FEN RESTORATION

FINAL PROJECT REPORT

By

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INTRODUCTION

There are about 1,600 acres of peatland currently harvested for horticultural peat in Minnesota. Several proposed developments could potentially double this acreage in the near future. Peat companies are required by law to restore these areas to functioning wetlands after harvesting has ceased to conform to State and Federal “no-net-loss” of wetlands policies. Although only a few areas are currently in need of restoration, the environmental review and permitting process requires new peat harvesting operations to provide detailed restoration plans prior to development. Therefore, reliable peatland restoration techniques are needed not only to maintain the current level of peat harvesting, but also to allow the industry to expand in the future.

BACKGROUND

As part of previous research funded by the Legislative Commission on Minnesota Resources (LCMR), the Natural Resources Research Institute (NRRI) has established peatland restoration demonstration sites at two post-harvested peatland sites. The restoration strategy used at these sites follows the “North American Approach” developed primarily for restoring bog vegetation to sites harvested for Sphagnum moss peat. However, similar studies have not been conducted on fen peatlands harvested for sedge peat (Cobbaert and Rochefort 2002). Several Minnesota peat operations are currently harvesting such peatlands and changes in horticultural peat use in Europe and parts of North America suggest a trend toward using more sedge peat in the future. Restoring these areas will require different management techniques to re-establish fen vegetation and prevent exotic species invasion.

This project was conducted at the Hawkes Company peat operation located near Newfolden, Minnesota (northwest of Thief River Falls), which unlike the Sphagnum peat study sites was originally a fen composed of predominantly sedge peat. After peat harvesting has ceased, Hawkes Company will reclaim the site to a wetland condition by blocking ditches, re-grading fields, and collecting, transporting and spreading restoration donor material. A sedge-based peatland should be able to re-establish with these interventions, although factors contributing to success of this kind of restoration have not been previously studied and reported. Sedge meadow restoration methods evaluated as part of this project included donor soil applications, cover crops, and wetland plant core transplants. Areas previously restored by Hawkes Company were also examined to determine restoration success.

STUDY AREA

The study area is located at the Hawkes Company peat operation in Section 10, Township 157 North, Range 44 West, Marshall County, Minnesota. Sedge peat had been harvested from the site (Site #5) from 1998 until the fall of 2001.
STUDY GOAL

The goal of this study is to determine the success of sedge meadow restoration on post-harvested fen peatland sites as affected by donor soil applications, cover crops, and wetland plant core transplants.

MATERIALS AND METHODS

The research was divided into three areas of study: 1) donor soil/cover crop applications on small-scale plots, 2) wetland plant core transplants, and 3) monitoring of large-scale donor soil applications previously conducted by Hawkes Company.

Small-Scale Donor Soil/Cover Crop Applications

One of the first steps in preparing a fen peatland for peat harvesting is to remove the surface vegetation and the top layer of peat (0.25 m-0.5 m) containing most viable plant seeds. This “overburden” material is generally stockpiled on or near the site for eventual replacement on the site when harvesting ceases. In the peat harvesting process approximately 0.5 m to 2 m of peat is removed and sold as product. What remains after harvesting is a substrate relatively void of viable wetland plant seeds. The bare peat surface can also be a harsh environment, which can inhibit plant establishment and growth. Compared with undisturbed peatlands, bare peat surfaces tend to have higher temperatures, lower relative humidity, and increased exposure to the drying effects of wind. To re-establish wetland vegetation at the site, plant seeds have to be re-introduced by direct seeding or donor soil applications (Brown and Bedford 1997, Galatowitsch et al. 1999). Wetland plants, particularly sedges (Carex spp.), can be difficult to establish from seed (Budelsky and Galatowitsch 1999, van der Valk et al. 1999). Where available, donor soil applications are generally more cost-effective and result in wetland vegetation better adapted to the site. Once seeds are re-introduced, germination and survival are dependent on a number of microclimatic factors. Maintaining water table levels and establishing a cover crop can moderate these factors and have a positive effect on restoration success.

