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Technical Report

No. 96-4

Restoration and Creation of Forested Wetlands: A Guide

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and
Bonnie Lee Appleton²

Introduction

Federal directives aimed at increasing the quality and quantity of wetlands in the nation recognize the importance of the functions of wetlands and the phenomenal loss in acreage since Colonial times. In the 1600's approximately 95% of the Chesapeake Bay watershed was covered with trees. Fewer than 60% of those forests remain today. Lumbering, agriculture, and urban/suburban development have led to the disappearance of forested wetlands. Highway construction continues to impact substantial areas of wetlands. An average of 100 acres of forest per day have been lost during the past 20 years in the Chesapeake Bay watershed (Blankenship, 1993).

Types of Forested Wetlands in Virginia

Forested wetlands in Virginia are primarily palustrine wetlands, including both tidal and nontidal areas. They border tidal and nontidal rivers and lakes or develop in upland seepage areas or depressions. Forested wetlands in brackish water areas where ocean derived salts are >0.5 ppt are classified as estuarine. Some wetland forests within freshwater (<0.5 ppt salinity) river channels are part of the riverine systems (Cowardin et.al., 1979).

Flooding of these systems may range from permanent to seasonal with surface water present for most of the growing season, or the soil may be saturated with groundwater seepage, with saturation well below the soil surface during the

growing season in most years. Forested wetlands range from swamp areas throughout the bottomland of the floodplain zone to intermittently saturated areas adjacent to upland (Mitsch and Gosselink, 1986).

Alluvial rivers originate in the Piedmont or mountains of Virginia and form flat, often terraced wetlands within the floodplain. These areas are immediately adjacent to their drainage systems and are characterized by turbid, sediment-bearing water flowing in well defined channels with seasonal overland flooding. The elevation of the terrace relative to the river determines the plant community (Wharton et.al., 1982).

Blackwater rivers originate in the large swamps of the coastal plain, and the hydrology of the associated wetlands is dependent primarily on local precipitation although groundwater seepage is an important component. Associated cypress swamps have multiple channels or sheetflow slowly draining into blackwater rivers. In coastal Virginia the most extensive palustrine forested wetlands are found in the Great Dismal Swamp complex, the nontidal areas of the Chickahominy River watershed, and the watersheds of the Blackwater, Nottaway, Meherrin and Dragon Run (Silberhorn, 1992).

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Protection and Mitigation

More than two decades since protection of wetlands emerged as a fundamental concern of national environmental policy, debate continues over the scope and intent of that policy. Generally, there are three recognized stages of protection:

1. Avoidance
2. Minimization of Impacts
3. Compensatory Mitigation

Avoidance is simply the designing of a project without impacting a wetland. Both natural and created vegetated buffer areas, should be established around existing wetlands for protection.

If avoidance cannot be achieved, minimization of impacts is the next approach. This may require project design changes such as relocating structures, to reduce the amount of wetland acreage affected.

If the above procedures have been followed, but impacts are determined to be unavoidable, compensatory mitigation is usually required for the areas impacted. The goal of compensation is to replace or reestablish the functional values of the impacted wetlands giving consideration to regional loss trends and replacement needs (Clearwater et al., 1987). As with mitigation, the goals of wetland restoration and creation

include regaining or establishing high diversity in plant as well as animal species and, ultimately, the functions of a self-sustaining ecosystem. The general lack of understanding of wetland ecosystem development has often led to unsatisfactory results for otherwise well-intended projects. The purpose of this paper is to describe some of the problems encountered during construction of forested wetlands and to recommend steps which will help to avoid them.

Project Planning

Defining Objectives

Establishing definitive objectives at the onset of a project cannot be overemphasized. Many projects have become mired in the final determination of success or failure because clear, measurable goals were not established in the early planning stages.

Idealistically, the goal in restoring/creating forested wetlands would be to "duplicate an original forest stand in terms of species composition, structure and function" (Clewell and Lea, 1990). In reality, this can only be approximated. Natural wetland forests are dynamic, ever-changing ecosystems. Alterations within the watershed area may not permit a return to the original forest. Changes in hydrology, elevation, sediment, nutrient, or exposure (as in the case of fire or storm damage) may prevent formerly indigenous species from surviving or flourishing. Current functional needs or local land use plans may dictate changes. In such situations altered (out of kind) forest restoration/creation may be the only option.

The recommended standard for assessing the success of restored or created wetlands is functional performance, but often the criterion for success has been merely the establishment of wetland plants on the site (Larson, 1987).

