The two other forest types, the dry-fresh red oak deciduous forest types and the dry-fresh white oak deciduous forest type are dominated by red and white oak respectively, and are common in both site regions.

Dominant Trees	red oak, white oak, or black oak, either as single or mixed-species stands
Less Common Associates	red maple, white pine, and black cherry; sugar maple is an uncommon associate
Common Shrubs	wintergreen, low sweet blueberry
Common Herbs and Ferns	bracken fern, starflower
Soil Moisture Regime	dry (MR 0) to fresh (MR 1,2)
Soil Drainage	rapid (DR 2) to well-drained (DR 3)
Equivalent Ecosite in Central Ontario	ES14 but no black oak in Site Region 5E, white oak uncommon; occasionally occurs on moist soils (Chambers *et al.* 1997)

Dry-fresh oak-maple-hickory deciduous forest ecosite (FOD2)

This ecosite is typically found on sands and coarse loams having some silt and clay particles, as well as fine loams and clays. It appears to represent a transition from sites subject to periodic droughty conditions to sites with more available soil moisture. Like the preceding ecosite, gley is absent and mottles are found below a depth of 60 cm. Canopy closure tends to be higher than for the preceding ecosite. It is also often found on upper to mid-slope or tableland topographic positions.

Disturbance may occur infrequently on this ecosite. This factor, together with increased soil moisture availability, allows mid-tolerant hardwoods such as red maple, shagbark hickory, and bitternut hickory to become associated with the more intolerant oak species. If disturbance such as fire is suppressed, a shift in dominance to more shade-tolerant hardwoods is quite possible.

The ELC for southern Ontario describes four forest types for this ecosite. The dry-fresh red oak and dry-fresh oak-sugar maple deciduous forest types are common in both Site Regions 6E and 7E. The dry-fresh red oak-red maple deciduous forest type is common in Site Region 7E but only occurs sporadically on the Canadian Shield in Site Region 6E. The dry-fresh oak-hickory forest type is common on the Napanee limestone plain, but occurs sporadically elsewhere in southern Ontario. The dry-fresh hickory forest type is considered rare in southern Ontario.

Dominant Trees	red oak, and to a lesser extent, white oak, dominate or share dominance with other deciduous trees, commonly red maple, shagbark hickory, and bitternut hickory
Less Common Associates	sugar maple, white ash, beech, basswood, ironwood, and black cherry; sugar maple comprises less than 25 % of canopy cover
Common Herbs and Ferns	trilliums, hepaticas, bellwort, Jack-in-the-pulpit, zigzag goldenrod
Soil Moisture Regime	primarily fresh (MR 1,2,3) but may also be moderately dry (MR 0)
Soil Drainage	well-drained (DR 3) to moderately well-drained (DR 4)

Dry oak-pine mixed forest ecosite (FOM1)

This ecosite is comprised of mixed forest (i.e., conifer and deciduous) growing on dry upland sites. Soils are usually rapidly drained sands and loams. The canopy is typically open in nature.

The ELC describes two forest types for this ecosite. The dry pitch pine-oak mixed forest type only occurs in the Thousand Islands region on the Frontenac Axis. Pitch pine is considered to be a provincially rare species, and often grows on south-facing slopes, with red oak, white oak, white pine, and eastern red cedar. The dry chinquapin oak-pine mixed forest type is found sporadically throughout Site Region 7E, usually growing on shallow, coarser soils (e.g., sands). Common associates of this forest type include red oak, chinquapin oak, white oak, and white pine. Both these forest types benefit from disturbance such as fire that controls competition and encourages regeneration of the oaks and pines.

Dominant Trees	white oak, red oak, chinquapin oak, pitch pine, white pine in variable mixtures
Common Shrubs	low sweet blueberry, buffalo-berry, and common juniper
Common Herbs and Ferns	bracken fern
Soil Moisture Regime	dry (MR 0) to fresh (MR 1).
Soil Drainage	rapid (DR 2) to well-drained (DR 3)

Dry-fresh white pine-maple-oak mixed forest ecosite (FOM2)

The vegetation on this ecosite is also mixed conifer-deciduous on upland sites. It is found on both shallow and deep sands, loams, and clays.

