MAXIMIZING THE ENVIRONMENTAL AND ECONOMIC BENEFITS OF A MILLION ACRES OF FORESTATION IN MINNESOTA THROUGH AN ECOSYSTEM RESTORATION APPROACH

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Executive Summary

On January 15, 2010, the Minnesota Forest Resources Council (MFRC) released a report entitled, "Assessing Forestation Opportunities for Carbon Sequestration in Minnesota" (MFRC 2010). The report was directed by the 2009 Minnesota Legislature in response to a key recommendation of the Minnesota Climate Change Advisory Group (MCCAG). The MCCAG proposed the planting of 1,000,000 acres of trees in Minnesota as one component of a statewide strategy for mitigating greenhouse gas emissions (MCCAG 2008). The purpose of the MFRC report was to evaluate the feasibility of creating one million acres of new forests in the state within the context of increasing carbon sequestration. MFRC identified 7.6 million acres of potentially forestable land, almost eight times the land area needed to achieve one million acres of forestation.

The purpose of this report is to demonstrate that a holistic approach to forestation, based on the diversity of Minnesota's ecosystems and the services provided by those ecosystems, will maximize the benefits of such an initiative. We conducted literature reviews, expert interviews, and introductory analyses to explore the environmental and economic impacts of a million acres of forestation. Specifically, we show that: (1) there are multiple benefits of forestation beyond carbon sequestration; (2) a million acres of forestation in Minnesota is a feasible goal; and (3) existing resources can be used in large part to accomplish large-scale forestation.

Forests provide a host of ecosystem services that benefit people, including timber, fiber, and food production; climate regulation; wildlife habitat; water quality protection and flood control; and recreational opportunities. An ecosystem-based approach to forestation in Minnesota is consistent with national and global efforts to place economic value on ecosystem services and with state efforts to enhance water quality, soil conservation, and wildlife habitat while pursuing carbon sequestration goals.

Historical data in Minnesota and recent data from other states demonstrate that large-scale tree planting, including direct seeding, is logistically feasible. Numerous other states – most of them smaller than Minnesota – have planted over 100,000 acres of trees annually, approximately four times the number of acres planted in Minnesota in comparable years. At 100,000 acres of trees per year, one million acres of forestation could be achieved in ten years. Adding one million acres of forest would expand Minnesota's existing forests by just over 6%. The Conservation Reserve Program (CRP) and other programs have been used in the southeastern U.S. to plant trees for restoration of the longleaf pine ecosystem, which may serve as a model for Minnesota to emulate.

A large proportion of the potentially forestable area identified in the MFRC report involved land cover classified as privately owned grasses. Private grasses often ranked highly for amount of land that would be converted to forest under the different scenarios examined in the report (MFRC 2010). Given the vulnerability of grassland wildlife species to habitat loss, we conducted an initial analysis to improve understanding of the trade-offs to wildlife from large-

scale forestation. We used Geographic Information Systems (GIS) to exclude certain grassland areas from the potentially forestable area identified by MFRC.

There were 5.4 million acres of potentially forestable area remaining after the grassland exclusions. Much of the potentially forestable area corresponded to the state's prairie-forest transition zone, which runs in a diagonal belt from southeastern to north-central Minnesota. The benefits of forestation to wildlife depend on recognition that sensitive species in the Eastern Broadleaf Forest and the Tallgrass Aspen Parkland provinces, which make up the transition zone, are associated with a variety of habitats – from prairies and grasslands to savannas, shrublands, and forests. An introductory analysis of breeding bird distribution in Minnesota suggested that restoration of savannas, in particular, would be an important component of a large-scale forestation initiative. The grasses and open tree canopies that characterize savannas offer opportunities for carbon sequestration and other ecosystem services and may be more ecologically appropriate in many areas than forestation involving a closed canopy.

An overall approach to forestation that balances the importance of forests, savannas, and grasslands in Minnesota's landscape will maximize environmental benefits. Based on our initial GIS and avian analyses, we offer the following specific recommendations for forestation strategies within Minnesota's prairie-forest transition zone, with an emphasis on the Eastern Broadleaf Forest province.

- Use a range of numbers of trees per acre rather than a constant density of trees to reflect that the goal is to restore a balance of habitats that are native to the prairie-forest transition zone. Having variable per-acre targets opens the door to opportunities that haven't been addressed in analyses to date (such as oak savanna restoration, tree planting in urban areas, and forestation on small parcels).
- Consider alternatives such as the use of prescribed burning, prescribed grazing, or direct seeding, as appropriate for specific restoration objectives, to avoid some costs of large-scale tree planting.
- Consider historical habitat complexity, along with existing land uses and individual landowner preferences, when deciding where different types of grasslands, savannas, and forests are appropriate, and incorporate measures to improve habitat connectivity such as wildlife corridors and habitat buffers.

We offer the following recommendations for forestation strategies outside of Minnesota's prairie-forest transition zone.

- Use native tree planting in the Laurentian Mixed Forest province of northeastern Minnesota to restore degraded areas (including along rivers and streams), enhance existing high-value areas, and expand extent of existing forest tracts, and recognize that even within the "North Woods" there were historically "open" areas such as shrublands upon which certain wildlife species depend.
- In the Prairie Parkland province of southwestern and western Minnesota, limit forestation to restoration of oak savannas and riparian areas that were forested historically and ensure that significant environmental co-benefits (such as wildlife habitat, water quality improvements, and flood control) would result from such restoration activities.

There are economic constraints to adding a million acres of forest to Minnesota's landscape. These constraints include the capacity to produce seedlings, costs associated with forest establishment and maintenance, the need to make forestation an economically viable option for landowners whose land is currently in agricultural production, time lines associated with planting rotations, and uncertainties over funding sources and market forces.

Numerous incentives for tree planting already exist in the form of market payments and public payments and could be combined to accomplish forestation at the proposed scale. Minnesota's Outdoor Heritage Fund and Clean Water Fund, alone and in collaboration, offer an unprecedented opportunity to leverage financial resources and achieve broad, overlapping objectives.

"Planting trees in strategic locations such as formerly forested corridors along impaired streams and rivers in agricultural areas is a classic win-win situation in that it benefits wildlife habitat and water quality simultaneously." - page 31

We recommend the following analyses as next steps toward examining the environmental and economic feasibility of large-scale ecosystem restoration in Minnesota.

(1) *Use a more in-depth GIS analysis to refine the potentially forestable areas.* Where are there additional limitations to forestation? Where are the opportunities most stakeholders can agree on (such as urban or riparian areas throughout the state)?

(2) *Envision a large-scale restoration within the Eastern Broadleaf Forest province.* Include a mix of grassland, savanna, and forest, and conduct a holistic assessment of the potential for carbon sequestration, enhanced wildlife habitat, improved water quality, and other ecosystem service improvements.

(3) *Explore the potential economic benefits.* What is the potential for job creation through expanded nursery production, economic growth through value-added activity, increased sustainability of farming practices, and tapping of bioenergy markets?

(4) *Quantify the level of resources available from existing programs and incentives.* How much funding is currently available and how does it compare to the total cost estimate of a million-acre restoration? What other programs would need to be created or adapted to make up the difference?

We encourage decision makers to consider the environmental benefits of large-scale ecosystem restoration in Minnesota, the value of ecosystem services to public health and our state's economy, and the potential for coordinated, collaborative funding approaches and policies to bring about these environmental and economic benefits.

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Abbreviations

CCC	Civilian Conservation Corps
CWLLA	Clean Water, Land, and Legacy Amendment
CPA	Conservation Priority Area
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
EQIP	Environmental Quality Incentives Program
FSA	Farm Service Agency
GIS	Geographic Information Systems
GBCA	Grassland Bird Conservation Area
L-SOHC	Lessard-Sams Outdoor Heritage Council
MCCAG	Minnesota Climate Change Advisory Group
MN DNR	Minnesota Department of Natural Resources
MFRC	Minnesota Forest Resources Council
NRCS	Natural Resources Conservation Service
REDD	Reducing Emissions from Deforestation and Degradation
RIM	Reinvest in Minnesota
SGCN	Species in Greatest Conservation Need
USDA	U.S. Department of Agriculture
UNFCCC	United Nations Framework Convention on Climate Change
WHIP	Wildlife Habitat Incentives Program

Introduction

On January 15, 2010, the Minnesota Forest Resources Council (MFRC) released a report entitled, "Assessing Forestation Opportunities for Carbon Sequestration in Minnesota" (MFRC 2010). The report was directed by the 2009 Minnesota Legislature in response to a key recommendation of the Minnesota Climate Change Advisory Group (MCCAG). The MCCAG proposed the planting of 1,000,000 acres of trees in Minnesota as one component of a statewide strategy for mitigating greenhouse gas emissions (MCCAG 2008). The purpose of the MFRC report was to evaluate the feasibility of creating one million acres of new forests in the state.

Due to the nature of the legislative mandate, the MFRC report was necessarily focused on forestation[1] in the context of increasing carbon sequestration. While carbon sequestration is one desired outcome, numerous other environmental and economic benefits can be achieved through forestation. An articulation of the co-benefits of forestation and a description of how they can be realized should help leverage resources and maximize Minnesota's return on investment by providing far-reaching returns relative to environmental health and the state's economy.

*The term **ecosystem** refers to the interaction of plants, animals, and other organisms with the physical elements of their environment (soil, rocks, water, air) and the processes that occur in that environment (such as nutrient cycling).*

A forestation initiative in Minnesota needs to take into account the diversity of the state's landscape. Minnesota is situated in a place of continental ecological importance. North America's three major biomes – prairie, deciduous forest, and boreal forest – converge here. This ecological context has largely dictated Minnesota's growth as a state and contributes much to our sense of identity. It is against this backdrop that forestation on any scale must occur. This report illustrates that a holistic, ecosystem-based approach will maximize the benefits of a forestation initiative. Specifically, our objectives are to show that: (1) there are multiple benefits of forestation beyond carbon sequestration; (2) a million acres of forestation in Minnesota is a feasible goal; and (3) existing resources can be used in large part to accomplish large-scale forestation.

We conducted literature reviews, expert interviews, and introductory analyses to explore the environmental and economic impacts of a million acres of forestation. We provide an overview of forestation benefits as they relate to ecosystem services; describe historical and regional perspectives on forestation; and discuss where forestation might occur in Minnesota with an emphasis on wildlife impacts and grassland protection. We also address economic benefits and constraints specific to Minnesota and outline how combining or adapting existing programs and stacking incentives can be used to achieve target levels of landowner compensation that would promote forestation in appropriate areas.

[1] We use the term "forestation" as a generic term to refer to afforestation (which refers to establishing a new forest where one did not previously exist or has not existed for at least 50 years) and/or to reforestation (which is the restoration or replanting of a forest on a site that was recently under forest cover), according to the United Nations Framework Convention on Climate Change Clean Development Mechanism; see http://cdm.unfccc.int/Reference/glossary.html. We also use "forestation" as a broad term that may encompass different management scenarios and objectives, ranging from the management of tree plantations for maximized timber and fiber production to the use of tree planting for forest enrichment or ecological restoration that provides diversified forest benefits and ecosystem services.

MFRC Report

MFRC estimated the amount and location of "potentially forestable" area in Minnesota by identifying parcels that are not currently forested but that could likely sustain forest vegetation. Historical vegetation and soils[2] data were used to indicate where forests occurred historically and thus where the soil moisture regimes and the nutrient characteristics needed for forest growth are likely to be present today. This approach excluded from analysis the majority of productive cropland in the state and areas that were native prairie prior to European settlement.

Not all of Minnesota's original 30-32 million acres of forest land (Cunningham et al. 1940, Morgan 1960) were considered forestable according to MFRC's analysis. MFRC excluded urban areas, areas already forested, parcels less than 20 acres, and publicly managed areas with management objectives that generally preclude forestation (e.g., Wildlife Management Areas, Scientific and Natural Areas, state and national parks, and wilderness areas).

MFRC identified 7.6 million acres of potentially forestable land. This result offers almost eight times the land area needed to achieve one million acres of forestation. MFRC cautioned, however, that forestation policies must carefully consider impacts on grasslands and productive croplands, and we address these trade-offs throughout this report.

To evaluate forestation feasibility, MFRC compared the estimated financial return to landowners from existing land uses to returns possible under five different scenarios.[3]

(A) No forestation incentives are put into place ("business as usual").
(B) Business as usual except the average price for pulpwood doubles.
(C) Prices from 2009 prevail with the addition of a carbon market that pays an average of $30 per ton of CO_2 sequestered per year.
(D) Prices from 2009 prevail plus landowners receive a 50% cost-share for forestation costs.
(E) All public lands identified as potentially forestable (about 77,500 acres) are converted to forest.