Except for cover or nurse crops, only desirable indigenous species should be planted. These preferred species represent those typical of undisturbed, mature, local stands of the forest community being restored. In addition to trees, consideration must also be given to undergrowth replacement to create a forest rather than a tree farm appearance (Clewell and Lea, 1990).

In an attempt to define success criteria for Southeastern forested wetlands, federal and state agen-

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Commonwealth's Declared Policy: "to preserve the wetlands and to prevent their despoliation and destruction..."

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cies, along with universities and industry, developed the Mitigation Site Type Classification System (MIST), which relies on the concept of reference wetlands. A successful forested wetland should resemble the previously selected reference wetland, with at least 400 trees over 6 feet in height per acre. Ten percent of the herbaceous, understory species must be the same as in the reference wetland, with fewer than 10% nuisance species (Haering et.al., 1992).

As objectives are established, this is the time to develop an efficient site specific protocol to monitor the project during construction and continuing through completion and final release by permitting agencies. These goals need to be stated with criteria for success that can be measured objectively.

Monitoring

Monitoring alerts the project engineer to any additional project activities and provides information for the agency personnel to expedite release of the project from regulatory control. Two modes of monitoring, inspection and quantitative sampling, have been recommended (Clewell and Lea, 1990). Inspections allow the prompt recognition of problems as they arise enabling timely maintenance and corrective implementation. Weekly tours the first few weeks following final earth-moving work may be needed to check for sediment and erosion problems and to monitor the function of any water control devices. Monthly inspections thereafter should be maintained until the project is released, which generally coincides with canopy closure.

Quantitative sampling permits periodic assessment of the progress of the project. Annual quantitative monitoring should occur for the first 5 years or more with final monitoring to document that all the criteria for success have been met. Density of saplings, density of recruitment, and percent of saplings and herbaceous material should be noted. Recruitment includes both natural and facilitated regeneration of indigenous species.

Such data should include photos with initial reports documenting permit requirements, site description, success criteria, site preparation and planting activities. Initial monitoring data and description of monitoring methods need to be included. Details of maintenance activities since the previous report and monitoring data should be presented in subsequent reports. Con-

sistency in description and evaluation of parameters established for success criteria are essential.

Site Evaluation and Preparation

Accurate assessment of the site is essential to determine the feasibility of the project. The objectives of the project, in addition to the history and hydrology of the area, must be considered. A very slight alteration in water flow, volume, clarity, or siltation can dramatically alter the complexion of herbaceous wetlands, and over time can select for different woody species. A newly created wetland will not resemble a 30 year old wetland ecosystem.


Hydrology

The most critical factor is hydrology. The timing of water delivery, water depth and quality determine the composition of the forested wetland and, consequently, must be determined in the site analysis. Any alterations or proposed changes within the watershed may alter the hydrology of the project area. Changes in grade will need careful monitoring to determine if the proposed grade consistently provides the desired hydrology. Water control devices should be in place before revegetation begins to help minimize losses from storms or river floods, and to provide necessary irrigation to prevent water stress to newly planted vegetation, especially in exposed sites where species adapted to shady swamps have been planted. Essential to any wetlands creation project is proper watershed management (Clewell and Lea, 1990).

Soils and Substrate Stabilization

Adequate soil volume must be available to allow seedlings to anchor and to support the mature tree. The depth to the water table and mechanical resistance (compaction and bulk density) of the soil are to be considered. Because of the oxygen requirements of the vegetation, most wetland trees are shallow rooted, and with inadequate soil volume may eventually topple.

To minimize compaction by heavy equipment at the project site, earthmoving needs to be scheduled during the dry season. Subsoil rippers have been effective in heavy clay soils to augment soil root volume, mix in surface organic matter, and to break up plow pan layers from previous agricultural use.



Zone	Aquatic Ecosystem		Bottomland Hardwood Ecosystem			Bottomland upland transition
Name	I	II	III	IV	V	VI
Water Modifier	Open Water	Swamp	Lower Hardwood Wetlands	Med. Hardwood Wetlands	Higher Hardwood Wetlands	Transition to Uplands
Flooding freq. % of years	Continuously Flooded	Intermittently Exposed	Semipermanently Flooded	Seasonally Flooded	Temporarily Flooded	Intermittently Flooded
Flooding duration, % of growing season	100	~100	51-100	51-100	11-50	1-10
	100	~100	>25	12.5-25	2-12.5	<2

Zonal classification of bottomland forest wetlands showing average hydrologic conditions. (After Clark and Benforado, 1981, p.8). (From Mitsch and Gosselink, 1986. Wetlands.)

