Figure 1 • Constructed wetlands at the JH Stone Nursery 10 mo after planting.

Photo by David Steinfeld

Experiences Establishing Native Wetland Plants in a Constructed Wetland

David Steinfeld

ABSTRACT

Over 8000 seedlings, representing 10 wetland plant species, were grown from locally collected seeds and planted in a constructed wetland system. Seeds were, for the most part, easily collected and cleaned, but *Scirpus* and *Carex* seeds required tumbling treatment to remove the perigynia. Germination was high when seeds were kept moist, hot (32 to 35 °C [90 to 95 °F) and in light following a 30 d stratification at 1 to 2 °C (34 to 36 °F) in moistened sphagnum peat moss. Seedlings were grown in water tanks for 3 mo and planted in early fall. Initial establishment was 100% but when the constructed wetlands were filled in late spring, submerged seedlings died. Our constructed wetland system was a cooperative effort of several public and private agencies and is providing many educational opportunities to our community.

KEY WORDS: *Carex, Scirpus, Juncus*, partnerships, water quality, container nursery, seed treatments

NOMENCLATURE: Hitchcock and Cronquist (1973)

For over a decade, we at Stone Nursery have looked at ways to control sediment from our nursery fields. In 1993, we constructed small sediment collection ponds to capture surface water from high rainfall events. Although efficient, the ponds only treated a small section of our 87-ha (215-ac) farm. We really needed something larger. Two years ago, the Bureau of Reclamation approached us with a proposal to use a section of our nursery fields as a constructed wetland to clean a portion of water from Jackson Creek, a tributary to the Rogue River and a stream that bisects our property. The Oregon Department of Environmental Quality had recently designated Bear Creek, of which Jackson Creek is a tributary, as a water quality limited stream due to high nutrient levels, sediment loads, bacterial contaminations, and other water quality factors. The Bureau of Reclamation's interest in this partnership was to demonstrate the types of potential water quality benefits derived from this type of constructed wetland. The proposal was to divert 0.014 m^3/s (0.5 CFS) of creek water through a 1.2-ha (3-ac) constructed wetland and return the water to the stream in a cleaner condition. We saw another opportunity—to divert a portion of the nursery field runoff into this system to settle out sediments before the water entered Jackson Creek.

BENEFITS OF CONSTRUCTED WETLANDS

From initial conversations, our staff began to see spin-offs from the project that would be very beneficial to the long-range goals of the nursery. We recognized 6 direct benefits from an on-site constructed wetland: 1) clean suspended sediments, nitrogen, phosphorus, and pesticides from a portion of Jackson Creek water; 2) control sediment produced from our farm during high precipitation events; 3) learn how to economically grow native wetland species from seeds; 4) use the constructed wetland as a source for source specific seed production; 5) establish studies and monitoring projects to evaluate plant growth, water quality changes, and effectiveness of the wetland system; and 6) develop education opportunities for our clients, local students, and the community to learn about constructed wetlands and wetland plant propagation.

These benefits reflect the growing recognition of the importance of wetlands to stream and watershed health. Natural and constructed wetlands function as systems that can effectively remove organic matter, sediment, metals, and excess nutrients from nonpoint agricultural runoff. Wetland plants play a major role in this process by supporting microbial populations that reside on the leaves, stems, and roots of wetland plants. The large plant surfaces are sites for bacteria, fungi, algae, and protozoa which breakdown pollutants, using them as energy sources (Smith 1989). Wetland plants also transport oxygen to their root systems, creating an aerobic environment in an otherwise anaerobic zone (Guntenspergen and others 1989) where large microbial populations

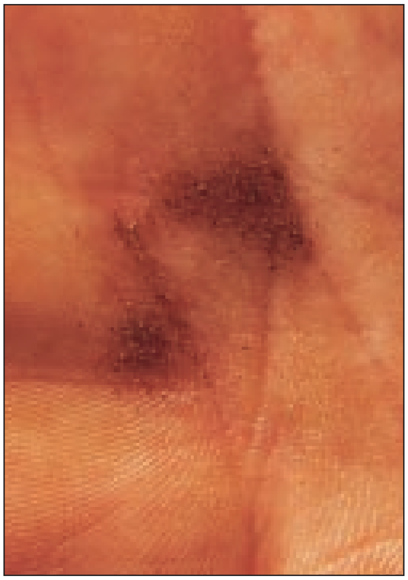

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Figure 2 • Dust-like seeds of Juncus ensifolius *average 152 million seeds per kg (69 million/lb).*

modify nutrients, metallic ions, and other compounds (Steiner and Freeman 1989).

