Chapter 9: Other Options for Revegetation

Although direct seeding and planting seedlings are the two most widely used techniques for reestablishing bottomland hardwood trees, there are several other regeneration methods available. In this chapter, four methods of revegetation are covered: use of cuttings, transplanting, topsoiling, and natural regeneration.

Cuttings

Several species of bottomland hardwoods can be readily propagated with cuttings, or short lengths of young shoots. Cuttings can be rooted first in a nursery and then planted as seedlings, or they can be directly planted on the restoration site. Cuttings of black willow, cottonwood (fig. 9.1), green ash, and sycamore have been successfully planted as unrooted cuttings. For most other species, using rooted cuttings is likely to be more successful.

Cuttings should be obtained in the dormant season and can either be stored until spring or planted right away. Effective temporary storage methods include placing the cuttings in cool water or covering them with wet burlap or similar material. Long-term storage can be achieved by bundling cuttings and refrigerating them in moist sand or plastic bags.

Success has been obtained with cuttings ranging in size from 10-15 cm (4-6 inches) “slips” to poles of 2.5-3 m (8-10 ft) in length, depending on the species. In general, cuttings 40-50 cm (16-20 inches) long and no less than about 0.6 cm (1/4 inch) in diameter at the top end should be used. Larger cuttings may be necessary on sandy or drought-prone soils.

Cuttings are usually planted vertically with the buds pointing upwards and the tops of the cuttings projecting 5-10 cm (2-4 inches) above the soil surface. Cuttings of cottonwood, green ash (fig. 9.2), sycamore, and black willow have also been planted horizontally, in slits about 2.5-5 cm (1-2 inches) deep.

Cuttings should be planted when dormant because survival generally decreases substantially if they are planted once the buds have begun to open. Ideal planting sites are moist but not flooded for long periods. Seedlings usually survive better than cuttings in areas with extensive flooding in the growing season.

Transplants

Seedlings or saplings transplanted from natural forests (also known as “wildlings”) are sometimes used in restoration projects. Depending on size, the planting material can be transplanted by using hand tools or heavy equipment such as tree spades (fig. 9.3) or backhoes. Unless the transplanting is done very carefully, mortality will be high, and surviving transplants will suffer so much shock that they will not begin to grow for a year or more after transplanting.

Figure 9.1. Bundle of cottonwood cuttings.

Figure 9.2. One-year-old green ash seedling grown from a horizontally planted cutting.

Figure 9.3. Tree spade used for planting large saplings or small trees. Photo courtesy of Dr. Schilling, Louisiana State University School of Forestry.

Transplanting is most successful when done in the dormant season. The roots of large transplants (those with basal diameters larger than about 5 cm) should be balled and bagged before transporting to the restoration site. Smaller transplants can be transported without being placed in bags, as long as their roots are protected from drying out. If possible, transplants should be taken from open sites, rather than from under dense forest canopies, since the chances of shock caused by exposure to full sunlight and high temperatures will be somewhat reduced.

Transplanting has been most frequently employed on restoration projects in Florida (Clewell, 1981; Posey and others, 1984). Clewell (1981) suggests that about 200 saplings can be transplanted in a week using a tree spade.

Some restorationists working in Florida observed that transplanting can also introduce desirable understory plants (Clewell, 1999). A few species appear to become successfully established by transplanting yet not by topsoiling, perhaps because the soil surrounding the seedling's or sapling's roots is kept more intact than it is with topsoiling. Of course, undesirable species may also be introduced by transplanting, depending on the species composition of the donor site. Another advantage of transplanting is that the larger size stock provides perches for birds and therefore provides vertical structure and enhances natural seed dispersal of some plant species.

Topsoiling

Topsoiling involves the transfer of topsoil from a natural wetland site to a restoration site. With this method, topsoil is spread out over a restoration site in the hopes that the seeds, stumps, rhizomes, and other plant parts contained within it will produce new plants. Topsoiling is commonly employed in marsh restoration but has been used much less frequently to restore forested wetlands.

A major advantage of topsoiling is that it has the potential to introduce many of the native understory tree, shrub, and herbaceous species that ordinarily are not planted. Also, it may result in successful introduction of mycorrhizal fungi or soil biota that enhance soil conditions.

There are several possible disadvantages, however, of topsoiling. A potentially serious drawback is that topsoiling requires disturbance of an intact wetland. Unless the topsoil can be taken from a wetland about to be destroyed, it means that one wetland has to be damaged to restore another. A second disadvantage is that species composition is difficult to predict and control. In some cases, topsoiling may also introduce exotic or otherwise undesirable species.

