Rose Lake Plant Materials Center

2006 Technical Report

East Lansing, Michigan

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ROSE LAKE PLANT MATERIALS CENTER

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INTRODUCTION

History The Rose Lake Plant Materials Center (PMC), as part of the USDA Natural Resources Conservation Service (NRCS) Plant Materials Program, was established in 1958 on a 40-acre site at the Michigan Department of Natural Resources, Rose Lake Wildlife Research Station (42.8° N. Lat., 84.4° W. Long, Elevation 875 ft), and located eight miles northeast of Lansing, Michigan. Soil association is Boyer-Marlette-Houghton with well drained and moderately well drained, gently sloping to steep loamy sands to loams on moraines and very poorly drained muck in depressions.

Responsibilities The NRCS Plant Materials Program develops, tests, and transfers effective state-of-the-art plant science technology to meet customer and resource needs. The Plant Materials Program:

- Focuses on using plants as a natural way to solve conservation issues and re-establish ecosystem function.
- Collects, selects, and releases grasses, legumes, wildflowers, trees, and shrubs.
- Cooperates with public, private, commercial, and tribal partners and land managers to apply new conservation methods using plants.
- Provides plant materials and new applied technologies for national initiatives, like the Farm Bill.
- Offers plant solutions to battle invasive species, heal lands damaged by natural disasters, reduce the effects of drought, promote air and water quality, and produce alternative energy.

It is the responsibility of the Rose Lake PMC to:

- assemble, test, and release plant materials for conservation use;
- determine techniques for the successful use and management of conservation plant species;
- facilitate the commercial increase of conservation plant species; and
- provide for the development and transfer of state-of-the-art applied science technology.

Long Range Plan PMC operations are guided by a Long Range Plan which is a compilation of Plant Materials LRPs from Indiana, Ohio, Michigan, and Wisconsin. The PMC LRP is consistent with goals and objectives identified in the NRCS Strategic Plan.

STUDIES

Study Number	Study Name	Purpose	Year Initiated	Report Page
26A097F	Prairie Sandreed (*Calamovilfa longifolia*) for Stabilizing Dune Areas	Release	1989	18
26C126V	Vegetative Hedges for Controlling Erosion in Areas of Concentrated Flow	Technology	1996	23
26I080J	Tick-trefoil (*Desmodium* spp.) for Wildlife Food Plots	Release	1987	43
26I106E	Shrub Willow (*Salix spp.*) for Restoration of Riparian Areas	Release	1992	16
26I124L	Common Elderberry (*Sambucus canadensis*) and Red Elderberry (*S. pubens*) for Streambank Stabilization	Release	1997	17
MIPMC-P-0201-CR	Development of Great Lakes Composite of Virginia Wildrye (*Elymus virginicus*)	Release	2002	26
MIPMC-P-0204-CR	Development of Great Lakes Composite of Bottlebrush Grass (*Elymus hystrix*)	Release	2002	28
MIPMC-P-0207-CR	Increase and Release of Riverbank Wildrye (*Elymus riparius*)	Release	2002	28
MIPMC-P-0208-CR	Evaluation and Release of Miscanthus Grass (*Miscanthus sinensis*)	Release	2002	25
MIPMC-P-0209-CR	Evaluation of Dune Willow (*Salix cordata*)	Release	2002	22
MIPMC-T-0004-CR	Arrest Erosion Threatening Raspberry and Outer Island Light Stations	Technology	2000	13
MIPMC-T-0301-WO	Direct Seeding Tree and Shrub Establishment	Technology	2003	38
MIPMC-T-0302-PA	Eastern Gamagrass (*Tripsacum dactyloides*) Cultivar Evaluation	Technology	2003	32
MIPMC-T-0303-PA	Eastern Gamagrass (*Tripsacum dactyloides*) Production Evaluation	Technology	2003	32
MIPMC-T-0402-WO	Direct Seeding of Northern Red Oak (*Quercus ruba*)	Technology	2004	40
MIPMC-T-0404-BU	Windbreaks in Muck Soils	Technology	2004	37
MIPMC-T-0502-PA	Timing Eastern Gamagrass (*Tripsacum dactyloides* L.) Planting to Break Seed Dormancy	Technology	2005	35

PARTNERSHIP AND PROGRAM DEVELOPMENT

The Rose Lake PMC partners with other federal, state, and local agencies; tribes; and private entities to achieve its missions and goals. The PMC is always looking to create new partnerships while strengthening its many existing partnerships. Partnering has two advantages: First, partnering allows expedient and effective land conservation by garnering the skills, knowledge, and abilities of each agency or group involved. Second, it broadens the PMC's range of plant and conservation skills thereby widening the customer base and demand. Often partnerships are established as *reimbursables* which help fund staff and equipment needs.

