is small scale and in most cases funding comes from scientific or applied research projects. Hence, restoration goals are often highly ambitious with regard to species-rich site-specific plant community assemblies. However, strategies for large-scale restoration projects are needed. In Europe and in the United States there is a need to evaluate and share effective techniques for reestablishing native vegetation in diverse ecosystems. Use of native hay, for example, has received little use in the United States and could be tested in appropriate areas. In both Europe and the United States, certification of native seed and plants across biogeographic regions, developing new market niches for growers, and providing increased stability in demand are all critical issues to increasing the availability and expanding the use of native materials. Tools to aid in selection of appropriate plant materials for restoration in light of climate change, issues of ex situ and in situ conservation of species and communities and discussions surrounding assisted migration are all critical to the future of ecological restoration on both continents.

In the future, the EU and the United States need to share local, regional, national, and international approaches and policies regarding the development and use of native plants at all levels. In addition, we must improve communication with the public, growers, and users to improve our understanding of native plant materials and healthy native ecosystems.

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Manipulating Internal System Feedbacks to Accelerate Reed Canarygrass (*Phalaris arundinacea*) Control: From Theory to Practice

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Reed canarygrass (*Phalaris arundinacea*) displaces indigenous species and creates extensive monocultures that frustrate restoration efforts. Restoration gains are typically short-lived at sites heavily impacted by this species, but suppression may be feasible at sites in the early stages of invasion (Annen et al. 2008). However, even under these conditions, reversal of invasion and replacement of reed canarygrass by desired endpoint species may require 5 to 6 consecutive growing seasons of effort (pers. obs.).

State and transition models predict that internal feedbacks maintain vegetation in one state (reed canarygrass monoculture) rather than an alternate state (remnant sedge meadow). Local and landscape-scale disturbances make sites vulnerable to reed canarygrass invasion, while feedbacks maintain the invaded state and resist restoration to a pre-invasion state. In other words, invaded states are internally reinforced by indirect feedbacks involving interactions among disturbances and species characteristics (Zedler 2009). Litter accumulation is one example of a feedback mechanism that maintains reed canarygrass dominance. Senescent reed canarygrass litter has a suppressing effect on competing species. As reed canarygrass increases in abundance and comprises a greater proportion of a site's standing crop, more litter accumulates each subsequent growing season, which further hinders emergence of competing species. This feedback cycle helps maintain reed canarygrass dominance and must be broken for restoration to be successful. Using fire to disrupt litter feedbacks is relatively easy compared to uncoupling other feedbacks that maintain a reed canarygrass-dominated state (e.g., hydrological disturbance). Nevertheless, Herr-Turoff (2005) documented that sethoxydim herbicide applications were more effective when disturbances were addressed prior to initiating chemical control efforts. Consequently, successful reversal and restoration of a reed canarygrass-dominated state requires not only properly implementing effective control techniques, but also disrupting feedbacks that maintain the invaded state. Regrettably, control efforts for reed canarygrass are rarely applied in conjunction with removal of disturbances and manipulation of the feedbacks indirectly responsible for maintaining a system in a degraded condition.

The 186-ha Swamplovers Nature Preserve, located in southwestern Wisconsin, USA, includes a 10.5-ha sedge meadow remnant. When the property was acquired as a nature preserve, this sedge meadow remnant was on a trajectory toward reed canarygrass dominance. Ten hectares immediately north of the sedge meadow had been planted to row crops for several decades. To make the area more suitable for agricultural production, a drainage ditch and drain tiling system had been installed in the sedge meadow, disconnecting it from its original hydrology. Nitrogen levels were low (10.7 ppm NH_4-N and 9.2 ppm NO_3-N), but available phosphorus was high (57 ppm) when measured in 2007. Long-term absence of fire encouraged successional progression to shrub-carr/lowland forest dominated by fire-intolerant shrub and tree species. This change in vegetation composition exacerbated hydrological losses, as these species have high evapotranspiration rates. Three and one-half hectares of the sedge meadow remnant were dominated by reed canarygrass, with additional outliers of reed canarygrass expanding into canopy gaps in relic populations of sedge meadow species. An additional 2.8 ha existed in the wet meadow condition, dominated by a matrix of reed canarygrass intermixed with aggressive perennial forbs such as Canada goldenrod (*Solidago canadensis*) and sawtooth sunflower (*Helianthus grosseserratus*).

