

Table 6.2.3: Guide for rating red oak acorn crops (from Dey and Buchanan (1995)).

Crop rating	Number of acorns/ha (thousands)	Average number of acorns/m²	Average number of acorns/60 cm branch tip
Bumper	>600	>60	= 25
Good	300-600	30-59	17-24
Fair	160-300	16-29	9-16
Poor	50-160	6-15	4-8
Trace to none	<50	<5	<3

Seedbed preparation

Seedbed preparation is not necessary for oaks. However, summer or fall logging appears to benefit oak establishment by increasing mineral soil exposure, tramping advanced shade-tolerant regeneration, and burying acorns.

Controlling competing vegetation

Control of competing vegetation is also essential. Cutting treatments often result in rapidly growing sprouts that continue to pose a competition problem. Reduction of understory competition improves the rate of growth for seedlings and new sprouts by helping to ensure they receive sufficient moisture and sunlight. Jacobs and Wray (1992) suggest a method to evaluate the severity of understory competition. If 30 % of a series of 6 m² circular plots used to inventory the understory vegetation are dominated by competing species and the oak regeneration is less than 30 cm tall, control of competing understory vegetation is highly recommended. Where oak regeneration in the plots consists of mainly stump sprouts and regeneration is greater than one meter in height, understory vegetation control is only necessary when 70 % of the plots are dominated by undesirable species.

Herbicide treatment and prescribed fire are the two most effective means of controlling the competing vegetation and maintaining the growth of the desired oak species. Further details on vegetation management treatments are provided in **Section 8.1**, but details more particular to regenerating oak by use of prescribed fire are provided here. Unfortunately, in many parts of southern Ontario that are now dominated by agricultural and urban land uses, prescribed fire is not a feasible option. Instead, managers use manual cutting and/or herbicides to mimic the effects of ground fires.

Prescribed fire

Prescribed fire is used to control understory competition for sunlight and reduce the regeneration potential of non-oak species. Periodic understory burns create a more open environment on the forest floor by reducing the amount of understory vegetation, especially on mesic sites (MR 2-4), where oaks can be considered to be fire subclimax species. Oaks can survive high intensity and repeated burns because they have a large supply of dormant buds at the root collar (Korstian 1927) and a large root system (Dey and Parker 1996). The dormant buds are



protected from the heat of the fire by being located in the mineral soil (Little 1974). These characteristics provide oak with a competitive advantage over hardwood species that have fewer, more exposed buds, and smaller root systems. Prescribed fires do not increase the number of advanced oak regeneration but they do improve their vigour, form and height growth (Brose and Van Lear 1998).

The number of burns required to effectively control competing understory vegetation is unknown but research and experience suggest that on most sites, a minimum of two burns is required to reduce the competition (Dey 1994b). In one multi-burn trial near Bracebridge, Ontario, Mutchmor and Morneau (1995) found that there was no improvement in advanced oak regeneration after two consecutive spring prescribed burns. Research by Nyland *et al.* (1983) indicated that two burns, four years apart, effectively controlled competing understory vegetation and oaks were able to resprout and grow without serious difficulty. Dey and Parker (1996) recommend scheduling prescribed burns every three to five years; shorter return intervals have indicated no improvement in oak regeneration.

Studies in Ontario have shown that fire-caused mortality of red oak decreases with age; seedling mortality was 30 % for three-year-old seedlings (Dey 1994b, Mutchmor and Morneau 1995) and up to 70 % for one-year-old seedlings following a spring burn (Johnson 1974, Mutchmor and Morneau 1995). For this reason, Dey and Parker (1996) recommend that burns be conducted either right before a good acorn crop or three years following a good crop, to allow sufficient time for germination and seedling establishment.