Problems Many partners lack either the skills or facilities to produce plants or complete research on various, adopted conservation projects.

Needs Plants, planting skills, and/or facilities to grow plants for conservation projects on public lands are needed.

Memorandum of Understanding with Indiana Department of Natural Resources

Background The Indiana Department of Natural Resources (INDNR) Division of Fish and Wildlife and NRCS have mutual interests and goals concerning wildlife habitat management and conservation, specifically related to native plants from Indiana. The NRCS is the lead Federal agency for providing conservation assistance on private lands. The NRCS Plant Material Center's mission is to develop, test, and transfer effective state-of-the-art plant science technology, providing timely and effective vegetative solutions for identified customer and resource needs. The INDNR's mission is to professionally manage Indiana's fish and wildlife for present and future generations, balancing ecological, recreational, and economic benefits.

The Natural Resources Conservation Service and INDNR are cooperating to meet the demands of both public and private lands for establishing high quality wildlife habitats with native Indiana seed. Both agencies recognize the concern of introduced plant species (native and non-native) and the potential for these species to alter the genetics of existing native plant communities. Moreover, both agencies have recognized the need for testing and selecting plants native to Indiana for use in implementing their individual and mutual programs.

Memorandum of Understanding Through a Memorandum of Understanding (MOU) the INDNR and Rose Lake Plant Materials Center have agreed to cooperatively promote and propagate native plants from Indiana genotype sources for the expansion and implementation of both agencies' missions and programs. Specifically, they will cooperatively:

- Identify a list of plants that each agency deems important and set priorities for which species to work on first.

- Harvest seed from established fields or from remnant stands.
- Cooperatively review their MOU to determine any necessary revisions.
- Cooperatively release plant materials through the NRCS Plant Materials Program and publicize to commercial growers for establishment and increase for availability to the public.
- Secure Indiana Native Seed Certification of all seed.
- Promote the use of the released native plant material.

Releases Seed was collected from native stands (as designated by the Indiana Department of Natural Resources, Wildlife Division) of big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and Indiangrass (*Sorghastrum nutans*) within the State of Indiana in the early to mid 1990s. Seeds from these populations were planted into single crossing blocks for each species. Resultant seeds were planted in nine field plantings in central Indiana. Field plantings were evaluated for adaptability, potential for invasiveness, and usefulness in conservation planting.

Based on (1) the excellent field performance of these big bluestem, Indiangrass, and little bluestem composites over several years and locations; (2) the limited availability of plant material; and (3) the need for these products in ecosystem restoration and enhancement, seed stock of Prairie View Germplasm of these composites was released in 2005.

Prairie View Indiana Germplasm big bluestem is a perennial, warm-season bunch grass with short, scaly rhizomes. Big bluestem attracts insects and provides seeds that are used as food sources by songbirds, game birds, and small mammals. Many wildlife species also utilize big bluestem for nesting, escape, and winter cover. Other anticipated uses of Prairie View big bluestem include increasing species diversity, controlling erosion, and restoring native plant environments.

Prairie View Indiana Germplasm little bluestem is another perennial, warm-season bunch grass. Its anticipated uses also include providing food/cover for wildlife, increasing species diversity, controlling erosion, and restoring native plant environments. At 2 – 4 ft in height at maturity, it is the shortest of the Prairie View grasses.

Prairie View Indiana Germplasm Indiangrass, like the other Prairie Views, is a perennial, warm-season bunch grass. A distinguishing characteristic is a narrow, plume-like seed head that turns golden at maturity. Its anticipated uses also include providing food/cover for wildlife, increasing species diversity, controlling erosion, and restoring native plant environments.