A variety of methods have been employed to remove topsoil from the donor site, transport it, and spread it on the restoration site. If tree cover exists on the donor site, the first step is usually removal of the trees. The topsoil can then be removed using equipment such as draglines, scrapers, or bulldozers. Only the top 20-30 cm (8-12 inches) of topsoil should be removed because below that depth the number of viable seeds drops off significantly.

Transportation methods for moving topsoil will depend on the distance between the donor and the restoration sites. Dump trucks are generally used for transportation distances in excess of 1.6 km (1 mile). Scrapers (fig. 9.4) can be cost effective for shorter hauls, although they do not work well in very wet situations or with heavy clay soils that may require additional heavy equipment to push or pull them. For very small distances, simply pushing the topsoil to the restoration site with a bulldozer or transporting it with a front end loader may be effective. Light, crawler-mounted bulldozers (fig. 9.5)

Figure 9.4. Scrapers are useful for short-distance transport of topsoil.

are recommended for spreading the topsoil on the restoration site because they minimize soil compaction.

Topsoil should be spread on the restoration site to a depth of about 10-20 cm (4-8 inches). Depths shallower than about 7 cm (3 inches) may not contain enough seeds and other plant material to ensure adequate plant establishment. Spreading topsoil to depths much greater than 20 cm (8 inches) may actually be counterproductive because costs become excessive, and many seeds will be buried too deep for germination.

In general, topsoiling will be most successful on sites where the topsoil will remain moist. In most of the Southeast, spring is the best time of year for topsoiling. On exposed sites where the soil surface is likely to dry out, irrigation will be required. In most situations, topsoiling should be viewed as a useful secondary means of revegetation with one of the other methods used as the primary means of reestablishing trees.

The term “mulching” is often used when referring to topsoiling, but mulching is technically a broader term that describes the process of applying any organic or inorganic material to the soil surface. Examples of other materials occasionally used as mulches include agricultural residues such as straw, hay, or bagasse and wood residues such as bark, sawdust, or wood chips.

Natural Regeneration

Natural regeneration—allowing vegetation to become established from natural sources—is an attractive alternative for restoration because the cost of planting is avoided. Also, any plants that become established on the restoration site should be well adapted to the site. If conditions are suitable, natural regeneration can be quite rapid, but highly degraded sites or sites far from a seed source will take much longer to naturally revegetate.

Many restoration projects rely on natural regeneration for all or part of vegetation establishment. In the Lower Mississippi Alluvial Valley and on some western Kentucky coal-mined sites, for example, only hard mast producing tree species are planted on most old-field restoration projects, and natural regeneration is relied upon for establishment of light-seeded tree species, understory tree species, and herbaceous vegetation.

Sites where use of natural regeneration is most appropriate include small or narrow sites where most of the site is no farther than about 70-90 m (75-100 yds) from an existing forest and sites that are subject to frequent flooding. A general rule of thumb is that natural regeneration will succeed without intervention in areas that are within a distance from an existing forest no greater than

Figure 9.5. Bulldozer spreading topsoil at Hall's Branch restoration site.

twice the height of the dominant canopy trees. Although disking is often used to reduce competition for the newly planted seedlings, Allen and others (1998) showed that disking of old-field sites reduced the number of invading woody seedlings that became established. They proposed that the added soil drying and elimination of microrelief (old bedding rows) resulted in reduced opportunity for seedling establishment.

Seedlings of species not dispersed by wind are often missing from naturally regenerated stands, or stands show a clumped distribution related to bird roosting and/or animal eating habits. Providing perches, planting of a few large trees, and even placing snags on a restoration site can encourage the natural regeneration of plant species dispersed by birds.

The major disadvantage of natural regeneration is that species composition is difficult to control. Light-seeded or undesirable species may need to be thinned out to allow the higher value heavy-seeded species time and space to become established and grow.

Another potentially serious disadvantage is the longer time period required for establishment of tree cover. A naturally regenerated site is likely to go through a successional process where the site is first dominated by annual plants, then perennial herbaceous plants, then shrubs and light-seeded, shade-intolerant tree species, and finally heavy-seeded and shade-tolerant tree species. On large old-field sites, the herbaceous plants may dominate a site for 10 years or more. On other types of sites (e.g., clay settling basins), willows, boxelder, swamp red maple, river birch, or other species that provide less wildlife value (compared with hard mast species) may dominant for many years (see table 4.1).

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Chapter 10: Establishing Native Undergrowth Vegetation

Most species of plants occurring in forests are not trees. For example, a bottomland hardwood forest in western Kentucky contained 143 species, of which 80 (56%) were terrestrial herbs, and only 38 (27%) were overstory trees; the remainder were shrubs and woody vines. In hardwood forests along the upper reaches of the Alafia River near Tampa, Florida, 71% of the 409 plant species were terrestrial herbs (292 species), consisting largely of ferns, sedges, grasses, and wildflowers (Clewell and others, 1982). Only 36 plant species were overstory trees. The remaining 81 species were small understory trees, shrubs, woody vines, and epiphytes.