Soil samples taken after final grading will indicate nutrient deficiencies. Disking straw, bark, wood fiber, sludge, green manures, or quick cover crops into the soil will contribute organic matter and micro and macrofauna at forest creation sites. Fertilizer may be necessary to help new seedlings better compete with more vigorous and aggressive weeds.

The pH of the soils after grade changes may vary significantly from the original or reference wetland. Most wetland plants prefer pH 4.5 - 6.5. Essential nutrients will be unavailable to plants if the pH is extremely high or low.

Normally the topsoil is stripped and stockpiled while the site is contoured and then replaced when grading is complete. The addition of topsoil may not be required when planting trees and shrubs in wetlands with mineral soils if nutrients and organic amendments are added (Garbisch, 1993).

Erosion and sediment accumulations may present serious problems during the first 6-18 months following grade changes and contouring. Careful monitoring is required in order that timely repairs can be made to prevent smothering vegetation and reducing water quality. Project failure may occur if gullying or sediment deposition prevents consistent water delivery to the site (Clewett and Lea, 1990).

Vegetation

Study of adjacent wetland communities can provide biological benchmarks for determining both type and elevation for planting desirable species; however, wetlands supported by groundwater or surface water runoff generally do not have such benchmarks (Garbisch, 1993). Hydrologic sensitivity groups vegetation into zones for planting. To comply with most agency requirements for wetlands, at least 50% of the desirable vegetation must be FACW or OBL.

After the final grading of the site and the area has been allowed to settle for at least 3 months during the growing season, the different planting zones can be determined and flagged to define planting areas (U.S. Army Corps of Engineers, 1995).

Consideration must be given to undergrowth to complete the ecosystem. The native seedbank is often recommended as a source for revegetation of desirable undergrowth species, but nuisance

species will also be present. Initial testing of the seedbank will reveal the flora present and enable the developer to plan appropriate strategies to reduce aggressive colonizers which may suppress the desired seedlings.

Often seeds native to the area are available in the natural seedbank and together with wind-blown recruitments are assumed to provide adequate undergrowth in time. This is dependent upon the condition of the seedbank, its handling during construction, the available source vegetation and its distance to the site, the topography of the land, the climate, and the method of seed dispersal. Open sites are often the first to be naturally seeded, but may be slowed by competition from weeds (Haynes and Moore, 1987).

Additionally, studies of upland forests and disturbed areas have demonstrated accelerated ecological succession with the placement of snags or "planting" of dead trees in open areas to provide bird perches thereby encouraging seed rain, an approach which may also be advantageous for forested wetlands (McClanahan and Wolfe, 1993).

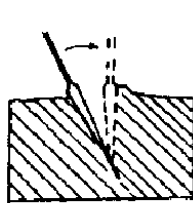
Competition

Herbicide treatment followed by disking during site preparation may be required where vines or perennial turf grasses are abundant. Two disc passes to the depth of 6-15" no more than two months prior to planting or seeding has been effective in reducing weed competition. By eliminating cover, this also reduces rodent problems in newly established vegetation (Allen and Kennedy, 1989).

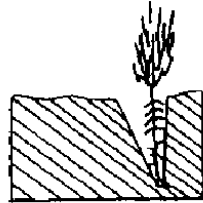
Some herbaceous cover may serve as nurse crops, or facilitators, providing shade, temperature regulation, and nutrients. Thorny plants may help protect seedlings from browsing; however, vines may deform, strangle, or pull desirable species to the ground (Haynes and Moore, 1987).

In initial site assessments, the number and variety of both desirable and potential nuisance members of the wildlife population need to be determined. Heavy damage can be inflicted on newly planted seedlings by herbivores; however, establishing or restoring wildlife habitat will invariably be one of the project goals. Consequently, success requires careful planning, monitoring, protection, and maintenance.

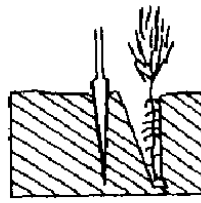
PLANTING WITH BAR



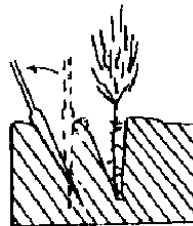
1. Insert bar at angle shown. Push forward to upright position.



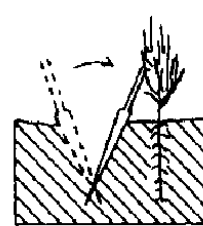
2. Remove bar. Place seedling at correct depth.



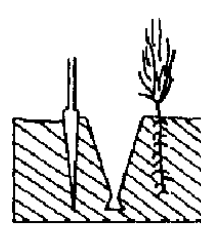
3. Insert bar 2 inches toward planter from seedling.