Quantities of pure live seed produced in 2005 under this Memo of Understanding at the Jasper-Pulaski Fish & Wildlife Area and processed by the Rose Lake PMC were approximately 100 lbs of little bluestem, 325 lbs of big bluestem, and 300 lbs of Indiangrass. This seed was distributed to five growers and three demonstration plantings. Seed harvested in 2006 will be available for distribution to growers and for demonstration plantings in 2007. Seed requests may be submitted to:

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Cooperative Agreement for Ash Tree (*Fraxinus spp.*) Seed Collection

Background Ash trees in the PMC Service Area are being attacked and destroyed by Emerald Ash Borer (*Agrilus planipennis* (Fairmaire)). This introduced pest, first detected in summer 2002 in Southeast Michigan, has already spread to Illinois, Indiana, Maryland, Ohio, and Ontario.

With this impending disaster (already more than 20 million trees have been killed) Rose Lake PMC entered into a non-funded cooperative agreement with the USDA Agriculture Research Service (ARS). The agreement states that the PMC will initiate an ash tree seed collection and that the ARS National Center for Genetic Resource Preservation Center in Ft. Collins, Colorado will store samples of all the seed collected in their long term seed storage facility. Tribes are specifically mentioned in the agreement because of the PMC's previous assistance to tribes with black ash and other culturally significant plants.

Voluntary seed collections are being sought. The PMC receives, processes, labels, and sends seed to the Preservation Center. Tribal seed remains tribal property in storage with tribes retaining authority over sharing and distribution.

Presentations Plant Materials Specialist David Burgdorf and Plant Materials Center staff have made numerous presentations on the ash collection effort to government agencies including tribes, partners, and the general public. Posters and brochures are being distributed to NRCS Field Offices and other partners. The effort has also received popular press and television coverage.

Collection Ash seed samples were collected in Illinois, Michigan, Minnesota, Ohio, and Wisconsin on tribal and non-tribal lands by NCRS and District personnel and the general public. PMC staff checked seeds for fill and obvious pests. The staff cleaned, labeled, and forwarded seed to the USDA Forest Service National Seed Laboratory in Dry Branch, Georgia for X-ray analysis (nondestructive viability test). Seeds were then shipped to the ARS National Center for Genetic Resource Preservation Center for long-term storage. After culling, six samples of 2005 growing season seed were sent by the PMC to the National Center for Genetic Resource Preservation. Approximately 125 samples were received by the PMC in 2006.

The collection continues. Collection information is available on the web at:

www.ashseed.org

Memorandum of Understanding for Ft. Custer Vegetative Restoration

Background Fort Custer Training Center (FCTC) in Southwest Michigan is 7500 acres of military tactical training area used by the Michigan National Guard and other branches of the armed forces. While FCTC is an important training facility, it is also home to a wide variety of natural resources, e.g., wildlife, forests, wetlands, surface water, and various rare plant and animal species. Moreover, historic and cultural resources are located on the property. The facility is federally-owned and operated by the Michigan Department of Military and Veterans Affairs (MDMVA).

Memorandum of Understanding A memorandum of understanding between the NRCS Rose Lake PMC and the MDMVA was developed for restoration of native vegetation and habitats at Fort Custer. PMC staff will provide consultation and on-the-ground assistance for collection, propagation, establishment, and maintenance of native vegetation. PMC assistance with research and selection of proper native vegetation that meets the needs of the firing ranges, ammo bunkers, and convoy reaction course areas will mutually benefit MDMVA, FCTC, and NRCS.

Deliverables The following are being realized from the cooperative agreement between MDMVA and NRCS Rose Lake PMC:

- Identification and selection of specific native plant species for collection, increase, testing, and evaluation for conservation uses at FCTC, including grasses to reduce mowing needs on ammunition bunkers (see below) and firing ranges and native grasses for roadsides.
- Established production plots/fields of selected native plants (e.g., little bluestem, big bluestem, and Indiangrass) to provide seed to commercial growers and for use at FCTC for prairie plantings on post. Seventeen thousand Indiangrass and 5,000 big bluestem plants were grown in the PMC greenhouse and transplanted into FCTC production areas in 2006.
- Technical expertise on plan development for establishing native prairie plants on the convoy reaction course.
- Consultation and hands on implementation of weed control, planting, plot/field production, and management.
- Protocols for harvesting, cleaning, and handling of seed. Big bluestem seed harvested at FCTC in 2005 and little bluestem harvested in 2006 was transported to the PMC for cleaning and return to FCTC.