These and similar observations elsewhere demonstrate that bottomland hardwood forest restoration is incomplete until a representative contingent of undergrowth species is established. This conclusion complicates revegetation activities, which, in the past, have focused on tree planting. Four basic questions are immediately raised: (1) are understory species so important ecologically that we should be concerned about them? (2) will undergrowth species colonize a newly restored forest by means of natural regeneration? (3) how many undergrowth species should be established to restore a forest adequately? and (4) how can undergrowth species be intentionally established at restoration project sites? This chapter attempts to answer these questions.

Although the importance of understory species is widely recognized by virtually all involved with bottomland hardwood restoration, some are of the opinion that, over time, the overstory plantings will develop conditions conducive to the natural establishment of understory species from an existing seedbank or from species brought into the area by wind, wildlife, or floodwater. Such natural invasion of understory species has not been conclusively demonstrated, but most restoration projects are still relatively young. The restorationist must determine if the time and resources spent on physically establishing understory species are well spent or if they may be better spent on other projects.

Ecological Importance of Understory Plants

Biodiversity

The aforementioned 292 species of terrestrial herbs occurring along Florida's Alafia River were tallied in sample areas totaling only 4.6 ha (11.3 acres). In spite of this small sample size, these herbs represented 8% of all vascular plant species known from the entire state of Florida. This floristic wealth vividly demonstrates the importance of forest undergrowth with respect to regional biodiversity. If ample biodiversity is a goal of restoration, then undergrowth cannot be ignored. Undergrowth vegetation that would likely overtop newly planted tree seedlings may best be planted one to several years later to allow the tree seedlings time to attain sufficient height to be above the undergrowth.

Ecological Functions

When considered by forest ecologists, the numerous undergrowth species are generally treated collectively by stratum or by life form. The functional roles of individual species are poorly known because the autecology (relationship between an individual species and its environment) of very few have been investigated. Perhaps the best known functional roles of undergrowth are those pertaining to wildlife habitat in terms of providing cover, forage, and nesting sites. Another obvious benefit provided by undergrowth is anchorage of the soil, which counters the erosive forces of runoff and overbank flooding. Undergrowth vegetation also contributes friction (roughness) to the forest surface, thereby retarding the velocity of floodwater. Anchorage and reduction of flood velocities both contribute to substrate stability and encourage sedimentation on floodplains. Sedimentation, in turn, increases the reservoir of nutrients available to vegetation.

Another function of the undergrowth that is not well documented but may contribute substantially to herbivore control and food chain stability is the harboring of predacious arthropods, mainly insects and spiders. A given species of arthropod spends much of its lifetime inhabiting a particular species of plant. The greater the number of plant species available in an area, the greater the diversity of predacious arthropods. This feature is realized by specialists in the biological control of crop pests. They have found that pest control is enhanced by having a diverse array of native plant species growing in close association with crops. It seems likely that these same predacious insects and spiders are also controlling herbivorous insects that attack native forest trees. Another array of insects associated with floristically diverse undergrowth may serve to pollinate flowers, including those of trees.

Undergrowth vegetation adds complexity to biogeochemical cycling of nutrients because root systems vary from species to species. The greater the diversity in the kinds of root systems, the greater the efficiency of conserving and cycling nutrients released by detrital decomposition. Undergrowth vegetation contributes to detrital biomass upon which soil microflora and detritivores depend. Undergrowth vegetation may also provide benefits to a forest in terms of mycorrhizal associations (a symbiotic relationship between certain fungi and the roots of some plants). In addition, understory vegetation can incorporate a tremendous amount of organic matter into the soil.

In summary, undergrowth plays various roles in forest processes and ecological functions. The importance of these roles may be much greater than has thus far been appreciated.

Natural Regeneration of Undergrowth

A considerable area of bottomland forests has been cleared for agriculture and later left to lay fallow. These lands generally become reforested through the well known process of old-field succession. This natural regeneration includes a substantial development of herbaceous and shrubby vegetation beneath the new forest canopy. Initial undergrowth may consist largely of relatively undesirable species that persist for some time following canopy closure. The undergrowth may be dominated by one or a few species such as goldenrod or wild onions or exotics such as Johnson grass or Japanese honeysuckle.

In contrast, forests occupying undisturbed soils have more undergrowth species, with no one species being disparately abundant. These species tend to be less weedy and more characteristic of deep forest conditions. The weedier species predominate only in disturbed areas, such as in canopy gaps formed by the loss of an overstory tree. Plant species (including overstory trees) that are typical of mature, undisturbed forests are particularly welcome at a restoration project site because they may hasten forest development. For this reason, they may be termed “preferred species.”

