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Restoring Upland Hardwood Forests Using Tree Shelters

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Introduction

In the Great Lakes Region of the United States and Canada, animal browsing and competition are important concerns in restoring upland hardwood forests (Carey and Robertson 1995, Robertson and Robertson 1995, Jeff Whorhol, District Nursery Manager, personal communication, April 15, 1997). These stressors can cause high mortality rates after much work has gone into acquiring quality plant material, soil remediation, and restoring a site's natural hydrology. Tree shelters were designed for forestry applications and are used in many tree planting programs outside of forestry. There is no *one* target ecosystem for this technique but tree shelters are most commonly used in hardwood plantings on upland mesic sites. Tree shelters are attractive to ecological restorationists working with upland hardwood sites because tree shelters protect seedlings from animal browsing and make herbicide application easier.

Tree shelters were developed primarily to protect seedlings from animal browsing. They were also designed to create a favorable microclimate for growth in the shelter. Hunt (1996) identified three main advantages of using tree shelters with hardwood plantings: 1) increased growth during initial establishment after planting; 2) protection against damage from browsing, herbicide, and machinery; and 3) increases seedlings' competitiveness, most notably with grasses. The advantages of tree shelters vary by brand and the factors important to seedling establishment: seedling handling, site, species, weather (Widell 1996), and planting stock quality. Tree shelters' ability to protect hardwood seedlings from browsing has been sharply criticized, and their ability to encourage growth has also been questioned.

Using Tree Shelters

Tree shelters are typically transparent or translucent and made of light weight, soft but rigid plastic material. This material is usually corrugated or twin-walled polypropylene (Widell 1996). Polypropylene is a relatively cheap (Potter 1991) material that will deteriorate after 5 to 10 years in sunlight (Potter 1991, Kerr 1996). Their tubular shape makes them more resistant to wind gusts than a square shape (Potter 1991). Tree shelters range in height from 60 cm to 2 m tall and from 8 to 12 cm in diameter.

Tree shelters must be tied to high quality, weather resistant stakes for support (Kerr 1996, Perry 1996). Stakes should be treated lumber that can withstand the persistent moisture associated with being in the ground (Potter 1991). Stakes are pounded into the ground at least 30 cm and reach just below the top of the shelter (Potter 1991). Potter (1991) recommended metal rods instead of wood stakes for extremely stony sites if there is no potential for severe wind. Metal rods do not offer enough resistance to heavy wind gusts and can be difficult to get out of the ground after a couple of years because they oxidize (Potter 1991). Plastic stakes can also be used but the advantages and disadvantages are not known.

Tree shelters should be attached to stakes so the shelters can be easily removed to replace dead seedlings. Plastic cable clips are quickly undone and are frequently used (Potter 1991). Staples have also been used as an inexpensive alternative to secure tree shelters to stakes. However, the area stapled becomes unstable when tree shelters disintegrate (Potter 1991) and the force of wind can damage the seedlings.

Tree Shelter Applications

Tree shelters were originally designed in Britain for forestry applications. Now that more native species are planted in forestry applications, in Britain and elsewhere, the research done on tree shelters in forestry contexts will be useful to determining their application to ecological restoration of upland hardwood forests. Tree shelters are used in non-forestry applications such as ecological restoration (Gutowski and Overton 1996), mine land reclamation (Fisher et al. 1986, 1990), landscaping (Burger et al. 1996), and agroforestry plantings. They are not often used in lowland areas that are prone to flooding because sheltered seedlings have greater risk of being washed away during flooding.

Tree shelters are also used to protect seeds after direct seeding. This application is less common and not well studied. In Wisconsin, 60 cm tree shelters were found to be the most effective protection against seed predation except in areas where deer populations were high where 1.2 m tree shelters were the most effective (Severeid 1996). Severeid (1996) suggests that the new "Tree Shepherd" cone may be a better choice because of its concoidal shape. Walters (1993) tried tree shelters with direct seedling northern red oak acorns without success due to intense seed predation.

Using tree shelters on arid sites for ecological restoration in California has been fairly well documented (Bainbridge 1994, Bainbridge et al. 1995, Bainbridge and MacAller 1995). However, less literature is available on the use of tree shelters on upland mesic hardwood sites in the Great Lakes Region of the United States and Canada.

