Tree Planter's Notes, Volume 44, No. 3 (1993)

Using a Constructed Wetland to Treat Waste Water and Propagate Wetland Species

Glenn Beagle and John Justin

Coordinator and nursery coordinator, Utah Division of State Lands and Forestry
Lone Peak Conservation Center, Draper, Utah

Constructed wetland ponds at Lone Peak State Nursery near Salt Lake City, Utah, produce herbaceous plants for both wetland restoration projects and creation of new wetlands in agricultural, urban, and industrial applications. In response to the new demands for specialized wetland plant materials, the nursery developed partnerships with both private businesses and government agencies to develop a constructed wetland system. This innovative system not only catches and treats agricultural runoff by physical, chemical, and biological processes from the container nursery, it also serves as a propagation system for wetland plants such as sedges (Carex spp.), *rushes* (Juneus spp.), *spikerushes* (Eleocharis spp.), *and bulrushes* (Seirpus spp.). *An additional benefit of this project is that new vegetative and seed propagation techniques are being developed and made available to other nurseries.* Tree Planters' Notes 44(3): 93-97; 1993

The demand for riparian plants is increasing rapidly, especially for nonwoody species. The national policy of "no net loss of wetlands" has resulted in many mitigation projects that require wetland plants. Water quality improvement projects are also creating a market for these plants. Lone Peak State Nursery (operated by the Utah Division of State Lands and Forestry near Salt Lake City, Utah) recognized these trends in 1991 and began looking at various economical methods of producing wetland species such as sedges *(Carex spp.)*, rushes *(Juncus spp.)*, bulrushes *(Scirpus* spp.), and spikerushes *(Eleocharis spp.).*

Another difficulty facing many nurseries today is the need to control point-source pollution from greenhouse operations. In the near future, many nurseries will have to address their runoff pollution problems because of stricter enforcement of current laws and passage of tougher new laws.

Lone Peak State Nursery has developed an innovative constructed wetland system that deals with nonpoint-source pollution while providing an environment for propagating obligate wetland plant species (figure 1). Obligate wetland species almost always (> 99%) grow in wetlands under natural conditions (Reed 1988). Formerly, the nursery's greenhouse runoff leached into a bareroot production field and eventually drained into an irrigation canal below the nursery. The affected field experienced a high incidence of disease and seedling mortality because the soil was saturated and had high nitrate levels.

Figure *1-Constructed wetland production ponds of sedges* (Carex) *and rushes (Juncus) species. The Lone Peak Nursery's bareroot seedling fields can be seen in the background, and the]or dan River irrigation canal can be seen in the upper right.*

We decided that a water collection system below the greenhouse should capture the runoff and take it to collection ponds where it could be treated. Treatment of waste water by wetland systems can be characterized by the removal of dissolved pollutants, nitrates, phosphates, suspended solids, trace metals, and pathogens by physical, chemical, and biological processes. Treatment mechanisms of wetland systems include sedimentation, filtration, chemical precipitation, absorption, microbial interactions, and uptake by vegetation (Watson et al. 1988).

At about the same time, we came up with the idea of propagating wetland plants in these ponds. The Washoe State Nursery of the Nevada Division of Forestry was collecting "meadow plugs" of a mixture of wetland species and propagating them in containers. We decided to modify Nevada's system so that we could isolate individual species and propagate them separately.

We developed the following objectives for the proposed constructed wetland project:

1. Improve the water quality of greenhouse waste water before it leaves the Lone Peak Nursery property.
2. Develop commercial methods to propagate five obligate wetland species.
3. Produce and harvest seed from four selected wetland plant species.
4. Generate sufficient revenue from wetland plant sales to make the program self-supporting.

Search for Political and Financial Support

Because the nursery did not have the funding for such a large project, we needed to generate financial support for our constructed wetland. The Utah Department of Agriculture (UDA) was a strong advocate for the project. Because it could benefit from a supply of wetland plants for agricultural filter strips, the UDA provided initial funding and collaborated with the USDA Soil Conservation Service (SCS) to design a collection and water storage system to Lone Peak's operational specifications. Utah Power, a private utility company that had begun using native plant communities to improve water quality and soil stability, saw the long-term benefits of creating a commercial source of wetland plants and provided a major construction grant. The USDA Forest Service assisted the project by providing Cooperative Forestry funding. The nursery also received political support from numerous private and government cooperators that were potential users of wetland plants.