The ELC describes one forest type that might correspond to upland oak forests. The dry-fresh white pine-oak mixed forest type is commonly found on the Frontenac Axis and occurs sporadically throughout Site Region 6E. It is rare in Site Region 7E but may have been more prevalent prior to logging (Lee *et al.* 1998). The most common dominant species are red oak, white oak, and white pine. Common associates include ironwood and red maple. Disturbances such as fire control competition and allow the pine and oaks to dominate.

Dominant Trees	white pine with sugar maple, red oak and to a lesser extent, white oak; dominant species varies
Less Common Associates	red maple, basswood, white ash and ironwood
Common Shrubs	serviceberry, wintergreen, downy arrowwood, low sweet blueberry, partridgeberry
Common Herbs and Ferns	bracken fern, gaywings, bristle-leaved sedge, white trillium and rough-leaved (mountain) rice grass
Soil Moisture Regime	dry (MR 0) to fresh (MR 1,2,3)
Soil Drainage	rapid (DR 1) to moderately well-drained (DR 4)

Carolinian species associations

Upland oak forests found in Site Region 7E (i.e., Carolinian Life Zone or Deciduous Forest Region) often include tree species found only in southwestern Ontario. These species include American chestnut, dwarf chinquapin oak, Hills oak, pignut hickory, and sassafras. If these species exist in the stand being considered for management, contact the OMNR District Ecologist to determine their degree of rarity within the local area and the greater region. The habitat of species considered to be locally or regionally rare or in serious decline should be protected. Endangered species, such as the cucumber magnolia, and their habitats, are protected by the Endangered Species Act.

Changes since the presettlement era

Many oak forests may have originated with human fires (Foster *et al.* 1992). In the northern conifer and hardwood forests of New England and the Lake States region, red oak increased dramatically following early logging and the subsequent fires set by settlers to clear land. Also early rail transport probably started many severe fires (from hot coals). Repeated burning may have contributed to soil sterilization in some areas. In eastern Ontario, studies at the turn of the century demonstrated that the diversity and density of trees was lowest in areas that were subjected to greater numbers of burns (Keddy 1993). But the frequency of red and white oak typically increased with repeated burning.

Studies of dendro-ecology and successional dynamics of several old-growth forests indicate that prior to European settlement, oak species grew and regenerated in uneven-aged conditions. Oak species were present in relatively low numbers in the overstory of the presettlement forest, but may have been pervasive in the understory of former pine forests (Abrams 1996). The expansion of oaks following large-scale fire disturbances was also helped by the widespread dispersal of acorns by birds and small mammals. Oak species also benefited from the elimination of overstory American chestnut trees as a result of the chestnut blight fungus in the early 1900s.

Throughout the northern tolerant hardwood forest, oaks exhibited continuous recruitment into the canopy during the 17th, 18th and 19th centuries, but this stopped in the early 20th century. Since that time, more shade-tolerant, late-successional species have dominated understory and canopy recruitment, coinciding with the period of fire exclusion throughout most of northeastern North America. Harvesting of oak forests that have understories dominated by later successional species often accelerates the oak replacement process (Abrams 1996).

A more recent and severe deterrent to oak seedling longevity and height growth that was probably not a major factor in presettlement forests is the browsing of oak seedlings by deer. In the eastern United States and much of southern Ontario, as later successional species invade oak understories and deer populations grow, oak seedlings are readily being over-topped and exhibit very low recruitment beyond the seedling stage (Abrams 1996). The continued exclusion of fire, together with competition from shade-tolerant species and browsing pressure from deer, are contributing to decreased percent composition of oak species in southern

Ontario forests. Therefore, management techniques that help recruit oak into the overstory will be important to maintaining oaks on suitable sites in southern Ontario.