Even old-growth forests contain contingents of weedier undergrowth species in their canopy gaps that presumably contribute to ecological functioning and should not be discounted. In fact, four categories of undergrowth species can be distinguished, although some species may defy easy classification. Each category description is followed by examples of species for the category, as they occurred in mature forests along the Alafia River (Clewell and others, 1982). These species do not necessarily belong in the same categories in other regions or other forest types. See appendix B for scientific names of all species.

Category 1. Species largely or entirely restricted in their regional distribution to mature, undisturbed stands (e.g., restricted to a floodplain swamp and also to adjacent mesic forests in the same valley). These are all preferred species: aquatic milkweed, small-spike falsenettle, shiny spikegrass, millet beakrush, water pimpernil, and species of swamplily, bugleweed, lizard’s tail, and ferns (*Osmunda, Thelypteris,* and *Woodwardia*).

Category 2. Species that are frequent or at least locally abundant in mature stands and are also abundant in other regional ecosystems (e.g., in a floodplain swamp as well as in open marshes). These are all preferred species: small-fruit beggartick, Mexican water-hemlock, hairlike mock bishop-weed, and species of pickerel weed, smartweed, and burreed.

Category 3. Species occurring much more frequently or abundantly in other regional ecosystems **or** species that are much more abundant in disturbed or early serial stages than in more mature stands. These are **not** preferred species: bushy bluestem, southern carpetgrass, sheathed flatsedge, small dogfennel, Peruvian seedbox, Florida pokeweed, licorice weed, and cattail.

Category 4. Species occurring adventively **or** exotic species, including naturalized exotics. These are **not** preferred species: annual ragweed, American wormseed, crabgrass, Japanese climbing fern, and coffeeweed.

A satisfactory restoration should have a diversity of undergrowth species, including most species from Category 1. In order to determine in which category each species belongs, an experienced botanist will have to use baseline information to group the undergrowth species into the four categories.

Number of Species Necessary for Restoration

A mature, fully restored forest should contain most of the “preferred species,” as determined from baseline studies, particularly those from Category 1. In the Alafia River study (Clewell and others, 1982), at least 60 (20%) of the 292 terrestrial herbaceous species qualified as preferred species (i.e., Categories 1 and 2).

Preferred species need not be planted concurrently with trees. Several years will pass before the planted trees can provide the shade that many forest undergrowth plants require for their survival. At that time, an inspection can be made to determine what preferred species have already colonized the project site through natural regeneration. Category 1 species that are absent may then be planted. Preferred species of vines, however, should not be intentionally established. As a class, vines tend to proliferate and become nuisance species at new restoration sites, sometimes threatening the establishment of key tree species.

The remaining question is, how many plants of each preferred species should be established? The answer is only a few of each species. The guiding assumption is that as forested conditions develop, preferred plants will proliferate at the expense of the weedier species, which initially colonized the site and are succumbing to competition from the planted trees. Such proliferation indeed happened at two maturing restoration sites on mined and reclaimed land in central Florida: Hall Branch Restoration (Clewell, 1999) and Dogleg Branch Restoration (Clewell et al., 2000). Clusters of a few plants of each preferred species should be planted at wide intervals to ensure establishment on different parts of the project site. Clustering is needed to ensure cross-fertilization in self-incompatible species. Particularly large project sites can be partitioned into smaller units of perhaps 4 ha (10 acres), in which each preferred species will be established.

Establishing Undergrowth Plantings

Transplanting

There is currently little demand for preferred species of forest undergrowth, and native plant nurseries rarely stock them. Over time, this situation should improve, but presently it is usually necessary to collect seeds, rootstocks, or whole plants from natural populations. Ideally, collections of rootstocks and whole plants should be made as rescue or salvage operations at sites that are scheduled for development. These collections can be transferred directly to the project site, or, if a nursery is available, salvaged stock can be propagated for later distribution. Some Natural Resources Conservation Service facilities are making space available to propagate such native plant materials.

Plant material may have to be removed from donor forests that are not scheduled for development. Plants selected for removal should be spaced far enough apart to prevent localized extirpation. Holes where plants are removed should be filled. A posthole digger frequently proves useful in removing herbaceous plants. This work is labor-intensive and expensive in the absence of volunteer effort. Transplants should be planted in semishade in moist soil. Care should be taken not to leave air pockets around the root balls. For many species, transplanting from the shade of a closed canopy forest to an open field is fatal, therefore, the restoration site must have developed sufficiently enough to provide at least semishaded conditions for these species.

Topsoiling

Topsoiling (mulching with topsoil) is another method of preferred species establishment. The method has been attempted at reclaimed phosphate mines in central Florida. A layer of topsoil only 10 cm (4 inches) thick can provide a bountiful regrowth of vegetation (see topsoiling section, Chapter 9). Topsoiling has proven most successful when the soil is transferred from the donor site directly to the restoration site without stockpiling and when the restoration site is permanently moist or wet (see restoring soil characteristics section, Chapter 5).