Ammunition Bunkers Demonstration plots were established on an ammunition bunker so that vegetation species and establishment methods could be evaluated (Table 1). Treatment strips were 30 ft up-and-down the slope and 3 or 7 ft wide. Replicates were established to face northeast, east, and southeast, respectively. Evaluation will be conducted in collaboration with FCTC environmental staff. Criteria include ease of establishment, mowing and maintenance requirements, soil stabilization on the 30-40° slopes, fire hazard, etc.

Table 1. Vegetation and establishment methods for Ft. Custer ammunition bunker trials.

Common Name		Scientific Name	Establishment Method	Approximate Seed or Plant Population	Observations
Bermudagrass		*Cynodon dactylon* (L.) Pers.	Plugged into coir biodegradable mattress (with potting soil); established off-site; and transported to bunker in fall 2005	6 plants/ft^2	Greenup was slow in spring. Sod was green and well formed by end-of-season.
Periwinkle		*Vinca minor* L.	Plugged into coir biodegradable mattress (with potting soil); established off-site; and transported to bunker in fall 2005	Actual planting population not calculated due to stoloniferous nature of Periwinkle	Didn't provide adequate groundcover during 2006 growing season.
Sedum	Two row stonecrop	*Sedum spurium* Bieb. 'Tricolor'	Plugged into soil overlaid with 0.75-in X 0.75-in mesh coir fiber, biodegradable mats covering in summer 2005	3 plants/ft^2	Established well but vegetative growth was slow. Didn't provide adequate ground cover in 2006 growing season.
	Stone- crop	*Sedum acre* L.	Same as above	Same as above	
	Orange stonecrop	*Sedum kamtschaticum* Fisch. & C.A. Mey.	Same as above	Same as above	
	Orange stonecrop	*Sedum spurium* Bieb. 'Fudlaglut'	Same as above	Same as above	
Red fescue		*Festuca rubra* L.	Direct seeded on-site at bunker into soil overlaid with 0.5-in X 0.4-in mesh coir fiber, biodegradable mats in fall 2005	4 lbs/1000 ft^2	Good germination in fall 2005 and good sod formation during 2006.
			Established off-site by direct seeding into coir biodegradable mattress (with potting soil); overlaid with 0.5-in X 0.4-in mesh coir fiber, biodegradable mats and transported to bunker in fall 2005	4 lbs/1000 ft^2	Good growth and sod formation in mats off site and good establishment on bunkers in 2006.
Buffalograss		*Buchloe dactyloides* (Nutt.) Engelm. 'Top Gun'	Direct seeded on-site in summer 2006	3 lbs/1000 ft^2	Very poor germination.
Pink		*Dianthus* sp.	Transplanted into biodegradable mattress in summer 2006	≈1 plant/ft^2	

Study No. MIPMC-T-0004-CR
Arrest Erosion Threatening Raspberry and Outer Island Light Stations

Introduction The Apostle Islands National Lakeshore is comprised of Raspberry Island, Outer Island, and others in Lake Superior near Bayfield, Wisconsin. Several of these islands have historic lighthouses that once guided mariners through the rough waters of Lake Superior. Continuous erosion of steep slopes has jeopardized these historic facilities. This project was initiated in 2000 to produce native plant stock for stabilizing slopes, preventing erosion, preserving native plant resources, and revegetating at Apostle Islands National Lakeshore.

The National Park Service entered into several reimbursable agreements with NRCS and the Rose Lake PMC to provide technical assistance and to assist with collecting and growing plants. Under a Memorandum of Agreement grass, forb, and shrub species were selected for propagation based on the materials' availability, viability, and site adaptability for the intended use.

Accomplishments The NRCS Great Lakes Region Plant Materials Specialist has provided training to the Apostle Islands National Lakeshore employees on several slope stabilization techniques including guidance on the installation of a vegetative crib wall and slope grid system for the Outer Island. Park staff have constructed their first vegetative crib wall on Raspberry Island under the direction of the Plant Materials Specialist.

Following is a list of species propagated and number of plants delivered to Apostle Islands National Lakeshore in 2006:

American Beachgrass – 237	Grayleaf Red Raspberry – 60
Arborvitae – 49	Hairgrass – 186
Beach Wormwood – 19	Prickly Rose – 35
Canada Goldenrod – 697	Red Elderberry – 2181
Canada Wildrye – 23	Redtop – 238
Dwarf Scouring Rush – 89	Smooth Rose – 10
Evening Primrose – 194	Wavy Hairgrass – 340
Field Stagwort – 498	Western Pearly Everlasting – 277
Fireweed – 203	

Technology Development The NRCS Great Lakes Region Plant Materials Specialist has provided training to the Apostle Islands National Lakeshore employees on several soil bioengineering slope stabilization techniques including guidance on the installation of vegetative crib walls and slope grids for Outer Island. Park staff constructed several vegetative crib walls on Outer and Raspberry Islands.