Choosing an appropriate silvicultural system

The upland oaks are among the most difficult tree species to consistently regenerate successfully, regardless of the silvicultural system used. The selection of the most appropriate silvicultural system is critical for the management of upland oak forests and depends on several factors including:

- an understanding of the autecology of the desired species
- site potential or capability
- presence of advanced regeneration
- wildlife habitat and other natural heritage values
- other considerations

These factors are briefly discussed below and summarized in **Table 6.2.2.**

Autecology of oaks

Some knowledge of the autecological characteristics of oak species described below is an important prerequisite for the selection and implementation of the most appropriate silvicultural system(s) designed to encourage successful establishment and regeneration of upland oak stands. **Table 6.2.1** summarizes more specific autecological information for five species that occur in southern Ontario and more detailed information can be found in **Appendix B**.

Reproduction and early growth of upland oak species

a) *Seeds and germination*

- Acorn production varies greatly among oak species and individual trees, and in different locations and years (Aucmoody *et al.* 1993; Sork *et al.* 1993; Dey 1995). It is influenced by weather, insects, wildlife, tree age and size, crown position, and genetics (Dey 1995).
- In many areas, predation by insects, disease, and consumption by numerous mammals and birds can substantially decrease germination of new generations, except in bumper crop years.
- Viability of seed is high.

b) *Site factors*

- Ideal seedbeds for acorns are fresh, well-drained mineral soils.
- Best germination rates occur when acorns are either three to five cm below the soil surface or are in contact with mineral soil, with a layer of leaf litter covering them (Sander 1979).
- Seedlings are more numerous where mineral soil has been disturbed (e.g., by fire or logging).

c) *Early growth*

- Germination is followed by vigorous, rapid tap-root development.
- On productive sites, where competition is often most intense and germination is greater than survival, lower understory light conditions due to high canopy closure typically result in mortality of the comparatively large cohort of young seedlings before the next bumper acorn crop occurs (i.e., within a few years (Johnson 1994)). Consequently, advanced regeneration on these sites develops from a single bumper acorn crop (Dey and Parker 1996).
- On drier, less productive sites, there may be more sunlight in the understory, but other conditions are less favorable for seed germination. As a result, fewer seedlings become established but they tend to persist for a longer time in the understory. Here, advanced regeneration may represent seedlings and seedling sprouts that accumulate and develop from several acorn crops, particularly bumper acorn crop years.
- Although oaks grow slowly in heavy shade, survival rates are relatively high in moderate shade. Here, they often develop little above the ground (i.e., the top usually dies and resprouts) but grow a large root system that allows them to grow rapidly in height once favorable conditions occur.
- Seedling survival and development are largely dependent on adequate light levels, but are also influenced by soil moisture, nutrients, levels of browsing, insect defoliation, drought, and frost (Johnson 1994; Crow 1992; Gottschalk 1988).
- They grow more rapidly under full sunlight conditions than their more tolerant associates.

d) *Sprouting*

- Since oaks are usualy difficult to regenerate satisfactorily, the use of stump sprouts as prime growing stock can help to encourage successful regeneration of these species. These sprouts, when supported by large, established root systems, represent the fastest growing form of oak regeneration (Dey 1994).
- Stump sprouts are an acceptable form of regeneration when they originate from within 2.5 cm of the groundline (Roth and Hepting 1969). Even stump sprouts originating from below the surface of the ground can produce high quality mature trees (Johnson 1994).
- Red oak is usually a prolific stump sprouter, especially trees less than 60-years- old; oaks more than 80-years-old have less than a 50 % chance of producing a competitive stump sprout (Sander *et al.* 1984; Phillips and Shure 1990). Oaks less than 20 cm DBH and 80-years-of-age are usually good sprouters. Oaks larger than 50 cm DBH sprout infrequently. The decreasing ability of oaks to sprout from stumps as they increase in age and size may be due to the inability of the dormant buds to penetrate the thicker bark of older trees (Dey and Parker 1996).

Reaction to competition

- Relative diameter growth is usually greater than that of common hardwood associates.
- Oaks have a high root/shoot ratio. The relatively higher root mass then facilitates rapid shoot growth after overstory harvest or destruction by natural forces (Johnson 1994).
- Oak is well adapted to disturbance since it has the ability to resprout, a deep root system, and thick bark (i.e., fire resistant). Stand disturbance offers oaks a competitive advantage provided that advanced regeneration has accumulated before the disturbance occurs (Larsen and Johnson 1998).
- Oak responds well to release from suppression; sapling and pole-sized dominants or codominants respond best.
- Oaks are susceptible to epicormic branching following heavy release; dominant and codominants develop fewer sprouts than suppressed trees and there is less serious development in older trees.