Plant propagules (seeds, rootstocks, spores) can quickly lose their viability when stockpiled, owing to poor aeration and to the generation of lethally high internal temperatures. Topsoil that is subjected to seasonal drying after being spread at an open restoration site is unable to sustain most undergrowth plants as they arise from its propagule bank. These plants are adapted to uniformly moist soils. If the amount of topsoil is scarce, it can be transferred from a donor site with a tree spade and planted as if it were a tree. The soil is transferred intact, and undergrowth plants within the soil are less traumatized than they would be if they were spread in a layer. Topsoiling by any method introduces both organic matter and soil microbiota, both of which may hasten soil development, especially on surface-mined sites.

Topsoiling as a technique is largely limited to salvage operations at wetlands that are being cleared for development. Because such sites are rarely permitted for development, the opportunity of using topsoil is becoming rare. Whenever a wetland is permitted for clearing, its topsoil should be salvaged for restoration projects in the vicinity. Unfortunately, hauling costs are prohibitive for transport of topsoil to all but local projects.

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Chapter 11: Postplanting Control of Undesirable Vegetation

Bottomland hardwood forests have an abundance of naturally occurring woody and herbaceous plants that may be regarded as undesirable in a restoration project, especially in the early stages when they might affect the survival and growth of planted trees. Also, exotic species are very well established in all areas covered by this guide. In southern Illinois, for example, early stages of succession on old-field sites used to be dominated by native broomsedge, smooth and winged sumac, sassafras, and common persimmon. Now, similar sites might be dominated by sericea lespedeza, Chinese bushclover, Japanese honeysuckle, multiflora rose, and autumn olive, all of which are exotics.

Control of undesirable plant species is typically only needed in the first few years of a restoration project, after which the planted vegetation should be large enough to compete on its own. Control can be achieved manually, with machines, or with herbicides.

Although an intensive program of postplanting weed control may substantially increase survival and growth of planted stock, control should be employed sparingly. Weed control will reduce the initial value of a restoration site for small mammals and bird species that use the weeds as food and cover. Also, these weeds may be promoting forest development by contributing humus to the soil and partial shade to forest tree seedlings.

Another reason to use postplanting weed control sparingly is that the long-term benefits may not justify the costs. In some experiments where a significant growth enhancement with weed control was found over the first 5 to 10 years, the effect virtually disappeared after a few more years.

Manual Vegetation Control

Vegetation control using hand tools such as hoes, axes, brushhooks, and machetes has the potential advantage of being highly selective in what is removed (fig. 11.1). A disadvantage of manual methods is that they usually result in a very temporary form of control; unless the undesirable plants are being uprooted, they are likely to resprout quickly. Because the labor forces employed for weeding are likely to be relatively inexperienced, there is also a high probability of injury to workers and inadvertent damage to desired species.

Manual weed control may be best employed on small projects or as a supplement to other forms of weed control on larger projects. It also may be the safest method to use to remove vines from young hardwood trees because the vines grow too close to the tree to be removed by cultivation, and herbicide applications may also damage the tree.

Figure 11.1. Manual vine control can be accomplished using brushhooks or machetes.

Mechanical Vegetation Control

Mechanical weed control is widely used in commercial forestry operations and has proven to be highly effective on bottomland sites. A disadvantage of mechanical weed control is that it is difficult to employ if the trees are not planted in rows. Other disadvantages are the high equipment costs and energy consumption.

Cultivation should begin early in the first growing season (March or April) and may need to be repeated as many as three to four times during the first year. Supplementary hand weeding may also be needed to control vines that are too close to planted trees to be removed mechanically. There are many types of equipment available for cultivating bottomland hardwoods, but most foresters prefer tractors of about 110 horsepower. Tractors of this size are small enough for cultivating between rows but also large enough for other jobs such as clearing, disking, and planting.

Front-mounted cultivators allow the driver to have better visibility and control than rear-mounted cultivators, resulting in less damage to planted trees. Cultivators equipped with chisel- or shovel-type plows allow tillage close to the young trees but do not damage them appreciably. Two types of cultivators are most frequently used. One is a large, front-mounted cultivator with 19 to 21 shanks that will straddle one row while covering the space within the rows. The second type is an offset front-mounted cultivator equipped with five or six shanks that straddle the row while covering a small area on each side; with this system, a disk or spring-tooth harrow drawn behind the tractor covers the area between rows.

The unit in a cultivation operation therefore consists of a tractor plus either a large cultivator or a small cultivator with a disk or harrow (fig. 11.2). When the trees become too tall to straddle, the cultivators are removed and tillage between rows is accomplished with just a disk or harrow.