Other Techniques

Tree shelters are different from "tree guards" which are made of plastic or wire mesh and protect seedlings from animal browsing. However, tree guards do not change the microclimate around the seedling as a tree shelter does. Tree guards are also commonly used to protect seedlings from machinery such as lawn mowers. Tree guards can adversely affect the seedling because lateral branches may grow into the wire or plastic mesh (Potter 1991).

Animal repellents are another method of deterring browsing. Typically these are liquids that are sprayed onto the leaves of target seedlings. These chemicals are usually water soluble so after it rains they must be re-applied. Many of these products are expensive and/or costly to apply as needed (Fisher et al. 1986). Fisher et al. (1986) found that animal repellents are not as effective as barriers. The vinegar smelling spray (Hinder) is not as effective as the rotten egg smelling spray (trade name unknown) at deterring deer from browsing hardwood saplings that are not tall enough to be out of the reach of deer (Jeff Whorhol, District Nursery Manager Hennepin Regional Parks, personal communication, April 15 1997).

Fencing is another common method of deterring deer browsing. Small browsers such as rodents and rabbits are difficult to exclude. If a fence is tall and strong enough deer and moose can be excluded. Spatial scale and cost are important issues when considering fencing. Small scale plantings may not warrant the expense of fencing and fencing large scale projects may also be too costly in terms of labor and materials.

Field trials

Tree shelters have mainly been tested for forestry applications and much of the literature is relevant to restoration plantings because it explores the fundamentals of seedling establishment for native species. These studies also investigate survival and growth of sheltered and unsheltered seedlings on open sites and under partial canopies. Hunt (1996) summarized the potential problems of using tree shelters: 1) seedlings have to grow tall and straight to reach the top of the tube, making them weak and causing them to lean to one side when they emerge from the tree shelter (Kerr 1995 and Beetson et al. 1991 also noted this); 2) stakes need to be tall enough to keep the tube and therefore the seedling, upright (Potter 1991 also noted this); 3) stakes may rot before the seedlings are established; 4) rodents chew through the bottom of tree shelters; 4) birds fly in the tubes and cannot escape; 5) vandals are attracted to the tubes (but seedlings are not necessarily harmed); 6) a poor site may be compensated for by planting more seedlings and using more tree shelters rather than finding a more suitable site; 7) the benefit of being more competitive does not apply to seedlings before they are established; 8) weeds are still an issue after the initial expense of tree shelters (Kerr 1995 also noted this); 9) often tree shelters do not break down when the seedlings need to be free of the tree shelters; 10) long tubes discourage monitoring seedlings and short tubes often do not provide enough protection; 11) on floodplains, seedlings in tree shelters are at more risk of being washed away than seedlings without tree shelters; 12) tree shelters are unsightly when planted in rows or on a large scale; 13) wasps nest in shelters.

In southern Missouri, Ponder (1995) planted northern red oak (*Quercus rubra*) seedlings in canopy gaps in a northern hardwood forest. Ponder (1995) confirmed the favorable microclimate in the tree shelter by finding significantly higher temperatures and humidities inside the tree shelters than outside. After three growing seasons, survival and above ground growth were significantly higher for seedlings grown with tree shelters. Interestingly, root growth measurements were all significantly greater for unsheltered seedlings. The authors concluded that tree shelters could help in oak under-plantings.

Sheltered seedlings are forced to grow straight up to the top of the tube. This may encourage height growth at the expense of root and stem diameter growth. If the major stressor is deer browsing, then it may be advisable to use tree shelters to get the seedlings tall enough to be out of deers' reach. However, if the root development suffers as a result, the consequences on environmentally extreme sites may be grave. When under moisture or nutrient stress, plants will allocate their energy to root development. Open sites may have more extreme temperatures which may stress seedlings with poor root development while their most fierce competitors, grasses, have extensive root masses. Soils under a mesic hardwood forest are typically not nutrient poor so a poorly developed root system may only be a slight disadvantage for a seedling planted under a canopy. Perhaps using tree shelters when planting under forest canopies is more advantageous than on open sites.

