

Summary of Functional Benefits of Native Plants in Designed and Natural Landscapes

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Summary

This document is intended to provide articles and papers focused on the functional benefits of native vegetation in the landscape, to assist designers and natural resource managers. Major topics covered include stormwater treatment, project sustainability, wildlife habitat, bioenergy, erosion control, and carbon sequestration.

Links are provided to PDF files, websites or abstracts for each reference. This document will be updated as more information becomes available. Users of this document are encouraged to submit additional information to Dan Shaw at dan.shaw@state.mn.us.

Stormwater Treatment

The following resources provide information about the use of plants for stormwater infiltration, filtering and evapotranspiration.

- [Assessing Bioretention Cell Function in a Midwest Continental Climate](#)
This study examined the performance of bioretention cells with five plant species: fragrant sumac (*Rhus aromatica*), yellow twig dogwood (*Cornus stolonifera*), buffalo grass (*Buchloe dactyloides*), switchgrass (*Panicum virgatum*), and daylily (*Hemerocallis*), and an unplanted control. Preliminary results indicate that switchgrass and daylilies perform best. Switchgrass enhanced infiltration and reduced discharge volume by 70% (Culbertson et al., 2004).
- **Comparison of Water Interception and Infiltration by Selected Grass Dominated Communities**
The goal of this study was to determine how interception and infiltration rates differ in four grass communities with differing levels of diversity. Results from the study show significantly higher interception rates ($p < 0.001$) in the warm-season grass plots than in the Kentucky bluegrass and mixed brome plots. Infiltration rates were significantly ($p < 0.001$) higher in the warm-season grass plots compared to the low diversity plots. The addition of forbs to the warm-season grass plot did not significantly increase infiltration or interception (Benedict et al., 2010).
- [Nutrient Retention in Vegetated and Nonvegetated Bioretention Mesocosms](#)

Thirty well-established 240L bioretention mesocosms were used to investigate retention of dissolved nutrients by bioretention systems (Lucas & Greenway, 2008).

- [Phosphorus Retention Performance in Vegetated and Non-Vegetated Bioretention Mesocosms using Recycled Effluent](#)

The aim of our study was to evaluate phosphorus retention in vegetated and non-vegetated (barren) bioretention mesocosms. Over the 31 week period, the difference in retained loads was $15.4 \text{ g-m}^{-2} \text{ P}$ in the vegetated loam mesocosms, $16.9 \text{ g-m}^{-2} \text{ P}$ in the vegetated sand mesocosms, and $23.5 \text{ g-m}^{-2} \text{ P}$ in the vegetated gravel mesocosms. These removal rates substantially exceed typical phosphorus uptake rates for plants, suggesting that other plant-soil-microbe interactions are influencing phosphorus retention in the vegetated mesocosms.

- [Evaluation of Turf-Grass and Prairie-Vegetated Rain Gardens in a Clay and Sand Soil, Madison, Wisconsin, Water Years 2004–08](#)

Two rain gardens, one planted with turf grass and the other with native prairie species, were constructed side-by-side in 2003 at two locations with different dominant soil types, either sand or clay and compared over a 5-year study period. Results of the study show that each rain garden, regardless of vegetation or soil type, was capable of storing and infiltrating most of the runoff during the 5-year study period. Median infiltration rates for rain gardens in sand were greater than those in clay. Within each soil type, rain gardens with prairie vegetation had greater median infiltration rates than those with turf grass (Selbig, 2010).

- [Do Macrophytes play a role in constructed treatment wetlands](#)

A summary of how macrophytes influence the treatment process in wetlands. The paper suggests that contrary to earlier belief, the growth of macrophytes does not increase the hydraulic conductivity of the substrate in soil-based subsurface flow constructed wetlands. The metabolism of the macrophytes affects the treatment processes to different extents depending on the type of constructed wetland. Macrophyte mediate transfer of oxygen to the rhizosphere by leakage from roots increases aerobic degradation of organic matter and nitrification (Brix, 1997).

- [Can Urban Tree Roots Improve Infiltration through Compacted Sub-soils for Stormwater Management?](#)

The following examined whether tree roots can penetrate compacted sub-soils and increase infiltration rates in the context of a novel infiltration BMP (I-BMP). The study found that tree roots penetrated the geotextile and subsoil and increased average infiltration rate 27-fold compared to unplanted controls. Although high water tables may limit tree rooting depth, some

species may be effective tools for increasing water infiltration and enhancing groundwater recharge in this and other I-BMPs (e.g., raingardens and bioswales) (Bartens et al., 2008).