To ensure the best results from cultivation and to minimize tree damage and equipment breakage, the restoration site should be as free as possible from stumps, large roots, and other debris. The cultivator shanks that straddle the trees should be set to plow 8-10 cm (3-4 inches) deep to within 8-10 cm (3-4 inches) on each side of the tree. The area between rows should be plowed to a depth of 10-15 cm (4-6 inches). Cultivation to these depths will probably cut some of the roots that lie in the top 20 cm (8 inches) of soil, but some researchers believe that cutting causes root proliferation and is therefore beneficial because it increases the absorptive surface.

Disking patterns should be alternated during cultivation; that is, a row cultivated in, say, a north-south direction during the first trip down a row should be cultivated south-north during the next trip. If tandem disks are used, the front blades should be set to throw soil toward the trees and the rear ones to throw soil away from the trees. The disk blades should be about 50-60 cm (20 to 24 inches) in diameter. The width of the disk or harrow would be determined by tree spacing but would be 0.6-0.9 m (2-3 ft) narrower than the spacing to allow plowing to within 30-45 cm (12-18 inches) of the trees.

Cultivation should be postponed during wet weather to avoid soil compaction, damage to tree roots, and equipment damage.

Figure 11.2. Mechanical cultivation of a restoration site.

Vegetation Control with Herbicides

The many different herbicides and herbicide application methods available for use on restoration projects are continuously evolving. It is important to refer to the most up-to-date sources of information on such issues as personal and environmental safety and relevant State and Federal regulations. Recent sources of information on herbicides for forestry and agricultural use are cited at the end of this chapter, but keep in mind that little research on the appropriate herbicides for use in bottomland hardwood sites has been conducted (but see Miller, 1993 and Ezell and Catchot, 1998). When herbicide use is planned, a combination of proper herbicide prescriptions, technically sound applications, and a commitment to minimizing negative impacts to the environment are the keys to successful use.

Table 11.1 lists some of the most commonly used herbicides for control of herbaceous and broad-leaved (woody) vegetation. This table is meant to serve as an initial source of information on herbicides, not as the final basis for herbicide selection and does not constitute an endorsement of any of the herbicides listed. Also, not all these herbicides are labeled for herbaceous or woody vegetation control in all states.

The weed species controlled by specific herbicides should be investigated thoroughly before making the final selection(s) for use on a particular project. Information such as that presented in table 11.2 is available for most herbicides and should be referred to once the restorationist knows which weeds are most in need of control.

The optimum timing for herbicide applications varies with the type of weeds being controlled and the particular herbicide and application method being used. Guidance on timing for some of the most common herbicides used in commercial forestry operations is presented in fig. 11.3.

Since weed control should be used very sparingly on most restoration projects, only the most selective application methods are recommended. To control herbaceous vegetation around individual planted trees, backpack or hand-held sprayers (fig. 11.4) are very effective. To control undesirable woody species, tree injectors, hypo-hatchets, hatchet and spray bottle combinations, or spot guns are recommended.

Table 11.1. Commonly used herbicides (adapted from Mitchell and Lowery, 1994).

Common Name	Trade Name	Use
Atrazine	Atrazine 4L	Herbaceous
	AAtrex 4L	Herbaceous
	AAtrex 80W	Herbaceous
	AAtrex Nine-O	Herbaceous
Dicamba	Banvel CST	Broad-leaved
Dicamba + 2,4,D	Banvel 720	Broad-leaved
Fluazifop-butyl	Fusilade 2000	Herbaceous
Glyphosate	Accord CR	Herbaceous
	Roundup	Herbaceous
Hexazinone	Pronone 5G	Herbaceous
	Velpar L	Herbaceous
Imazapyr	Arsenal Applicator Concentrate	Herbaceous
Oxyfluorfen	Goal	Herbaceous
Picloram + 2,4-D	Tordon	Broad-leaved
Sethoxydim	Poast	Herbaceous
Sulfometuron methyl	Oust	Herbaceous
Triclopyr	Garlon 3A	Broad-leaved
Triclpoyr + Butoxyethyl ester	Garlon 4	Broad-leaved
2,4-D	Weedone 2,4,DP	Broad-leaved