STABILIZATION OF STREAMBANKS AND SHORELINES

Soil bioengineering is the art and applied science that uses living plant material as a main structural component to control erosion, sedimentation, and flooding. It is a unique technology offering a responsible, attractive, and distinct approach to land stabilization and habitat restoration. Soil bioengineering systems are intended to form a positive interaction with the complex relationships that connect our natural resources.

Problems Reduced water quality from sedimentation and nutrient accumulation in our lakes and waterways is a concern in the Great Lakes and Midwest states. Poor urban, agricultural, and forestry land management practices resulting in excessive erosion and nutrient runoff have contributed to this situation. Nonpoint source pollution is responsible for sediment, nitrates, and phosphates deposition and increased biological oxygen demand in our lakes and streams.

Needs Although many other best management practices treat the cause of water quality degradation, soil bioengineering focuses on restoration. With emphasis placed on native species, developing acceptable plant materials and innovative soil bioengineering techniques has been pushed further to the front. Focus in the Great Lakes and Midwest States has been placed on native shrub species that:

- propagate vegetatively
- establish rapidly
- grow vigorously
- exhibit excellent erosion control qualities or features
- provide food, shelter, or nesting for wildlife
- are low maintenance and wear resistant
- possess aesthetic qualities

Study No. 26I106E
Shrub Willow (*Salix spp*.) for Restoration of Riparian Areas

Background Willow is a genus of extremely diverse woody plants having a wide adaptation range from temperate to arctic. More than 50 species occur in North America along with numerous subspecies, varieties, and hybrids. A shrub willow reaches less than 20-ft tall and has multiple stems growing from or near the ground. Typically, willows do well where there is plenty of moisture and light. Many species of willow commonly occur on streambanks and riparian areas and propagate readily by vegetative means.

Procedure Dormant woody cuttings from 120 accessions of various shrub willow species were collected from Indiana, Michigan, and Wisconsin during the winter of 1991-92. Based on years of evaluation of vigor, height, canopy width, and canopy density at the Rose Lake PMC, Riverbend Germplasm Silky Willow (accession 9069052) was released as a tested class of natural germplasm in 2003 and is now available for increase purposes.

Observations Riverbend Germplasm Silky Willow was rated 'excellent' in vigor and disease tolerance following the 2005 growing season at the USDA/NRCS National Plant Materials Center in Beltsville, MD. However, it was completely defoliated by what staff there identified as leaf roller moth larvae.

Following the 2004-05 winter, Riverbend Germplasm Silky Willow at Rose Lake was diagnosed with Cytospora by pathologists at Michigan State University Diagnostic Services. Cytospora is an endophytic fungus that infects and causes cankers when environmental conditions are adverse. Salt spray from the road next to the willow may have created good entry points for the fungus.

Observations of insects and fungus will continue on Silky Willow at the National Plant Materials Center and at Rose Lake during 2007.

Study No. 26I124L
Common Elderberry (*Sambucus canadensis*) for Streambank Stabilization

Background Elderberry is an upright, native shrub that can grow to 10-ft tall. The thick, yellowish-brown to light brown bark roughens and furrows with age. Stems and twigs are commonly covered with numerous, small, wart-like bumps (lenticels). Leaves are compound opposite with 5 to 11 coarse-toothed, elliptical leaflets. Common elderberry has white pith. Flowers are borne in white, flat-topped clusters. Fruit is purple to black. It is often found on wet or moist sites, such as along drainage ditches and wet fields.

Description of Study Assemble, select, and release native ecotypes of common elderberry for use in (a) soil bioengineering practices as locally-adapted plant material to stabilize streambanks, (b) native plant restoration projects, and (c) wildlife plantings as a food and shelter source. Additionally, this species has potential as an income source from berry production for human consumption. Exploring such uses in production agriculture would necessitate advanced testing to insure that quality and performance standards would be met.