MFRC found that more acres would be forested under Scenario C than any of the other scenarios they considered.[4] Annual carbon market payments of $30 per ton of CO_2 sequestered generated 616,711 acres of forestation. Scenarios B and E also resulted in notable amounts of forestation (25,472 acres and 77,494 acres, respectively). The area of land likely to be forested varied with the level of annual landowner payments. Annual payments of $30 per acre resulted in approximately 34,000 acres of forestation; $88 per acre resulted in approximately 407,000 acres. The one-millionth acre was estimated to require a payment of $114 per acre (Figure 2 in MFRC (2010)).

[2] MFRC included some prairie-forest transition soil types in addition to soil types formed exclusively under forest vegetation.
[3] MFRC assumed forestation would occur if expected returns to landowners exceeded current land uses. No other motivations for forestation were included in their analysis.
[4] As with all modeling exercises, MFRC's analysis was based on several assumptions. These assumptions are beyond the scope of our discussion but can be reviewed in MFRC (2010).

The area of land converted from different existing land uses varied by scenario. At $88 per acre, for example, the forested acres would come from approximately 46 acres of Conservation Reserve Program (CRP) land; 37,000 acres of public grassland; 38,000 acres of cropland; and 332,000 acres of private grassland (Table 9 in MFRC (2010)). The estimated number of acres forested by different forest types also varied, given that carbon credit payments favor conifer plantings (due to higher carbon sequestration potential) and forest product revenues favor aspen (due to its higher yield). Hybrid poplar was not preferred under any of MFRC's scenarios because of its shorter rotation (8-10 years versus 40-75 years for hardwood or conifer species) and the resultant higher site preparation costs or lower sequestration potential. MFRC concluded that, regardless of scenario, forestation of a million acres would require higher seedling production by in-state nurseries, greater reliance on out-of-state seedling production, or both.

We have restricted the scope of our report to opportunities for forestation on private land (as opposed to public land) because there is more private acreage available in the state for forestation and because it allows market forces to contribute more readily to the economic feasibility of the proposal. Accordingly, later in this report, we will address the first two of MFRC's five recommendations ("combine existing programs" and "stack policy incentives") as they relate to forestation on private land, while leaving agency directives and further analysis for others to address.[5]

Historical Perspective

The forestation of a million acres may sound like a tall order. Considering that MFRC assumed a planting density of 907 trees per acre, the idea of planting nearly a billion trees is even more daunting. When viewed in context, however, one million acres or one billion trees are realistic numbers. There are over 74 billion trees in U.S. metropolitan areas and over 300 billion trees on commercial timber land in the U.S. (Dwyer et al. 2000). Adding one million acres of forest would expand Minnesota's forests by little more than 6%. Minnesota currently has approximately 16 million acres of forest,[6] about half of the forest acreage that was present historically. Much of the state's currently forested area has been replanted since being cleared at the time of European settlement. The historical data summarized below demonstrate that large-scale tree planting has occurred in Minnesota through a variety of programs.

[5] MFRC made five recommendations in its January 2010 report.

1. Combine existing programs and funding to meet multiple environmental goals.
2. "Stack" policy incentives with new and existing markets to maximize forestation efforts.
3. Direct the Department of Natural Resources (DNR) to plant northern white cedar, white spruce, balsam fir, tamarack, and/or black spruce, the native tree species with the highest potential for long-term carbon sequestration, on 5,000 acres of suitable DNR-administered land by 2025.
4. Direct the DNR to help private tree nursery businesses be more competitive with out-of-state seedling producers.
5. Conduct lifecycle analyses of the carbon sequestration and climate change mitigation benefits associated with forest resource management and use.

[6] http://www.dnr.state.mn.us/faq/mnfacts/forests.html

Tree planting in Minnesota has been carried out at both commercial and institutional scales.[7] The earliest records of plantings date back to the 1870s, and by 1903 the Minnesota Forestry Board was experimenting with planting trees on state forest reserves. The U.S. Forest Service established some of the earliest stand-sized plantings in what are now the Chippewa and Superior National Forests around 1910. By the 1920s there were extensive efforts to reforest federal lands from which timber had been harvested, and many millions of trees were growing in agency nurseries at Cass Lake and Eveleth. In the 1920s, Cass Lake produced over 10 million trees for the Chippewa National Forest. Production increased dramatically during the years of the Civilian Conservation Corps (CCC); nearly 73 million trees were produced at the Cass Lake nursery from 1930 to 1943. While production declined for the Chippewa National Forest after 1943, it ramped up for the Superior National Forest; between 1 and 7 million trees were produced annually from 1937 to 1953. Because some seedlings produced by Minnesota nurseries were shipped out of state, nursery production figures do not necessarily equate to numbers of trees planted within Minnesota. These figures are often the only data available for planting efforts in the first part of the 20th century, however. According to MN DNR (1971), the CCC had planted some 25 million trees on state-owned lands by 1942.

Land acquisition programs in the 1940s and 1950s led to a new surge in tree planting on state-acquired abandoned farmland through the 1960s. During this era, planting stock in Minnesota nurseries ranged from nearly 900,000 trees produced in 1947 to almost 15 million trees in 1970, with a peak of over 41 million trees in 1961 (MN DNR 1971).

Tree planting on private land has also been historically important. Between 1936 and 1996, as part of the Agricultural Conservation Program,[8] approximately 7 million acres of trees were planted nationally on non-industrial private land – as many acres as accomplished by the combined efforts of the CCC (2.3 million acres in the 1930s and 1940s), the Soil Bank program (a predecessor to CRP; 2.2 million acres from 1956 to 1961), and CRP (2.6 million from 1986 to 1996) (Moulton and Snellgrove 1997). Certified "tree farms" have offered timber production opportunities for private family-owned land since 1941.[9] In Minnesota, there are currently about 1,700 tree farms covering approximately 235,000 acres.[10]

Data from other states illustrate that tree planting, including direct seeding, can occur at much larger scales than what has occurred in Minnesota. In 1998, Georgia topped the list with over 400,000 acres of trees planted, and Mississippi and Alabama came in second and third, respectively, with over 300,000 acres planted (Moulton and Hernandez 2000). Eleven states planted over 100,000 acres of trees compared to approximately 24,000 acres of trees planted in Minnesota. Although many of the "top eleven" states may have had a greater proportion of historical forest cover than Minnesota, it is worth noting that all but two of them have less total land area.

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[7] Much of the uncited information in this paragraph, including nursery figures, was obtained from Keith Matson, History Chair and Council of Elders, Minnesota Society of American Foresters.

[8] This program was terminated in the 1996 Farm Bill and replaced by the Environmental Quality Incentives Program.

[9] http://www.treefarmsystem.org/

[10] Data according to Tom Witkowski, Minnesota Tree Farm Coordinator.

Forests and Ecosystem Services: An International Perspective

Forests provide us with thousands of useful products – fuel, building materials, wood chips, paper pulp, and non-timber products ranging from rubber and traditional medicines to maple syrup and mushrooms. While people have long valued forest products, there is growing awareness about the services that forests (and other ecosystems) also provide. The discussion of establishing a million acres of new forest in Minnesota is consistent with a global effort to value ecosystem services in general and to mitigate climate change in particular.

Ecosystem services *include production of food, fiber, and timber; regulation of climate and water flow; supporting services such as soil formation and nutrient cycling; and aesthetic and spiritual benefits (MEA 2005).*

Forests have garnered particular attention for contributing significantly to ecosystem services such as climate regulation and biodiversity (Nasi et al. 2002). Although the contributions of different ecosystems depend on complex physical and biological interactions, there is little debate that forests provide a host of ecosystem services. They regulate climate by moderating temperature, sequestering carbon (i.e., by removing CO_2 from the air and storing carbon in wood tissues), and playing a role in the hydrologic cycle. Forests also clean air; filter water; help to control floods and soil erosion; host animals that act as pollinators, seed dispersers, and natural pest control agents; and provide opportunities for tourism, hunting, fishing, and other recreational and economic activities.

Unlike forest products, a financial value has typically not been placed on most forest ecosystem services. Consequently, those who own or control forests tend not to reap the economic benefits of the forests' ecosystem services (Nasi et al. 2002). This situation is related to the so-called "free rider" problem, in that the costs of owning or managing forest land are borne by certain people (i.e., landowners), while many of the benefits of having that land in forest accrue to others (most commonly, the general public) (Niskanen 1998). The end result is that forests are often converted to other land uses or sold for development because of the costs of forest ownership, even when maintaining and managing the forests might be more beneficial to society.

Efforts are underway at many levels to address the broad issue of placing economic value on ecosystem services. The Millennium Ecosystem Assessment was initiated by the United Nations in 2000 in order to assess the consequences of ecosystem change for human well-being and to establish a scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems (MEA 2005). The U.S. Forest Service is exploring national opportunities to advance markets and payments for ecosystem services,[11] and the U.S. Department of Agriculture (USDA) recently created the Office of Environmental Markets to catalyze the development of these markets.[12] Market-based mechanisms, which can involve both governmental and non-governmental initiatives, include public payments (such as the USDA's Conservation Reserve Program), tax incentives and subsidies, cap and trade programs, and eco-labeling and consumer actions (Fernholz et al. 2008).

[11] http://www.fs.fed.us/ecosystemservices/
[12] http://www.fs.fed.us/ecosystemservices/OEM/index.shtml

Carbon credits provide one example of how ecosystem services can be valued. A credit represents the removal of one ton of CO_2 or its equivalent from the atmosphere and can be traded internationally to meet greenhouse gas emission reduction targets established by the Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC). Emission reduction projects in developing countries earn credits that can be traded or sold to industrialized nations to meet their reduction targets.

A United Nations program called Reducing Emissions from Deforestation and Degradation (REDD), which may soon be included under the UNFCCC (REDD 2010), has been advocating the multiple co-benefits that forests have to offer. In addition to carbon sequestration, forests provide opportunities for biodiversity conservation and improved economic and social conditions for local people (Brown et al. 2008). In fact, forest conservation and restoration can be optimally effective when approached within an ecosystem services framework rather than with carbon sequestration as a singular goal. Large monoculture plantations of exotic species can help to mitigate climate change, for example, but may lack the co-benefits of diverse native plantings that sequester similar amounts of carbon while also enhancing wildlife habitat.

As with similar efforts worldwide, a forestation initiative in Minnesota could provide numerous co-benefits by using an ecosystem restoration approach. Indeed, such an approach is consistent with the intent of the MCCAG, which stipulated in its report that public values such as water quality, soil conservation, and wildlife habitat not be diminished as carbon sequestration goals are pursued (MCCAG 2008).

Minnesota's Forests and Ecosystem Services: An Ecological Perspective

Assessing the impacts of forestation requires an understanding of where trees grew in the past – whether those trees were part of coniferous forests in northeastern Minnesota, deciduous forests in the southeast, riparian forests in the prairie zone, or oak and aspen savannas anywhere in between. It is also important to understand how historical plant communities have been replaced with the vegetation and land uses that make up the landscape we see today. The purpose of examining historical patterns of forest growth and land use change is not to make a case for a complete restoration of historical conditions, but rather to recognize where newly planted trees have the greatest chance of success and under what circumstances they are likely to provide the best enhancement of ecosystem services. The use of historical patterns must be tempered with consideration that past distributions of dominant forest species are likely shifting northward as a result of climate change.

Minnesota's Ecosystems, Past and Present

The convergence of prairie, boreal forest, and eastern deciduous forest in Minnesota gives the state a unique ecology that is best understood within a framework of ecological provinces (MN DNR 2006). Ecological provinces are units of land characterized by climatic zones, soil types, and the native vegetation that existed prior to European settlement (Cleland et al. 1997). There are four provinces in Minnesota (Figure 1).

- The *Laurentian Mixed Forest* occupies the northern two-fifths of the state and was historically characterized by coniferous or mixed hardwood and conifer forests; it extends northward into Canada and east to Michigan.
- The *Prairie Parkland* occupies one-third of Minnesota in the western and southern parts of the state; it is part of the historic tallgrass prairie system that stretched westward to the Dakotas, north into Canada, and south into Iowa.
- Minnesota's portion of the *Tallgrass Aspen Parkland* is the southern tip of a transitional province extending northwestward into Canada, where prairie and northern forest historically met.
- The *Eastern Broadleaf Forest* represents another transitional zone, where the prairies to the west met more southerly forests and formed a belt of deciduous forest that extended through Wisconsin and northeast Iowa to southern Michigan and then wound to the south through Ohio, Indiana, and beyond.

*The framework of **ecological provinces** is intended to guide resource planning and management from an ecosystem perspective (Cleland et al. 1997). There are several levels of classification in the hierarchy above and below ecological provinces, and different levels are used for different purposes. In planning how to use constitutionally dedicated funds allocated to fish and wildlife habitat, for example, Minnesota's Lessard-Sams Outdoor Heritage Council uses a modified map of ecological provinces (Figure 4). Minnesota's State Wildlife Action Plan is integrally tied to the province classification and also makes detailed use of ecological subsections, which are one level of classification below provinces (MN DNR 2006).*

Due to the coarse scale at which provinces are characterized, the names of Minnesota's provinces mask the variety of land forms and plant communities that occupy each area. The name of the Eastern Broadleaf Forest is particularly deceptive, in that it oversimplifies what was actually a mosaic of prairie, savanna, and forest types.