Factors limiting growth and development

- *Gypsy moth:* The most significant impact of gypsy moth infestation on oak is not mortality but reduced growth, yield, and wood quality (Johnson 1994). Gottschalk (1993) describes strategies designed to minimize gypsy moth impacts, including reducing the proportion of oaks in the stand, applying insecticides, and removing trees that are the preferred hosts or refuges for the insect.
- *Oak shredder*: This insect continues to cause pockets of defoliation in southcentral Ontario (e.g., 525 ha in 1997, 2078 ha in 1998, and 1,580 ha in 1999 (Howse and Scarr 1999).
- *Oak decline:* It is probably initiated by drought stress and/or defoliation and then exacerbated by further insect and disease attack (Wargo and Haack 1991). Older stands on unproductive sites are most susceptible to it (Oak and Starky 1991). There is some evidence that partial cuts in declining stands may increase the severity of decline, due partly by providing an increased food supply for shoot string root rot (Starkey *et al.* 1989).
- *Oak wilt:* This potentially lethal vascular disease is common in the Lake States. lt is spread by an insect vector (*Nutidulid* sap-feeding beetles) and may be detected in southern Ontario in the future.
- Although the oaks are considered to be relatively decay-resistant, they can be susceptible to several diseases and fungi. There are four major white trunk rots and one major brown butt rot fungi that affect red oak. Others include shoestring root rot and *Strumella coryneoides* that causes a severe girdling canker (OMNR 1998*a*). Galleries created by the carpenterworm and red oak borer may become infected with decay fungi.
- White-tailed deer readily browse oaks, often eliminating patches of regeneration. In many parts of the United States and southern Ontario, browsing by high deer populations is believed to have reduced the proportion of oak species in many northeastern hardwood forests since the time of settlement (Abrams 1996).
- Oak seedlings and saplings are vulnerable to fire, however the thick bark of older trees allows them to resist light fire damage. Burns are beneficial in re-establishing oak on a site.

Table 6.2.1. Autecology of common species in the upland oak forest cover type (Burns and Honkala 1990*a* and *b*).

Species	Red oak	Bur oak	White oak	Black oak	Chinquapin oak
Site	Well-drained, fresh, loam-silt loam	Shallow over limestone; tolerates wide range of soil and moisture conditions	Wide range of soils and sites	Fresh, well-drained soils; light, dry sands	Well-drained upland soils derived from limestone or over limestone
Canopy openings to secure regeneration/growth	Uniform canopy (60%)	Uniform canopy (60%)	Uniform canopy (60%)	Uniform canopy (60%)	Uniform canopy (60%)
Seed periodicity	2-5 years	2-3 years	4-10 years	2-3 years	4-7 years
Seedbed type	Mineral soil, humus, mineral-humus mix; best if covered with light layer of leaf litter	Disturbed litter	Humus	Mineral soil	No data
Sprouting ability	Very good	Poor	Very good	Good	Good
Likelihood of advanced regeneration	Low (upland sites only)	Common under thinned plantations	Low-moderate	No data	No data
Shade tolerance	Intermediate	Intermediate	Intermediate	Intermediate	Intolerant
Tending need	Competition	No data	Competition	Competition	No data
Self-pruning	Moderate	Moderate	Moderate	No data	No data
Response to release	Moderate (poles & saplings only)	No data	Very good (poles & saplings only)	Very good (codominant, above-average intermediate crown classes only)	Very good
Rot/stain defect	Moderate-low	Low	Low	No data	No data
Bole/form defect	Epicormics	Branching, epicormics	Branching, epicormics	Crooked stems, epicormics	No data
Decline hazard	Moderate-high	High (serious decline caused by canker, oak wilt)	No data	No data	No data
Growth rate	Moderate-fast	Slow	Slow	Slow-moderate	Slow
Wildlife values	Mast, wildlife browse	Mast	Mast, cavities	Mast, cavities	Mast

Site potential or capability

Landowners and managers must determine whether the prevailing site conditions and growth rates permit the production of timber products. If not, the stand is better suited to management for other values such as wildlife habitat, that may not require timber harvesting.