Procedure Thirty-seven collections of common elderberry cuttings were processed and planted in the greenhouse in late 1997 through early 1998. Cuttings were transplanted into three initial study areas located in Wisconsin, Indiana, and the Center. Data was recorded on fruit abundance, plant height, canopy width, canopy density, and vegetative spread at the Center site from 1998 through 2000 but adverse weather forced the termination of studies in Wisconsin and Indiana. PMC-harvested material was sectioned and used to grow cuttings for new field trials in Indiana, Wisconsin, and Ohio, but these were terminated after 2003 due to poor long-term survival.

Anticipated Release Data collected from the Rose Lake Plant Materials Center trial indicates that Accession 9084126 has excellent growth characteristics for height, canopy density, spread, fruit abundance, and re-growth after pruning. Further evaluation is ongoing at the Rose Lake and National PMCs and in Wisconsin and is anticipated in several MLRAs and plant hardiness zones in the Rose Lake PMC service area. A new production block was established at the Rose Lake PMC in 2005 and a release is expected.

STABILIZATION AND RESTORATION OF DUNE AREAS

A diversity of landforms and plant and animal communities make up the Great Lakes shoreline, including those of the dune system. The greatest dunes of the Great Lakes occur along the east coast of Lake Michigan. This is principally due to the massive amounts of sand and sediment that eroded into Lake Michigan as glaciers retreated northward, and the prevailing westerly winds that gather energy traveling across this uninterrupted expanse of water. Wind velocity and direction, water levels, direction of water current, topography, and existing vegetation determine the rate of erosion and deposition.

Problems Development and other human activities along these dune systems alter protective dunes and wetlands, remove stabilizing vegetation, and generally reduce the shoreline's ability to combat strong winds and waves.

Needs The Great Lakes region needs commercially available plant varieties, the technology to establish them, and information on dune systems. Released plant material should:

- be native to the dune systems
- have good vigor and establish readily
- exhibit erosion control qualities

Testing of Prairie Sandreed (*Calamovilfa longifolia*) Potential Release (Accession 9086408) from Study No. 26A097F

Background *Calamovilfa longifolia* is a tall, coarse, perennial, sand-binding grass with two distinct varieties: *magna* and *longifolia*. Literature indicates var. *longifolia* occurs in many dry prairies on the interior plains of Canada and the United States whereas var. *magna* characteristically occurs on active and semi-established dunes fringing Lake Huron and Lake Michigan. Studies have shown var. *magna* is a dominant dune builder on sites with slower sand deposition or windward blowout slopes, but has limited representation on rapidly depositing surfaces.

Prairie sandreed is a C_4 species that reproduces vegetatively by rhizomes and sexually by seed. *Calamovilfa longifolia* expands into adjacent territory by producing short rhizomes on the periphery of a clump. The species follows a conservative growth form of slow radial spread. Such a growth form consolidates a local patch of resources and is resistant to invasion by other plant species. A 1985 study suggested prairie sandreed does not establish vegetatively in nature because the rhizomes are woody, do not bear any dormant buds, and do not fragment by wave action.

In response to sand accretion, the tillers and rhizomes adopt an erect habit of growth, emerge from sand, and produce tillers at the new sand surface. The growth form with a

high density of stout tillers within a localized area of clumps is exceptionally adept in trapping windblown sand.

Recurrent phenotypic selection breeding procedures were employed to develop a superior release of *Calamovilfa longifolia* var. *magna* with improved seed production, drought tolerance, and seedling vigor for the Great Lakes states using four accessions previously selected for the desired characteristics.

Objective Develop potential release (Accession 9086408) and compare growth to parental lines and standards.

Potential Release Development Prairie sandreed (*Calamovilfa longifolia* var. *magna*) Accession 9086408 was derived from the four most promising accessions from Rose Lake PMC Project 26I057F (Table 2). The potential release was developed through three phenotypic mass selection cycles as described below.

Table 2. Parents of potential Rose Lake PMC release prairie sandreed (*Calamovilfa longifolia* var. *magna*) Accession 9086408.