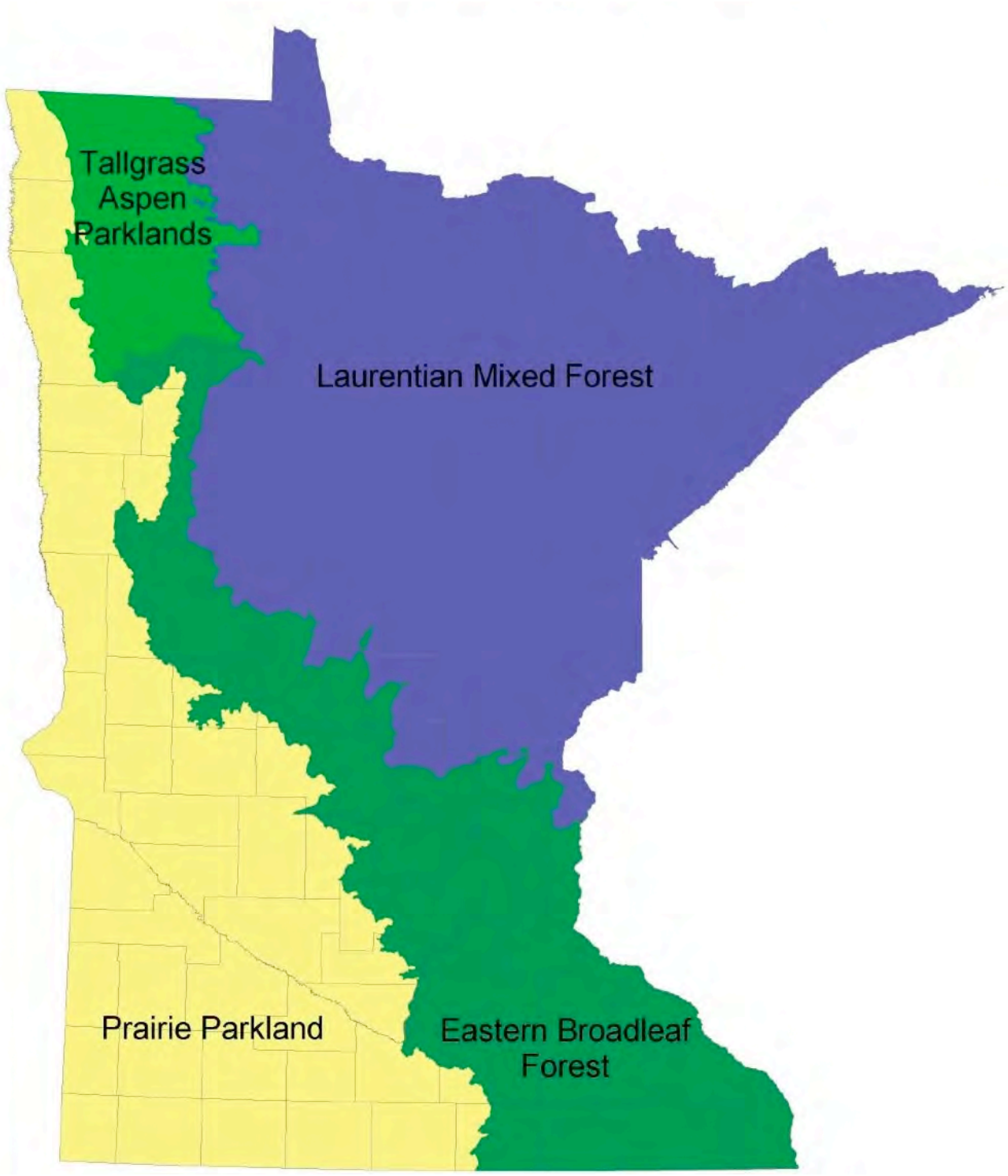


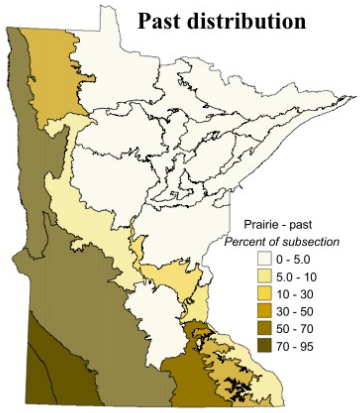
Figure 1. Minnesota's four ecological provinces.
Reprinted from Minnesota's State Wildlife Action Plan (MN DNR 2006).

Since European settlement, land cover has changed most profoundly in Minnesota's prairie region. It is estimated that 90% of prairie wetlands and 99% of tallgrass prairie in the Prairie Parkland and Tallgrass Aspen Parkland provinces have been converted primarily to agricultural use (LCCMR 2007). Much of the state's Eastern Broadleaf Forest has also been converted primarily to agriculture. Wetland losses and alterations have occurred at a somewhat lower rate than in the prairie region, but more than 99% of oak savannas have been converted or degraded in this province (LCCMR 2007). Minnesota's Laurentian Mixed Forest is unique among the state's provinces in that its land cover is almost the same now as in the past (66% forest cover currently vs. 76% historically). This land cover percentage belies important changes in forest age, composition, and structure, however. Aspen is the dominant tree species in northern forests today, whereas white pine and other conifers dominated in the past. In fact, the ratio of coniferous to deciduous species has essentially reversed, from approximately 3:1 in the 1880s to 1:3 in 1990 (LCCMR 2007). Forest age, species composition, and community structure are important factors in the type and magnitude of ecosystem services that forests can provide.

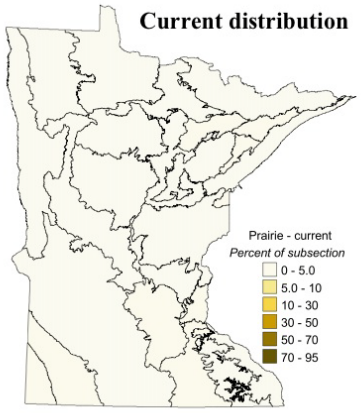
Prairie *and* ***forest*** *are familiar terms that conjure up accurate images of grasses and trees, respectively. The term* ***savanna*** *is more likely to mean different things to different people. Here it refers to an intermediate type of land cover, where trees grow at sufficient spacing so that the canopy remains open, allowing a layer of herbaceous vegetation (primarily grasses) to thrive underneath.*

Wildlife Habitat

Land cover changes have had profound impacts on wildlife populations. In many cases, population trends mirror the scope and magnitude of habitat changes. Birds classified as grassland species, for example, show the most consistent declines of any bird group monitored by the national Breeding Bird Survey (Sauer et al. 1995). One of the greatest challenges in trying to enhance wildlife habitat as an ecosystem service on a statewide scale is that the needs of particular wildlife species vary greatly, and what benefits one species can negatively impact another. Using historical patterns as a baseline can add to the complexity, because habitat losses in one region are sometimes offset by gains of similar habitat elsewhere. As an example, the once widely distributed prairies in southern and western Minnesota and savannas in the prairie-forest transition zone have both been replaced in part by so-called surrogate grasslands (Figure 2). Surrogate grasslands have developed as a result of human activities since European settlement and consist of old fields, hayfields, pastures, and roadside areas. Although surrogate grasslands are dominated by non-native grasses, they provide important habitat for certain prairie-adapted wildlife species that are able to meet their needs in these "substitute" habitats (MN DNR 2006).

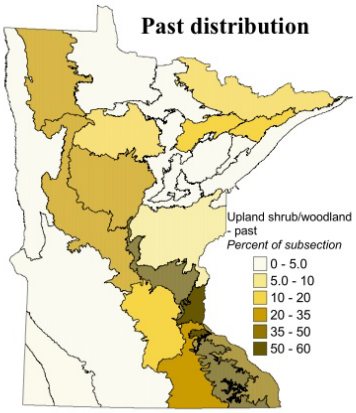


Source: Marschner 1930



Source: MN GAP 1993

Prairie



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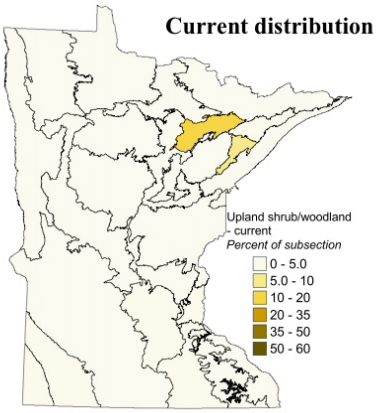
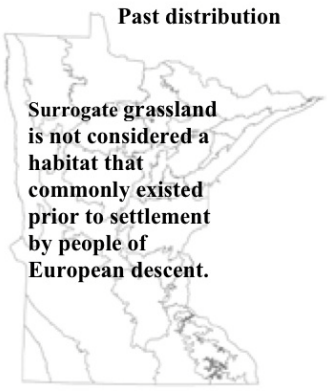
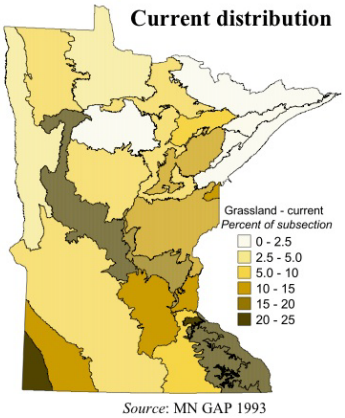


Source: MN GAP 1993

Savanna/Shrubland





Source: MN GAP 1993

Surrogate Grassland

Figure 2. Comparison of current distribution of surrogate grasslands to past and present distributions of prairie and savanna habitat (MN DNR 2006).

GIS Analysis of Potential Wildlife Impacts from Forestation in Minnesota

A large proportion (2.8 million acres) of the potentially forestable area identified in the MFRC report involved land cover classified as privately owned grasses. The acreage of private grasses was second only to cropland (which comprised 4.2 million acres), and private grasses often ranked highly for amount of land that would be converted to forest under the different scenarios examined in the report (MFRC 2010).

The value of grasslands to wildlife depends on many factors, including the size of the area, plant species composition, location, and proximity to other habitat elements such as water or trees. Woody vegetation has been shown to have deleterious effects on grassland nesting birds, whether the woody vegetation is within the grassland, at the periphery, or in the surrounding landscape (Bakker 2003).

Given the vulnerability of grassland wildlife species and the potential for a high percentage of new forest to replace grasslands in the state, we conducted an initial analysis using Geographic Information Systems (GIS) to improve understanding of the trade-offs to wildlife from large-scale forestation. We used GIS to exclude certain grassland areas from the potentially forestable areas identified by MFRC. We considered grasslands as defined by the following sources to be important to exclude.

- *Grassland Bird Conservation Areas* (GBCAs): These areas were identified by the U.S. Fish and Wildlife Service as important for grassland breeding birds. Importance of the areas was based on several factors, including size (some species will not use small areas), shape (round or square tracts minimize edges that can harbor predators), and features in the surrounding landscape (nearby trees provide travel corridors and perches for predators). GBCAs were classified into three types, based on a minimal size for core areas (Type I = 640 acres, Type II = 160 acres, and Type 3 = 55 acres). The three types also vary by the width of the area and the percentage of grassland in the core area plus a 1-mile wide matrix (Johnson et al. 2010).
- *Surrogate Grasslands*: These grasslands, as defined above, were mapped by the Minnesota Department of Natural Resources (MN DNR). MN DNR used Type I and Type II GBCAs, plus two other sources of GIS data for two subsections in the Eastern Broadleaf Forest province where GBCAs had not been identified.[13]
- *Native Prairies*: MN DNR used data from the Minnesota County Biological Survey to map the location of native prairie remnants in the state. They also incorporated prairies identified by a separate analysis for native prairie within railroad right-of-ways. The data do not provide the location of all native prairies in Minnesota because some counties have not been surveyed and some remnants were excluded due to size (less than 5-10 acres) or high levels of disturbance.[14]

Our GIS analysis is preliminary for several reasons. The incomplete nature of the native prairie data highlights a common constraint in attempting to map land cover – we cannot say certain

[13] Daren Carlson, MN DNR Division of Ecological and Water Resources
[14] Jared Cruz, MN DNR Division of Ecological and Water Resources

habitats do not occur where surveys have not been done. In addition, land cover can change quickly as a result of human activities. Most importantly, analysis at a statewide scale is a first step rather than an end point. Decisions about whether to establish forest on a given parcel will need to occur at the local level, based on specific land uses, existing land cover, landowner preferences, and other factors. This GIS analysis can be a starting point, however, for the development of ecological criteria that will facilitate decision making and support an appropriate balance between forestation and grassland protection.

Figure 3 shows that much of the potentially forestable area, after excluding grasslands as described above, corresponds to Minnesota's prairie-forest transition zone. This was true in the original map produced by MFRC as well (Figure 1 in MFRC (2010)). The distribution of most potentially forestable area in a diagonal, north-central-to-southeast belt through the state is not surprising, given that much of the land to the northeast is already forested, and the land to the south and west was historically prairie and does not contain the forest-derived soils on which forestation potential was based. Excluding the important grassland areas resulted in considerably less forestable area in the Tallgrass Aspen Parkland province. Otherwise the exclusions resulted in some "holes" in the distribution of forestable area but did not change its overall spatial pattern.