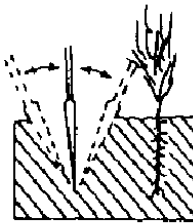
4. Pull handle of bar toward planter firming soil at bottom of roots.



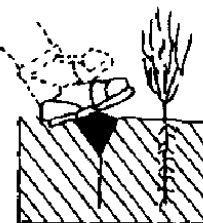
5. Push handle of bar forward from planter firming soil at top of roots.



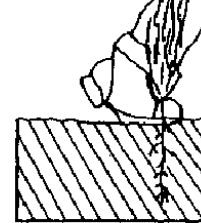
6. Insert bar 2 inches from last hole.



7. Push forward then pull backward filling hole.

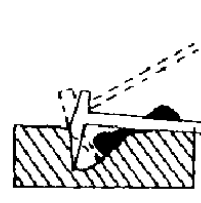


8. Fill in last hole by stamping with the feet.

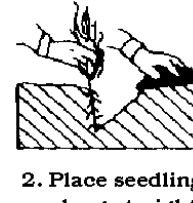


9. Firm soil around seedling with the feet.

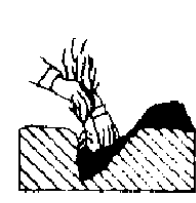
PLANTING WITH MATTOCK



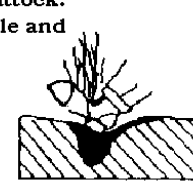
1. Insert mattock. Lift handle and pull.



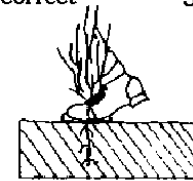
2. Place seedling along straight side at correct depth.



3. Fill in and pack soil to bottom of roots.

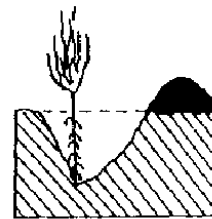


4. Finish filling in soil. Firm with heel.

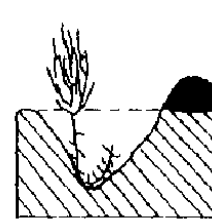


5. Firm around seedling with feet.

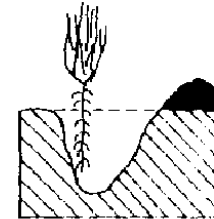
CORRECT AND INCORRECT DEPTHS



CORRECT: At same depth or 1/2" deeper than grew in nursery.



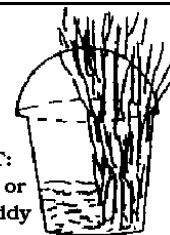
INCORRECT: Too deep. Roots bent.



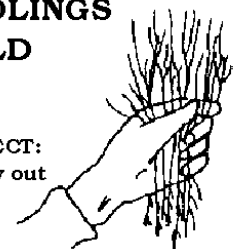
INCORRECT: Too shallow. Roots exposed.

HANDLING SEEDLINGS IN THE FIELD

CORRECT: Wet moss or thick muddy water.



INCORRECT: Roots dry out in hand.



If the first choice of plant species is a preferred food source for a large indigenous wildlife population, changes in plant selection may be necessary. For example, Atlantic white cedar is preferred by deer, and without protection, is not a good choice in areas of high deer populations.

Fencing may be required to prevent deer, raccoons, rabbits, and other small mammals from browsing young seedlings or saplings. Small rodents, like squirrels and chipmunks, may ex-hume directly seeded acorns. Indigenous or migrating birds or waterfowl may consume seeds or tender vegetation of preferred food choices. Tree shelters may be recommended to protect seedlings from large rodent or deer populations. A variety of types is available, from wire cages to photo- or biodegradable plastic tubes, some with mesh guards to prevent bird entrapment.

Weed control around young trees or a frequently disked buffer zone around the project will deter rodents by eliminating their cover, and such a buffer also serves as a fire break.

Planting

Species Selection

Soil, hydrology, geography, hardiness zone and latitude, natural predators, and other environmental factors must all be considered during species selection. The frequency of soil saturation, whether permanent, temporary, regular, or seasonal will help determine suitable species. The water table may be a few inches below the surface, at the surface, or the area may be permanently inundated. Some plants may tolerate occasional flooding or complete soil saturation, but for only a specific, limited time. Some tolerate dormant season flooding but have intolerance or considerably less flood tolerance during the growing season. Seedlings frequently have greater sensitivity to flooding than the mature plant forms. Immature woody plants must be taller than the available water depth to survive.

