ADVANCING ECOLOGICAL RESTORATION PRACTICE IN MINNESOTA

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INTRODUCTION

Over the past few decades, efforts to counteract habitat loss through ecological restoration have greatly increased. Ecological restoration is now seen as an integral part of conservation in Minnesota. To truly contribute to conservation, restorations must be of comparable value to our remaining ecosystems in order to sustain the state's biodiversity and ecosystem services, such as waterfowl production, pollinator habitat, and water quality improvement. Not all restored ecosystems match up to their natural counterparts—in fact, many don't. So, it's important for restoration to become a more reliable practice, one capable of addressing the complex challenges posed by habitat loss and degradation.

A major catalyst for restoration in Minnesota has been support from the Environment and Natural Resource Trust Fund (ENRTF). **Since 1991, ENRTF has provided funding for over 450 projects to restore prairies, wetlands, forests and savannas statewide.** In 2013, the Legislative-Citizen's Commission on Minnesota Resources, which administers ENRTF, enlisted the University of Minnesota to evaluate their restorations. The aim of this evaluation was to glean lessons learned about the factors contributing to successful restoration outcomes. **Learning what's worked and what hasn't over the past 25 years should help organizations proposing projects and LCCMR, who selects projects for support, make decisions that improve the outcomes of future ecological restorations**.

This document presents best practices for ecological restoration based on this evaluation of ENRTF funded ecological restorations. Field surveys, interviews with leaders of project teams, and review of proposals, plans and records formed the basis for this evaluation. Details are provided at the end of this document. Forests, savannas, prairies, and wetland restorations on public lands were included in the evaluation (lakeshore and stream channel restorations were not). Site attributes (size, level of degradation), methods used, and type of organization varied widely among projects, and so are representative of restoration efforts statewide. These guidelines are broadly relevant to ecological restorations in the Upper Midwest.

What is Ecological Restoration? *It's the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.*

What is the Environment and Natural Resource Trust Fund (ENRTF)? *ENRTF is a constitutionally dedicated fund for natural resources that originates from a combination of Minnesota State Lottery proceeds and investment income.*

EVALUATING RESTORATION SUCCESS

What plant community a natural resource management team decides to restore has as much to do with a desired ecological outcome as with what was there historically. Going back in time is seldom possible. It's often difficult to figure out what plants and animals historically occurred on a specific site. Even when that information is available, conditions may be too different to accomplish a historic reconstruction. Under those circumstances, a restoration team usually work towards a modern version of an ecosystem typical of that locale. For completely converted sites, like agricultural fields, the details of a restoration plan are often oriented to providing desired ecosystem services. For projects aimed at restoring degraded remnant ecosystems though, a restoration team may focus on invasive species removal in order to promote the native plant and animal communities already found there.

The extent to which a project has successfully restored an ecosystem, then, is ideally evaluated based on goals articulated by the restoration team during planning. All restoration projects should be guided by a set of written goals. The number of goals needed depends on the project's scope and complexity. Each goal needs to be specific enough to provide a basis for planning restoration actions. Each restoration goal also needs to be measurable, that is, progress towards achieving it can be objectively tracked.

Without sound goals, it isn't possible to for others to understand the restoration team's intentions or basis for decision-making. **For projects included in this study, fewer than 5% articulated specific, measurable goals, and 59% had no goal beyond something very general like "restoring a wetland".**

When goals are lacking, restorations need to be evaluated based on commonly used metrics of ecological quality. Two metrics useful for evaluating many kinds of ecosystem restorations are Potential Natural Vegetation (PNV) and Invasive Species abundance. Taken together, they can be used to determine how similar a restoration is to natural ecosystems found in a comparable environmental and geographic setting. We developed assessment and analysis methods that can be used across ecosystems. Because few Minnesota restoration projects have specific goals, projects in this study were evaluated based on these general ecological goals, as described under "Evaluation Approach" in this document.

Potential Natural Vegetation *is the plant community that would be expected in a particular locale given environmental conditions, such as climate, soils, landform, without human modifications*

Example of specific goals from Minnesota Restoration*: "Remove and control non-invasive native woody species as needed to enable effective, long-term management of mesic tallgrass prairie with prescribed fire."*

HOW LONG DOES IT TAKE TO RESTORE AN ECOSYSTEM?

Restored ecosystems often take decades or more to recover**. For Minnesota ecosystems, research has shown that prairie and wetland vegetation requires 5-10 years, forests many decades, prairie soils likely a century, and peatlands many centuries.** During this recovery phase, restored ecosystems aren't as resilient as their natural counterparts. That means they often don't "bounce back" after disturbances and extreme events and are more susceptible to stresses, such as spread of invasive species.