Exclusion of important grasslands had varying effects on the categories of existing land use and land ownership on which the map was based. When important grasslands were excluded, the amount of potentially forestable area decreased by 73% on CRP land and by 47% on publicly owned lands with grass cover types (Table 1). These percentages suggest many of the important grasslands are already protected (at least temporarily) from conversion or disturbance to some degree, either through enrollment in CRP or through public ownership. Crops and private grasses decreased to a lesser degree (23% and 30%, respectively). There were 5.4 million acres of potentially forestable area left after the grassland exclusions.

Table 1: Acres of Potentially Forestable Land After Excluding Important Grasslands

	Prairie Parkland	**Tallgrass Aspen Parkland**	**Eastern Broadleaf Forest**	**Laurentian Mixed Forest**	**Total after grassland exclusion**	**Original acreage from MFRC**
CRP	8,863	34,836	61,704	19,614	**125,017**	**461,335**
Crops	455,119	220,167	2,387,771	198,442	**3,261,499**	**4,213,057**
Grasses (private)	26,901	52,818	1,047,582	863,555	**1,990,856**	**2,838,758**
Grasses (public)	1,537	1,682	19,174	18,833	**41,226**	**77,494**
Totals	**492,420**	**309,503**	**3,516,231**	**1,100,444**	**5,418,598**	**7,590,644**

The spatial distribution of forestable land has important implications for the potential impacts that one million acres of forestation could have on Minnesota's wildlife. Below we discuss these implications within the context of historical habitat and land use change for each of Minnesota's ecological provinces.

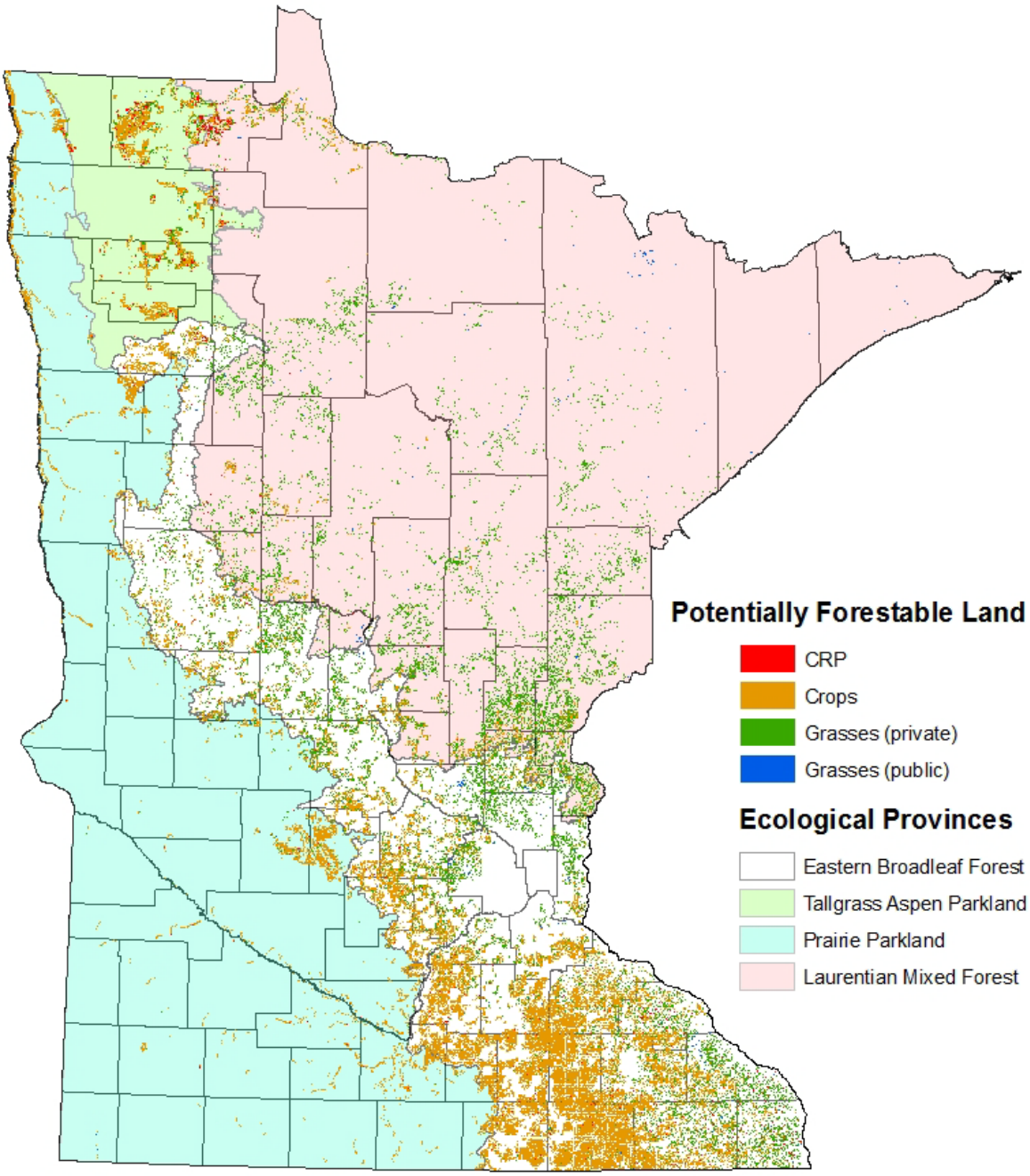


Figure 3. Potentially forestable land after excluding important grasslands, classified by cover type (grasses, crops, or CRP) and land ownership (public or private).

Laurentian Mixed Forest

The habitats in northeastern Minnesota include forests as well as shrublands, lakes, conifer bogs, and peatlands (MN DNR 2006). Forest characteristics are largely dependent on proximity to water and on the region's topography, which varies from low plains to highlands. Habitat impacts in this part of Minnesota have been caused by changes in forest types due to logging, expansion of agriculture, and development (LCCMR 2007). The reversal of the ratio of coniferous to deciduous trees, as described above, means there is generally less (or lower-quality) habitat available for conifer-dependent species (such as bay-breasted and Cape May warblers) and more habitat for species that utilize aspen-dominated forests (such as American woodcocks and ruffed grouse). The quantity and quality of available habitat depend on more than the presence of individual tree species, of course; other factors such as fire frequency and particular combinations of tree species and other plants also come into play and have been altered in complex ways.

One indicator of habitat status is the number of Species in Greatest Conservation Need (SGCN) that occur in an area. SGCNs are animal species whose populations are rare, declining, or vulnerable to decline, and the number of SGCNs in a given area is often correlated with the level of habitat loss or alteration. Although an SGCN designation does not carry statutory protection for species in the way that endangered or threatened status does, identification of SGCNs does facilitate agency planning for conservation of wildlife species and their habitats. According to Minnesota's State Wildlife Action Plan, there are 292 SGCNs in Minnesota, 171 of which potentially occur in the Laurentian Mixed Forest province (MN DNR 2006). Included on the list for this province are species as varied as Canada lynx, smoky shrews, northern goshawks, boreal owls, piping plovers, spruce grouse, boreal chickadees, and spotted salamanders.

Another indicator of habitat status is the frequency of Key Habitats in an ecological province (MN DNR 2006). For non-aquatic habitats, Key Habitats are defined as those that (1) are used by the greatest number of SGCNs, (2) have changed the most over the past 100 years, or (3) have a high percentage of SGCNs that are habitat specialists (MN DNR 2006). The non-aquatic habitats that are identified as Key Habitats most frequently in the Laurentian Mixed Forest province are upland conifer forest, lowland conifer forest, shrubland, and upland forest dominated by hardwood or aspen.

The Key Habitats in northeastern Minnesota highlight the potential benefits of forestation and the approach needed to maximize those benefits. Although there is still extensive forest cover in this part of the state, the habitat needs of many SGCNs could be better addressed. Three specific priorities for Minnesota forests have been tentatively identified as part of the planning process for Minnesota's constitutionally dedicated Outdoor Heritage Fund:[15] (1) restore and enhance forest wildlife habitat in priority areas defined for each planning section (Figure 4); (2) protect contiguous forest complexes; and (3) protect and restore riparian forests (MFRC/MFRP 2010). Forestation can help meet these goals by using native tree planting to restore degraded areas

[15] http://www.lsohc.leg.mn/planning.html

(including along rivers and streams), to enhance existing high-value areas, and to expand the extent of existing forest tracts.

Forestation efforts in this province also need to be tempered with recognition that even within the "North Woods" there were historically "open" areas such as shrublands. The MN DNR's Priority Open Landscapes Program is working to identify where forest management practices in the Laurentian Mixed Forest province can be used to benefit wildlife species, such as sharp-tailed grouse, that depend upon more open habitats within the broader landscape.

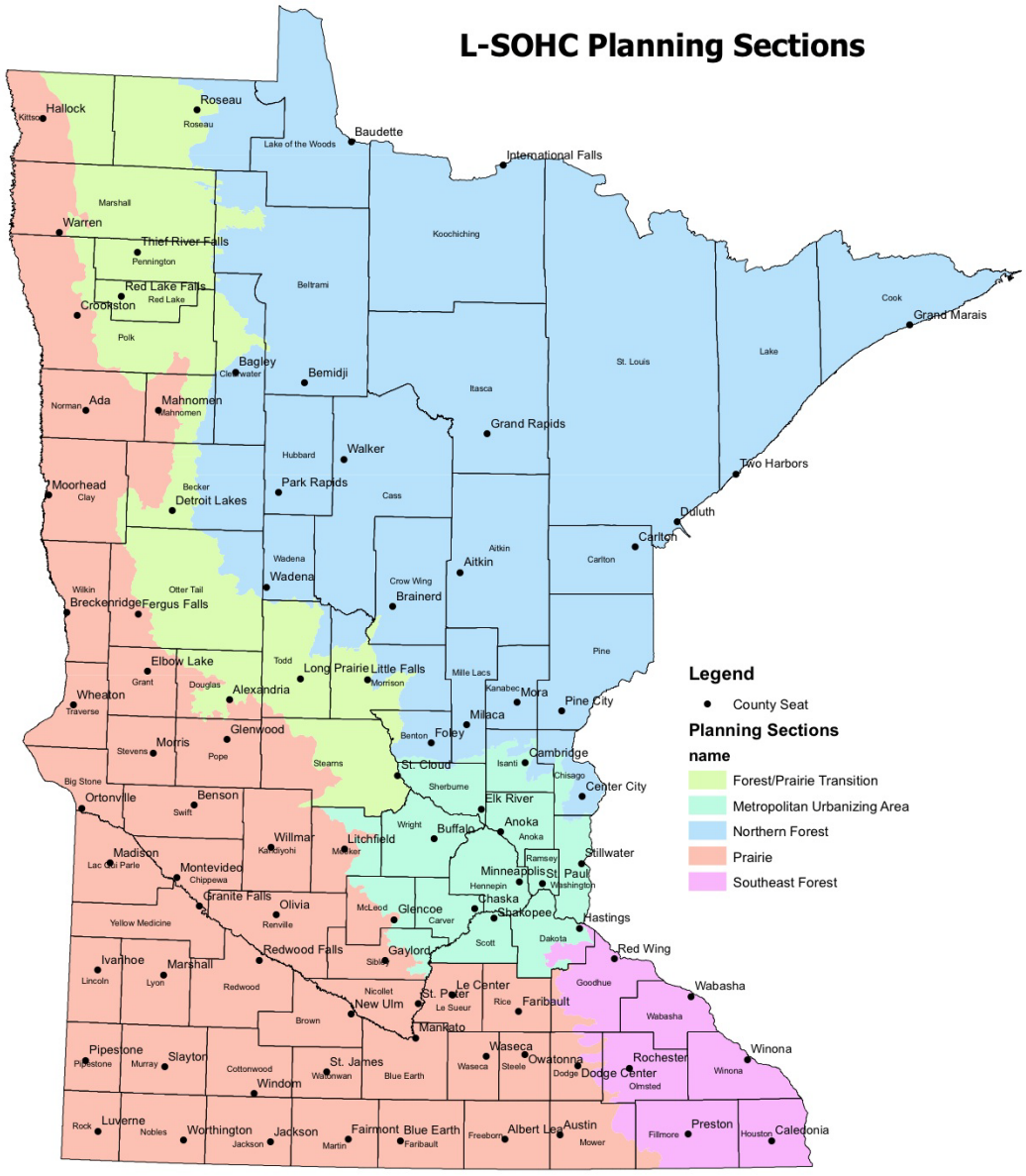


Figure 4. Planning sections used by the Lessard-Sams Outdoor Heritage Council (L-SOHC), which provides recommendations to the Minnesota legislature on how Outdoor Heritage Fund dollars should be spent on the restoration, protection, and enhancement of wetlands, prairies, forests, and habitat for fish, game, and wildlife.