On a mesic mixed northern hardwood site, Teclaw and Zasada (1996) planted bareroot and containerized northern red oak seedlings under a forest canopy and in a clear cut. They protected half the seedlings with 1.2 m, tan tree shelters and the other half with 1.2 m clear, fiberglass shelters. The authors found lower height growth in the tree shelters, and suggested it was due to the lower light intensity and quality in the shelter. Burger et al. (1996) found that the response, in terms of height growth, to microenvironment of hardwood shade trees grown in tree shelters for two years varied by species. Different species response in terms of survival has been observed elsewhere (Jeff Whorhol, District Nursery Manager, personal communication, April 15, 1997). Perry (1996) suggested planting pioneer species with tree shelters instead of slower growing climax species

Tree shelter products are available in various weights so the time to shelter break down can be predicted. Photodegradation is important to sapling development because shelters must be removed as soon as trees emerge from the tube (Burger et al. 1996). Evans (1996) used the older, more durable tree shelters with hardwood forestry species in Britain and found that the tubes did not break down even by the time the trees' stems fully occupied the shelter. Evans (1996) suggested cutting the tube vertically so the stem can continue to grow while the shelter can still provide some protection to the sapling.

In Pennsylvania, Walters (1993) compared the effect of translucent tree shelters, fencing, and gyphosate application on northern red oak seedlings planted in a shelterwood. After two years growth, fenced seedlings had the highest survival rate and unsheltered seedlings were significantly shorter than sheltered seedlings. The effect of the herbicide treatment was dramatic: survival of sheltered seedlings was 82% and unsheltered seedlings was 40%.

Teclaw and Zasada (1996) found that overall, northern red oak seedlings in tree shelters had lower survival than seedlings planted under fiberglass shelters. Unsheltered seedlings had an intermediate survival rate. Barerooted seedlings had better survival with the tree shelters than containerized seedlings. Barerooted seedlings tend to have a greater root mass than containerized planting stock which is an advantage after outplanting. This may explain the difference in survival between stock types. The authors concluded that there was no benefit from the tree shelters in the clear cut because of temperature extremes and late spring frost. The tubes did not provide protection from frost at night.

Kerr (1995) found that where there was a large deer population and a large hare population tree shelters did not give enough protection from animal damage because the shelters were too short. Seedling tops also can be damaged from the tubes, themselves. When a seedling reaches the top of a tube, wind can cause its stem to rub against the rim of the shelter. Some tree shelter products are available with flared top rims to prevent stem abrasion. Stem abrasion has been reported as a problem with hardwood seedlings by Nixon (1994) and Hunt (1996).

In a suburb of Philadelphia, PA, Robertson and Robertson (1995) restored a mixed mesophytic woodland on a mesic site using tree shelters. They planted tulip tree, white ash, black cherry

(*Prunus serotina*), Eastern hemlock (*Tsuga canadensis*), red oak (*Quercus rubra*), and shagbark hickory (*Carya ovata*). One of the project's goals was to under-plant native species in canopy gaps to re-initiate regeneration. The existing forest was composed of: red maple (*Acer rubrum*), red cedar (*Juniperus virginiana*), white ash (*Fraxinus americana*), and tulip trees (*Liriodendron tulipifera*). Two percent of their initial restoration budget ($200 of $10,000) was spent on tree shelters.

They recommended fences in large open areas to protect seedlings from deer because they may be more efficient and aesthetically pleasing than tree shelters. In canopy gaps, they used tree shelters to protect seedlings from deer browsing, and found that the shelters were effective. The tree shelters held moisture, kept temperatures from the extremes, and decreased wind stress. Seedlings planting with tree shelters had 95% first year survival while they reported 20-50% survival rates for seedlings that were not planted with tree shelters. They used different colored shelters in different areas. In sunny openings in the forest they used the pink tubes which keep out 60% of ambient light and translucent tubes, which keep out 40% of ambient light, in shady planting spots.

Carey and Robertson (1995) have made much use of tree shelters in woodland restoration to protect seedlings from deer browsing. They found that shelters helped reduce browse but that songbirds, notably eastern bluebirds (*Sialia sialis*) and European starlings (*Sturnus vulgaris*), flew in the tubes. The birds could not escape and died in the tree shelters. Seedlings eventually died as well because the dead birds attracted rodents that tunneled under the tube. The authors concluded that holes made by rodents allowed cold air in the tree shelter which resulted in seedlings death by desiccation.