When selecting a site for prescribed burning, the following factors should be considered:

- *Site type:* Sites that are good candidates for red oak shelterwood management and that are drier and less herb-rich will likely need fewer fires to promote red oak regeneration than the moister, richer sites with a higher component of hardwoods (OMNR 1998a).
- *Understory distribution and species composition of shrubs and hardwood regeneration:* Used to assess competitiveness of site and potential for the need for more than two burns or a follow-up chemical/manual tending treatment. Spring prescribed burns of low to moderate intensity can kill balsam fir from 3 to 15 cm in basal diameter (Methven and Murray 1974) and the above ground portion of hardwood shrubs and trees up to 10 cm in diameter (McCarthy and Simms 1935, Lotti *et al.* 1960) depending on the local fire intensity and stand conditions. Although the conifer understory is easily killed by fire, hardwood trees and shrubs resprout. Some species sprout more vigorously than others. Hazels are very vigorous sprouters and can only be reduced by repeated summer burns (Van Wagner 1963, Buckman 1964). Basswood, red oak and white birch are vigorous sprouters while elm, bur oak, ironwood, and red maple are slightly less vigorous (Perela 1974). The least vigorous sprouters are sugar maple, beech and yellow birch (Perela 1974).
- *Presence of advanced oak regeneration:* prescribed fire is most effective when advanced oak regeneration has a well established root system (three years or more).
- *Access:* Must be adequate to move people, fuel and equipment at a reasonable cost.



- *Values*: Check for values that may need to be protected or where people must be notified about the prescribed fire.
- *Boundaries*: Good natural boundaries (low, wet area in spring, creek, river) reduce the complexity and cost of a burn.
- *Water sources*: A good water source for suppression. Can be as small as a creek or pond, but its suitability should be checked if it is likely to be seasonal.
- *Topography and slope*: Used to assess difficulty of burning, layout of ignition lines, and potential scorch damage to overstory trees.
- *Size of area*: Will affect resources needed for the burn and the burn cost.

The *Prescribed Burn Planning Manual* (OMNR 1996) describes the planning process, content of an operational plan, and process for public input and review into the plan. This manual should be reviewed when considering prescribed burning as a silvicultural treatment on crown land.

Advanced regeneration

During the time period between the initial regeneration cut and the first removal cut, sufficient numbers of healthy seedlings of the desired species should be accumulating. It is important to monitor seedling density, distribution, growth, and competition, and to intervene when necessary to produce a cohort of desirable regeneration that can respond and dominate the site following overstory removal. The status of oak advanced regeneration can be used to time additional shelterwood cuts including final overstory removal (Dey and Parker 1996).

Sander (1979) suggests that overstory stocking can be reduced to 50 % when the advanced oak regeneration is about 0.9 m tall. In the upland oak forests of the midwestern United States, adequate advanced oak regeneration must be at least 1.4 m tall or 13 mm in diameter at ground level (Clark and Watt 1971; Sander 1971, 1972; Sander *et al.* 1976). Stems of this size or larger will more likely produce reproduction in the dominant and codominant crown classes (Sander *et al.* 1984). Approximately 1075 stems per hectare are required to produce a polewood stand containing 30 % oak by basal area (Sander *et al.* 1976).

According to Clarke and Watt (1971), the seeding cut and subsequent tending and regeneration treatments should focus on producing 1,000 to 10,000 advanced oaks and other target species per hectare. These seedlings should be at least 0.70 to 1.5 meters tall and above the competition.

Although the actual number of required oak advanced regeneration will really depend on factors such as the pre-harvest size of the regeneration, desired level of oak stocking, site conditions and quality, and management intensity, generally higher stocking and larger stems of oak advanced regeneration are required as site quality, competition, and desired level of oak stocking increase; and management intensity decreases (Dey and Parker 1996).

Oak regeneration may still be successful with smaller stems of oak advanced regeneration but Dey and Parker (1996) report that there are numerous examples of oak regeneration failures despite abundant small advanced regeneration.