Prairie Parkland and Tallgrass Aspen Parkland

Minnesota's native prairie habitats included sparsely vegetated sand dunes, vast expanses of tallgrass prairie, short-grass prairie in the southwest, and aspen and brush prairie to the north (MN DNR 2006). Various types of wetlands also featured prominently in the landscape and still do today. Shallow wetlands known as potholes are critical to waterfowl breeding, such that North America's Prairie Pothole Region (of which Minnesota's prairie region is a part) is known as the continent's "duck factory." As described above, habitat losses in this part of Minnesota were severe as prairies were converted to farms with the arrival of European immigrants. Prairie wildlife species were negatively impacted by the initial widespread transition to agricultural land use and then again by the later shift from perennial-based pastures and diversified cropping systems to a predominance of annual row crop monocultures (LCCMR 2007). Enrollment of land in CRP has mitigated the impacts of agriculture to some degree.

There are 139 SGCNs in the Prairie Parkland province, and the non-aquatic habitats that are identified as Key Habitats most frequently are prairie, non-forested wetland, lowland deciduous forest, and a group of habitats including shorelines, sand dunes, cliffs, and rock outcrops. There are 85 SGCNs in the Tallgrass Aspen Parkland province, and the most frequently identified non-aquatic Key Habitats are grassland, prairie, shrubland, and non-forested wetlands. Although surrogate grasslands are important throughout the state, the inclusion of grassland as a Key Habitat in the Tallgrass Aspen Parkland indicates its critical role in this province, consistent with our GIS finding that considerably less potentially forestable area occurred in the Tallgrass Aspen Parkland province after excluding important grassland areas (see above).

Little new forest will be established in the Prairie Parkland province if forestation is limited to those areas identified in Figure 3. Although there are almost 0.5 million potentially forestable acres within this province, most of the acreage is along the eastern edge of the province where the transition to forest begins. Given that 5 million acres are available for forestation elsewhere, it would be advisable to set the following limitations on forestation activity in this province:

- restoring intermediate habitat types such as oak savanna, where appropriate (see the discussion for Eastern Broadleaf Forest below);
- restoring suitable riparian areas that were forested historically (namely the Red and Minnesota Rivers and their tributaries and the eastern side of large lakes); and
- ensuring significant environmental co-benefits (such as wildlife habitat, water quality improvements, and flood control) could occur.

Wildlife in the Tallgrass Aspen Parkland province have a greater potential to be impacted by forestation than in the Prairie Parkland, due to the nature of this area as a prairie-forest transition zone and the importance of surrogate grasslands. The MN DNR's Priority Open Landscapes Program has targeted the entire province for openland management, though it is recognized that emphasis will vary over such a large area. Several grassland-dependent bird species breed entirely or predominantly in this part of the state; these species include marbled godwits and short-eared owls (both species of special concern) and sharp-tailed grouse. Figure 3 identifies some areas of potentially forestable land in this province. Although historical roles and characteristics of forests in the Tallgrass Aspen Parkland province differed from those of the Eastern Broadleaf Forest province, appropriate forestation strategies are similar for these two prairie-forest transition provinces and are discussed together below.

Eastern Broadleaf Forest

As mentioned above, the "forest" moniker of this province belies the complexity of the province's role in the prairie-forest transition. Native habitats varied from the maple-basswood forests of "Big Woods" fame to oak and aspen savannas, tallgrass prairies, lakes, and wetlands (MN DNR 2006). In addition to the impacts of agriculture on habitats (especially oak savannas) in this province, urbanization and development have caused substantial habitat loss, degradation, and fragmentation. The prevalence of human-altered landscapes has caused populations of certain adaptable species (such as American robins and common grackles) to increase, while so-called "area-sensitive" species (such as pileated woodpeckers and wood thrushes) have declined as large tracts of habitat have disappeared (LCCMR 2007). As with all of Minnesota's provinces, fire suppression has played an important role in landscape change here.

The Eastern Broadleaf Forest province has more SGCNs – 205 – than any other province in the state (MN DNR 2006). Bird SGCNs generally breed in at least one other province, though some species (such as Bell's vireos and blue-winged warblers) breed primarily in southeastern Minnesota. Several species of insects, amphibians, and reptiles (such as smooth softshell turtles and timber rattlesnakes) are unique to the Eastern Broadleaf Forest. The non-aquatic habitats that are identified as Key Habitats most frequently in this province are savanna, grassland, prairie, and upland forest dominated by hardwood or aspen.

Given that much of the potentially forestable area identified in Figure 3 corresponds to Minnesota's prairie-forest transition zone (71% of the 5.4 million acres), the Eastern Broadleaf Forest and the Tallgrass Aspen Parkland are the most likely provinces to be impacted from a wildlife perspective by forestation. The benefits of forestation to wildlife depend on recognition that SGCNs in the prairie-forest transition provinces are associated with the full spectrum of non-aquatic Key Habitats – from prairies and grasslands to savannas, shrublands, and forests.

Implications of Forestation on Bird Species in Minnesota

In order to gain a better understanding of what the trade-offs of forestation may be in Minnesota's prairie-forest transition zone, we used information from Minnesota's State Wildlife Action Plan (MN DNR 2006) and data on breeding birds from the Minnesota County Biological Survey[16] to conduct an initial avian analysis. We used birds as indicators of habitat trade-offs because they are typically more visible than other groups of animals, and their behaviors and population trends have been particularly well studied.

We compiled a list of all avian SGCNs whose Key Habitats include the five non-aquatic habitats that were identified most frequently as Key Habitats in the Eastern Broadleaf Forest and Tallgrass Aspen Parkland provinces: prairie, grassland, savanna/shrubland, upland forest (aspen), and upland forest (hardwood) (MN DNR 2006). We then looked at the breeding distribution of these species and categorized their distributions according to ecological provinces and geographic range.

[16] http://www.dnr.state.mn.us/eco/mcbs/bird_map_list.html

Of the 57 bird species we examined, nine are known to breed throughout the state. The distributions of the other species, and the implications of what we observed for forestation, are summarized below.

- *Prairie/Grassland Species*: These species are generally not using the northeastern or eastern parts of the state. Forestation in the Laurentian Mixed Forest province and the eastern portion of the Eastern Broadleaf Forest, even where privately owned grasses currently exist, is unlikely to have significant impacts on breeding birds that depend on prairie or grassland habitat, though localized effects could occur and merit further analysis. The importance of prairie and grassland habitat increases moving westward through the state.
- *Savanna/Shrubland Species*: These species are using all parts of the state. Especially given that more than 99% of native oak savannas in the Eastern Broadleaf Forest province have been lost (LCCMR 2007), consideration should be given to savanna restoration rather than forestation at a constant density in certain areas. The grasses and open tree canopies that characterize savannas offer opportunities for carbon sequestration and other ecosystem services, including wildlife habitat, and may be more appropriate in many areas than forestation involving a closed canopy.
- *Aspen/Hardwood Species*: These species are generally found in the northeastern or eastern parts of the state. Forestation in these areas is likely to benefit wildlife, especially where attention is given to priority areas, contiguous forests, and riparian forests as described above in relation to Outdoor Heritage Fund planning.

Conclusions drawn from this preliminary analysis are limited to breeding birds. Non-breeding birds and other species (mammals, reptiles, amphibians, insects, fish, and mollusks) may show somewhat different distribution patterns throughout the state based on habitat preferences. A more in-depth analysis, especially one using GIS to quantify patterns spatially, would be useful in understanding trade-offs between forestation and other types of habitat protection or restoration. It should also be noted that other habitats that were frequently identified as Key Habitats in Minnesota's State Wildlife Action Plan may provide forestation opportunities outside the prairie-forest transition zone; namely, lowland deciduous forests in the Prairie Parkland province and upland and lowland coniferous forests in the Laurentian Mixed Forest province (MN DNR 2006).

Wildlife Summary

Forestation in the Laurentian Mixed Forest province would be relatively straightforward and likely to benefit wildlife, as long as appropriate consensus-based, ecologically minded strategies were used. Forestation in Minnesota's northeastern forest region is unlikely to have broad impacts on grassland species, though attention should be given to the role of shrublands and other openlands within the broader landscape. Forestation within the Prairie Parkland province is generally not being proposed, although an increase in tree cover along rivers and streams could help stabilize banks while providing carbon sequestration benefits and habitat for wildlife species that use riparian areas.

Most potentially forestable land occurs within Minnesota's prairie-forest transition zone, made up of the Eastern Broadleaf Forest and the Tallgrass Aspen Parkland provinces. Forestation in this region would maximize benefits to wildlife and provide other ecosystem services most effectively if carried out using an ecosystem restoration approach that balances the importance of forests, savannas/shrublands, and prairies/grasslands in the region. The transitional nature of this region and the land use change that has occurred make ecosystem restoration challenging, though these factors also present some opportunities. The potential for climate change to affect the conditions under which different habitats will thrive adds to the challenge. The occurrence of most of the potentially forestable area in Minnesota's prairie-forest transition zone has the following key implications.

- *Acres vs. Numbers of Trees*: Targeting a set number of acres for forestation may not be appropriate in all areas, at least when a constant density of trees for those acres is implied. A large-scale forestation initiative may be most effective if a range of numbers of trees per acre is used in goal-setting. Approaching the effort as an ecosystem restoration instead of as a "forestation" initiative may help communicate that the goal is to restore a balance of habitats that are native to the prairie-forest transition zone. Having a variable number of trees per acre also opens the door to opportunities that haven't been addressed in analyses to date.
    - *Oak Savannas*: Restoring oak savannas would provide wildlife habitat that has been almost entirely lost from the state. Lower tree densities would affect the carbon sequestration levels estimated by MFRC (2010), but the significant amount of carbon sequestered in the root systems of native grasses may compensate and merits further analysis. Lower tree densities would also affect the potential economic return to landowners, but maintaining grass as part of the landscape could provide other economic opportunities such as pasture-based agricultural systems or the harvest of grasses for bioenergy. Wildlife benefits can also accrue through the use of grasses for livestock grazing (Renfrew and Ribic 2001) and bioenergy. Meehan et al. (2010) estimated, for example, that replacing annual bioenergy crops with diverse perennial bioenergy crops in the Midwest could increase the number of bird species by more than 200% and improve the recovery of some species of conservation concern.
    - *Urban Trees*: The planting of trees on small parcels[17] and in urban areas could enhance mature upland and riparian forests that offer stopover habitat for migratory birds (Rodewald and Matthews 2005, Pennington et al. 2008). There are approximately 1.5 million acres of urban area in Minnesota.[18] Minneapolis, noted as a green city with a well-established city tree program, has a tree density of only 26.2 trees per acre. If Minneapolis and other cities in the state could support an additional five trees per acre, over 7 million trees could be planted in urban areas alone.
- *Alternatives to Tree Planting*: Many historical habitats in Minnesota were maintained through periodic fire and grazing by large mammals such as bison. Restoring habitats

[17] MFRC's analysis of potentially forestable areas excluded parcels smaller than 20 acres, largely due to limitations of GIS data sources.
[18] http://mapserver.lmic.state.mn.us/landuse/

such as savannas or shrublands through prescribed burning or grazing by domestic livestock may avoid some costs of large-scale tree planting. Direct seeding using local seed sources may also be appropriate for restoring some forest types.

- *Habitat Complexity and Connectivity*: Patches of high-quality habitat have become smaller and farther apart due to human activities, and the negative effects of habitat fragmentation on wildlife have been well documented. In Minnesota's prairie-forest transition zone, however, extremely large tracts of the same type of habitat are not necessarily appropriate or needed to achieve wildlife benefits. Ecosystem restoration efforts can use the historical mosaic of habitats as a template to guide decisions about where different types of grasslands, savannas, and forests are appropriate, given existing land uses and individual landowner preferences. Because some restored habitats will still often be isolated from others, incorporating measures to improve habitat connectivity into restoration planning will be essential. Creating wildlife corridors and expanding habitat buffers to facilitate plant and animal migration is also an important mitigation strategy for climate change, which is anticipated to shift the prairie-forest transition northward.[19]

Water, Air, and Soil

Although we have given considerable attention to the role of forestation in improving Minnesota's wildlife habitat, other ecosystem services stand to benefit as well. As mentioned above, forests have substantial impacts on soil conservation, air quality, water quality, flood control, and drinking water supplies.

According to data cited in Brown et al. (2008), three-quarters of the world's usable freshwater supplies come from forested catchments.

Millions of tons of topsoil are carried to the Gulf of Mexico by the Mississippi River each year, and it is estimated that one-third of U.S. topsoil has eroded since cultivation began (Manahan 2007). Much of this erosion has been attributed to the clearing of riparian forests for agriculture. Where riparian buffers consisting of trees and other vegetation are in place, they can reduce sediment loss by 97% (Schultz et al. 2004). Riparian buffers also help keep pollutants and nutrients out of the water, thereby providing soil conservation and water quality benefits at the same time.