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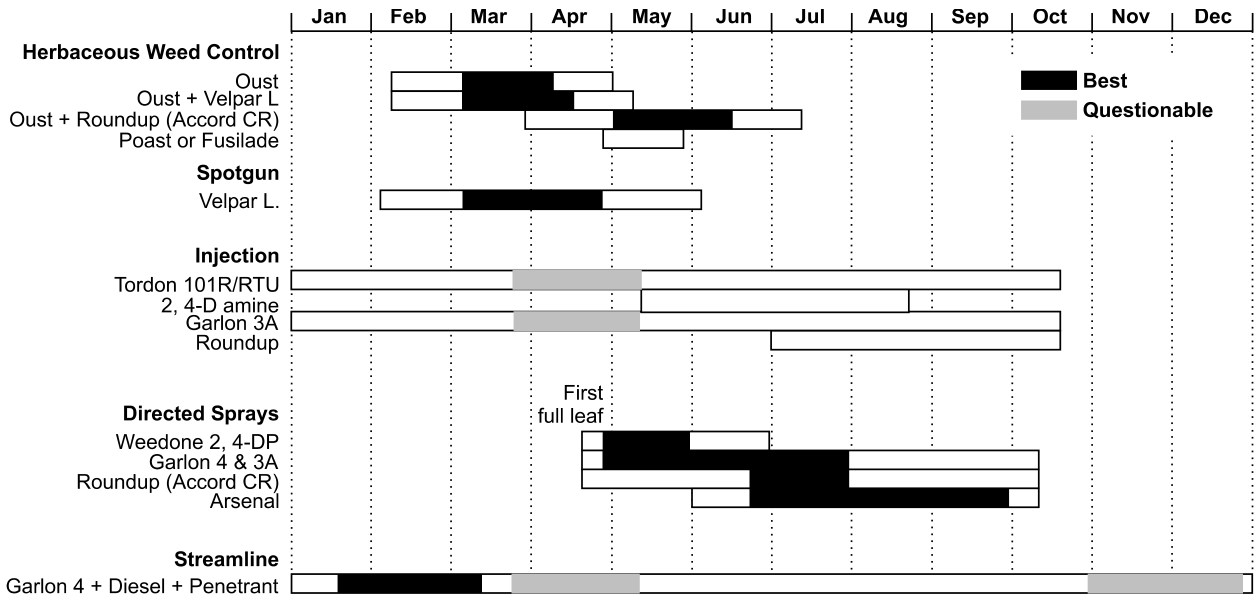
Table 11.2. Weed species susceptible to Oust (Mitchell and Lowery, 1994).

Susceptible Controlled by 3 oz/acre	Moderate Controlled by 5 oz/acre	Tolerant Not controlled
Panic grasses	Goldenrod	Bermuda grass
Fescue	Dogfennel	Morning glory
Horseweed	Bahia grass	Broomsedge
Burnweed	Johnson grass	Wooly croton
Boneset		Trumpet creeper
Ragweed		Sicklepod
Sunflower		Cocklebur
Poorjoe		Nutsedge
Dewberry		
Vetch		
Geranium		
Goldenweed		
Sweet clover		
Crabgrass		



Dates are approximate for the upper coastal plains. Spring dates will shift
plains to the mountains because of earlier frost.

Figure 11.3. Guidance on the timing of herbicide applications in commercial forestry (modified from Miller and Bishop, 1989).

Figure 11.4. Herbicide application with a backpack sprayer.

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Chapter 12: Protection of the Restoration Site

Restoration projects can be damaged or destroyed by a variety of agents, ranging from depredation by herbivores to vandalism. To the degree possible, the needs for protection from these agents should be anticipated in the site evaluation stage, and plans should be drawn up for implementing protective measures.

Protection from Animals

Herbivores (and the occasional omnivore) can seriously damage or destroy planted seed or seedlings. The most frequent offenders are deer, raccoons, squirrels, beaver, nutria, and small rodents. In some cases, cattle, hogs, or birds may cause damage.

One of the best forms of protection against the smaller rodents is to plant seed or seedlings on a relatively weed-free site, since this minimizes the amount of cover available to protect rodents from predation. Usually by the time the weeds provide enough cover for small rodents, the seedlings are relatively safe; however, if there is evidence of damage to seedlings (e.g., girdling, clipped twigs), it is advisable to carry out some postplanting weed control.

Protection of some planted sites can be achieved by controlling water levels, but specific guidelines for use of this technique are not available. For example, water tolerant species can be temporarily flooded to protect them from small rodents, or in the case of beaver and nutria, the site can be kept drained until the seedlings are well established. In large open fields, provision of perches for raptors may be an effective strategy for reducing rodent populations.

More direct forms of control may be necessary in cases where animal populations are particularly high and/or cover cannot be reduced adequately by other means. These forms of control, however, should only be employed as a last resort, especially near populated areas and on public lands. Traps or poison can be used to temporarily reduce populations of small rodents. Larger animals can also be shot. For instance, shooting nutria or beaver can be a very effective means of short-term control; one technique is to go out at night with a light and use a .22 rifle (which is fairly quiet). The only practical direct control measure for deer is an either-sex harvest in conjunction with state hunting seasons, which is obviously out of the control of most restorationists.