- [Flood Tolerance In Wetland Angiosperms: A Comparison of Invasive and Noninvasive Species](#)

Study assessed the biomass production, biomass allocation patterns, height growth, and root airspace of seventeen wetland plant taxa, including two potentially invasive species, grown under high nutrient conditions and subjected to four hydrologic regimes: constant drawdown, cyclic flooding and drawdown, cyclic flooding and drought, and constant flooding. The study found that among the five taxa that were most sensitive to flooding were slow-growing habitat specialists; such species will likely experience declines in areas that become impounded or experience greater volumes of runoff (Kercher & Suzanne, 2004).

Landscape Sustainability

The following resources provide information about the use of plants in sustainable landscapes where vegetation is planned to minimize maintenance needs and resource use.

- [Native Roadside Perennial Grasses Persist A Decade After Planting In The Sacramento Valley](#)

Restoring native grassland along roadsides can provide a relatively low-maintenance, drought-tolerant and stable perennial vegetative cover with reduced weed growth, as opposed to the high-maintenance invasive annual cover (requiring intensive mowing and herbicide treatments). A survey of long established roadside native-grass plantings in Yolo County showed that once established and protected from disturbance, such plantings can persist with minimal maintenance for more than a decade, retaining a high proportion of native species (O'Dell and Young, 2007).

- [Plant Community Change Following Fifty-years of Management at Kalsow Prairie Preserve, Iowa, U.S.A.](#)

Study found that 50 y of management has succeeded in reducing the frequency of exotic species and, thus, improved the overall integrity of the native plant community. However, during this same period dramatic changes in the frequency of many native species have also occurred. A general increase by mesic and late flowering species and a decrease by xeric natives was observed. Results emphasize the need to merge our current understanding of the processes that help sustain diversity into implemented management practices that will prolong the diversity of our remaining small isolated prairie preserves (Dornbush, 2004).

- [The Economics Of Native Plants In Residential Landscape Designs](#)
 Results of paper suggest that people are willing to pay more for well-designed yards including native plants than for lawns, and that their increased willingness to pay exceeds any increase in costs associated with the native plantings. (Helfand, 2006).

- [Maximizing Arthropod Mediated Ecosystem Services in Agricultural Landscapes: The Role of Native Plants](#)
 Reintegration of native plants into agricultural landscapes has the potential to support multiple conservation goals, and will require the collaboration of researchers, conservation educators, and native plant experts (Isaacs et al., 2009).

- [Biodiversity and Multiple Ecosystem Functions in an Organic Farmscape](#)
 To increase ecosystem services provided by their lands, farmers in the United States are managing non-production areas to create a more biodiverse set of habitats and greater landscape heterogeneity. Relatively little is known, however, of the actual environmental outcomes of this practice, termed 'farmscaping'. Researchers inventoried communities of plant and soil organisms and monitored indicators of ecosystem functions in six distinct habitats of an organic farm in California's Central Valley to better understand the ecological costs and benefits of farmscaping (Smukler et al., 2010).

- [How to build multifunctional agricultural landscapes in the U.S. corn belt: add perennials and partnerships](#)
 The goal was to determine constraints to, and leverage points for, broad-scale implementation of practices that use perennial vegetation to bolster ecosystem services in agricultural landscapes. Our data highlight the adaptive capacity of regional actors to act as intermediaries to shape macro-scale markets, technologies, and policies in ways that are compatible with the needs, the capabilities, and the conservation of local human and natural resources (Atwell et al., 2010).

Wildlife Habitat

The following resources provide information about the wildlife benefits of native plant species.

- [Conservation Value of Roadside Prairie Restoration to Butterfly Communities](#)
 Researchers evaluated the effects of roadside vegetation management programs of several Iowa counties. The study found that management of roadsides profoundly affected the butterfly community. Species richness of habitat-sensitive butterflies showed a two-fold increase in prairie compared with grassy and weedy roadsides, and abundance increased 5 times more on the prairie than on grassy roadsides (Ries et al., 2001).

- [Attractiveness Of Michigan Native Plants To Arthropod Natural Enemies And Herbivores](#)

The use of plants to provide nectar and pollen resources to natural enemies through habitat management is a growing focus of conservation biological control. Current guidelines frequently recommend use of annual plants exotic to the management area. Study finds that native perennial plants are likely to provide similar resources and may have several advantages over exotics. The most attractive native plants identified are *Eupatorium perfoliatum* L., *Monarda punctata* L., *Silphium perfoliatum* L., *Potentilla fruticosa* auct. non L., *Coreopsis lanceolata* L., *Spiraea alba* Duroi, *Agastache nepetoides* (L.)Kuntze, *Anemone canadensis* L., and *Angelica atropurpurea* (Fielder and Landis, 2007). 2003).