Our wetland system is composed of 4 large ponds that span 240 m (800 ft) in length and average 30 m (100 ft) in width (Figure 1). We estimate that it will take 24 to 48 h for water to move through the system during which most of the sediments and pollutants will be removed. The primary function of the first 2 ponds is to detain sediments and suspended solids while the last 2 ponds are designed to immobilize nitrogen and phosphorus.

PARTNERSHIPS

This project brought together several partners with specific roles: the Bureau of Reclamation would facilitate, design, and oversee the construction; the Rogue River Valley and Medford irrigation districts would construct the wetlands and the later would supply water rights; the Rogue Valley Council of Governments would facilitate planting of seedlings by local students and be involved with water monitoring and educational activities after site establishment; and JH Stone Nursery would donate land, produce wetland seedlings, complete environmental assessment documents, and maintain the area over time.

Even though most of these organizations are local and work on projects in the Rogue River Valley that directly or indirectly influence the nursery, we have had very little interaction with them. This project gave us an opportunity to get to know each other over the common issue of water. It was not surprising to find that we had many similar interests pertaining to the welfare of this watershed and the community in general. Success of this collaboration increases the likelihood of future local and regional watershed and educational partnerships.

SEEDS

In August and September 1998, I went looking for ripened seeds of native sedge (*Carex* spp.) and bulrush (*Scirpus* spp. and *Juncus* spp.) species (Table 1). Juncus species were easy to find in wet ditch lines or poorly drained portions of irrigated fields. Once located, I placed the base of a brass soil sieve under seed heads and gently tipped and shook the plant spilling the fine dust-like seeds onto the plate. *Juncus* seeds reside in capsules and will spill once the capsule is tipped by the first strong gust of wind. It is important to collect it just after ripening to beat the winds and the rains. Seed cleaning can take place at this time by gently blowing across the surface of the seeds. Only after many plants have been shaken will the bottom of the pan fill up with a layer of seeds (Figure 2). Although it does not seem like many seeds for the effort, a small vial of *Juncus* seeds represents hundreds of thousands of seeds; seeds per kilogram range from 96 million seeds per kg (44 million/lb) for common rush (*Juncus effuses*) to 152 million seeds per kg (69 million/lb) for swordleaf rush (*Juncus ensifolius*) (Hurd and Shaw 1991).

Carex species were much harder to find. My first attempt at locating beaked sedge (*Carex utriculata*) was from a tip given me by a local botanist. I spent most of an afternoon looking for the stand and when I did find it, I realized that the seeds were still green. I came back 2 weeks later only to discover that the stand had been beaten to the ground by a herd of cattle. Nevertheless I combed through the thatch and collected what I could find. Other species like water sedge (*Carex aquatilis*) are more prevalent and usually found around lakes. Torrent sedge (*Carex nudata*) grows in and under flowing streams. It ripens much earlier than other *Carex*. I collected it in late spring just when the snow runoff was receding from a valley stream. *Carex* seeds are ripe when the perigynium (the saclike covering around the seed) has a golden-brown appearance and detaches from the seed head easily.

Two *Scirpus* species are relatively easy to locate in our area: hard stem bulrush (*Scirpus acutus*) and small fruit bulrush (*Scirpus microcarpus*). *Scirpus acutus* can be found in many irrigation ditches and ponds around the valley. I located *S. microcarpus* in the open riparian areas and wet meadows at mid elevations in the Cascade Mountains.

For most *Scirpus* and *Carex* species I stripped seeds using my hands and placed them into a paper bag to dry. Once dried, seeds and other debris were run through a tumbler until the perigynium detached. Excessive tumbling can damage seed coats and reduce germination. For each species,

TABLE 1

Species propagated for planting in constructed wetlands at JH Stone Nursery

Family	Species	Common Name
Juncaceae	*Juncus articulatus* L.	Jointed rush
	Juncus effusus L..	Common rush
	Juncus ensifolius Wikst.	Swordleaf rush
	Juncus torreyi Cov.	Torrey's rush
Cyperaceae	*Carex aquatilis* Wahl.	Water sedge
	Carex cusickii Mack.	Cusick's sedge
	Carex nudata W. Boott	Naked sedge
	Carex utriculata Boott	Beaked sedge
	Scirpus acutus Muhl.	Hardstem bullrush
	Scirpus microcarpus Presl	Small fruit bullrush

we determined the necessary amount of time to remove perigynia by checking the seeds at specific intervals (usually 1 min) and observing under a microscope the amount of seed coat damage. Seeds were then cleaned with a vacuum separator and stored in containers at 1 °C (34 °F). Dried seeds of intermountain rushes maintain viability for at least 2 y if kept in dry storage (Hurd and Shaw 1993).