Expected stump sprouts from trees to be removed in the harvest cut can compensate for deficiencies in advanced oak reproduction. **Table 6.2.4** was developed to assess oak regeneration potential from stump sprouts in the Missouri Ozarks (Sander 1989). To use this table, find the expected proportion of stumps that will produce one codominant stem, based on the site index and parent age of the stand for each diameter class of trees that will be harvested. Multiply this number by the number of trees per hectare in the diameter class that will be harvested. Add these values for each diameter class to be harvested to determine the expected contribution that stump sprouts will make to advanced regeneration following harvesting. The values in **Table 6.2.4** should be used with caution since they were not derived from data from southern Ontario oak stands. If advanced regeneration numbers are still too low, then underplanting can be used to increase the quantity of oak.

For underplanting, Johnson *et al.* (1986) recommends an overstory stocking of 55-65 % with removal of all low competition and subcanopy shade tolerant tree species. He also suggests planting seedlings from 0.7 to 1.3 m tall, with a 10 mm diameter at 2 cm above the root collar.

Removal cut

One or more removal cuts are used to release the advanced regeneration. When the overstory is closed, more than one removal cut may be required to maintain good crown form of seedlings (Bey 1964). Generally final overstory removal should not occur until advanced growth is well established. In Elliott *et al.* (1997), Ralph Nyland suggests that final overstory removals should occur six to ten years after the regeneration cut and before saplings reach 2.5 cm DBH. Often, the final removal cut should not occur before regeneration reaches waist height (0.70 to 1.5 m) and certainly should be completed before these saplings reach 4.6 m in height (Elliott *et al.* 1997).

Black oak and white oak growing in xeric (i.e., drier) ecosystems (MR 0-1) may require two or more decades before they accumulate the root mass necessary for competitive shoot growth after overstory removal. Delaying the final overstory removal inhibits oak reproduction and favors the shade-tolerant species. Furthermore, late removals make larger regeneration more susceptible to severe logging damage that will significantly reduce oak stocking levels. Also removal and release cuts should be carried out when the ground is frozen to protect advanced regeneration.

It is not necessary or always desirable to remove the entire overstory in the final shelterwood cut. A few supercanopy trees (5 to 35/ha or up to 6 m²/ha) left standing may be important for wildlife, aesthetics, and long-term seed sources. Although these trees will have little impact on the development of the new stand, their survival into the next generation helps to mimic natural processes occurring in the forest stand (Dey and Parker 1996).



Suggested modifications for unique stand conditions

Management of upland oak stands by group shelterwood system

Silvicultural objective

To maintain patches of oak trees in an existing stand that may not be dominated by oak species, and where these are unevenly distributed throughout the stand (e.g., on hilltops).

Site description

See the discussion earlier in this subsection of site productivity or capability for a description of suitable sites within a stand where this modification of the shelterwood system is applicable.

Silvicultural prescription

The group shelterwood system creates patch openings (i.e., canopy gaps) to accomplish oak regeneration objectives. The patches have diameters of 1.5 to 2 times the height of the canopy (i.e., opening is equal to or < 60 m across). The location of patch openings should follow the same guidelines as for the location of openings for group selection, discussed in the following section; guidelines for harvest regulation are also the same. Each patch is carried through the series of shelterwood system treatments described previously for the uniform shelterwood system, creating regeneration under the protection of an overstory.

The area between the shelterwood groups can be left to maintain higher stocking levels, large-diameter trees, and/or old-growth features or they can be treated with the group shelterwood system during future cutting cycles. Future patches should be placed against shelterwood patches from previous cutting cycles.

Less than 10 to 20 % of the stand area should be treated as new patches during any one cutting cycle. To minimize both invasion by exotic species and dessication, a buffer of 20 m or more should be left untreated around the forest edge. This silvicultural prescription should not be applied in the interior of core forests.



Table 6.2.4: Expected proportion of stumps that will produce at least one codominant or larger stem at age 20 based on data from the Missouri Ozarks (Sander 1989).