The potential of the site for oak production, as suggested by the ecosite and current site and stand conditions, also helps to determine the silvicultural system of choice. Site quality assessment is an evaluation of soil characteristics (e.g., texture, drainage, fertility, depth), topography (e.g., aspect, elevation), climate, and other factors that influence growth and species composition, and ultimately provide an indication of the suitability of a site for the growth of certain species or forest types. This assessment is essential to determine the amount of effort required to manage a stand for upland oaks.

The upland oak forest type is usually found on sites with dry to fresh moisture regimes (MR 0-3). When managing for oak species, Johnson (1993, 1994) found that dry sites were considerably easier to work with because advanced oak regeneration readily accumulates. Although it is often easier to regenerate red oak on drier sites (Hilt 1985; Trimble 1973), fresh to moderately moist sites (MR 1-4) have better potential for higher quality, growth, and yield. However the latter are prone to numerous silvicultural challenges such as regeneration success and competition.

Red oak site index curves have been developed from data from forests in northern Wisconsin and Upper Michigan (Carmean *et al.* 1978), and are reproduced in **Appendix E**. Data collected in the future from growth and yield plots (**Section 7.3**) will also help to determine the most suitable ecosites for the management of oaks in southern Ontario. In the meantime, Sander (1977) provides a description of three general site quality types that may help managers assess the potential for oak production, of sites in southern Ontario. They are:

1. Good quality sites = 22 + m at 50 years. It will often be difficult and impractical to perpetuate pure oak stands on these sites because of intense competition from other species.
2. Medium quality sites = 16 - 20 m at 50 years. These sites are well suited to oak management and the perpetuation of oaks should not be difficult. It is still important to ensure that adequate advanced regeneration is established.
3. Low quality sites = 10 - 14 m at 50 years. These sites are often exclusively occupied by oaks and white pine of poor timber quality. Frequently it is best not to manage these stands or to consider encouraging mixtures of pine and oak.

The site index curves provided in **Appendix E** should not be used for coppice stands, uneven-aged conditions, or mixed species stands (E. Boysen, OMNR, personal communication, 1997).

Presence of advanced regeneration

Knowing the amount and requirements of the existing advanced regeneration on a site makes it easier to select the most effective silvicultural treatment designed to encourage successful oak

regeneration, and to schedule operations. For example, red oak seedlings require one-third of full sunlight for maximum photosynthesis to occur (Dey 1994) and silvicultural treatments would need to be designed to provide this level of light. Also removal of the overstory should not occur before there is sufficient healthy oak advanced regeneration in the understory (Sander 1979; Johnson 1993, 1994; Dey and Parker 1996), and some supercanopy trees (**Section 4.4, Table 4.4.1**) should be retained in the stand.

Wildlife habitat and other natural heritage values

Upland oak forest often support many wildlife habitats, as well as rare species and other important forest values. **Section 4.4** and **Tables 4.4.1**, briefly discuss many significant wildlife habitats that managers and landowners should be aware of when considering silvicultural management.

Dey (1995) notes that nearly 200 wildlife species utilize acorns as a food source including chipmunks, squirrels, deer, bears, foxes, raccoons, waterfowl, woodpeckers, blue jays, and numerous insects. Oak is used by more species of wildlife than any other hard/soft mast producer.

The importance of upland oak forests is recognized by the OMNR. Current OMNR guidelines (Voigt *et al.* 1997) recommend the management of oak stands within two km of deer yards, to maintain and perpetuate mast production. Black bears may depend heavily on acorns to help them accumulate fat reserves required for hibernation. In parts of southern Ontario, acorns are also very important forage for recently re-introduced wild turkeys. Even when the provision of wildlife habitat is not a management objective, forest managers should encourage landowners to retain good mast-producing trees for the benefit of wildlife. The wildlife habitat guidelines provided in **Table 4.4.1** should be adhered to when managing oak forest cover types in southern Ontario.