- [Roadsides and pollinator conservation: The relationship between native bees and floral diversity](#)

Comparisons of bee populations were made in Northeastern Kansas between seven roadsides seeded with native prairie vegetation and seven roadsides that had not been seeded and had an abundance of weedy, non-native plants. Only 14 bee species were unique to weedy roadsides, while 41 species were found only in restored roadsides. The effects of floral resources and roadside characteristics on bee abundance and richness were also investigated, and a prairie remnant was sampled for comparison. Results indicate that increasing floral richness, floral abundance and percent of bare ground encourages greater bee abundance and richness (Hopwood, 2006).

- [Plant Species Redundancy and the Restoration of Faunal Habitat: Lessons from Plant-Dwelling Bugs](#)

Paper assess whether there is redundancy among a subset of native plant species chosen to restore fauna habitat following a severe disturbance. Additionally, the paper determines if reestablished plants support similar faunal assemblages as the same plant species in less disturbed forest (Brennan et al., 2010).

- [Changes in Breeding Bird Populations with Habitat Restoration in Northern Iowa](#)

Native tall grass prairie and wetland habitat in the Prairie Pothole Region of the United States have declined over the past two centuries. Article investigates the changes in bird populations in an ongoing grass and wetland restoration (Fletcher and Koford, 2003).

- [Pollinators in Natural Areas: A Primer on Habitat Management](#)

A brief article about the importance of pollinators, as well as, general habitat management considerations (Black et al., 2007).

- [Habitat and Landscape Associations of Breeding Birds In Native and Restored Grasslands](#)

Study assessed the effects of habitat restoration and the relative contribution of local habitat and landscape factors on breeding grassland birds in northern Iowa. The results indicate that restored grassland habitats contain bird communities generally similar to those in native prairie habitats in northern Iowa (Fletcher, 2002)

Bio-energy

The following resources provide information about the use of native plant species for producing bio-energy for incineration or ethanol production.

- [Switchgrass As A Sustainable Bioenergy Crop](#)
Switchgrass (*Panicum virgatum* L.) shows potential as a sustainable herbaceous energy crop from which a renewable source of transportation fuel and/or biomass-generated electricity could be derived (Sanderson et al., 1999.)
- [Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass](#)
Research on the benefits of using biofuels derived from low-input high-diversity (LIHD) mixtures of native grassland perennials. LIHD biomass can provide more usable energy, greater greenhouse gas reductions, and less agrichemical pollution per hectare than can corn grain ethanol or soybean biodiesel (Tilman et al., 2008).
- [Life Cycle Assessment Of a Willow Bioenergy Cropping System](#)
The environmental performance of willow biomass crop production systems in New York (NY) is analyzed using life cycle assessment (LCA) methodology. Study supports the assertion that willow biomass crops are sustainable from an energy balance perspective and contribute additional environmental benefits (Heller, 2002).
- [Nonnative Species and Bioenergy: Are We Cultivating the Next Invader?](#)
Many invasive species have horticultural or agronomic origins with long periods of cultivation that precede their escape, naturalization, spread, and subsequent environmental impacts. In response to the economic and environmental incentives for low-input biofuel crops and the desire to prevent future invasions, this study screened the leading candidates for biofuel feedstock crops in the United States (Barney & Ditomaso, 2008).
- [Adding Biofuels to the Invasive Species Fire?](#)
A brief overview of plants deemed ideal as a bioenergy crop (Raghu et al., 2006).

- [Development of switchgrass \(*Panicum virgatum*\) as a bioenergy feedstock in the United States](#)

A 10-year US Department of Energy-sponsored research program designed to evaluate and develop switchgrass (*Panicum virgatum*), a native perennial warm-season grass, as a dedicated energy crop is reviewed (McLaughlin and Kszos, 2005).

Soil Quality/Remediation

The following resources provide information about the use of native plant species to improve soil quality and remediate contaminated soils.

- [The Use of Plants for the Removal of Toxic Metals from Contaminated Soil](#)

A comprehensive overview of phytoremediation (Lasat, 2000).

- [Grass Strips Help Curb Erosion, Herbicide Transport](#)

Researchers studied the ability of seven plant species to study the effect of different species on herbicide transport and degradation in field and growth chamber studies. Among the species tested, eastern gammagrass showed the highest capacity for promoting atrazine degradation. More than 90 percent of applied atrazine was degraded to less toxic forms (Science Daily 2011).