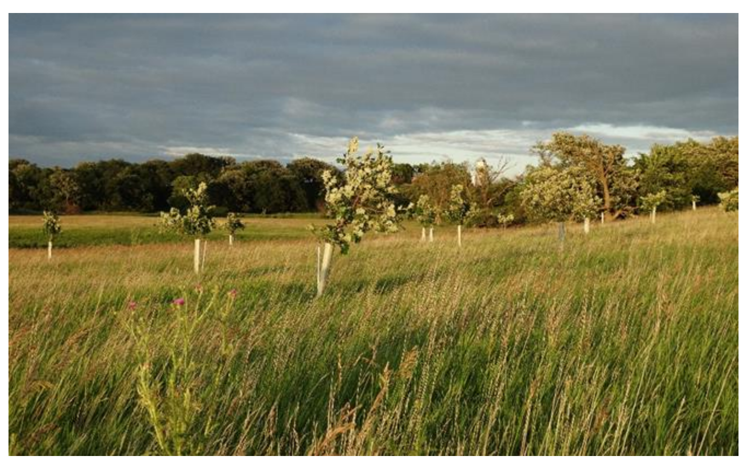
Intensive ongoing management is needed until ecosystems have developed their own self-reinforcing mechanisms. Because most restoration grants, including those through ENRTF, typically fund the initial 2-3 years of work, restoration teams need to rely on their own internal resources for long-term management, including invasive species removal, reseeding or planting, as needed, and repairs to structures, such as wetland dikes and water level controllers. **However, less than half (46%) of restoration projects assessed for this evaluation were managed after the grant ended. It is critical that organizations receiving public funding for restoration are committed to at least 5 years of post-implementation management while the restoration is least resilient and most vulnerable to invasion and failure.**

METHODS MATTER

In the realm of restoration, time alone doesn't heal. **Pursuing a sound course of action from the start of a restoration is critical to its long-term outcome. Restorations that do not begin well seldom become better over time (Figure 1).**

The extent of degradation in the surrounding landscape, the condition of the site, and the kind of ecosystem being restored all matter in choosing a suitable restoration approach. This approach will be comprised of a set of methods known to be effective for a particular set of circumstances. Restoration of some degraded sites requires a longer period of site preparation to control aggressive perennial weeds prior to seeding or planting. Unfortunately, some projects are constrained by grant requirements to seed or plant before the site is properly prepared, thereby compromising the quality of the restoration from the outset.

Restoration practitioners in Minnesota have been refining methods for decades—starting in earnest in the 1940's. For those new to the practice of restoration in Minnesota, there is no reason to learn by trial and error—it wastes money, opportunities, and results in high rates of project failure. There are many resources that provide guidance for selecting appropriate restoration practices and implementing a restoration**. As part of this evaluation initiative, "best practice" advice was solicited from some of Minnesota's most highly regarded practitioners and organized into a planning tool so the information can be readily accessed.** This planning tool is in the form of a spreadsheet, organized by the type of ecosystem to be restored and the condition of the site at the start of restoration. Additional resources that provide advice for restoration methods are also listed at the end of this document.



RESTORATION PLAN: WHO NEEDS IT?

Developing a written restoration plan is a professional "best practice" for all projects regardless of their size and complexity. Even small, seemingly simple projects benefit from a plan because it serves as a record of decisions at the onset of a project. Throughout the restoration process, as progress is reviewed and plans are adjusted, this record is an important baseline for multiple decision-making episodes.

A restoration plan has four core components: 1) descriptions of current conditions and problems that need to be addressed (including a project area map), 2) specific goals for the project, 3) restoration approach (i.e., the methods), 4) ongoing monitoring, management, and record-keeping protocols. A funding proposal should not be used as a substitute for a restoration plan: while some of the plan information may be included in the funding proposal, restoration plans focus more on the logistical details of a project than do proposals, which are primarily about making a persuasive case for support.

Developing a restoration plan is a critical way to ensure all project partners have the same vision for the restoration and that the restoration team has thought through what they will need to do to make it a success. For inexperienced teams, developing a plan is an important opportunity to learn what they'll need to know to actually implement the restoration. **One of main predictors of whether a restoration will turn out poorly (i.e., be of low ecological quality), is whether a restoration team wrote their own plan (Figure 1). Restoration teams that do not prepare their own plans run a greater risk of restoration project failure.**

Because the initial stages of many restorations are logistically challenging, a restoration plan can ensure everyone is working in a coordinated way. A plan also serves as a record of commitments made by each project partner, minimizing the likelihood that an important part of the project is neglected.