Fencing the site will protect it from cattle and hog damage. Fencing may also provide protection from beaver and nutria, although these animals, especially nutria, may be able to burrow under or even climb over a fence. Fencing will only work well if it is done right (using good quality fencing material and sturdy, metal or treated wooden posts) and if it is periodically inspected and maintained.

Individual seedlings can be protected by using either wire predator guards or plastic tree shelters (fig. 12.1a,b), but costs can be prohibitive on large projects.

a. b.

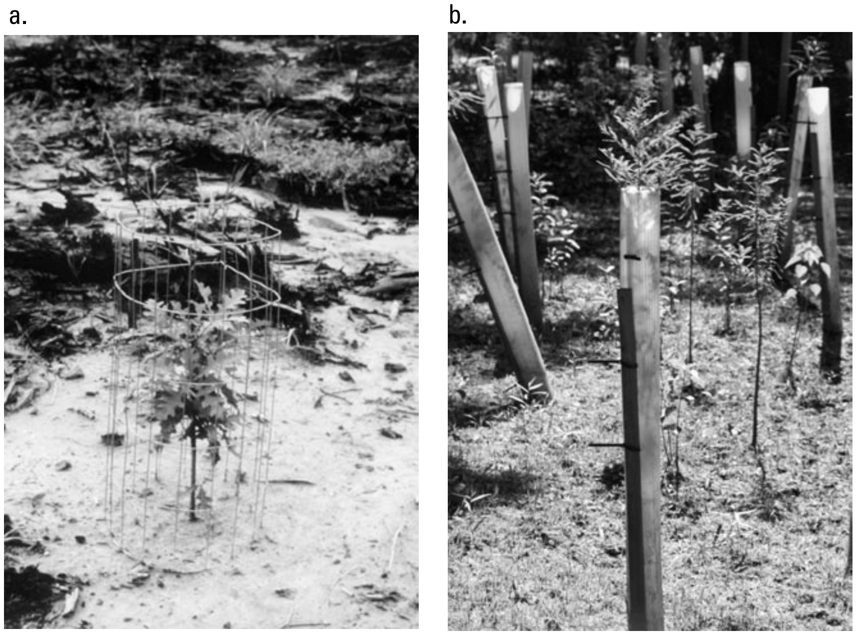

Figure 12.1. Herbivory protection by (a) wire predator guard and (b) plastic tree shelter.

Tree shelters have the additional advantages of enhancing growth and making it easier to safely apply herbicides around the base of individual seedlings. While generally effective, neither wire guards nor tree shelters can ensure complete protection in cases where animal populations are high and alternative food sources are low. For example, both methods have occasionally failed to protect newly planted baldcypress seedlings from nutria, which have burrowed under, climbed over, knocked over, and chewed through these protectors. In extreme cases, these wire guards or tree shelters should be used in conjunction with direct population control measures.

Protection from Fire

Although most bottomland hardwood sites are wet throughout much of the year, they do occasionally dry out, and there are several instances in which restoration sites have been damaged by fire. The best protection is to make a firebreak around the site, usually by disking (see fig. 5.1). Firebreaks should be periodically inspected and maintained, particularly before and during periods of peak fire danger. Firebreaks are particularly important in areas where prescribed fire is frequently used or where the restoration site is close to a heavily traveled road.

In peninsular Florida and in the northern Gulf of Mexico Coast the rapid spread of cogongrass, an exotic species, has created a fire hazard. This species burns readily and can spread and intensify a fire rapidly. Heavy applications of herbicides are being made to eliminate this grass as it appears in bottomland hardwood creation sites on mined lands. As cogongrass continues to spread, its threat of carrying fires could increase substantially in the next few years.

Protection from Human Impacts

In most areas, restoration sites are subject to some damage from humans, be it intentional or unintentional. Fencing and “No Trespassing” signs may prove necessary in areas that could be used by off-road recreational vehicles, play areas for children, or places to dump trash and yard wastes. Informing nearby residents of the project and/or putting an informative sign about the project on the site (fig. 12.2) may also help reduce damage.

Figure 12.2. An informative sign such as this can provide useful information to individuals using or visiting the site.

In agricultural areas, some restoration sites have been damaged or destroyed by farm machinery or aerial drift from nearby herbicide applications. Farmers on adjacent land should be informed about restoration sites on which they might potentially have an impact.

In urban areas, plants have actually been stolen from some restoration sites. This is most likely to happen when larger, high-value planting stock has been used, such as tree seedlings that were in 1-gallon or larger size containers. Sites where theft is a possibility should be protected by fencing. In some cases armed guards have been employed to protect restoration sites. Where theft or vandalism is likely to be a problem, it may be desirable to use smaller, less conspicuous (and less valuable) planting stock.

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