The study was established on Site #5, on the northern edge of the Hawkes Company peat operation on August 6 and August 7, 2002. Although peat harvesting ceased on this site in the fall of 2001, plots were not established until August 2002 because of above normal spring and summer rainfall that essentially inundated the site with standing water. Plots were arranged in a randomized block/split plot design. The experimental treatments for this study consisted of 4 donor soil treatments (fresh donor x 1, fresh donor x 3, outside stockpile, and no donor) x 2 cover crop treatments (cover crop, no cover crop) for a total of 8 treatment combinations. Donor soil treatment plots were 5 m x 6 m (30 m²) in size, with 2 m spacing between plots. Each was split into 2 adjacent plots 3 m x 5 m (15 m²) split plots for the cover crop treatment. Eight replications of each treatment combination resulted in a total of 64 plots. The plot layout is shown in Figure 1.
The donor soil treatments consisted of materials found at or near the site. The “fresh donor” treatment was surface overburden removed by backhoe from a soon to be developed peat harvesting expansion area (Site #6) directly south of the study area (see Figure 2). This material included live vegetation and newly deposited wetland plant seeds, as well rhizomes, roots and other reproductive structures. This is the ideal situation where one harvested area is being restored as a new area is being developed, although in practice it usually doesn’t happen that way. The “fresh donor x 1” treatment represents approximately 0.5 cm of donor soil spread equally over the plot. The “fresh donor x 3” treatment represents 1.5 cm of donor soil.

The surface soil (overburden) originally removed from the restoration study area (Site #5) in 1998 was stockpiled on site. Donor soil from the outer surface of this stockpile served as the “outside stockpile” treatment. The soil was collected from approximately 30 cm below the surface to avoid introducing reed canary grass (*Phalaris arundinacea*) that was growing on the stockpile.

The “no donor” treatment served as the control. Because the remaining peat is relatively void of viable plant seeds, plants establishing on these plots are expected to come from seed carried by wind, water, and by birds or other animals.
The cover crop treatment consisted of a seed mix similar to the Minnesota Department of Transportation’s (Mn/DOT) 100A Mod (130b) formulation for temporary cover (Mn/DOT 2000). The mix included (by weight) 40 percent oats (*Avena sativa*), 40 percent winter wheat (*Triticum aestivum*), and 20 percent annual ryegrass (*Lolium multiflorum*), and was broadcast at a rate of 100 pounds/acre.

Because of poor plant growth in 2002 due to delayed planting, the companion crop treatments were reseeded on May 12, 2003. The established plots immediately after donor soil applications are shown in Figure 3.
Plant cover data was collected on June 16 and September 10, 2003. The plant species were identified (when possible) and the number of stems per 1 m² sampling plot was noted. Two 1 m² sampling plots were assessed in each 3 m x 5 m split plot for a total of 128 sampling plots. Sampling plots in the eight westernmost plots were also photographed on both dates for future reference.

**Wetland Plant Core Transplants**

Small diameter cores of desirable wetland plants collected from donor sites can serve as transplants for restoring disturbed fen sites. The practice of using plant cores rather than completely stripping the surface vegetation should preserve the donor site and allow it to serve indefinitely as a source for seed and transplants. Plant cores consisting of a viable plant with a developed root system may establish wetland vegetation faster than conventional seeding (Galatowitsch et al. 1999) especially on disturbed sites where harsh conditions can inhibit seed germination and survival. Plant cores can also serve as a cover crop, increasing establishment success for conventional seeding and donor soil applications.

To determine the efficiency and success of plant core transplants for fen restoration, studies were established at the Hawkes Company research site on May 13, 2003, and the south parcel of the Natural Resources Research Institute’s Fens Research Facility (T55N-R18W, Section 26) on May 21, 2003. Wetland plant cores, approximately 2.5 inches in
diameter, were collected using long-handled garden bulb planters (see Figure 4). Three replications were transplanted on a grid at densities of 4, 9, and 16 cores per 1 m² (see Figure 5). Plant cores at Hawkes Company were collected from Site #6 and transplanted near the donor soil study at Site #5. The species included in the cores were primarily lake sedge (Carex lacustris) and wiregrass sedge (Carex lasiocarpa). The time required to collect the cores and transplant them was recorded to determine the efficiency and cost of the technique.

At the Fens Research Facility study area the surface vegetation was removed to resemble post-harvested conditions similar to those occurring at the Hawkes Company site. Plant cores consisting of primarily Canada bluejoint grass (Calamagrostis canadensis) were collected from a nearby wet meadow and transplanted to the site. Canada bluejoint cores collected at the Fens Research Facility area were also transplanted at the Hawkes Company site on June 16, 2003. The study sites were monitored in June and September 2003 to determine transplant survival and seed head production.

Figure 4. Collecting plant cores – May 2003.
Figure 5. Transplanting cores to study area – May 2003.