Given that restored ecosystems take a long time to recover, it shouldn't be surprising that most restoration projects experience a change in leadership. Restoration plans and documentation of changes to the plan is essential to ensuring that the new project managers have adequate perspective to move the project forward. Many of the restoration teams of projects supported by ENRTF do not have adequate plans or the component documents for their projects. **Managers for 43% of the projects provided inadequate planning documents. More specifically, 28% of projects did not provide a map of the project site. 56% of projects did not have a plan for ongoing management. Nearly half (43%) of the current managers for restoration projects in the study reported that a lack of project documentation hindered their current attempts to keep the project on track.**

EXPECT THE UNEXPECTED

Setbacks and surprises are not unusual in ecological restorations. Extreme weather, poor quality work from contractors, and unanticipated impacts from invasive species or pests are among the many situations that can cause significant damage to the progress of restoration efforts. These setbacks often affect a significant portion of a site, potentially causing restoration failure unless the team can act to get the project back on track. **According to project managers of Minnesota restorations, 25% have experienced serious setbacks.**

When a project experiences a serious setback, the management team must have the capacity to re-do critical steps of the action plan or adjust the plan entirely. It may seem that this capacity is mostly about money: who will pay to repeat site preparation or planting? Funding, though, is only one dimension of a team's capacity to keep a project on track. That's because some setbacks are preventable and even for those that aren't, responding rapidly to problems is often the most efficient way to counteract them. Minimizing and managing risks during an ecological restoration also is a function of the team's internal expertise, leadership, and organization. Collectively this is called "adaptive capacity".

A setback is something that happens that reverses, delays or prevents forward progress.

For Minnesota restoration projects there are three shortcomings, in addition to insufficient funds, that most commonly hinder restoration teams' capacity to keep their ecological restoration projects on track: inadequate staffing, incomplete records, and leadership change. The most common limitation is staffing, which was reported by 60% of project managers as a reason critical restoration work, such as weed control or prescribed burning, was often not performed. Nearly half of project managers (45%) reported that they were hindered in diagnosing why a project was failing because their predecessor or a project partner did not keep adequate records, such as what was seeded or planted or which herbicides were applied by contractors. Leadership change was noted by 24% of project managers as hindering restoration progress; these transitions are most problematic when written plans and records are lacking or when the team also lost critical expertise with the leader's departure. Insufficient funding, especially to support ongoing management, has affected 41% of projects.

Adaptive capacity is the ability of organizations, individuals, or systems to respond successfully to setbacks, adapt to change, take advantage of opportunities, or to cope with the consequences.

Because ecological restoration is a labor- and skill-intensive enterprise, it should not be surprising that the ecological outcome of restoration greatly depends on a team's capacity and functioning. **Teams proposing restorations should be evaluated as part of project selection to minimize the incidence of restoration failures. Teams with demonstrated expertise to perform the work, that follow best professional practices, including developing written plans and keeping sound records, and that have the internal capacity to follow through on commitments, are more likely to avoid or adequately respond to setbacks during the course of restoration.**

PREDICTING RESTORATION SUCCESS

Using Potential Natural Vegetation (%PNV) and a Composite Invasive Species Abundance score (CISA), researchers were able to determine which restoration projects were of relatively high quality or low quality and find factors that correspond to those outcomes.

Nineteen of the 59 projects (32%) were evaluated to be "high quality" because they have higher than median %PNV and lower than median CISA. Sixteen projects (27 %) with lower than median %PNV and higher than median CISA were judged to be "low quality". The remaining 24 projects were categorized as medium quality.

Four factors (2 ecological, 2 social) are most important for determining the extent to which restorations will be successful (i.e., quality): starting condition of the site, the kind of ecosystem being restored, the internal capacity of the restoration team, and whether the project was guided by a plan written by the team. Many factors evaluated were not useful for predicting project quality; two notable ones are age of the project, and quality of the restoration plan.