Woody wetland plants are usually restricted to specific locations. Some species are found primarily in the intertidal zone, while others naturally occur just above the mean high water level in tidal areas. A study of nearby reference wetlands can be invaluable. Often there is varying elevation within a natural wetland and the vegetation reflects this. A hummock or rise supports different vegetation than the surrounding

area that is more deeply inundated. Even slight variations in elevation can mean the difference between success and failure of plantings. Cherrybark oak tolerates soil saturation in winter but no more than 3 consecutive weeks of saturation in the growing season. It prefers the water level 2-6" below the soil surface and may not tolerate it higher or lower. Knowledge of the site requirements for the species that normally dominate the type of site being developed is critical (Hook, 1987).

Determining the salt content or salinity of the soil and whether it is ocean or land derived salt is very important. Brackish water has a salinity of 0.5 - 30 ppt due to ocean salts, but equivalent salinity may result from land derived salts, as in runoff from agricultural, industrial, or mining sources. Plants which do not tolerate >0.5 ppt ocean salts may be damaged by brackish conditions.

The use of a nearby reference wetland (recommended within 100 miles) helps to ensure suitable plant selection for the hardiness zone as well as similar soil and water conditions. Remember, however, that time will be required to achieve the mature look of a 20 year old forested wetland.

Target wildlife species must be considered during plant selection. Large seeded trees (oaks and hickories), small seeded species (maples), winter food sources, and cover for target species or their prey need to be provided for wildlife diversity.

Nurseries (within 100 miles) carrying local, native plant material are often suitable and offer the greatest potential for success. However, Papetti (1993) and others believe that contract specification of "local" species is unrealistic and the appropriate species will adapt, regardless of its origin. Frequently, seed or liners from distant sources are grown by local suppliers and after a year (two growing seasons) on their site are considered "local" (American Association of Nurserymen, 1990). This can be a problem with specific ecotypes. An ecotype is a subspecies or type within a species adapted to a particular set of growing conditions, generally within a geographic area. One ecotypic variation is bloom time within a species, especially those with a considerable north-south range. A southern ecotype may bloom much earlier than its northern counterpart, and will continue that pattern even if grown in a more northern climate. This

can pose serious problems if the plant has adapted the bloom time to avoid a serious pest at a vulnerable stage of growth or if pollinators are not available at the proper time, resulting in loss of reproductive potential. Unlike agricultural or horticultural crop cultivation where hybridized and uniform seed is preferred to streamline harvesting or ensure a selected trait, wild seed and plant propagation is preferred for wetlands to maintain biological diversity.

Seeding vs. Planting

Preferred food plants of indigenous wildlife populations may not survive unless protected; therefore, careful selection with possible protective barriers may be critical, or larger, more mature plants may be recommended. If seeding an area that is popular with water fowl, either on a migratory route or preferred by local birds, an increase in the seeding rate may be required, or the time of seeding may need to be altered. While seed is the least expensive plant material, it is not always appropriate for planting.

Large seeded woody species (oaks) have been planted as seeds very successfully in some areas. Acorns must be collected and stored until use; however, there is the advantage that such seeds may be planted almost anytime during the year, although July-September is not recommended. Acorns tend to remain dormant until environmental conditions are satisfactory. Such seeding is more successful in large open areas rather than under existing forest canopy or areas of high rodent populations. Direct seeding has been successful with certain oaks such as water, willow and cherrybark (Allen and Kennedy, 1989; Haynes and Moore, 1987). Lightweight wetland seeds are often tiny and should simply be pressed into the soil with a roller rather than worked into the soil.

Seedlings are the preferred choice for other oaks, green ash, sycamore, and tuliptree or yellow poplar. Seedlings are better for light seeded species and those with unique requirements for germination and establishment, such as bald cypress and tupelo. They may be more readily available either commercially or from adjacent wetlands. Although the cost is greater, there will be faster initial establishment.

Seedlings may be bareroot or container-grown. Using bareroot seedlings, while less expensive initially, limits the time period for planting. They

should be dug while dormant and will not tolerate substrate too wet or too dry. Extreme care must be taken in timing the arrival of the plants to the site at the time planting is ready to proceed. The seedlings must be protected from dessication during shipping, storage, and the planting process itself. Some growers use hydrogels to coat the roots to help prevent dessication (Papetti, per. com.). Bareroot material is recommended for deciduous shrubs, and is often the most cost effective form.