The effect of forests on water quality and air quality have been especially well studied in urban areas, where the high percentage of impervious surface creates large amounts of stormwater runoff, and the high densities of buildings and vehicles result in concentrated air pollutants. In an urban ecosystem analysis for the Houston metropolitan area in Texas, American Forests (2000) documented several ecological and economic effects from a loss of tree canopy cover between 1972 and 1999. Besides lost opportunities for carbon sequestration and energy savings, the reduction in medium and heavy tree canopy and the increase in light tree canopy that occurred in Houston had the following implications.

- The lost tree canopy would have removed 15.3 million pounds of air pollutants (sulfur dioxide, carbon monoxide, ozone, and particulate matter) from the atmosphere annually,

[19] http://www.dnr.state.mn.us/conservationagenda/direction/climate_change.html

at a value of approximately $38 million per year in terms of health care and other social costs.

- The total stormwater retention capacity of the existing tree canopy as of 1999 was valued at $1.33 billion based on infrastructure and other costs, and the lost tree canopy would have provided an additional $230 million worth of stormwater retention.
- Increasing average tree cover by 40% would provide $3.5 billion in one-time stormwater benefits and $297 million worth of pollutant removal benefits.

The potential for urban forests in the U.S. to provide ecosystem services is immense, given that nearly 8 of 10 Americans live in urban areas (Dwyer et al. 2000).

The air and water quality benefits of urban forests extend to rural areas, although the magnitude of the benefits is somewhat smaller as a result of the reduced stormwater runoff and air pollution that occur where human population densities are lower. Given the nature of weather patterns and watershed dynamics, there are clear links between urban and rural areas where air and water quality are concerned and thus a potential for forests in either location to provide valuable ecosystem services. Twenty-two of Minnesota's 25 largest cities are located in the Eastern Broadleaf Forest province (LCCMR 2007). Although urban areas were not included in MFRC's analysis of potentially forestable areas, the overlap of concentrated urban development with the region in which most potentially forestable area occurred suggests that forestation is likely to contribute to air and water quality improvements regardless of the specific locations of newly planted trees.

Forestation benefits can be maximized by developing specific strategies for tree planting in urban areas and by integrating tree planting into other goals and initiatives related to soil conservation, air quality, or water resources. Although the planning process for constitutionally dedicated funds allocated to the Clean Water Fund is still underway,[20] Minnesota's Clean Water Council has prepared budgetary recommendations that reflect watershed restoration and nonpoint source pollution reduction activities likely to include riparian buffers and other tools involving tree planting.[21]

Economic Perspective

The environmental benefits of a million-acre forestation initiative are unlikely to be realized if economic benefits do not also accrue. Below we discuss economic issues related to large-scale forestation, including nursery production, agricultural production, and the wood products industry.

[20] http://wrc.umn.edu/watersustainabilityframework/index.htm
[21] http://www.cdf.leg.mn/clean-water-fund

Nursery Production and Planting

To meet increasing demand for tree planting, nurseries in Minnesota will need to increase production. Otherwise, tree seedlings would need to be imported from other states and Canada to meet demand (with important ecological consequences arising from non-local sources). Besides increasing overall availability of seedlings, it may be necessary to diversify the species mix that is available if planting efforts include goals for restoring specific habitat types. Other forestation techniques, such as direct seeding, may be appropriate in some circumstances.

Costs of establishing and maintaining tree plantings are important budget considerations. Following site preparation and planting, actions to control weeds and other competing vegetation are commonly necessary, and even then young trees may die due to drought, browsing animals, and other factors. Trees planted at lower densities may require periodic weeding and perhaps even watering, adding considerably to establishment costs. Trees planted in urban areas are also likely to require additional investments[22] beyond planting to keep the trees growing and healthy.

Investments in equipment and training of planting crews and contractors may also be needed. The lack of nursery stock is a serious constraint to the success of a large-scale tree planting initiative, though such a major initiative also presents a significant opportunity to create nursery and nursery related jobs. Further evaluation may be warranted to identify the technical needs and economic opportunities related to the basic tree planting infrastructure and capacity in Minnesota.

Agricultural Production

Many areas identified for potential forestation are currently producing agricultural crops. A basic assumption of the MFRC report was that landowners would not convert cropland to trees unless it resulted in increased income. As with the discussion of grassland areas, decisions to plant trees on any agricultural lands would be made at the local level and by individual landowners. Barriers to forestation on agricultural land may be real or perceived and may involve personal preferences, issues related to converting production models, and concerns about local economic impacts or long-term viability. Overcoming these barriers will depend, in part, on how ecosystem service payments evolve, how alternative markets (such as biomass harvest for energy production) grow, and the willingness of landowners to consider diversification strategies such as earning income from hunting leases on newly wooded areas.

[22] A survey of municipal foresters in Connecticut and New York City indicated that they spend $20-30 per urban tree annually. This can be broken down by planting ($10/tree), pruning ($6-12/tree), removal and disposal ($2/tree), and administration ($4-7/tree) (McPherson et al. 2007).

Interest has been growing in farming practices that produce food and fiber while serving ecological functions such as conserving biodiversity and protecting water quality. Alternatives to conventional row cropping of corn and soybeans include systems based on perennials such as hay and pasture grasses or plants for fruit and nut production. Policy changes could give new life to perennial-based systems, which have declined in Minnesota in recent decades, and which open the door for various types of perennial cover including trees and an overall re-integration of farming with natural systems (Jackson and Jackson 2002). A study of alternative land management scenarios in two Minnesota watersheds showed that both environmental and economic benefits could be attained without increasing public costs. Economic benefits including social capital formation, greater farm profitability, and avoided costs could accrue from reorienting taxpayer-based farm payments to support agricultural diversification and enhance nonmarket ecosystem services instead of commodity production (Boody et al. 2005). The Conservation Stewardship Program[23] (CSP), administered by the USDA Natural Resources Conservation Service (NRCS), is an example of this type of policy change. CSP offers annual and supplemental payments to owners of private agricultural or non-industrial forest land for activities that conserve and enhance soil, water, air, and other natural resources.

Forest Products and Bioenergy Feedstock

In the long term, tree planting on private lands has the potential to diversify markets and income streams to farmers and other landowners. At the same time, increased tree planting could help stabilize (and potentially expand) the Minnesota forest products industry, estimated in 2008 at the following levels (MN DNR 2010):

- $8.6 billion (value of manufacturing shipments);
- $4.3 billion (value-added activity that stays in Minnesota);
- $1.67 billion (wages paid to forest industry workers);
- 36,211 total employees (primary and secondary industries); and
- 4th largest manufacturing industry in Minnesota (by employment).

Based on 2006 data, privately owned forests in Minnesota had the following economic impacts: providing 7.2 jobs per 1000 acres; generating payroll of $277 per acre, state tax contributions of $15.66 acre, and annual sales of $627 per acre; and contributing $272 per acre to state gross domestic product (F2M 2009). Increased tree planting can also generate value-added activity (MN DNR 2004), which involves processes or steps taken to increase the value of basic commodities. For example, $1.00 of timber sold in Minnesota becomes $41.60 if the timber is used to produce a cabinet in Minnesota, creating a multiplier effect in the state economy. Wood products manufacturing supports many rural communities by helping to sustain non-forestry businesses such as grocery stores, banks, insurance agencies, and repair shops. Much of the state's rural infrastructure has been built or upgraded because of the state's forest products industry.

[23] http://www.mn.nrcs.usda.gov/programs/csp2/index.html

A vital Minnesota forest products industry that provides ongoing economic benefits, and multiplier effects that greatly increase its impact, is highly dependent upon reliable availability of high-quality, moderately priced raw materials. Traditional forestry is a long-term investment, additional acres of forest could increase the available wood supply and increase the level of annual harvest that could be achieved and maintained over time. Although most fiber used by Minnesota's forest products industry is derived from trees that are 40 or more years old, having more young trees in the ground adds to the state's overall forest stock and allows for earlier harvesting of older trees than would be feasible with less stock. Indeed some wood fiber used in paper manufacturing does come from short-rotation plantings, and more wood fiber could be produced in the near term from additional short-rotation plantings. The use of shorter rotations would need to be balanced with carbon sequestration goals and economic considerations.

Different rotational strategies can also be paired with so-called "active management" strategies, such as expanded use of thinning and other techniques that provide intermediate material for the industry while enhancing forest health and reducing fire risks. These management objectives can, in turn, be paired with planting objectives. For example, a forest stand could be thinned in a manner to create openings for plantings that are designed to introduce additional species and age diversity to the stand. This approach could be applied to areas of maturing planted red pine stands with a goal of transitioning to a more diversified composition.

There is considerable potential to use trees for energy production. In the short term, private landowners could take advantage of markets for biomass-based fuels. The potential for combining wood fiber and agricultural residues could stimulate the developing bioenergy industry. Wood energy and biomass utilization would provide market opportunities for landowners and reduce dependence on foreign energy sources, improve bottom lines for logging and processing operations, and increase opportunities for forestry and wildlife management.

Opportunities for Implementation

Regional Model

Having discussed the benefits of forestation and the advantages of an ecosystem restoration approach for maintaining focus on ecosystem services, we turn our attention to the practicalities of implementing a large-scale tree planting initiative. Restoration of the longleaf pine ecosystem in the southeastern U.S. provides a potential model for use of federal program dollars.

A continuous sign-up CRP initiative for longleaf pine planting was launched by the USDA's Farm Service Agency (FSA) in 2006. The initiative was designed to reforest up to 250,000 acres of longleaf pine in nine southern states, using annual rental payments and up to 50% cost-share for establishment plus one-time sign-up incentive payments of $100 per acre and one-time practice incentive payments equal to 40% of eligible installation costs (USDA 2006). Longleaf pine trees defined an ecosystem that once dominated extensive areas of the southeastern U.S. The ecosystem was characterized by frequent fires that maintained the pines plus a diverse ground layer of native grasses; mid-story trees and shrubs were conspicuously absent, creating a savanna-type ecosystem.[24] Ecosystem restoration was motivated by several environmental benefits including wildlife habitat.

[24] http://www.longleafalliance.org/bigpicture.html

"The key ingredients to the longleaf pine initiative were that it was an entire ecosystem in serious decline, restoration benefitted not only participating private landowners but also taxpayers at large, and the effort was collaboratively supported and endorsed by a diversity of state, federal, and nonprofit wildlife and forestry conservation groups."

– Reggie Thackston, Georgia wildlife biologist

Planting of longleaf pine via CRP started before 2006, and tree planting in southeastern states via CRP dates back even further.[25] When CRP was initiated as part of the 1985 Farm Bill, planting of loblolly and slash pine was allowed as a strategy for reducing soil erosion. These species were often planted at high densities and managed primarily to maximize economic revenue with limited thinning and infrequent prescribed burning. This approach provided minimal benefit to wildlife; in fact, some negative impacts to wildlife became apparent. In general, loblolly and slash pine were historically limited to moist or poorly drained sites. As wildlife agencies pushed for Farm Bill programs to address more than soil erosion, the door was opened for longleaf pine planting. In 1996, Georgia proposed to the national FSA office that a Conservation Priority Area (CPA) be designated in the state for longleaf pine restoration via CRP. The designation quickly expanded to a national CPA involving nine states.

From 1996 to 2006, 208,000 acres were enrolled in CRP for longleaf pine planting. Since 2006, when the continuous sign-up began, 87,000 acres have been enrolled. An additional 42,000 acres were enrolled in response to Hurricane Katrina in 2005 under an Emergency Forestry CRP agreement. Thus, to date, CRP has been used to plant longleaf pine on 337,000 acres in the southeastern U.S. Acres continue to be added at an approximate rate of 1,000 per month.[26] More than 60% of enrolled acres were in Georgia as of February 2009 (Thackston et al. 2009).

The story of longleaf pine planting in the southeastern U.S. shares several features with a potential million-acre forestation initiative in Minnesota. The longleaf pine initiative has involved a similar scale, at a third of a million acres to date. Longleaf pines are part of a savanna-type ecosystem, which coincides with the once-prevalent oak savannas of the Eastern Broadleaf Forest province in Minnesota where most potentially forestable areas have been identified. In addition, the goal of longleaf restoration was not just to plant trees but to restore an ecosystem, and to restore it for multiple beneficiaries including private landowners, wildlife, and the public (through hunting opportunities, improved water quality, biodiversity conservation, and enhanced carbon sequestration) (Thackston et al. 2009). The longleaf pine initiative involved a broad collaboration of stakeholders, including federal agencies (FSA, NRCS, U.S. Fish and Wildlife Service), state agencies (such as wildlife divisions and state forestry commissions), and nonprofit groups (such as the Longleaf Alliance). As in the southeast, a broad-based coalition of stakeholders will have to collaborate in Minnesota in order for large-scale forestation to be both possible and effective.