Species	Site index (m)	DBH class (cm)	Age of parent tree (years)			
			40	60	80	100
Black oak	15	5 – 13	.36	.34	.32	.30
		15 – 30	.13	.11	.10	.08
		30 – 40	.06	.05	.04	.03
		43 +	---	.02	.02	.01
	18	5 – 13	.47	.45	.42	.40
		15 – 30	.16	.15	.13	.12
		30 – 40	.07	.06	.05	.04
		43 +	---	.03	.02	.02
	21	5 – 13	.61	.59	.56	.54
		15 – 30	.21	.19	.17	.16
		30 – 40	.19	.08	.07	.06
		43 +	---	.06	.04	.03
White oak	15	5 – 13	.47	.25	.12	.05
		15 – 30	.18	.10	.06	.03
		30 – 40	.06	.04	.03	.02
		43 +	---	.02	.01	.01
	18	5 – 13	.63	.38	.19	.08
		15 – 30	.26	.16	.09	.05
		30 – 40	.09	.07	.05	.03
		43 +	---	.03	.02	.02
	21	5 – 13	.81	.55	.31	.15
		15 – 30	.36	.25	.16	.09
		30 – 40	.15	.11	.08	.06
		43 +	---	.05	.04	.04
Red oak	15+	5 – 13	.86	.86	.49	.49
		15 – 30	.86	.86	.46	.46
		30 – 40	.86	.86	.38	.38
		43 +	---	.86	.24	.24



Group selection system

While this method has been used to successfully manage upland oak forests, most research from the northeastern and central United States suggests that the shelterwood system is preferable. In southern Ontario, oak is usually a difficult species to regenerate in openings, except on very dry sites. Therefore group selection is not recommended if the objective is to create an oak stand. However, it is a potential silvicultural option if the objective is to establish and maintain a component of oak within a larger tolerant hardwood stand, where site and stand conditions imply that this is highly possible.

The following disadvantages of the group selection system should be carefully considered when deciding whether to use this method for management of the upland oak forest type:

- Openings create a large amount of edge that can promote epicormic branching and lead to decreased log quality on residual trees that surround the openings.
- After a number of cutting cycles, it becomes increasingly difficult to mark stands to prescribed residual basal areas because of the challenge of finding sufficiently large areas left to make group openings. This could lead to large fluctuations in yields during some cutting cycles (Roach 1974).
- Unscrupulous operators have used group selection terminology to describe practices that are actually high-grades and diameter-limit cuts (Elliot *et al.* 1998).

Silvicultural objective

This method can be applied to good quality sites, including those with extensive shade-tolerant regeneration (e.g., sugar maple, beech) that prove costly to regenerate and manage uniformly across the stand using the uniform shelterwood system. It will appeal to landowners who want to regenerate oak on upland sites but do not want heavy or total canopy removals that occur with shelterwood methods. Group selection also allows regeneration within more manageable and aesthetically acceptable small openings.

Although this method can maintain an oak component on better sites, managers should not always *expect* the dominant cover type to be oak. Also, the group openings will require intensive management to ensure success.

Regulation of periodic harvests

See the ‘Harvest regulation’ discussion in **Section 6.1**, ‘Group selection system’, for detailed instructions on determining the amount of harvest.

Location of openings

The information collected during the stand inventory will prove useful for determining locations of the group openings. These group openings will create a new age class (e.g., seedlings). Again managers should concentrate their efforts on sites best suited to upland oaks.

There are several guidelines that can be used to determine where they should be located.

- First mark and remove the patches of poorest quality or unhealthy mature trees (i.e., areas where growth and returns are low compared to the rest of the stand (Miller *et al.* 1995).