- [Soil bacterial community structure under exotic versus native understory forbs in a woodland remnant in Indiana](#)

Using terminal restriction fragment length polymorphism (TRFLP) analysis of PCR-amplified 16S-rDNA sequences, researchers characterized eubacterial community structure in soil collected on the Bloomington campus of Indiana University beneath native Canadian wild ginger (*Asarum canadense* L.) and exotic invasive winter creeper (*Euonymus fortunei* (Turcz.) Hand.-Maz.). The results are consistent with the hypothesis that invasive exotics can influence belowground community structure (Swedo et al., 2008).

- [Impacts of Soil Microbial Communities on Exotic Plant Invasions](#)

Discusses how soil communities influence exotic plant invasions (Inderjit, 2010).

- [Low Impact Development: Technical Guidance Manual for Puget Sound: Appendix 6 Sampling of Plant Species Studied for Phytoremediation](#)

Paper containing a sampling of plant species that have been studied for phytoremediation (Hinman, 2005).

- [Soil Microbial Community Associated with an Invasive Grass Differentially Impacts Native Plant Performance](#)

This study is one of the first to show that invasive plant-induced changes in the soil microbial community can negatively impact native plant performance. This greenhouse experiment tested whether soil microbial communities specific to the rhizospheres of an invasive grass (*Aegilops triuncialis*) and two native plants (*Lasthenia californica* and *Plantago erecta*) affected invasive and/or native plant performance (Batten, 2007).

Carbon Sequestration

The following resources provide information about the use of native plant species to sequester carbon

- [Effects of Biological Invasions On Forest Carbon Sequestration](#)
This review provides a conceptual basis for improving our general understanding of biological invaders on ecosystem C. (Peltzer et al., 2009)
- [Comparative Analyses of Carbon Dynamics in Native and Cultivated Ecosystems](#)
Plant productivity, decomposition rates, and soil organic matter accumulation for winter wheat and for unbroken tall grass prairie were analyzed and compared. Study showed that CO₂ losses from above- and belowground litter decay, expressed as a percentage of total soil respiration, were twice as great under wheat as for native prairie (Buyanovsky et al., 1987).
- [Grass Invasion of a Hardwood Forest is Associated With Declines in Belowground Carbon Pools](#)
Review suggests that invasive grass may accelerate C-cycling in forest soils and deplete C stocks. (Strickland et al., 2010)
- [Soil Carbon Sequestration and Land-Use Change: Processes and Potential](#)
Article discuss the essential elements of what is known about soil organic matter dynamics that may result in enhanced soil carbon sequestration with changes in land-use and soil management. Paper reviews literature that reports changes in soil organic carbon after changes in land-use that favor carbon accumulation. This data summary provides a guide to approximate rates of SOC sequestration that are possible with management, and indicates the relative importance of some factors that influence the rates of organic carbon sequestration in soil (Post et al., 2000).
- [The Fate of Carbon in Grasslands Under Carbon Dioxide Enrichment](#)
An annual budget focusing on below-ground carbon cycling for two grassland ecosystems exposed to elevated CO₂ concentrations is presented. Three years of experimental CO₂ doubling increased ecosystem carbon uptake, but greatly increased carbon partitioning to rapidly cycling carbon pools below ground (Hungate et al., 1997).

- [Carbon Sequestration And Rangelands: A Synthesis Of Land Management And Precipitation Effects](#)

Management of rangelands can aid in the mitigation of rising atmospheric carbon dioxide concentrations via carbon sequestration. Study provides a review of current knowledge on the effects of land management practices (grazing, nitrogen inputs, and restoration) and precipitation on carbon sequestration in rangelands.

Soil Stabilization

The following resources provide information on the management of erosion through using native vegetation to stabilize soils.

- [Root Depth Comparison of Introduced Grasses to that of Native Grasses](#)

Illustrations of why native grasses provide good long-term erosion control (MNDNR, 2010).

- [Shoreline Stabilization: Bioengineering Alternatives](#)

Paper covering shoreline restoration using bioengineering solutions. Paper describes the process of shoreline stabilization using vegetation, live staking, fiber rolls, and A-jacks (Illinois Environmental Protection Agency, 1996).

- [Post-fire Seeding for Erosion Control: Effectiveness and Impacts on Native Plant Communities](#)

Non-native annual or perennial grasses typically are used to provide quick temporary ground cover to hold soil in place until native plants are reestablished. Critics argue that seeded grasses compete with native vegetation and do not effectively reduce erosion. Research paper further investigates post fire erosion control results (Beyers, 2004)