Large-Scale Donor Soil Applications

In the fall of 2000 the Hawkes Company replaced approximately 8 to 12 inches of stockpiled peat overburden on a 40-acre mined-out parcel (Site #2). Preliminary investigation suggested that wetland vegetation on the site was recovering well (see Figure 6 and Figure 7). To quantify this observation, a series of 22 – 1 m x 1 m plots were randomly placed along three north-south transects across the site in June 2003, and assessed to determine wetland plant species percent cover. Species present at the site were noted and percent cover was determined according to the Braun-Blanquet cover scale (Mueller-Dombois and Ellenberg 1974).
Figure 6. Site #2 (State 40) – October 2000.

Figure 7. Site #2 (State 40) – June 2003.
RESULTS AND DISCUSSION

Small-Scale Donor Soil/Cover Crop Applications

Post-mining conditions at the study site were not conducive to plant growth. Approximately 3 to 12 inches of peat remained on the research area after mining ceased. Peat samples collected from the donor area, research site, and stockpiles were analyzed by the Hawkes Company laboratory to determine percent ash, pH, and electrical conductivity (see Table 1).

Table 1. Peat sample analyses for donor area, research site, and stockpiles.

<table>
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<tr>
<th>Sample Site</th>
<th>Depth (cm)</th>
<th>Ash (%)</th>
<th>pH</th>
<th>EC (mS/cm)</th>
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<tr>
<td>Site #6 - Donor Area</td>
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<td>13.2</td>
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<tr>
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<td>0.14</td>
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In general, percent ash was lower for peat from the research area than either the donor site or the stockpiles. The pH was close to neutral for all samples. Electrical conductivity (EC) for the research area and donor site was higher than the stockpile area. The range of soil parameters found at the site was consistent with a moderate to rich fen habitat (Wind-Mulder et al. 1996, Wind-Mulder and Vitt 2000).

Water table levels remained quite low throughout the study period, even though the main ditch draining the site was completely filled immediately following plot establishment in August 2002. We did, however, encounter standing water on the research site during our June 16, 2003, site visit, even though data collected by Hawkes Company personnel showed water levels ranging from 50 cm to over 1 m below the soil surface on the site for most of the study period. This could be the result of a regionally low water table due to agricultural drainage in the area, or the lack of peat substrate remaining to retain moisture. It is likely that plant cover, once established, would help to moderate fluctuating water levels.
Plant cover data collected at the site in June 2003 is presented in Figure 8. At this time it was very difficult to identify plants on the plots, so the stems were not differentiated as to species. Even though the average stems/m² for all of the treatments was quite low (less than 7), the “fresh donor” did considerably better than the “stockpile” and “no donor” treatments, especially when combined with a cover crop. Also, the “fresh donor x 3” treatment shows about a three-fold increase in plant cover over the “fresh donor x 1” treatment, indicating that the amount of donor soil applied can also be important for restoration success.

The September 2003 plant cover data are shown in Figure 9. At this point in the growing season, we could identify plant species and differentiate between cover crop and other species. As in June, the “fresh donor” treatments continued to have the most plant cover, especially by species other than cover crops. These other plants were primarily native Carex and Juncus species, characteristic of fen peatlands. The “stockpile” and “no donor” treatments showed an increase in plant cover since June; however, this increase was primarily due to cover crops. The cover crop most commonly found across all treatments was annual ryegrass. Oats were much less common, and winter wheat was not present at all. There were no invasive plant species observed on any of the research plots.
Figure 9. Small-scale donor soil/cover crop study - September 2003.

The vegetative cover on even the best treatment plots in this study was quite poor (see Figure 10). Harsh site conditions and delayed planting contributed to slow plant establishment. However, in general, native plants often take longer to establish and flourish than cultivated species. Because native wetland plants are present and surviving on the site there is still potential for them to grow and spread.

Wetland Plant Core Transplants

Survival and seed head production were determined for transplanted wetland plant cores at the Hawkes Company and Fens Research Facility sites in September 2003. The survival rate for the lake sedge and wiregrass sedge cores transplanted at the Hawkes Company site was 90 percent. Seed heads were not present on any of the plants and there was no evidence of plants spreading by rhizomes. Canada bluejoint transplanted at the site in June 2003 had a survival rate of about 98 percent and seed heads were present on 10 percent of the transplants. In general, the plants appeared to be doing quite well despite dry site conditions.
At the Fens Research Facility site the Canada bluejoint grass survival rate was 99 percent. Although there was no evidence of plant spreading by rhizomes, approximately 20 percent of the surviving transplants produced seed heads. Conditions at this site were much wetter than at the Hawkes Company site, and several other species of grasses and sedges were beginning to colonize the site as well.