Some tree shelter manufacturers have developed a plastic mesh sock to cover the tube to prevent birds from flying in. However, the elastic tension that is supposed to keep the mesh over the tube becomes brittle and either blows off or slides down the tube (Carey and Robertson 1995).

Carey and Robertson (1995) reported that Bern Sweeney, Stroud Water Research Center, Avondale, PA, used duct tape to keep the sock on. Sweeney acknowledged that although the tape disintegrates, it is easily replaced. Since using duct tape, he has not found any dead birds in shelters nor lost any seedlings. Carey and Robertson (1995) also support using duct tape to affix the plastic mesh sock.

Blakeman (1996) also found that the plastic mesh did not keep its soft and strong properties for a long time, and it did not prevent birds from entering the tube. Instead of trying to prevent birds from flying in, he tried to give birds a way to escape. Blakeman (1996) placed a stalk of common reed (*Phragmites australis*) in the shelter so that a bird that gets into it would be able to climb out. Blakeman (1996) recommended collecting reed in the winter or early spring. It is easy to collect and remains structurally sound for three years (Blakeman 1996). He recommended cutting the reed so that it is one centimeter below the top of the tube but does not explain why. He put reed stalks into 50 shelters and found no birds in those shelters. He did not indicate if there were any birds found in shelters in which he did not put a reed. Blakeman (1996) did not do an experiment to test this method but he believes that using reeds is a low cost method of saving song birds.

Carey and Robertson (1995) observed small "ecosystems" within tree shelters. Seedlings’ new growth attracted leaf-eating insects. Subsequently, vespid wasps nested in the tube and fed on the leaf-eaters. They did not noticed much damage to seedlings by the leaf-eating insects. Unfortunately, wasps were a danger to field workers who clean debris out of the shelters.

Hennepin Regional Parks has been restoring upland hardwood forests in the suburbs of Minneapolis, MN. They planted more seedlings than they normally would have with the tree shelters, reasoning that the tree shelters would lower maintenance costs (Jeff Whorhol, District Nursery Manager, personal communication, April 15, 1997). They had many problems with tree shelters. Wind rubbed off lateral branches. When they used tree shelters with oak tublings, they had approximately 20% survival. The tree shelters did not provide adequate protection because deer browsing pressure was heavy and the tree shelters were too short to deter deer. The tree shelters also did not photodegrade. One advantage they found was easier herbicide application. They do not recommend using tree shelters for large-scale plantings.

Recommendations

Tree shelters are species and site specific so Widell (1996) suggested that the manufacturer or distributor be sure of a planting’s details before recommending a product. Important issues in selecting a brand include: how the product is shipped (flat or in tubes), the type of ties and stakes provided or not provided, the type and color of the material, its durability, cost, if it has a flared rim, if netting is provided for the top, and knowledge of the product’s previous field performance in a relevant application (Widell 1996). (See Widell (1996) for details of many tree shelters products.)

Tree shelters are commonly used for establishing seedlings on a small spatial scale in Britain (Kerr 1995), Canada, and the United States. After the initial cost of tree shelters, weeds must still be controlled. So applying this method to large-scale upland hardwood restoration projects is risky without more field tests. Using tree shelters with seedlings planted under a canopy may be better than in a large opening. Additionally, response to the change in microclimate varies by species so, for a given restoration project, small plots should also be tested with all species under all canopy cover conditions. Also, the benefits of improved growth due to a favorable microclimate may not be felt until after seedlings are established. It is clear that before deciding to incorporate tree shelters into a restoration plan, species; nutritional, light, and moisture status of the site; and spatial scale of the project should be considered.

Literature Cited

Bainbridge, D. A. 1994. Tree shelters improve establishment on dry sites. Tree Planters’ Notes 45(1):13-16.

Bainbridge, D. A., and M. W. Fidelibus. 1994. Tree shelters improve woody transplant survival on arid lands (California). Restoration and Management Notes 12(1):86.

Bainbridge, D. A., M. Fidelibus, and R. MacAller. 1995. Techniques for plant establishment in arid ecosystems. Restoration and Management Notes 13(2):190-197.