- If patches of existing oak regeneration of target size are present, locate opening to release them.
- Provide openings in the path of significant seed sources of desired species, to be timed with seed years.
- Locate openings in areas with excessive numbers of trees from a particular size class (Law and Lorimer 1989).
- Try to space the openings fairly uniformly across the stand (Miller *et al.* 1998).
- Consider aspect. (**Table 6.1.9**) On north-facing slopes use openings of a size towards the large end of the suggested range (see “Size of openings” below) to increase the amount of sunlight reaching the floor; on south-facing slopes use openings of a size towards the small end of the suggested range to minimize desiccation of regenerating seedlings, especially during periods of drought.
- Maintain sufficient distance between edges of openings (i.e., minimize long, narrow openings) to prevent shading from reducing the amount of required sunlight to promote regeneration of the desired oak regeneration within the opening (Miller *et al.* 1998).
- New group openings should be placed against previous openings to:
 - avoid promoting epicormic branching in unopened portions of the stand because this reduces timber quality)
 - minimize wind and ice damage (Miller *et al.* 1998)
- Consider the limitations imposed by the landscape, wildlife habitat concerns, and aesthetics and how there might affect silvicultural activities.
- Buffers of at least 30 m should be left around the forest edges to minimize both invasion of exotic species and dessication.
- In large woodlands, group openings should not impact on core areas identified for interior habitat conservation.

Size of openings

Researchers have tested a wide range of opening sizes (Dale *et al.* 1995; Leak and Filip 1977; Minckler 1989) and **Table 6.1.10** summarizes some of these studies on red oak. The results tend to indicate that larger openings up to or greater than twice the height of the stand provide conditions suited to the regeneration of intolerant species such as poplar, white birch, black cherry, and tulip tree. Smaller openings of less than one-half the stand height create conditions best suited to tolerant species including sugar maple, red maple, beech, and hemlock (Dale *et al.* 1995; Minckler 1989).

Minckler and Woerheide (1965) studied oak stands with 10-year-old group opening diameters ranging from 25 to 200 % of tree height and found that opening size had little effect on number of stems of reproduction but strongly affected species composition of saplings taller than 3 m. Opening diameters greater than 100 % of tree height had little added effect on species composition or reproduction growth. In smaller openings, growth was less and shade-tolerant species were more prevalent.



Minckler (1989) re-examined the same trial after 40 years and found that the red oak saplings taller than 3 m were most abundant in gaps of about 100 % of tree height. He concluded that regeneration in canopy openings with diameters from 100 to 200 % of tree height was successful in terms of species, tree numbers, and growth and that larger openings are not usually required or appropriate.

The upland oaks are generally mid-tolerant of shade and the associated hickories range from mid- to intolerant. To encourage regeneration of these species, group openings should provide a minimum of one-third of full sunlight (Law and Lorimer 1989).

It is recommended that forest managers try to create openings with diameters from 1 to 2 times the average canopy tree height and vary their location according to local topography of the stand. For example, Law and Lorimer (1989) note that aspect and other site conditions can affect the size of openings required to provide one-third of full sunlight (i.e., an opening on a north-facing slope will receive less sunlight than a similar-sized opening on a south-facing slope). See **Table 6.1.9**.

Shape of openings

The shape of group openings can vary but more round or square gaps may provide better light conditions for regeneration than longer, narrower gaps that result in increased shading in the opening.

Number of openings at each periodic harvest

This will be determined by the regulation. See the heading “Harvest regulation” in the discussion of group selection in **Section 6.1**.

Harvesting and seedbed preparation of openings

Openings should be cleaned by removing all trees 2.5 cm DBH or greater (Miller *et al.* 1995). Advanced regeneration should be carefully protected. As with the shelterwood treatments, the presence of advanced oak regeneration prior to creating the group openings improves success of this system (Sander and Clarke 1971). Take care to avoid skidding through regeneration established in previously cut openings.

For stands or portions of them without advanced regeneration, it is likely that some form of site disturbance will be necessary to improve the seedbed and promote oak regeneration. This can be accomplished through the harvesting activity, additional scarification, or prescribed burning. These site preparation treatments should be conducted prior to or during the harvest operation. Harvesting during the summer/fall seasons may provide the best site preparation.

Treatment between group openings

The decision to conduct improvement cuttings between the group selection openings depends on overall stand management objectives. Sometimes wildlife habitat requirements or operational limitations make it difficult to improve by thinning, the growing conditions of the area between the group selection openings.