To determine the efficiency and cost of wetland plant core transplants for restoration, the time and personnel required for transplant collection and planting was recorded. At the Hawkes Company site the collection rate was approximately 60 to 90 transplants/hour/person. At the Fens Research Facility site the collection rate was about 180 to 360 transplants/hour/person. Transplant collection was much faster at the Fens Research Facility site primarily because the area had been burned the previous spring and mowed the previous fall. This removed accumulated thatch and reduced plant height, allowing faster identification of suitable transplants and more efficient use of the bulb transplanter to collect cores. Transplants were placed in plastic totes for transport to the restoration site.

Transplanting the cores required two people. One would remove and discard a core of soil from the ground, and the other would place the transplant and heel it in. Planting rates at both sites averaged about 120 transplants/hour/two people. However, in practice this can be done more efficiently. Assuming a crew of two people, if one person collects transplants at the donor site, while the other removes cores from the restoration site (both operations should take about the same time), and they place and heel in the transplants together, the planting rate can be increased to 240 transplants/hour/two people. Based on these estimates, a crew of two people collecting transplants and removing cores in the morning, and planting together in the afternoon, could potentially establish 500

Figure 10. Small-scale donor soil/cover crop study – September 2003.
transplants/day/person. This is approximately one-half the efficiency of tree planting crews that commonly establish 1,000 trees/day/person.

Assuming one transplant/ft$^2$, this would take a two-person crew approximately 44 days to completely cover one acre. This is not practical by any means. Therefore, wetland plant core transplants should only be used as a spot treatment in problem areas where other methods will not work, at reduced densities throughout the site, or as transects across a site to serve as windbreaks and seed sources.

**Large-Scale Donor Soil Applications**

Plant cover data collected in June 2003 at the large-scale donor soil site (Site #2 – State 40) is presented in Figure 11. The site had nearly complete vegetative cover dominated by wetland plants such as spikerush (*Eleocharis* sp.), manna grass (*Glyceria* sp.), rushes (*Juncus* spp.), reed canary grass (*Phalaris arundinacea*), and sedges (*Carex* spp.). A number of graminoids unidentifiable at the time of the survey were also significant. It is important to note that undesirable invasive species such as reed canary grass, although present at an average cover of 12 percent, have not dominated the site, as often is the case. The site presently maintains a diverse collection of desirable wetland plants. It remains to be seen if this situation will hold true in the future. To control the spread of invasive plant species spot spraying with glyphosate herbicide can be effective (Galatowitsch *et al.* 1999, Bohnen 2003).

This site achieved a high level of desirable wetland plant cover in just over two years. Because the site was not monitored until after the second year, it is difficult to say whether our first year small-scale donor soil study results are comparable. This site had 8 to 12 inches of stockpiled peat overburden applied, compared to less than 1 inch on our highest application plots. The fact that an entire 40-acre block was restored at one time may also contribute to restoration success. Our small plots suffered from wind-blown peat from adjacent open areas and edge effects between plots. Perhaps water conditions were also better on Site #2. Certainly more peat on that site would help to retain water and moderate fluctuating water levels. If it is available and can be cost-effectively applied, the more peat that can be returned to a restoration site, the better chance for success.
Recommendations for fen restoration are divided into three areas based on the studies presented in this report: 1) donor soil applications, 2) wetland plant core transplants, and 3) general guidance.

**Donor Soil Applications**

- Depending on availability and application costs, apply as much donor material as possible.
- When feasible, apply fresh donor soil rather than stockpiled, although timing and transportation costs may make this impractical.
- Always apply an annual cover crop such as oats, annual ryegrass, or wheat to help native plants establish and prevent wind erosion.
- When possible, apply the donor soil in the fall and seed the cover crop the following spring.
- Avoid donor soil containing invasive plant species seed.

*Figure 11. Large-scale donor soil study – June 2003.*

**RECOMMENDATIONS**
Wetland Plant Core Transplants

- Select a donor site that has the desired transplant species and avoid sites with invasive plant species.
- Burn the donor site the previous spring and mow it in the fall prior to transplant collection to remove thatch and reduce transplant height.
- Plant transplants as soon as possible after collection to avoid desiccation.
- Select areas for transplants that will provide the most benefit for the restoration site: spot treatment of problem areas, at reduced densities throughout the site, or as transects across a site to serve as windbreaks and seed sources.

General Guidance

- Maintain restoration site water levels at or just below the soil surface.
- Conduct restoration on large contiguous blocks (10 to 40 acres) to reduce edge effects and to avoid wind-blown peat from adjacent mining areas.
- Spot spray invasive plant species with glyphosate to keep them from spreading and dominating a restoration site.

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LITERATURE CITED