[25] Much of the information in this paragraph was provided by Reggie Thackston, Private Lands Program Manager with the Georgia DNR (Wildlife Resources Division, Game Management Section).
[26] Figures in this paragraph were provided by David Hoge, FSA Conservation Program Specialist, Washington, DC.

Tree planting is already an allowed practice for certain CRP contracts in Minnesota.[27] Moreover, trees are a component of some practices such as field windbreaks and shelterbelts, and a practice called CP3A is specified for hardwood tree planting in the Lower Mississippi Watershed as part of the Conservation Reserve Enhancement Program (CREP). Another practice, CP25, targets oak savanna restoration. CP25 is allowed in certain zones within Minnesota's portion of the national Prairie Pothole CPA.

CRP has been an important component in the longleaf pine initiative and has the potential to play a similarly important role in Minnesota, if CRP funds are used to plant trees where ecologically appropriate. It is important to note, however, that other programs have been used in combination with continuous sign-up CRP to achieve longleaf ecosystem restoration. These programs include a CRP-related FSA program called State Acres for Wildlife and various NRCS programs including the Environmental Quality Incentives Program (EQIP), the Wildlife Habitat Incentives Program (WHIP), the Wetlands Reserve Program, and the Healthy Forest Reserve Program (Thackston et al. 2009). A similar combination of programs is likely to come into play in Minnesota and will be discussed further in the next section.

Incentive Stacking

Large-scale forestation in Minnesota is likely to involve several markets and programs. Although the long-term prospects for a carbon market remain promising, the short-term prospects in the U.S. are uncertain, as exemplified by the recent shutdown of the Chicago Climate Exchange.[28] Publicly funded incentives via tax relief or direct payments to landowners could be combined with payments from new or existing markets (such as pulpwood, biomass for energy, or solid wood products) to provide landowners with the financial compensation necessary to promote forestation on their land. The predominance of potentially forestable areas on privately owned land in Minnesota echoes the national trend of private forest ownership. More than half of America's forests are privately owned, and most privately held forests are considered "family owned" (AFF 2010). The potential for privately owned forests to contribute to the public good are immense (Stein et al. 2009), making it imperative that forestation and forest stewardship be economically viable for private landowners.

Many programs offer one-time and/or annual payments for practices that involve planting or managing trees (Appendix I). Some programs occur at the state level; the MN DNR's Forest Legacy Program,[29] for example, allows landowners to establish easements through which forests are protected but can continue to be used for timber management, recreation, and hunting.

Most public payment programs are federally sponsored. For the first time in 2008, forests were included in Farm Bill conservation programs at a coordinated and deliberate scale (AFF 2010). While uncertainty over long-term continuity of federal programs is an economic constraint on the feasibility of a million-acre forestation proposal, AFF (2010) found that significant new

[27] http://www.mn.nrcs.usda.gov/technical/ecs/agron/crp/planform.html
[28] As announced on October 21, 2010, the Chicago Climate Exchange will conclude its emission reduction program at the end of 2010. Some activities will continue through 2012. http://www.chicagoclimatex.com/info/advisories/2010/2010-13.pdf
[29] http://www.dnr.state.mn.us/forestlegacy/index.html

investments were made in forest stewardship and conservation through Farm Bill programs in the first year alone. Funding for EQIP and WHIP increased substantially and has been used for site preparation, tree establishment, and various forest management activities. The percentage of state EQIP funds used for forestry varies widely. The fact that Minnesota ranked 38th, with less than two percent of EQIP funds used for forestry (AFF 2010), provides an example of untapped potential for the use of existing incentives to facilitate forestation in Minnesota. AFF (2010) cited outreach to state agency staff and un-enrolled landowners as factors for states with low EQIP utilization rates for forestry.

Combining Programs and Goals

The proposal to plant one million acres of trees in Minnesota by 2025 (MCCAG 2008) shares both a time line and similar objectives with the Clean Water, Land, and Legacy Amendment (CWLLA) passed by Minnesota voters as a constitutional amendment in 2008. The amendment stipulates that from 2009 to 2034, 3/8ths of one percent of sales tax will be deposited into four funds: the Outdoor Heritage Fund, the Clean Water Fund, the Parks and Trails Fund, and the Arts and Cultural Heritage Fund. As described above for the Outdoor Heritage and Clean Water Funds, long-term planning is underway for use of this revenue.

The potential for forestation to contribute to many of the Funds' goals, including habitat and water quality improvements, presents a unique opportunity to join forces and create efficient, effective outcomes. The recently released draft for 25-year planning for the Outdoor Heritage Fund echoed the sentiment that a strategy of integrating resources from other funds, particularly the Clean Water Fund, provides an opportunity to leverage funding and maximize benefits (L-SOHC 2010). Planting trees in strategic locations such as formerly forested corridors along impaired streams and rivers in agricultural areas is a classic win-win situation in that it benefits wildlife habitat and water quality simultaneously.

Such a unified approach would also be consistent with the MCCAG's recommendations for carbon sequestration (MCCAG 2008). Besides forestation, the MCCAG recommended policies that included land preservation, wetland protection, and use of the Reinvest in Minnesota (RIM) program for clean energy. The objective of converting marginal or sensitive agricultural land to permanent cover has clear overlap with the intention of CWLLA funds, with the proposal to achieve one million acres of forestation, and with the goals of other programs such as CRP.

Summary and Conclusions

We have attempted to show that a holistic approach will maximize the benefits of large-scale forestation in Minnesota by providing for a balance of ecological communities that will benefit wildlife and people through enhanced ecosystem services. Below we summarize our findings in the context of the objectives outlined at the beginning of this report and offer recommendations for additional analyses and considerations needed to carry the initiative forward.

Multiple Benefits of Forestation

Forest ecosystems serve people in multiple ways. Carbon sequestration in forests is an important climate mitigation strategy worldwide. Forestation for carbon sequestration offers numerous co-benefits, including enhanced wildlife habitat, water quality, flood control, air quality, and soil conservation. We examined these co-benefits as they relate to the proposal to plant one million acres of trees in Minnesota (MCCAG 2008, MFRC 2010).

We examined the potential for forestation to enhance Minnesota's wildlife habitat in particular. Minnesota's location at the confluence of three of the continent's major biomes gives the state a uniquely rich heritage of wildlife resources. Agriculture, urban development, and other human activities have resulted in dramatic land cover changes across the state, with profound losses in prairie and savanna habitat, substantial wetland conversions, and important changes in forest cover. These changes have left grassland-dependent wildlife species particularly vulnerable.

Because much of the potentially forestable area identified by MFRC (2010) would involve conversion of grassland areas, we examined the trade-offs between forestation and grassland protection with two introductory analyses. Our GIS analysis indicated that 5.4 million acres of potentially forestable area were left after excluding important grasslands. Most of the potentially forestable area occurred within Minnesota's prairie-forest transition zone, where a high number of SGCNs occurs. Our avian analysis suggested that forestation in certain potentially forestable areas could benefit forest-dependent birds without significant adverse impacts on prairie-dependent species but that oak savanna restoration be considered as a component of forestation, given that native savannas have almost entirely disappeared from the state and may be more appropriate in many areas than forestation involving a closed canopy.

We recommend an approach to forestation that balances the importance of forests, savannas, and prairies or grasslands in Minnesota's prairie-forest transition zone and allows for a variable number of trees per acre rather than setting a goal to plant a particular number of acres under a constant density. This approach facilitates opportunities including oak savanna restoration, tree planting in urban areas, and wildlife corridors that link habitat patches. Our analyses lay the groundwork for two key next steps.

(1) *Use a more in-depth GIS analysis to refine the potentially forestable areas.* Where are there additional limitations to forestation (such as MN DNR's Priority Open Landscapes)? Where are the opportunities most stakeholders can agree on (such as urban or riparian areas throughout the state)? Out of the 5.4 million acres we identified as potentially forestable, there is undoubtedly some "low-hanging fruit" – perhaps more than expected, and enough to eliminate debate over controversial areas.

(2) *Envision a large-scale restoration within the Eastern Broadleaf Forest.* Include a mix of grassland, savanna, and forest, and conduct a holistic assessment of the potential for carbon sequestration, enhanced wildlife habitat, improved water quality, and other ecosystem service improvements.

Logistical and Economic Feasibility

Large-scale forestation in Minnesota is a worthwhile goal because of the diversity of ecosystem services it could provide. It is also a feasible goal in logistical terms; we showed that large-scale tree planting occurred in Minnesota through much of the last century, and other (even smaller) states in the U.S. are known to plant several hundred thousands of acres of trees annually. CRP and other programs have been used in the southeastern U.S. to plant trees for restoration of the longleaf pine ecosystem, which may serve as a model for Minnesota to emulate.

There are economic constraints to adding a million acres of forest to Minnesota's landscape. These constraints include the state's capacity to produce seedlings, costs associated with forest establishment and maintenance, the need to make forestation an economically viable option for landowners whose land is currently in agricultural production, time lines associated with planting rotations, and uncertainties over funding sources and market forces. Each of these constraints has a counteracting benefit with the potential to be realized, including job creation through expanded nursery production, economic growth through value-added activity, increased sustainability of farming practices, and tapping of bioenergy markets. We recommend further analysis of these potential economic impacts.

Implementation Strategies

Numerous incentives for tree planting already exist in the form of both market payments and public payments and could be combined to accomplish forestation at the proposed scale. Minnesota's Outdoor Heritage Fund and Clean Water Fund, alone and in collaboration, offer an unprecedented opportunity to leverage financial resources and achieve broad, overlapping objectives. A more in-depth analysis of the programs outlined in Appendix I, including levels of available funding and a comparison of existing funding to the total cost estimate of a million-acre forestation program, is an important next step in determining the initiative's economic feasibility.

Final Thoughts

The feasibility of MCCAG's time line of restoring or establishing 250,000 acres of forest by 2015 and the remaining 750,000 acres by 2025 (MCCAG 2008) remains to be determined. Whether this time line – or even the target of planting exactly one million acres of trees – is maintained as a goal is not as important as the overriding intent of the million-acre proposal. We encourage decision makers to consider the environmental benefits of large-scale ecosystem restoration in Minnesota, the value of ecosystem services to public health and our state's economy, and the potential for coordinated, collaborative funding approaches and policies to bring about these environmental and economic benefits.

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Literature Cited

AFF (American Forest Foundation). 2010. Forest Conservation in 2009: A Farm Bill Progress Report. American Forest Foundation, Washington, DC.

American Forests. 2000. Urban Ecosystem Analysis For the Houston Gulf Coast Region: Calculating the Value of Nature. American Forests, Washington, DC.

Bakker, K.K. 2003. A synthesis of the effect of woody vegetation on grassland nesting birds. Proceedings of the South Dakota Academy of Sciences, 82: 119-141.

Boody, G., B. Vondracek, D.A. Andow, M. Krinke, J. Westra, J. Zimmerman, and P. Welle. 2005. Multifunctional agriculture in the United States. BioScience, 55: 27-38.

Brown, D., F. Seymour, and L. Peskett. 2008. How do we achieve REDD co-benefits and avoid doing harm? *In* Moving Ahead with REDD: Issues, Options, and Implications, A. Angelsen, ed. Center for International Forestry Research, Bogor, Indonesia.

Cleland, D.T., P.E. Avers, W.H. McNab, M.E. Jensen, R.G. Bailey, T. King, and W.E. Russell. 1997. National Hierarchical Framework of Ecological Units. *In* Ecosystem Management Applications for Sustainable Forest and Wildlife Resources, M.S. Boyce and A. Haney, eds. Yale University Press, New Haven, CT.

Cunningham, R.N., H.C. Moser, and H.G. White. 1940. Forests of Minnesota. Lake States Forest Experiment Station, St. Paul, MN.

Dwyer, J.F., D.J. Nowak, M.H. Noble, and S.M. Sisinni. 2000. Connecting people with ecosystems in the 21st century: An assessment of our nation's urban forests. Gen. Tech. Rep. PNW-GTR-490. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

F2M (Forest2Market). 2009. The Economic Impact of Privately Owned Forests. National Alliance of Forest Owners, Washington, DC.

Fernholz, K., J. Bowyer, A. Lindburg, and S. Bratkovich. 2008. Ecosystem markets: New mechanisms to support forestry. Dovetail Partners, Inc., Minneapolis, MN.

Jackson, D.L. and L.L. Jackson, eds. 2002. The Farm as Natural Habitat: Reconnecting Food Systems with Ecosystems. Island Press, Washington, DC.

Johnson, R.R., D.A. Granfors, N.D. Niemuth, M.E. Estey, and R.E. Reynolds. 2010. Delineating grassland bird conservation areas in the U.S. Prairie Pothole Region. Journal Fish and Wildlife Management, 1(1): 38-42.

LCCMR (Legislative-Citizen Commission on Minnesota Resources). 2007. Minnesota Statewide Conservation and Preservation Plan, Preliminary Plan – Phase I. http://www.lccmr.leg.mn/statewideconservationplan/ConservationandPreservationPlan.html St. Paul, MN.