Before finalizing silvicultural plans for upland oak stands managers should have a good understanding of the amount and distribution of forest cover, by forest cover type, in the surrounding local region. Silvicultural prescriptions designed to regenerate upland oak forest cover types create significant canopy openings at some time in the rotation. These open conditions can further fragment small, narrow forest patches and increase amount of edge habitat in the short-term. If the oak forest provides habitat to sensitive wildlife species, they may be negatively impacted during those times in the rotation that more open conditions prevail, and habitat loss may be inevitable. Managers need to balance objectives for regenerating and perpetuating oak species and forest cover types, against the risk of further forest fragmentation and increasing the amount of edge habitat. For small isolated forest stands (< 20 ha) with no connectivity to larger forest areas, treatments such as group selection and shelterwood that create more open conditions are less likely to create negative wildlife habitat impacts.

Other considerations

At least three other considerations, landowner objectives, available resources (e.g., financial, human, time), and the feasibility of conducting prescribed burns (**Section 8.1**), will also influence the choice of the silvicultural system for management of upland oak stands. The primary objectives for the management of most upland oak stands will likely be maintaining a significant oak component and encouraging the establishment and vigorous growth of (advanced) oak regeneration. However, many landowners and managers may have several other objectives (e.g., need for immediate generation of forest revenue, protection of wildlife habitat) that must be factored into the choice of the most appropriate silvicultural system.

In southern Ontario, the management of the majority of upland oak stands is likely to prove to be considerably more expensive and time-consuming than the management of tolerant hardwood forests because of the difficulties associated with assuring successful oak regeneration on most sites.

On many sites, the use of prescribed burns provides a competitive advantage for oaks, encourages oak regeneration, and discourages undesired competition from other species. However, in much of southern Ontario, this management tool may not be an option due to public concerns (e.g., neighbors fearing the escape of the fire) and local fire and burning regulations.

Recommended silvicultural treatments for upland oaks

Table 6.2.2 summarizes site and stand conditions and landowner objectives that help to determine the most suitable silvicultural system (i.e., group selection or uniform shelterwood) for the management of upland oak forests. If the uniform shelterwood system is chosen, and the stand is not yet mature enough to implement a preparatory cut, then the silvicultural treatment, crop-tree thinning could be considered. Crop-tree thinning, uniform shelterwood, and group selection, and their specific parameters for upland oak management are discussed in greater detail in the remainder of this section.

Table 6.2.2: Choosing an appropriate silvicultural treatment for upland oak forests in southern Ontario.

	Crop-tree thinning	Regeneration treatments	
		Uniform shelterwood	Group selection

Objectives for stand	• to produce high quality timber from future commercial harvests	• to develop new even-aged stand with representative component of oaks and other mid-tolerant species
		• landowner is flexibile with regard to timing of cutting treatments so that they can be done in years with good acorn crops
			• to develop patches of even-aged regeneration with some representation of oaks and other mid-tolerants, resulting in a stand with a patch mosaic of different ages (ultimately uneven-aged)
			• landowner is willing to:
			  • accept fluctuations in harvest yield by cutting cycle
			  • settle for moderate levels of oak composition to minimize risk of regeneration failure and insect damage