Container-grown plants offer the advantage of being planted almost any time of year if there is adequate soil moisture, and are preferred for late spring and fall plantings. Evergreen plants are often recommended to be container-grown. The logistics of transporting large numbers of containers to a large site must be considered, and plastic containers require collection and disposal after planting. Peat containers avoid this problem. Garbisch (1993) states that container plants have the highest rate of survival, followed by balled and burlapped (B&B) plants.

Some woody material is available balled and burlapped and poses some of the problems inherent with bareroot plants. If freshly dug and wrapped, they must be planted while dormant. Plants suffer some root damage in the digging process which could interfere with initial establishment in wet sites.

McKevlin (1992) recommends 200-500 seedlings/acre, the higher rates where animal (i.e. deer and rodent) competition is greater. Seedlings should have a root collar diameter of at least 1/4", have 12-18" shoots with at least an 8" tap root and a minimum of 5 good lateral roots (Hook, 1987; McKevlin, 1992). Saplings should have a minimum of three branches.

Plant/Seed Sources

The required quantities and species of tree seedlings often necessitate special orders and contract growing. Orders for plant material should be placed as soon as approvals are granted to allow time for contract growing, if that choice is selected. Scheduling should reflect the preferred planting season for the individual species, particularly bareroot seedlings. More vulnerable species such as those used for undergrowth may be best planted a year or more after initial plantings when the harsh open site conditions have been moderated by established plant material (Clewell

and Lea, 1990). Because timing is critical, it is advisable to get references on the selected grower, as delays in delivery become expenses for the contractor. Garbisch (1993) recommends visiting the growing facility before selection and during the growing period. He also suggests providing the grower with a list of preferred species along with a list of acceptable substitutes for each plant, and not permitting other substitutions to be made.

Wild seed collection in adjacent or nearby wetlands is sometimes recommended or may be followed by plant vendors, provided the source wetland is not depleted of adequate seed for perpetuation of indigenous species. Some vendors collect wild seed and cultivate it for sale as plants or to harvest additional seed. Other vendors may collect from a project's reference site to contract grow the specified plant material. It is imperative to emphasize the importance of careful wild seed collection in order not to harm or deplete a source wetland. Wild seed and plants will not be uniform in size, height, color or other characteristics, but it is precisely this variability that has allowed the species to survive over time.

Another practice of wild cultivation is to take cuttings from reference wetlands. Once again the same cautions regarding the source wetland must be emphasized. A concern with cuttings is the possibility of cultivating clones of a single parent plant, which over time diminishes biological diversity. Care must be exercised to take cuttings from a wide variety of source plants, and to rejuvenate stock frequently.

The question often arises about acclimation of woody species to wetland soil conditions, as specified by some contractors. Studies by McNinch et.al.(1994) indicate that appropriate wetland species grown in mesic conditions and with healthy fibrous root systems are more vigorous and adaptable to wetland sites than those grown under saturated or partially saturated conditions. Young (1-2 year old) seedlings, saplings or whips have also demonstrated greater adaptability to saturated conditions than more mature trees.

Planting Process

The importance of the arrival of plant material at the exact time it is to be planted can not be overemphasized. Entire shipments have been lost due to a truck's arrival with no one available to unload, and the plants sitting in the closed truck for hours in the heat. Plant material must be quickly unloaded, sorted by species, and inferior plants discarded. Plants not meeting specifications must be culled along with container plants with circling roots, or inadequate root systems. Roots should fill the container medium. Peat pots should have roots growing through the pots. The invoice must be carefully checked to confirm receipt of the entire shipment. The plants must be stored in a shady area, watered, and covered with mulch such as pine needles or straw to prevent drying. If planting is delayed, Virginia Department of Transportation (1993) recommends heeling in all bareroot plants not to be planted within 24 hours. The bundles can be opened, spread along a trench, and roots covered with soil. B&B plants should be heeled in if not used within 48 hours. No plants should be stored on site longer than 30 days.

The decision to use mechanical or manual planting must be made, and the appropriate equipment brought on site. Tractor pulled planters will allow faster planting, but the site may not permit the use of heavy equipment. Manpower, planting bars, plant bags, and marking wheels to determine spacing will be needed for manual planting. Planting zones should already be clearly marked and water control devices in place to control water levels. Dry planting is generally preferred and faster.

Care must be taken to dig holes the proper depth to avoid air pockets and "J" rooting or twisting of roots. Plants must be placed upright and vertical in the planting holes, along with slow release fertilizer, if recommended. Leaving labels on the plants facilitates monitoring at a later date. Flags left in place will help the observer locate desirable plants during the postplanting monitoring period.

After planting, water is returned to the site if water controls have been used, taking care not to submerge seedlings. Irrigation may need to be provided during establishment or until the required hydrology is reestablished.