Accession	Material	Comparative Strengths	Collection Location		Year	Collector
477007	Seed	Leafy foliage and later-maturing seed heads	Manistee National Forest Recreation Area	Mason County, MI	1971	Dorian Carroll
9004939	Vegetative material	Excellent vigor and abundant foliage	Ottawa County, MI		1978	Ellis Humphrey
9004944	Vegetative material	Abundant uniform foliate and good vigor	Huron county, MI		1978	Ellis Humphrey
9004959	Vegetative material	Good vigor and abundant foliage	Porter County, IN		1978	D.V. Wilson

Cycle #1 of the phenotypic mass selection process began in 1989. A grid system was used to select fifty healthy, greenhouse-grown plants of each accession (477007, 9004939, 9004944, and 9004959). These plants were established in a breeding block and F1 seed was harvested in 1991. The plumpest 3,000 seeds were selected and planted three seeds per cone-tainer in the greenhouse during late winter and early spring 1992. Plants were thinned to one per cone-tainer. In mid-summer the seedlings were transplanted to a field selection nursery. These plants represented the F1 progeny and were assigned accession number 9055449.

In **Cycle #2** the 100 best and most upright F1 plants in the field selection nursery were selected and retransplanted into a polycross nursery in 1993. Three thousand F2 seeds were collected from the polycross nursery. These 3,000 seeds were grown three per container in 1,000 containers, thinned, and transplanted into a selection nursery.

In **Cycle #3** one hundred F2 plants were selected and retransplanted into a polycross, breeder nursery. Seed from this nursery was designated F3.

A foundation seed block was established with F3 plants grown from F3 seed. F4 seed from this foundation seed block is the seed that will be released as the Koch germplasm prairie sandreed, Accession 9086408.

Materials, Methods, and Experimental Design for Progeny Test Plugs were established in the greenhouse in 2003 or earlier and planted in 2004 in two-row plots. Design was a randomized complete block with four replicates (or fewer for limited-inventory accessions).

Results No significant differences were observed among the potential release and its progenitors when vigor, disease, insect damage, lodging, and height were observed in early July (Table 2). Both 9055449 and 9086408 flowered later than the one parental accession (477007). Leaf rust (*Puccinia sp.*) and anthracnose (*Colletotrichum graminicola*) infected all plot entries without discernable differences. Standards Pronghorn and Goshen were significantly shorter than potential release and its progenitors.

Conclusion and Recommendation Since the potential release (9086408) was comparable to its progenitors and standards Pronghorn and Goshen in early vigor, early disease, early insect damage, and early lodging, this study presents no reason why Accession 9086408 should not be released by the Rose Lake Plant Materials Program.

Table 3. Prairie sandreed growth at Rose Lake PMC, 2006.

Accession	Early Vigor[1]	Early Disease[1,2]	E. Ins. Damage[1]	Early Lodging[1]	Height[1] (ft)	Flowering Stage[3]
9086408 (F2. Potential Release)	1	1	1	1	3.38	Preboot - Boot
9055449 (F1 of Parental Crossing Block)	1	1	1	1	3.50	Preboot – Boot
477007 (One of 4 Parents)	1	1	1	1	3.75	Flowering
Pronghorn (Standard)	1	1	1	1	2.63	Preboot
Goshen (Standard)	1.5	1	1	1	2.75	Preboot - Boot
$LSD_{(0.05)}$	n.s.	n.s.	n.s.	n.s.	0.59	

[1]Vigor, disease, insect damage, and lodging: 1=excellent vigor; no disease, insect damage, or lodging; 9=poor vigor; severe disease, insect damage, or lodging. Evaluated 3 July 2006.

[2]Leaf rust (*Puccinia sp.*) infected all accessions in August followed by anthracnose (*Colletotrichum graminicola*) in September. July precipitation was 4.3 in above normal. August and September precipitation were near normal.

[3]Median flowering stage evaluated on 3 July 2006.

Study No. MIPMC-P-0209CR
Evaluation of Dune Willow (*Salix cordata*)

Background *Salix cordata* propagates efficiently from dormant cuttings. It is found growing on dry dune areas. The plant has potential conservation and landscaping uses on dune areas. It has the potential to trap sand or sediment on dunes and stabilize dune areas that are vulnerable to erosion.

One concern with using this species in dune restoration is that a flea beetle (*Altica subplicata*) uses the plant as a food source. The flea beetle can nearly defoliate a dune willow plant by September or October. Multiple years of exposure of dune willow to the flea beetle causes significant plant loss, and subsequent loss of dunescape erosion protection.

Description of Study A dune willow population will be established at the Rose Lake Plant Materials Center and evaluated for three to five years for vigor, plant growth, and incidence of disease or insects throughout the growing season.