Site conditions	• see description for "uniform shelterwood"	• suited to medium to low quality sites with moisture regimes ranging from MR 1-4 • on good quality sites or under mesic and hydric conditions (MR 2-5), will likely require both overstory and understory density control and yet it may still be difficult to regenerate these sites to oak (Schuler and Miller 1995) • pockets of even-aged red oak/white pine exist within the stand • low risk of invasion by exotic shrubs or herbaceous vegetation	• overstory contains groups of defective or overmature trees and management for old-growth characteristics is not desired • intolerant and mid-tolerant species (e.g., basswood, white ash, red oak, yellow birch, black cherry) comprise 10 to 40 % of the stand composition and site and stand conditions are suitable for regeneration and growth of these species • low risk of invasion by exotic shrubs or herbaceous vegetation
Stand conditions	• if stand is even-aged and young (i.e., <45-years-old) then use crown touching • if stand is even-aged and >45-years-old but not within 10 years of rotation age (i.e., too young to implement shelterwood) then use crop-tree selection and thinning (based on stocking Aappendix E) to boost diameter growth and quality	• average stand DBH is 40-60 cm and/or average age is 50-100 years and it is time to consider regenerating the stand; the initial shelterwood cut should occur at least 10 years before the end of the rotation (Johnson 1994) • preferably little established or regenerating tolerant hardwoods • stands need to be large enough to permit a 30 m buffer on forest edges to protect interior habitat and reduce invasion by exotic species	• preferably little established or regenerating tolerant hardwoods or vegetation management will be required • preferably presence of sufficient healthy oak advanced regeneration • stands need to be large enough to permit a 30 m buffer on forest edges to protect interior habitat and reduce invasion by exotic species
Wildlife habitat	• see description for "uniform shelterwood"	• avoid implementation in areas where forest interior species may be negatively impacted by large canopy gaps	• avoid implementation in areas where forest interior species may be negatively impacted by large canopy gaps
Aesthetic considerations	• produces a more uniformly spaced stand with less diversity of sizes; crop trees will likely have paint on them	• most of the high forest canopy will be lost for a period of time following removal cut(s)	• stand develops patchy appearance and a significant proportion of high forest canopy is always maintained
Landowner follow-up commitment required	• when the even-aged stand must be regenerated either by uniform shelterwood or group selection	• frequent understory vegetation control to minimize undesirable species competition • may also need to consider supplemental planting where natural regeneration is not sufficient	• frequent understory vegetation control in openings to minimize undesirable competition • may also need to consider supplemental planting to boost stocking where natural regeneration in canopy gaps is not sufficient

Crop-tree thinning

In even-aged stands, thinning can be conducted using a crop-tree approach. Crop-tree thinning considers individual trees as candidates for a final crop and releases their crowns to allow for the development of high value products (Anderson *et al.* 1990). Two techniques can be used to accomplish crop-tree management:

1) Where even-aged upland oak stands are less than 45-years-old, the crown touching method is recommended.
2) In stands older than 45-years-of-age, but not yet within 10 years of rotation age (or where most trees have not yet reached 80 % of the rotation diameter), crop-tree management can be accomplished by thinning to specific residual basal area levels, determined by consulting the specific stocking guides for red oak given in **Appendix E**.

In general, thinning should be done by creating canopy gaps no larger than 1.5 m wide on three or four sides of selected crop trees (Sampson *et al.* 1983). Both thinning techniques are discussed in detail below. Regardless of technique, thinning should never reduce crown closure in upland oak stands below 70 %.

In stands that contain many stems from stump sprout origin, stump sprout thinning should be considered if high quality wood production is a management objective. Since stump sprout thinning is most economically conducted at the same time, it is also discussed in this subsection.

When to begin thinning

Thinning in young stands should be undertaken conservatively soon after crown closure but not until dominant stems can be recognized. Nyland and Marquis (1978) warn that ill-conceived early thinning treatments can delay natural pruning and promote epicormic branching, low forking, and sunscald. Furthermore it should only be conducted when it is necessary to maintain survival and stocking of potential crop-quality trees (Anderson *et al.* 1990).

Usually stands that have originated from advanced regeneration or seedlings do not need to be thinned prior to stand age 45 (Hibbs and Bentley 1983) and in some cases thinning prior to this could reduce potential financial returns because the value gained in additional diameter growth resulting from the thinning will not compensate for the value lost in merchantable height from lack of self-pruning (Hibbs and Bentley 1983). They suggest a rotation of about 95 years would maximize returns. Therefore the timing of first thinnings in even-aged upland oak stands is a compromise between shortening the rotation period and optimizing the effects on bole quality and value (Anderson *et al.*1990).

Where oaks are overtopped by long-lived competitors early in a rotation, early release may be necessary for oaks to attain dominance. Where this occurs, Miller *et al.* (1998) recommend deferring thinning until the 20- to 60-year-old codominant trees average 7.6-9.1 m tall.