Maintenance

Slow release fertilizer provided for each plant at the time of planting helps to get the seedlings off to a vigorous start and eliminate or delay later additional applications. Broadcast fertilization may improve desirable plant growth, but it will also encourage the growth of weed species, which may increase the rodent predation by providing cover.

Weed control by such means as mowing, disking or application of herbicides is often necessary until the seedlings have overgrown their competition. Replacement of dead or missing plants is required during the permit period and regular inspections will alert the project manager of this need.

Causes of Planting Failures

Any number of circumstances can contribute to plant mortality and often a combination of factors is to blame. The following list highlights areas of concern (Haynes and Moore, 1987; McMullen, 1987; Hook, 1987):

1. Lack of knowledge of species tolerance to drought, flooding, and soils.
2. Lack of adequate lateral root development.
3. Planting seedlings too deep or shallow.
4. Drought after planting and during growing season.
5. Late freeze following planting.
6. Standing water with ambient temperatures.
7. Extended flooding late into the growing season.
8. Damage or destruction of seeds/seedlings.
9. Plant species not suited for site.
10. Competition from herbaceous vegetation and vines.

Conclusion

The demand for development of forested wetlands continues to increase and wetlands disappear despite local, state, and federal regulatory efforts. Wetland degradation caused by urban impacts persists and the importance of restoration and creation of forested wetlands remains a primary issue. Although "it is virtually impossible to create the exact hydrology, soil, and topographic conditions that formed the mature wetland which is being impacted," persistent attempts to replicate nature will continue (Hett, 1994). As experience

and research answer more questions regarding forested wetlands, the creation success rate should climb. This may necessitate a redefinition of success and a clarification of possible stages in wetland forest succession, or it may require an entirely new approach. In the mean time, wetland managers, developers, and regulators must recognize the inherent limitations of the knowledge base for the creation and restoration of forested wetlands.

References

- Allen, J. and H.E. Kennedy, Jr. 1989. *Bottomland Hardwood Reforestation in the Lower Mississippi Valley*. U.S. Fish and Wildlife Service. National Wetlands Research Center. Slidell, Louisiana.
- American Association of Nurserymen. 1990. *American Standard for Nursery Stock*. Washington, D.C.
- Blankenship, K. 1993. Trees and the Bay. *Bay Journal*. Alliance for the Chesapeake Bay. November. pp. 4-7.
- Clearwater, D., M. Hollins, and D. Burke. 1987. Guidelines for Nontidal Wetland Mitigation in the Maryland Critical Area. In National Wildlife Federation Proceedings *Wetlands: Increasing our Wetland Resources*. John Zelazny and J. Scott Feierabend, Eds. Washington, D.C.
- Clewell, A. and R. Lea. 1990. Creation and Restoration of Forested Wetland Vegetation in the Southeastern United States In: *Wetland Creation and Restoration - The Status of the Science*. Kusler, J.A. and M.E. Kentula, Eds. Island Press. Washington, D.C. pp. 195-231.
- Cowardin, L., F. Golet, and E. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. U. S. Department of Interior. Fish and Wildlife Service. Washington, D.C.
- Garbisch, E. 1993. *Wetland Journal*. Environmental Concern. 5:2.
- Haering, K, J. Waller-Eling, W.L. Daniels, and M. Genthner. 1992. *Nontidal Wetland Soils and Wetland Mitigation: A Literature Review*. Virginia Polytechnic Institute and State University. Blacksburg, Virginia.