Design and Construction of Runoff Collection System and Treatment Ponds

Our constructed wetland was designed as four ponds lined with a 30-mil plastic membrane with inlets for runoff and field irrigation water (figure 2). We wanted a sealed system to prevent waste water from leaching out of the ponds, control water levels, and allow monitoring of pollutant levels in water drained from the ponds. Each pond has a French drain--a trench filled with rock--for adjusting the water table depth and draining the water for plant harvesting operations.

Figure *2-Smallest pond during construction, showing subsurface drain system and 30-mil plastic liner.*

A mixture of sandy loam topsoil and washed concrete sand was placed in the ponds to a depth of 2.5 feet (.76 m). This soil mix was selected to prevent introduction of weed seeds from nursery soils and to provide a coarse-textured, easily drained soil.

Water enters the pond in two ways. The primary source is non-point-source water from upslope and greenhouse runoff that is captured in a French drain oriented along the contour below the greenhouse, drains into a settling box, and is piped underground to the ponds (figure 3). Additional water enters the ponds via the field irrigation system, which is connected to the underground drains and pond inlet piping. This feature has proven valuable for the following reasons: runoff sediment accumulates quickly in the underground pipes and the entire system can be flushed under pressure with irrigation water. Also, during dry summer months it has been necessary to supplement runoff with irrigation water to maintain proper water levels in the ponds.

The constructed wetland design has been in use for 1.5 years with very few problems. The only change in design we recommend is reducing the top width of the pond dikes from 10 feet (3.05 m) to 2 feet (.61 m) and the height of the pond dikes from 5 feet (1.5 m) to 3 feet (.9 m). Our dikes were overdesigned for the project's needs, and significant construction savings could be realized with smaller dikes. If local topography allows, complete elimination of the dikes would be extremely economical. Digging shallow depressions with a bulldozer may be all that is necessary.

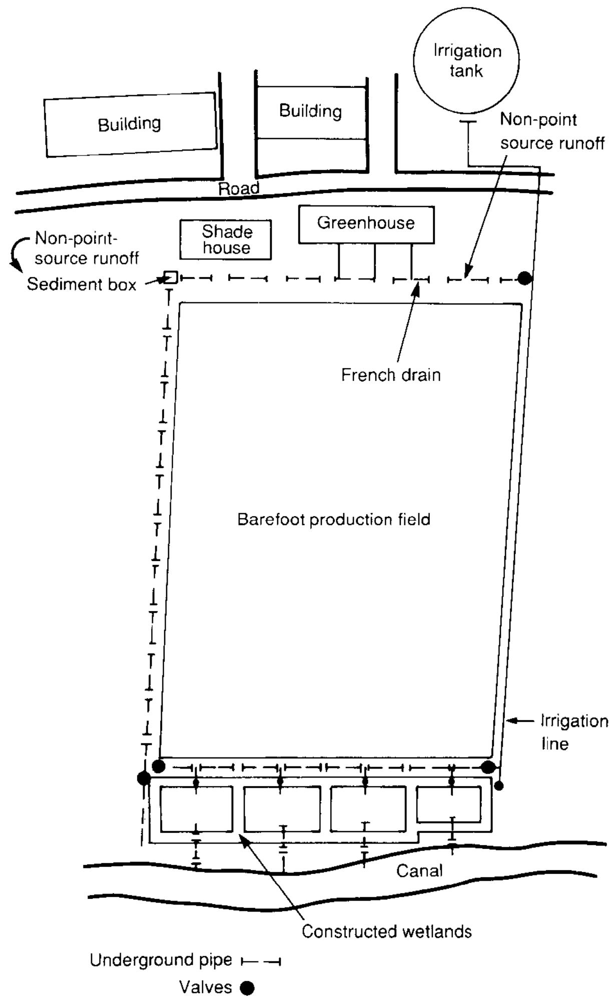

Figure *3-Overhead diagram of the constructed wetland project showing the collection area below the greenhouse complex and the location of the ponds.*

Vegetative Propagation System for Wetland Plants

The propagation system developed for the ponds is designed to vegetatively produce container seedlings ("plugs") of individual wetland plant species. The design minimizes field collection costs, transplanting losses, and associated high labor costs.