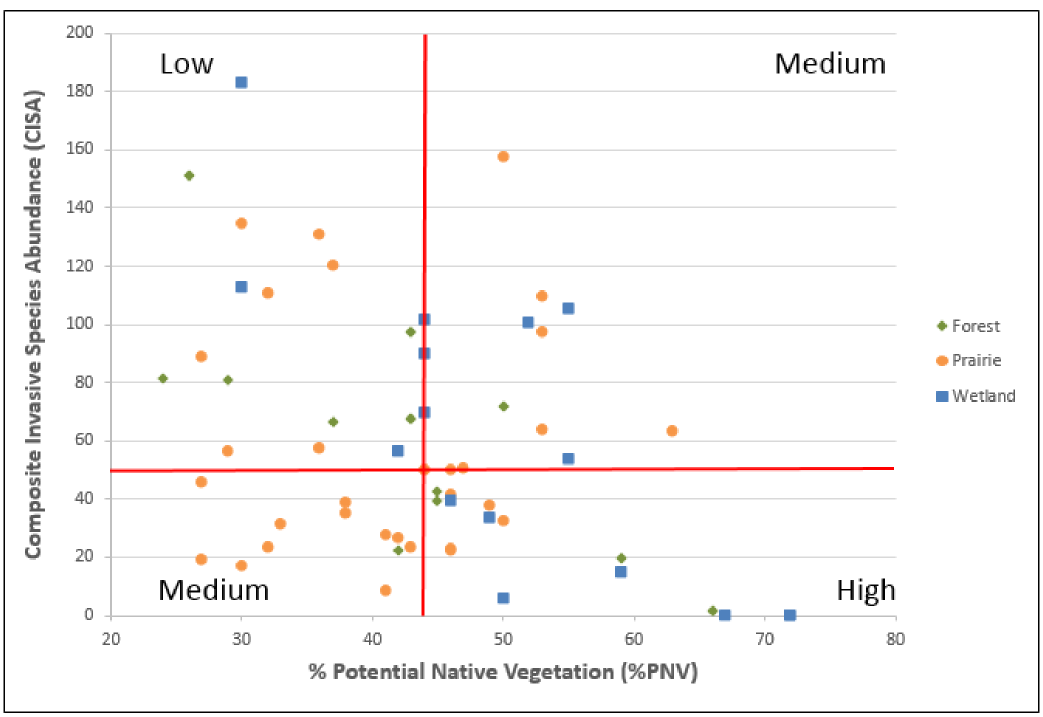
Restorations of highly altered sites are much riskier than those undertaken on remnant natural areas, and so are less likely to result in high quality outcomes. Restoration of remnant natural areas typically only requires invasive species removal, whereas highly altered sites typically must be seeded or planted. Restorations of forests are also much riskier than prairie or wetland restoration. Forests require much more time to recovery, and early in the process planted trees are vulnerable to competition from weeds and browsing by a variety of wildlife, such as rabbits and deer.

Although the quality of the restoration plan used to guide a project didn't affect project outcome, whether that plan was written by the team doing the restoration, rather than someone else, like a contractor, did matter. Projects were more likely to be successful if they were guided by a plan written by the team itself. A plan should be the product of decisions made by the team and reflect their understanding of the project. So, if a team lacks a plan they are less likely to succeed with their project; if a team has a plan that they don't know how to implement or don't care to use, they won't succeed either. This factor is probably linked to internal capacity, which also explains project success. Teams that had low internal capacity, especially lacking in restoration expertise or sufficient staff, are more likely to do restorations that result in "low quality" outcomes. Even extensive use of contractors can't fully compensate for a lack of internal capacity.

GUIDELINES FOR PROPOSED PROJECTS

- **Organizations requesting funding should have demonstrated organizational capacity to successfully implement the proposed restoration project.**
- **The capacity to implement a restoration should be reflected in a detailed restoration plan submitted with the project proposal.**
- **The restoration plan should include measurable goals that will help guide the restoration process and provide benchmarks for assessing progress toward achieving biodiversity or ecosystem services outcomes.**
- **The restoration plan should include a timeline commensurate with the complexity of the proposed restoration project to allow time for adequate site preparation prior to seeding when appropriate.**
- **The project proposal should include a management plan that demonstrates a commitment to ongoing management with an emphasis on the first 5 years post-implementation.**

Graph: Ecological Outcome for 59 Restoration Sites. Nineteen (32%) restorations evaluated ranked as high quality with Composite Invasive Species Abundance scores (CISA) ≤ the median of 50.5 and Potential Natural Vegetation (%PNV) ≥ the median of 44%. Sixteen (27%) of restorations ranked as low quality with CISA scores > than the median and %PNV < than the median.



EVALUATION APPROACH

To develop the guidance offered here, researchers gathered information from LCCMR files, project manager files, project manager interviews, and field surveys of restoration sites. They used this information to figure out which organizational and ecological factors mattered most to restoration outcome, i.e., the extent to which restoration projects are similar to natural ecosystems. This research study had 5 steps: 1) an initial review of all projects, 2) a review of plans and documents for selected projects, 3) field surveys of projects, 4) manager interviews, and 5) data analysis.