- Haynes, R. and L. Moore. 1987. Reestablishment of Bottomland Hardwoods within National Wildlife Refuges in the Southeast. In National Wildlife Federation Proceedings *Wetlands: Increasing our Wetland Resources*. John Zelazny and J. Scott Feierabend, Eds. Washington, D.C. pp. 95-102.
- Hett, J.W. 1994. Wetland Mitigation Monitoring: A Natural Approach. *Wetland Journal*. Environmental Concern. 6:3.
- Hook, D. 1987. Criteria for Creating and Restoring Forested Wetlands in the Southern United States in National Wildlife Federation Proceedings *Wetlands: Increasing our Wetland Resources*. John Zelazny and J. Scott Feierabend, Eds. Washington, D.C. pp. 51-58.
- Larson, J. 1987. Wetland Creation and Restoration: An Outline of the Scientific Perspective. In National Wildlife Federation Proceedings *Wetlands: Increasing our Wetland Resources*. John Zelazny and J. Scott Feierabend, Eds. Washington, D.C. pp. 73-78.
- McClanahan, T. and R. Wolfe. 1993. Accelerating Forest Succession in a Fragmented Landscape: The Role of Birds and Perches. *Conservation Biology*. 7:2. pp.279-288.
- McIninch, S., E. Garbisch, and D. Biggs. 1994. The Benefits of Wet-Acclimating Woody Wetland Plant Species. *Wetland Journal*. Environmental Concern. 6:2.
- McKevlin, M. 1992. *Guide to Regeneration of Bottomland Hardwoods*. U.S.D.A. Forest Service Southeastern Forest Experiment Station. North Carolina.
- McMullen, J. 1987. Selection of Plant Species for Use in Wetlands Creation and Restoration. In National Wildlife Federation Proceedings *Wetlands: Increasing our Wetland Resources*. John Zelazny and J. Scott Feierabend, Eds. Washington, D.C.
- Mitsch, W. and J. Gosselink. 1986. *Wetlands*. Van Nostrand Reinhold Company. New York.
- Papetti, R. 1993. Personal Communication. Bobtown Nurseries. Melfa, Virginia.
- Silberhorn, G. 1992. A Characterization of the Plant Community Structure of Palustrine Forested Wetlands in the Coastal Plain of Virginia. In Proceedings: *Saturated Forested Wetlands in the Mid-Atlantic Region: The State of the Science*. Annapolis, Maryland.
- U.S. Army Corps of Engineers. 1995. Branch Guidance for Wetlands Compensation - Permit Conditions and Performance Criteria (Unpublished Draft). Norfolk, Virginia.
- Virginia Department of Transportation, 1993. Specifications Manual.
- Wharton, C., W. Kitchens, E. Pendleton, and T. Sipe. 1982. *The Ecology of Bottomland Hardwood Swamps of the Southeast: A Community Profile*. National Coastal Ecosystems Team. Fish and Wildlife Service. U.S. Department of the Interior. Washington, D.C.

Trees and Shrubs for Forested Wetlands

Scientific Name	Common Name	Indicator
<i>Acer rubrum</i>	Red Maple	FAC
<i>Acer saccharinum</i>	Silver Maple	FACW
<i>Baccharis halimifolia</i>	Groundsel Bush	FACW-
<i>Betula nigra</i>	River Birch	FACW
<i>Carpinus caroliniana</i>	American Hornbeam	FAC
<i>Carya aquatica</i>	Water Hickory	OBL
<i>Celtis laevigata</i>	Sugarberry	FACW
<i>Chamaecyparis thyoides</i>	Atlantic White Cedar	OBL
<i>Clethra alnifolia</i>	Sweet Pepperbush	FAC+
<i>Cornus amomum</i>	Silky Dogwood	FACW
<i>Cornus stolonifera</i>	Red-osier Dogwood	FAC
<i>Fraxinus pennsylvanica</i>	Green Ash	FACW
<i>Ilex opaca</i>	American Holly	FACU+
<i>Itea virginica</i>	Virginia Willow	OBL
<i>Iva frutescens</i>	Marsh Elder	FACW+
<i>Juniperus virginiana</i>	Eastern Red Cedar	FACU
<i>Liquidambar styraciflua</i>	Sweetgum	FAC
<i>Liriodendron tulipifera</i>	Tuliptree; Yellow Poplar	FACU
<i>Magnolia virginiana</i>	Sweetbay Magnolia	FACW+
<i>Nyssa aquatica</i>	Water Tupelo	OBL
<i>Nyssa sylvatica</i> var. <i>biflora</i>	Swamp Tupelo	FACW+
<i>Nyssa sylvatica</i>	Black Gum	FAC
<i>Persea borbonia</i>	Red Bay	FACW
<i>Pinus serotina</i>	Pond Pine	OBL
<i>Pinus taeda</i>	Loblolly Pine	FAC-
<i>Platanus occidentalis</i>	Sycamore	FACW-
<i>Quercus alba</i>	White Oak	FACU-
<i>Quercus falcata</i>	Cherrybark Oak	FACW
<i>Quercus lyrata</i>	Overcup Oak	OBL
<i>Quercus michauxii</i>	Swamp Chestnut Oak	FACW
<i>Quercus nigra</i>	Water Oak	FAC
<i>Quercus palustris</i>	Pin Oak	FACW
<i>Quercus phellos</i>	Willow Oak	FAC+
<i>Salix nigra</i>	Black Willow	FACW
<i>Taxodium aquatica</i>	Pond-cypress	OBL
<i>Taxodium distichum</i>	Baldcypress	OBL
<i>Ulmus americana</i>	American Elm	FACW-