L-SOHC (Lessard-Sams Outdoor Heritage Council). 2010. 23-year Funding Framework: Draft for Council Review, dated November 1. Minnesota Management and Budget, St. Paul, MN.

Manahan, S.E. 2007. Environmental Science and Technology: A Sustainable Approach to Green Science and Technology, 2nd edition. CRC Press, Boca Raton, FL.

McPherson, E.G. , J.R. Simpson, P.J. Peper, S.L. Gardner, K.E. Vargas, and Q. Xiao. 2007. Northeast Community Tree Guide: Benefits, Costs, and Strategic Planting. Gen. Tech. Rep PSW-GTR-202. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Davis, CA.

Meehan, T.D., A.H. Hurlbert, and C. Gratton. 2010. Bird communities in future bioenergy landscapes of the upper Midwest. Proceedings of the National Academy of Sciences, published online before print at www.pnas.org/cgi/doi/10.1073/pnas.1008475107.

MEA (Millennium Ecosystem Assessment). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

MCCAG (Minnesota Climate Change Advisory Group). 2008. Final Report to the Minnesota Legislature. http://www.mnclimatechange.us/MCCAG.cfm. St. Paul, MN.

MN DNR (Minnesota Department of Natural Resources). 1971. Forestry in Minnesota. Division of Lands and Forestry, St. Paul, MN.

MN DNR (Minnesota Department of Natural Resources). 2004. Value-Added Economic Impact of Timber Harvested in Minnesota. Division of Forestry, St. Paul, MN.

MN DNR (Minnesota Department of Natural Resources). 2006. Tomorrow's Habitat for the Wild and Rare: An Action Plan for Minnesota Wildlife. Comprehensive Wildlife Conservation Strategy. Division of Ecological Services, St. Paul, MN.

MN DNR (Minnesota Department of Natural Resources). 2010. Minnesota's Forest Resources 2009. Division of Forestry, St. Paul, MN.

MFRC (Minnesota Forest Resources Council). 2010. Assessing forestation opportunities for carbon sequestration in Minnesota. http://www.frc.state.mn.us/documents/council/MFRC_Assessing_Forestation_Opportunites_Carbon_Sequestration_MN_2010-01-15.pdf. St. Paul, MN.

MFRC/MFRP (Minnesota Forest Resources Council/Minnesota Forest Resources Partnership). 2010. 25-Year Vision for Lessard-Sams Outdoor Heritage Council Investments in Minnesota Forests. Unpublished document presented to Lessard-Sams Outdoor Heritage Council, St. Paul, MN.

Morgan, J.T. 1960. The business of counting trees. Minnesota Conservation Volunteer, March-April: 38-42.

Moulton, R.J. and G. Hernandez. 2000. Tree Planting in the United States – 1998. Tree Planters' Notes, 49(2): 23-36.

Moulton, R.J. and J.D. Snellgrove. 1997. Tree Planting in the United States – 1996. Cooperative Forestry Staff, State and Private Forestry, U.S. Department of Agriculture, Forest Service, Washington, DC.

Nasi, R., S. Wunder, and J.J. Campos. 2002. Forest Ecosystem Services: Can They Pay Our Way Out of Deforestation? Discussion paper prepared for the Global Environment Facility for the Forestry Roundtable to be held in conjunction with the United Nations Forum on Forests II, New York, NY.

Niskanen, A. 1998. Value of external environmental impacts of forestation in Thailand. Ecological Economics, 26(3): 287-297.

REDD (Reducing Emissions from Deforestation and Degradation). 2010. A Casebook of On-the-Ground Experience. The Nature Conservancy, Conservation International, and Wildlife Conservation Society, Arlington, VA.

Pennington, D.R., J. Hansel, and R.B. Blair. 2008. The conservation value of urban riparian areas for landbirds during spring migration: Land cover, scale, and vegetation effects. Biological Conservation, 141: 1235-1248.

Renfrew, R. B. and C.A. Ribic. 2001. Grassland birds assoicated with agricultural riparian practices in southwestern Wisconsin. Journal of Range Management, 54: 546-552.

Rodewald, P.G. and S.N. Matthews. 2005. Landbird use of riparian and upland forest stopover habitats in an urban landscape. Condor, 107(2): 259-268.

Sauer, J. R., B.G. Peterjohn, S. Schwartz, and J.E. Hines. 1995. The Grassland Bird Home Page, Version 95.0. http://www.mbr-pwrc.usgs.gov/bbs/grass/grass.htm. Patuxent Wildlife Research Center, Laurel, MD.

Schultz, R.C., T.M. Isenhart, W.W. Simpkins, and J.P. Colletti. 2004. Riparian forest buffers in agroecosystems – lessons learned from the Bear Creek Watershed, central Iowa, USA. Agroforestry Systems, 61: 35-50.

Stein, S.M., R.E. McRoberts, L.G. Mahal, M.A. Carr, R.J. Alig, S.J. Comas, D.M. Theobald, and A. Cundiff. 2009. Private Forests, Public Benefits: Increased Housing Density and Other Pressures on Private Forest Contributions. Gen. Tech. Rep. PNW-GTR-795. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Thackston, R., E. Darracq, S. Holbrooks, S. Chapman, and K. Wooster. 2009. Georgia's Pine Savanna Restoration: Successes and Challenges. Presentation at the 63rd Annual Meeting of the Southeastern Association of Fish and Wildlife Agencies Farm Bill Workshop. Wildlife Resources Division, Department of Natural Resources, Forsyth, GA.

USDA (U.S. Department of Agriculture). 2006. Conservation Reserve Program Longleaf Pine Initiative Fact Sheet. USDA Farm Service Agency, Washington, DC.

Appendix 1: Sources of Payments for Conservation Practices Involving Trees in Minnesota

Admin-istering Agency	Program	Forestry/Woodlot Management	Habitat Restoration	Rare and Declining Habitats	Riparian Buffer, Forested	Tree/ Shrub Planting	Windbreak, Field	Windbreak/ Living Snow Fence	Windbreak/ Shelterbelt	Payment (one-time)	Payment (ongoing)	Source
FEDERAL												
Farm Service Agency	Conservation Reserve Program (General)	X	X			X				50% cost-share (seedling purchase, site prep), Mid-Contract Maintenance Payment	Annual rental payments for 10-15 year contract ($37.90 - $155.88 per acre in 2008)	MDA CFG (Selected Practices)[1]
	Conservation Reserve Program (Continuous)							X	X	50% cost-share (seedling purchase, site prep), Signup Incentive Payment ($10/acre/year enrolled up to 10 years), Practice Incentive Payment (40% of est. cost), Mid-Contract Maintenance Payment		
					X		X				Rental Rate Incentive of 20%, annual rental payments for 10-15 year contract ($45.48 - $187.06 per acre in 2008)	
			X[2]								Rental Rate Incentive of 10% or 20%, annual rental payments for 10-15 year contract ($41.69 - $187.06 per acre in 2008)	
						X[2]				50% cost-share (seedling purchase, site prep), Practice Incentive Payment (40% of est. cost), Mid-Contract Maintenance Payment	Rental Rate Incentive of 10%, annual rental payments for 10-15 year contract ($41.69 - $171.47 per acre in 2008)	

[1] MDA CFG = Minnesota Department of Agriculture Conservation Funding Guide (http://www.mda.state.mn.us/protecting/conservation/funding.aspx)
[2] MDA CFG categorized several CCRP practices under this heading. Not all practices are eligible for every incentive.

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Farm Service Agency and state agency partners	Conservation Reserve Enhancement Program (selected watersheds)		X		X	X				50% cost-share (seedling purchase, site prep), Practice & Signup Incentive Payments (CP22), Mid-Contract Maintenance Payment; 17 or 22% of estimated market value for 45-year or perpetual easement	Rental Rate Incentive of 30%, annual rental payments for 15 year contract	Natural Resources Conservation Service Web site[3]
Farm Service Agency	Voluntary Public Access And Habitat Incentive Program									(A competitive grants program available only to states and tribal governments to encourage owners and operators of privately-held farm, ranch, and forest land to voluntarily make that land available for access by the public for wildlife-dependent recreation, including hunting or fishing, under programs implemented by state or tribal governments; not known if Minnesota applying.)		Farm Service Agency Web site[4]
Natural Resources Conser-vation Service	Environ-mental Quality Incentives Program[5]	X								$89/acre for thinning and/or $87/acre for release cuttings to improve forest stands		MDA CFG (Selected Practices)[1]
			X							$0.41 or $0.81 per tree or $255/acre to plant trees/shrubs	Annual payment of $10/acre to manage native pollinator habitat on up to 120 acres for up to 3 years	

[3] http://www.mn.nrcs.usda.gov/technical/ecs/agron/crp/CREPelligibility.html
[4] http://www.fsa.usda.gov/FSA/newsReleases?area=newsroom&subject=landing&topic=pfs&newstype=prfactsheet&type=detail&item=pf_20100708_consv_en_vpa_hip.html
[5] See MN EQIP 2010 document for eligible practices and payment information: http://www.mn.nrcs.usda.gov/programs/eqip/local10/2010EQIPpayschedFINAL.pdf

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Natural Resources Conser-vation Service	Environ-mental Quality Incentives Program[5] (con't)			X						Oak savannah: $1.28/tree; Red & White pine: $0.25/seedling or $0.34/transplant; $30 - $38 per acre for controlled burning; $19 - $136 per acre for tree-planting site prep		MDA CFG (Selected Practices)[1]
					X					$2.15/tree or $627/acre (direct seeding); site prep/other payments; $0.13/foot (vegetated barriers)		
						X				$0.55/tree (conifer transplants or short-rotation planting), $0.43/tree (hardwood planting), $0.34/tree (conifer seedlings), or $383/acre (direct seeding); $12 - $84 per acre for site prep	$14/acre annually for chemical weed control (first 2 years) and/or various one-time payments for practices needed to establish new plantings	
							X			$0.12 to $0.47 per foot per row of trees/ shrubs; 22 - $236 per acre (site prep); $1,078/acre for old tree removal		
								X		$0.29/foot per row of trees/shrubs; $22 - $136 per acre (site prep); $1,078/acre for old tree removal		
									X	$0.36/foot per row of trees/ shrubs; $22 - $236 per acre (site prep); $1,078/acre for old tree removal		

Appendix I: Sources of Payments for Conservation Practices Involving Trees in Minnesota

Administering Agency	Program	Forestry/Woodlot Management	Habitat Restoration	Rare and Declining Habitats	Riparian Buffer, Forested	Tree/ Shrub Planting	Windbreak, Field	Windbreak/ Living Snow Fence	Windbreak/ Shelterbelt	Payment (one-time)	Payment (ongoing)	Source
Natural Resources Conservation Service	Wildlife Habitat Incentives Program[6]					X				Cost-share payments of $155 to $491 per acre for establishment depending on species and planting method		MDA CFG (Selected Practices)[1]
		X								$20 - $1,031 per acre for forest site prep, $60 - $89 per acre for forest stand improvement		
				X						Oak savannah: $583.75/acre with tree covers, otherwise $253.75/acre; Red & White pine: $364.97 - $755.97 per acre		MDA CFG (Selected Practices)[1]
									X	$0.93/foot per row (trees), otherwise $0.43/foot		
Natural Resources Conservation Service	Conservation Stewardship Program	*See Enhancement Activity Job Sheets for Forestry:* http://www.mn.nrcs.usda.gov/programs/csp2/MN%20Specifics/jobsheets.html#Forest										
Natural Resources Conservation Service	Wetlands Reserve Program	*State page is outdated:* http://www.mn.nrcs.usda.gov/programs/wrp/; *see national page:* http://www.nrcs.usda.gov/programs/wrp/										

[6] See MN WHIP 2006-2010 plan for eligible practices: http://www.mn.nrcs.usda.gov/programs/whip/2006%20State%20Plan.pdf

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STATE												
Depart-ment of Natural Resources	Forest Legacy Program	X								(Federal funds and local matching funds are used to purchase development rights and conservation easements on forests in targeted areas of Minnesota. The landowner retains ownership and can continue to foster forest uses such as timber management, recreation, hunting, and hiking as long as they don't conflict with the terms of the easement.)		Depart-ment of Natural Resources Web site[7]
Soil and Water Conser-vation Districts	AgBMP Loan Program				X	X	X			[Loans at 3% interest, may be combined with incentives or cost-share payments from other programs]		MDA CFG (Selected Practices)[1]
	State Cost Share		X	X	X	X	X		X	Up to 75% cost-share (planting in critical areas or filter strips; forest conservation practices incl. site prep)		
	RIM Reserve					X	X	X		90% of Assessor's Township Average Market Value for land enrolled in perpetual easements; 100% of establishment costs (up to $400/acre)		

[7] http://www.dnr.state.mn.us/forestlegacy/index.html

This report was prepared by

DOVETAIL PARTNERS, INC.

Dovetail Partners is a 501(c)(3) nonprofit organization that provides authoritative information about the impacts and trade-offs of environmental decisions, including consumption choices, land use, and policy alternatives.

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