The initial stock plants are collected by nursery crews from local native wetland communities. Collected plant materials should be handled like bareroot tree seedlings because they do not store well and must be replanted quickly. Cold storage of plants for longer than 2 to 3 days appears to reduce transplant success. The wild collections are first potted and grown to maturity so that the identity of the different species can be verified.

When the plants are correctly identified, single species are planted in each of the four ponds. Nebraska sedge *(Carex nebraskaensis),* beaked sedge *(Carex rostrata),* baltic rush *(funcus balticus),* and creeping spikerush *(Eleocharis palustris)* are currently growing in the ponds. Hardstem bulrush *(Scirpus acutus),* which is difficult to handle vegetatively because of its size and form, was not planted in the ponds.

The pond soil is saturated to soften it and then the ponds are planted with plugs containing 2 to 3 shoots on a 1-foot by 1-foot (.3-m by .3-m) spacing (figure 4). The plants spread vigorously throughout the soil by vegetative reproduction . After 9 months, when the ponds contain approximately 20 to 25 shoots per square foot, 40% of the surface area is harvested (figure 5). The coarse-textured pond soil easily falls away from plant roots during harvesting, which limits soil loss. Individual shoots and rhizomes are divided out and potted into 10-cubic-inch (163-cm3) Ray Leach super cells or 29-cubic-inch (475-cm3) D-pots. Pond soil is replaced after each harvest to fill in holes and level the soil surface.

The container plants are held in propagation areas-shadehouses or open growing areas-where they are exposed to full sunlight for 1 to 2 months. When multiple shoots appear, they are divided into single shoots, repotted, and returned to the propagation area. Several divisions occur each growing season, with each division increasing the number of plugs by about 50% (figure 5).

Figure *4-Work crew planting Nebraska sedge* (Carex nebraskaensis) *on 1-foot (.3-m) centers.*

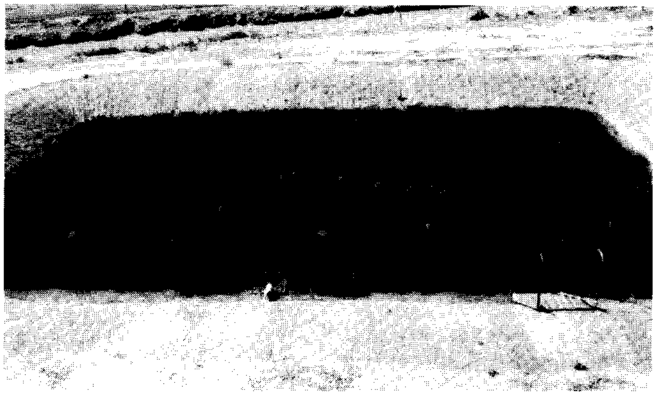

Figure *5-Constructed wetland ponds are harvested once a season, and then these plants are transplanted to containers and propagated by division 2 to 3 more times, with a potential 50% increase each time.*

This propagation system has proven satisfactory, but we are still experimenting with better production methods for wetland plants:

1. Trials have been conducted to determine the optimum growth container for sedge species. Fourinch-deep (10-crn-deep) geranium pots, 29-cubicinch D-pots, and 10-cubic-inch Ray Leach tubes have been tested. The geranium pots appear to allow the greatest rhizome development because they have the largest surface area. The D-pots and geranium pots are used for initial potting. Ray Leach tubes are used at the final division.
2. Managing the water levels in the ponds is very important for culturing wetland plants, and growth rates varied significantly between different species. Our experience and information supplied by the SCS Aberdeen Plant Materials Center indicates that the optimal water level for beaked sedge is at the soil surface; for Nebraska sedge, it is 1 to 2 inches (2.5 to 5 cm) above the soil surface; for creeping spikerush, it is 3 to 4 inches above the soil surface; and for baltic rush, it is 1 to 2 inches below the soil surface.
3. Labor costs can account for a large portion of the cost of wetland plant production. Field collection, transplanting, and plug division all require many worker-hours. Any methods that save labor should be considered. The construction of a wetland on nursery grounds allows on-site collection of plants, thus reducing overall production costs. Harvesting plants from dense, wet stands in heavy soils is labor intensive, and so we are currently evaluating several tools to ease this process.