Stratification

We based our operational stratification method on results from a series of germination tests we performed in our germination chamber. Methods we evaluated for germination were: 1) no stratification; 2) 30-d naked stratification; 3) 30-d naked stratification after scarifying seeds 2 min; 4) 30-d stratification between layers of sphagnum peat moss; and 5) 60-d stratification between layers of sphagnum peat moss. Generally the best germination occurred after either 30- or 60-d stratification when seeds were placed in sphagnum peat moss. For our production sowing, we soaked *Carex* and *Scirpus* seeds 48 h and then stratified them 30 d at 1 to 2 °C (33 to 35 °F) in linen bags layered between sphagnum peat moss. *Juncus* seeds required no stratification or soaking before sowing.

Germination

Stone Nursery has grown over 400 million conifers, deciduous trees, shrub, forb, and grass seedlings yet growing 8000 wetland plants really stretched our thinking about how to grow seedlings. Many culturing techniques for wetland species are very different than those for terrestrial plants. The small size of *Juncus* seeds presented a sowing challenge. After trying many techniques, including an eyedropper and watercolor brushes, we eventually settled on placing a small quantity of unstratified *Juncus* seeds in a salt shaker and sowing no differently than salting up a plate of scrambled eggs. *Carex* and *Scirpus* seeds were hand sown, though large orders could be sown through mechanized sowing equipment, onto a 1:1 (v:v) sphagnum peat moss:vermiculite medium. We used Spencer-Lemaire Rootrainers™ containers (Stuewe & Sons Inc, Corvallis, Oregon): 170 ml (10.5 in^3) for the *Juncus* species and 350 ml (21.5 in^3) for *Carex* and *Scirpus* species because of their larger mature plant size.

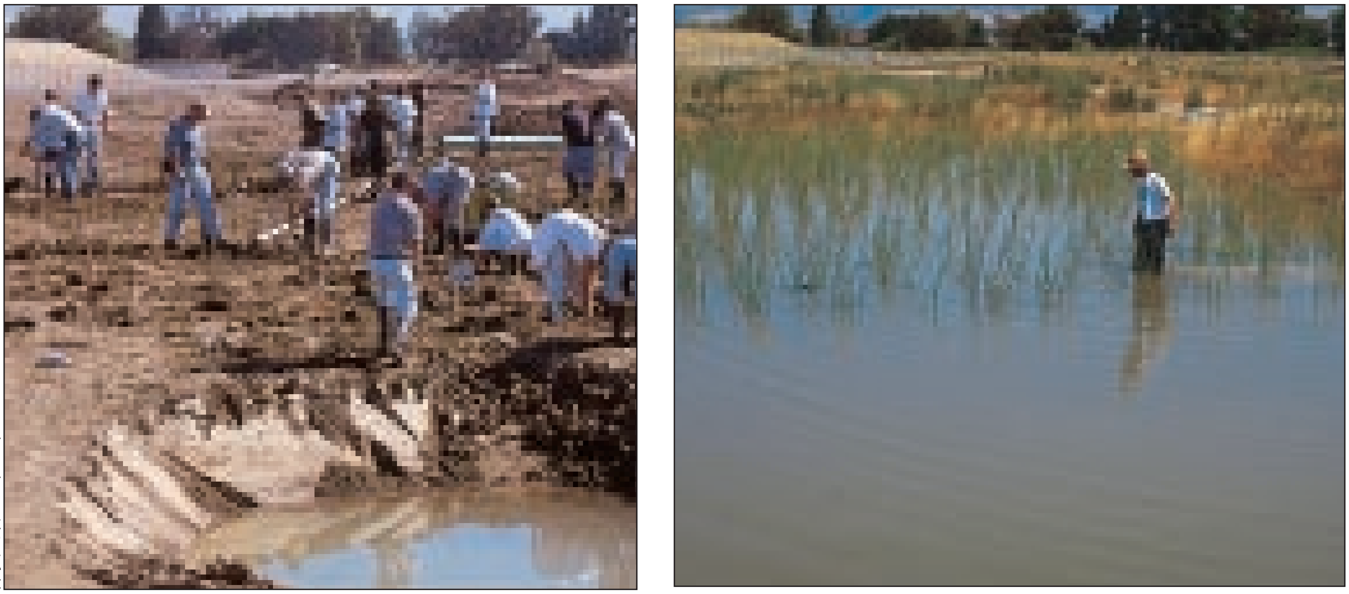
Figure 3 • Plants were grown in cattle troughs filled with water.

Three factors, high moisture, high temperatures, and exposure to light, are critical for seed germination. Unlike terrestrial species, we found that too much water is not a problem for wetland species; many wetland species can germinate in standing water (Marburger 1992). To maintain a high moisture environment, we used a small greenhouse equipped with foggers set at 90% to 100% humidity (we have learned since that these species will germinate just as well under a schedule of constant daily irrigations, just so long as the seed stays wet). We maintained air temperatures between 32 to 35 °C (90 to 95 °F) during the day and 21 °C (70 °F) at night (the growing area literally felt like a sauna during the day!). Our experience indicates these species germinate poorly without light. We obtained very good germination by covering *Carex* and *Scirpus* seeds with a 1-cm-deep (0.4-in) layer of silica grit that allowed light to penetrate to the seeds. *Juncus* seeds were left uncovered.