Crown touching method

In southern Ontario, this method is recommended for use in stands less than 45-years-old. All trees, except another crop tree, with crowns touching or overlapping above or below the crown of a crop tree, are removed. Generally tree removal is only warranted if it will benefit a crop

tree. This type of release can provide the crop trees with up to twice the diameter growth of the surrounding, unreleased trees (Anderson *et al.* 1997).

Silvicultural objective

In young even-aged stands (e.g., polewood to small sawtimber) or where precommercial harvests are under consideration, it is best to base these thinnings on a crop-tree approach, to focus future growth on trees with the best opportunity to increase in quality and value. Crop-tree thinning releases crowns to allow for the development of high value products (Anderson *et al.*1990). Crop trees can also be selected to meet wildlife, aesthetics and other management objectives (Perkey *et al.* 1993)

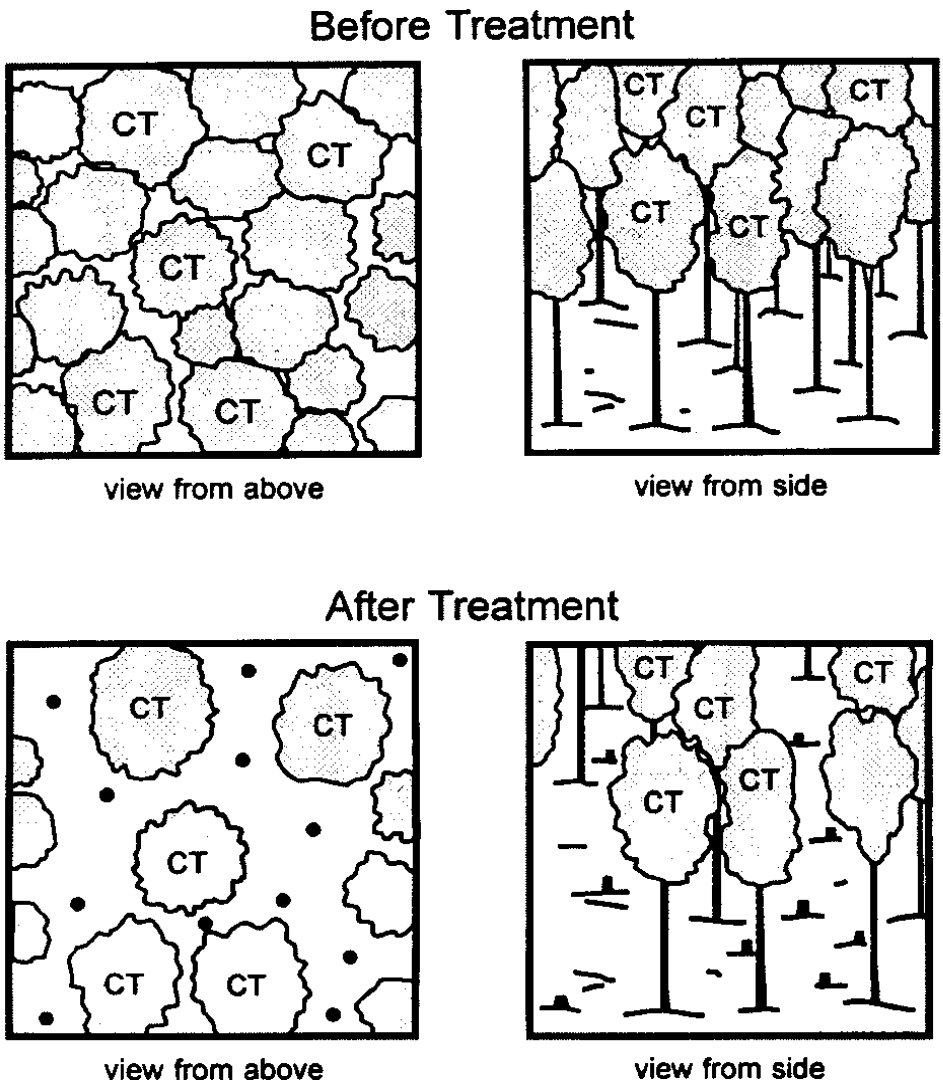

Figure 6.2.1: A schematical representation of a stand before and after treatment by crown touching method (from Perkey *et al.* 1993).