Limitations of the Current Design of the Constructed Wetland

Soon after our constructed wetland was operational, it became evident that precisely monitoring the system would be difficult. The French drain collection system below the greenhouse complex is not completely effective, and all greenhouse runoff is not captured. A better design would have a direct drainpipe from greenhouse floor drains to the treatment ponds.

Testing for different dissolved pollutants and analyzing the efficiency of the treatment ponds proved to be extremely expensive. Chemical analysis for single pollutants, especially pesticides, can cost several hundred dollars apiece. Another complication to monitoring the water quality was the introduction of the non-pointsource water to the system (figure 3). The runoff from the greenhouse and shadehouse is actually a minor component as compared to the non-point-source water and so precise monitoring is difficult with this system.

Propagation in the constructed wetland ponds required greater amounts of water than our one greenhouse operation provided. To maintain the proper water levels for the various species over the growing season, substantial amounts of water had to be added to the ponds from the field irrigation lines.

Future Needs and Opportunities

Need for more growing area. The demand for wetland plants for reclamation projects has exceeded our current vegetative production capabilities. Mitigation and conservation uses of wetlands for water treatment projects have created a substantial demand for reasonably priced wetland plants. Much of the nursery's small greenhouse is already needed for routine seedling production, and so additional space is required to meet the demand for the wetland program. The changeover to seed propagation of wetland plants will also require more greenhouse space. A new greenhouse with a closed irrigation system would also allow the monitoring of nutrient uptake of individual plant species and microbial activity responsible for improving water quality.

Seed propagation. The potential exists to produce some species of wetland plants from seed. Compared to vegetative means, seed propagation offers several advantages such as lower field collection costs, less growing area, and a shortened production cycle. Current obstacles to seed propagation include lack of knowledge on pre-germination treatments and seed storage viability, and limited availability of local seed sources. Lone Peak's seed research has been concentrated on the propagation of hardstem bulrush (Scirpus acutus) and alkalai bulrush (Scirpus maritimus). Initial plans called for planting hardstem bulrush in one constructed wetland pond. After working with this species, it was apparent that vegetative propagation was not practical because of the plants' large size. Propagation of sedges and rushes from seed may also be advantageous because of the high labor costs of dividing and transplanting plugs. We are currently exchanging information on pre-germination seed treatments for wetland species with the USDA Soil Conservation Service's Aberdeen Plant Materials Center and Nancy Shaw of the USDA Forest Service's Intermountain Experiment Station.

Some of the existing constructed wetland ponds could be converted to seed production areas to provide a known seed source of single species. The ponds would continue to be a component for water treatment of our existing greenhouse and non-point-source pollution.

Technology transfer. The production of wetland

Plants is a newly emerging aspect of the forest and conservation nursery field. The constructed wetland project was developed to produce salable plants and develop practical propagation techniques. The resulting information and technology may be used by other tion needs. Lone Peak State Nursery could supply plantlets or seed from our constructed wetland for private nursery propagation.

Many unknowns still exist in propagating wetland plants vegetatively and from seed. Development of seed collection, processing, and germination techniques may yield more economical production methods. Our wetland plant production will continue to be a cooperative project among Federal, State, and private organizations. For more specific information on this project, contact:

Glenn Beagle, Coordinator
Lone Peak State Forest Nursery
14650 Prison Road
Draper, UT 84020
Tel: (801) 571-0900
FAX: (801) 571-0468

Literature Cited

Reed, Jr., P B. 1988. National list of plant species that occur in wetlands: 1988. St. Petersburg, FL: U.S. Department of the Interior, Fish and Wildlife Service, National Wetlands Inventory.

Watson, J. T.; Reed, S. C.; Kadlec, R. H.; Knight, R. L.; White house, A. E. 1989. Performance expectations and loading rates for constructed wetlands. In: Hammer, D.A., ed. Constructed wetlands for wastewater treatment: municipal, industrial, and agricultural. Proceedings, 1st International Conference on Constructed Wetlands for Wastewater Treatment; 13-17 June 1988; Chattanooga, TN. Chelsea, MI: Lewis Publishers: 319-352.