CULTURING WETLAND SEEDLINGS

Seeds of all species germinated within 2 wk. Since greenhouse space was limited and we had to grow 4X the quantity of plants more than the greenhouse would hold, we moved germinants out of the greenhouse immediately to make room for the new crop. Containers of germinants were placed in cattle troughs filled with water to approximately 3 cm (1 in) below the top of the medium (Figure 3). We allowed the water in the troughs to completely dry out before we would refill them (generally every 10 to 14 d). Within a month after moving seedlings outside, roots had filled much of the containers and grown out into the water trough. Since this propagation system does not allow for air pruning, roots are free to wander out of their containers (and about a third of the root systems did). With a different container this could have presented a problem during seedling extraction but the Rootrainer container opens up like a book and allows the roots to be removed easily and without damage.

Seedling culture was simple once plants were placed into troughs. Disease, insect, and weed problems were insignif-



Photos by David Steinfeld

Figure 4 • Left: School children helped plant over 8000 seedlings during October 1999. Right: By July 2000, the wetland plants were thriving.

icant. Plants were fertilized by applying a soluble fertilizer (Excel $21N{:}5P_2O_5{:}20K_2O$) to each trough to bring the nitrogen concentration to 50 to 100 ppm. Later in the season, we top pruned seedlings that had grown over 50 cm (20 in) tall. However, from observations of seedlings planted in our constructed wetland, the younger, non-pruned seedlings appeared to out perform pruned seedlings. All species were ready to plant within 3 mo after sowing.

CONSTRUCTION AND PLANTING

In late September 1999 the site was laid out and constructed in less than a week. As the crew worked on the last pond, students were arriving in buses to plant the first one. Over 150 elementary and high school students planted over 8000 seedlings. Student volunteers from a local university (REAL Corp program) helped guide and educate younger students (Figure 4). Species were planted in different environments based on their predicted size at maturity. Larger sized species (*Scirpus* and *Carex*) were planted in deeper ponds, while *Juncus* species were planted in shallow water zones. Planting wetland species was new for us; we quickly learned that these species are ideal for this type of educational experience because they were more forgiving in how they were planted than traditional reforestation seedlings. Because of this, less time was spent nagging on how to plant correctly, and more time was spent experiencing the joy of planting a seedling.

SEEDLING ESTABLISHMENT

During the first year after construction, our primary objective was to create the most optimum conditions for seedling establishment, accomplished by maintaining optimum soil moisture for plant growth, while limiting the time seedlings were submerged in water. After planting, seedlings were irrigated with a fixed overhead irrigation system at least once a week. Fall temperatures at our site are very favorable for root growth and it is not uncommon to find that root mass can double between September and December. We found this to be the case for seedlings we planted. Seedling establishment was nearly 100%. As cold weather hit in December, most seedlings responded with a complete dieback of their shoots but with warmer weather in February, new seedling shoots emerged.

Occasionally during winter months the site flooded in response to rainstorm runoff. The wetland was designed for a maximum water depth of 46 cm (18 in). During the first winter and spring, we maintained a pool level < 15 cm (6 in). While some plants were covered with water during high precipitation events, the pool level would usually draw down within a week, exposing plants again. As plants continued to grow during spring and summer, we gradually raised the water level so that seedlings had at least half their shoots exposed above water (Figure 4). Due to variability in the grade of the wetland and different growth rates of the species we planted, not all seedlings kept up with the rising water and those that became completely submerged for any length of time subsequently died. For this reason, we preferred to err on the drier side and kept pool levels so that some seedling foliage was exposed. However, invasion of the site by terrestrial weeds was controlled by frequent flooding. In late February, additional seedlings were planted and they survived and grew very well. We noted no differences in seedling growth by planting date, but seedlings planted in shallow soil (< 30-cm [12-in]) grew far less than those grown in deeper soils.

FUTURE WORK

Now that the site is fully established, creek water is passing through the system and the Rogue Council of Governments is monitoring the water to assess the effectiveness of the system in removing sediment, phosphorous, and nitrogen. Since our nursery is in close proximity to several large communities and their schools, we have a great opportunity for educating students in wetland systems. The Rogue Valley Council of Governments is currently applying for grant money to develop an interpretive trail and monitoring facilities for this site. This plan includes landscaping the terrestrial portion of the area in native riparian and upland plants. As need for wetland plants increases in the valley, we believe this need can be met through harvesting plants or collecting seeds from our site.

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