Restoration began in 1998, when a wet-mesic prairie buffer was planted into the former cropland bordering the remnant (50 species were planted). The drain tile system was destroyed with a backhoe in 1999 to partially restore the site's hydrology. Hydrological restoration was completed in 2007 when the agricultural drainage ditch was filled and 4 small scrape ponds were created. Recontouring and scrape pond construction created 0.6 ha of bare ground, a condition that facilitates subsequent reed canarygrass invasion unless a closed vegetation canopy is established. Bareground space was seeded with 60 native species at a rate of 11.9 kg/ha following recommendations of Wisconsin's Reed Canarygrass Working Group (2009). Contractors also planted plugs or bare root tubers of an additional 15 sedge meadow and aquatic vascular plant species. The next phase of the restoration was to remove fire-intolerant trees and shrubs and reintroduce wildfire to the site, which was accomplished in 2009 and 2010.

At this point, with the major disturbances addressed, reed canarygrass suppression efforts were initiated. As expected, reed canarygrass quickly reestablished in the bareground space adjacent to the scrape ponds. The initial response was to apply a 4% glyphosate (Credit Extra, NuFarm Products, Burr Ridge IL) solution to re-emerging reed canarygrass. Thereafter, spring applications of grass-selective herbicides were employed to enable planted and plugged species to survive and establish. A 2.25% (a.i.) solution of sethoxydim (Sethoxydim G Pro, Etigra Manufacturing, Cary NC) and 1.0% (v/v) nonionic surfactant/methylated seed oil blend (Dyne-Amic, Helena Chemical, Memphis TN) was applied to reed canarygrass in May 2008. A 0.5% (a.i.) solution of clethodim (Intensity, Loveland Products, Greeley CO) and 1.0% NIS/MSO was applied to reed canarygrass in April 2009 and 2010.

In the remainder of the sedge meadow remnant, late spring grass-selective herbicide applications were used for reed canarygrass suppression. In 2008, high water levels resulting from snow melt and abnormally high spring rains delayed sethoxydim applications until June, and the onset of panicle emergence in mid-June quickly ended suppression efforts that year. In 2009, reed canarygrass was treated with clethodim from May through June. In 2010, reed canarygrass was again treated with clethodim from April through May. To close canopy gaps created by herbicide applications and provide competition for reed canarygrass, seed from 31 indigenous species (14 graminoids and 17 forbs) were collected from the remnant sedge meadow and interseeded at high rates (the approximate equivalent of 11 kg/ha) into areas denuded by herbicide application.

In the scrape planting, 44 of 60 planted species and 14 of 15 plugged species were observed in July 2010. Reed canarygrass was still present in the scrape planting but comprised less than 5% of the canopy. In the remainder of the remnant, the area covered by reed canarygrass had decreased by 68% following 3 consecutive years of treatment. It is interesting to compare this reduction to the 5 or 6 growing seasons typically required to affect a similar change in vegetation composition when grass-selective herbicides are used in the absence of mitigating underlying disturbances and disrupting feedbacks. There were substantial decreases in the effort and cost required for reed canarygrass suppression as this project progressed. In 2010, treatments required 33% less labor and 52% lower herbicide volume for coverage of the target area compared to the 2009 treatments. Where it was still present, reed canarygrass was intermixed with a diverse variety of native species dominated by the matrix clonal sedges, tussock sedge (*Carex stricta*) and hairyfruit sedge (*C. trichocarpa*), and cool-season grass, bluejoint (*Calamagrostis canadensis*). These species were present prior to reed canarygrass abatement and expanded rapidly in area following litter removal by burning and reed canarygrass suppression with selective herbicides. An indigenous population of Wisconsin-threatened groovestem Indian plantain (*Arnoglossum plantagineum*) more than doubled in abundance during this time period, with the majority of new individuals arising in areas that were formerly dominated by reed canarygrass.

Intriguingly, soil sampling in 2010 revealed that available phosphorus was 36% lower than in 2007. A more detailed study would reveal whether phosphorus mining can be achieved by annually burning sedge meadows.

While the reed canarygrass has not been completely eradicated from this site, the pace of progress achieved demonstrates how an integrated vegetation management strategy based upon a state and transition framework can enhance and accelerate progress over single-method (e.g., herbicide only) approaches. This approach involves mitigating disturbances (removal of hydrological disturbances), disrupting facilitating feedbacks that reinforce invasions (litter removal), strengthening feedbacks that augment community recovery and invasion resistance (reseeding after herbicide applications), and reestablishing natural disturbance (i.e., fire) regimes. Although the specific management actions described here were site-specific and not appropriate for all abatements, this case study highlights the importance of correcting the underlying causes of invasions in invasive species management.

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