With mid-tolerant species such as the upland oaks, thinning between groups may actually encourage the development of tolerant regeneration that can become a competition problem when those areas are later placed in group openings. However, some light improvement to remove trees with infectious diseases will improve economic returns and reduce overall stand health problems.

Care must be taken to ensure that residual basal areas are kept higher in the uncut areas between group openings to compensate for the openings. Miller *et al.* (1995) suggest that trees with the following defects or characteristics be removed in these areas to improve overall stand quality:

- culls and near culls, unless they provide wildlife habitat
- trees with significant rot in the butt log (> 40%)
- low-grade trees that are not expected to attain sawlog quality
- short-lived species or other species with low vigor that are expected to die before the next periodic cut
- invasive exotic species

Monitoring regeneration in the openings

It is critical to monitor the regeneration for stocking, growth, and competition problems. Successful development of oaks, hickories, and other mid-tolerant species depends on establishing sufficient natural or artificial regeneration and keeping it free from competition. These group openings will probably need vegetation management treatments during the early phases.

Vegetation management in the openings

As with the shelterwood treatments, competition control in the group openings is important to keep the desired regeneration both vigorous and dominant. Early and persistent control of competition is better than allowing the competition to overtop the regeneration. Both herbicide and cutting treatments can be used to control competing vegetation in the group openings (**Section 8.1**).

Thinning the regenerated saplings in the openings

A precommercial crop-tree release is an option for saplings growing in openings created earlier. A full crown release should be applied to obtain a maximum of 125 to 185 crop trees per hectare when saplings reach 7.6 m in height, approximately 9 to 15 years following the creation of the opening (Miller *et al.* 1998).

Planting group openings

Seedlings and/or seeds can be planted in the group openings when the likelihood of obtaining sufficient natural regeneration is uncertain, or when landowners have sufficient financial resources to reduce risk of regeneration failure.



Subsequent group opening treatments

It is also important to monitor the development of crown closure in the overstory within the portions of the stand around the group openings. The edges of older group openings may need to be expanded to maintain the growth of seedlings. This can be done during the next cutting cycle or may require intervention before the end of the cutting cycle in order to release the regeneration. These treatments are designed to enlarge the openings and should concentrate on removing suppressed and poor quality trees adjacent to the openings.

Suggested modifications for unique stand conditions

Management of oak regeneration in areas with high deer density

High numbers of deer and/or other herbivores can substantially reduce available acorns for regeneration and may consume or debark regenerating oak seedlings and saplings. Although oaks are well adapted to survive decapitation and can resprout, constant browsing pressure can reduce vigor and regeneration potential by favoring other less palatable species.

The Northeastern Forest Experiment Station in West Virginia has used tree shelters to protect planted and natural seedlings within group openings. Miller *et al.* (1998) state that the shelters have significantly improved seedling establishment by increasing both survival and rate of growth. As well as providing protection from deer browsing, tree shelters also provide an enhanced microclimate that promotes faster growth (relative to other less desirable vegetation) thereby minimizing the potential for competition for sunlight, moisture and nutrients that often occurs when oak seedlings are planted without tree shelters. If protection from deer browsing is the objective, the 1.8 m tall shelter size should be used. Subsequent crown release and competition control may be required six or seven years after planting when the trees have grown out of shelters.

Tree shelters are not recommended when using the uniform shelterwood silviculture system to regenerate oak stands. In this situation, the planted oak seedlings (up to a maximum of 125 superior quality red oak nursery stock per hectare) can be more inexpensively protected from deer browsing by using mesh shelters (e.g., the Texguard mesh shelter). Recent research in southern Ontario (Wagner *et al.* 1995) has found that the tree shelters provided no increased growth advantage in shaded canopy conditions (e.g., the 60 % canopy cover of a shelterwood overstory) as compared to seedlings protected only with mesh shelters.

Another option is to decapitate young oak (i.e., cut off the stem at ground level) already present in the stand or group opening and then protect the remaining stubs with mesh tree protectors or tree shelters to promote vigorous growth of the resprouts.