Initial review: More than 450 specific ecological restoration projects were identified in a search of LCCMR appropriations from 1990 to 2010. The restoration projects were categorized into 12 groups according to: ecosystem (prairie, forest, and wetland), age (3-10 years or 10+ years), and revegetation (planted or not planted). Up to 20 projects from each of the 12 groups (172 total) were selected for further review of project status and post-grant management. Managers from 153 of the 172 projects responded to the survey. Each of these restorations was then categorized according to the level of post restoration management they received: none-sporadic or periodic-frequent.

Plan review: The 153 projects with manager survey information were grouped into 24 categories using the 3 factors from the initial review, plus level of post restoration management. Three categories did not include any projects. A total of 85 projects from the 153 were randomly chosen to include representative projects for each of the remaining 21 categories. Project managers for the 85 projects were asked to provide restoration plans; when plans did not exist, managers were asked to share whatever equivalent documentation they had in their files. Managers representing 78 restoration projects responded to the request for restoration plan documents. The quality and detail of the information provided for the request for restoration plan documents varied widely from a few general sentences to highly detailed planning documents. Plans were reviewed to determine the extent to which they provided the detail needed to guide the project.

Field surveys: 61 projects representing the initial and plan review categories were selected for a field survey. A field survey protocol was developed to assess the quality of the restored habitat as determined by the composition of the plant community (vegetation survey) and to document site stressors within the restored habitat and land use impacts from the surrounding landscape (land use/cover assessment). Field surveys were conducted June-September in 2014 and 2015. Two restorations could not be located by current land managers. For 9 of the 59 sites visited, managers provided incorrect information regarding either the ecosystem restored (prairie, forest, or wetland) or the restoration action taken (planted or vegetation management only). These 9 projects were evaluated in categories that match the conditions found during site visits.

Manager interviews: Project managers for each of the 59 restoration projects for which a site visit was conducted were contacted by phone and interviewed regarding restoration implementation practices, ongoing management practices, and limitations to implementing the restoration or providing ongoing management. Interview questions related to process were tailored to each plant community type restored. Additional questions in the survey query managers for details regarding organizational changes or limitations that might impact project outcomes. The interviews consisted of 14 -21 questions depending on what habitat was restored. The transcripts from the interviews were analyzed using situational awareness, significant setbacks and keystone vulnerabilities as parameters to assess organizational resilience.

Analysis: To quantify the extent of ecological recovery of each site (i.e, restoration success), researchers calculated: 1) the portion of all plant species considered part of the potential natural vegetation (following DNR Field Guide to the Native Plant Communities of Minnesota) and 2) an index based on the abundances of all invasive species. These two parameters (%PNV, CISA) were used to classify ecological condition as high, medium or low quality. High quality restorations were those with greater than average %PNV and lower than average CISA; low quality restorations have the opposite scores, i.e., lower than average %PNV and higher than average CISA. Medium quality restorations have either higher than average %PNV or CISA, but not both. Researchers screened (using contingency analysis) a variety of factors related to site history (i.e., time since restoration, management, starting condition), organizational capacity, and type of ecosystem to determine which have the greatest potential to predict restoration outcome (i.e., post-restoration ecological condition).

RESOURCES

The Tallgrass Prairie Center Guide to Prairie Restoration. D. Smith, D. Williams, G. Houseal, K. Henderson. 2010, University of Iowa Press.

Board of Soil and Water Resources Native Vegetation and Seed Mixes Resources
http://www.bwsr.state.mn.us/native_vegetation/index.html

Board of Soil and Water Resources Wetland Restoration Guide
http://bwsr.state.mn.us/restoration/planning.html

Department of Transportation Seed Mixes Resources
http://www.dot.state.mn.us/environment/erosion/seedmixes.html

Department of Natural Resources Minnesota County Biological Survey
http://www.dnr.state.mn.us/eco/mcbs/plant_lists.html

Department of Natural Resources Native Plant Communities
http://www.dnr.state.mn.us/npc/index.html

Department of Natural Resources Prescribed Burn Resources
http://www.dnr.state.mn.us/rxfire/forms.html

Minnesota Pollution Control Agency (MPCA). 2014. Rapid Floristic Quality Assessment Manual. wq-bwm2-02b. Minnesota Pollution Control Agency, St. Paul, MN