Bainbridge, D. A., and R. T. MacAller. 1995. Tree shelters improve desert planting success. Proceedings of the Tree Shelter Conference. June 20-22, 1995, Harrisburg, PA. USFS Northeastern Forest Experiment Station, General Technical Report, NE-221. p. 57-59.

Beetson, T. B., D. W. Taylor, and M. R. Nester. 1991. Effect of tree shelters on the early growth of four Australian tree species. Australian Forestry. 54: 1-2, 60-65.

Blakeman, J. A. 1996. Placing stalks of common reed in tree shelters saves songbirds (Ohio). Restoration and Management Notes 14(1):81-82.

Bullivant., G. B., and M. P. C. Bertram. 1996. Tree shelters: a review. New Zealand Tree Grower. 17(2):27-30.

Burger, D. W., G. W. Forister, and P. A. Kiehl. 1996. Height, caliper growth, and biomass response of ten shade tree species to tree shelters. Journal of Arboriculture. 22(4): 161-166.

Carey, R. A., and D. J. Robertson. 1995. Tree shelters lead to unexpected problems (Pennsylvania). Restoration and Management Notes 13(1):134.

Evans, J. 1996. When to remove Tubex tree shelters: Notes from a closely observed plantation. Quarterly Journal of Forestry. 90(3):207-208.

Fisher, J. T., G. A. Fancher, and E. F. Aldon. 1990. Factors affecting establishment of one-seed juniper (*Juniperus monosperma*) on surface-mined lands in New Mexico. Canadian Journal of Forest Research. 20(7):880-886.

Fisher, J. T., G. A. Fancher, and R. W. Neumann. 1986. Survival and growth of containerized native juniper (Juniperus monosperma) on surface-mined lands in New Mexico. Forest Ecology and Management 16: 1-4, 291-299.

Gutowski, B, and R. Overton. 1996. Preface to the Proceedings of the Tree Shelter Conference. June 20-22, 1995, Harrisburg, PA. USFS Northeastern Forest Experiment Station, General Technical Report, NE-221.

Hunt, Clyde. 1996. Pros and Cons for tree planters: Summary comments of the 1995 Tree Shelter Conference. Proceedings of the Tree Shelter Conference. June 20-22, 1995, Harrisburg, PA. USFS Northeastern Forest Experiment Station, General Technical Report, NE-221. p. 76.

Kerr, G. 1995. The use of tree shelters: 1992 survey. Forestry Commission Technical Paper no. 11. 11 p.

Nixon, C. J. 1994. Effectiveness of tree shelters in upland Britain. Quarterly Journal of Forestry. 88(1):55-62.

Perry, P. 1996. What are some research results from experiments with tree shelters? Proceedings of the Tree Shelter Conference. June 20-22, 1995, Harrisburg, PA. USFS Northeastern Forest Experiment Station, General Technical Report, NE-221. p. 77.

Ponder, F. 1995. Shoot and root growth of northern red oak planted in forest openings and protected by tree shelters. Northern Journal of Applied Forestry. 12(1):36-42.

Potter, M. J. 1991. Tree shelters. London: Forestry Commission Handbook 7.

Robertson, D. J. and M. C. Robertson. 1995. Eastern mixed mesophytic forest restoration. Restoration and Management Notes 13(1):64-70.

Severeid, Larry R. 1996. Direct seeding using tree shelters. Proceedings of the Tree Shelter Conference. June 20-22, 1995, Harrisburg, PA. USFS Northeastern Forest Experiment Station, General Technical Report, NE-221. p. 67.

Teclaw, Ron, and John Zasada. 1996. Effects of two types of tree shelters on artificially regeneration of northern red oak in northern Wisconsin. Proceedings of the Tree Shelter Conference. June 20-22, 1995, Harrisburg, PA. USFS Northeastern Forest Experiment Station, General Technical Report, NE-221. (abstract) p. 68.

Walters, R. S. 1993. Protecting red oak seedlings with tree shelters in northwestern Pennsylvania. USFS Northeastern Forest Experiment Station Research Paper, NE-679, 5p.

Widell, Keith. 1996. Tree Shelter Update. USFS Technology and Development Program 2400, Timber Tech Tips. 6 p.