Procedure A Sand Dune willow was collected at Warren Dunes by Michigan DNR personnel in 2001. Plants were propagated by planting dormant cuttings in greenhouse containers and transplanting the rooted cuttings in a field trial in 2002. A total of 58 plants were transplanted into the field trial.

Summary No new data are available from 2006 field studies.

STABILIZE CROPPED AREAS OF CONCENTRATED WATER FLOW

Controlling sediment and nutrient runoff from cropland is a concern in the Rose Lake PMC service area. Developing methods that control erosion, while keeping the most land in production is a continuing effort.

Problems Grassed waterways are often utilized to address erosion and runoff in areas of concentrated flow within cropped fields. In small watershed areas where the water flow is less aggressive this practice is often dismissed in lieu of periodic filling and reshaping of the eroded area. This allows more land to remain in production and eliminates any hindrance the waterway may pose to farming operations. Erosion and runoff, however, continue to be a problem.

Needs Vegetative barriers should:

- not include potentially invasive or otherwise environmentally undesirable plants
- exhibit excellent erosion control qualities
- not impede normal farming operations
- be easy to maintain
- remove as little land from production as possible

Study No. 26C126V
Vegetative Hedges for Controlling Erosion in Areas of Concentrated Flow

Background Pre-established strips of perennial grasses (vegetative barriers) transplanted within the crop rows and designed to impede water flow may have application in erosion control. The concept is that where runoff concentrates in rills or ephemeral gullies, grass hedges will pond water upslope causing a large portion of the sediment load to settle and fill the eroding areas. This will create small, benched terraces that diffuse and slow runoff, thus limiting further erosion and increasing water absorption. This study was initiated for miscanthus (*Miscanthus sinensis*) at Michigan State University Kellogg Biological Station (KBS) near Battle Creek, MI in collaboration with NRCS Field Office Staff in 1993. In 1996 the study was expanded to include native warm-season grasses. Additional field plantings, including miscanthus or eastern gamagrass (*Tripsacum dactyloides*), were established in Michigan, Indiana, and Ohio in 2001-03.

Description of Study Vegetative barriers of miscanthus or eastern gamagrass were evaluated for their effectiveness to control erosion in cropped fields.

Procedure Whole plants from miscanthus or eastern gamagrass stands on the MI PMC were harvested and divided into sprigs. A line of sprigs was planted 5 to 10 inches deep, spaced 3 inches apart, in rows 3 inches apart in soil-filled troughs of varying lengths. Troughs were formed with rolled plastic material to contain root growth, and lined with coconut fiber to maintain trough integrity during installation. Material was grown for several months in the greenhouse prior to installation insuring good root development. Troughs were lifted by the coconut fiber liner and placed into excavated strips of the crop

field perpendicular to the path of concentrated flow, and within the row so as not to interfere with farming operations.

Summary The miscanthus plantings established well and were healthy. There was no evidence of miscanthus spreading from where it was planted, and no seeds were evident. Soil sediment and crop residue deposits were evident on the upslope side of each barrier at KBS, but heavy rains caused some breaks in the row. Survey stakes are present in the barriers and sediment buildup measurements are planned.

The eastern gamagrass planting in Indiana showed good growth. Visual evaluation of the gamagrass and miscanthus plots in Indiana showed no down slope erosion. The plots will be maintained to evaluate sediment or residue entrapment and to further monitor the development of rills or gullies.

Study No. MIPMC-P-0208-CR
Intercenter Component of
Evaluation and Release of Miscanthus Grass (*Miscanthus sinensis*)

Background The Rose Lake PMC has been working for about 15 years with miscanthus grass as a planting for vegetative barriers in concentrate flow areas. Miscanthus has performed extremely well in the field, but concerns have been raised (e.g. http://horticulture.coafes.umn.edu/miscanthus/) about the possibility of its becoming an invasive species. The PMC has had field plantings for about ten years and has not identified any spread of this specific collection by seed.

Procedure Plants from the Rose Lake PMC were divided, repotted in 2.5-in diameter plastic cones, and sent to seven other PMCs in 2002. Cooperating PMCs were requested to record plant growth data and collect seeds for viability testing.

Results Miscanthus growth and development were excellent at all reporting PMCs and other cooperating locations. In all the years of intercenter testing, no viable seed was reported from laboratory germination tests (Table 4). However, Missouri conducted a greenhouse germination test that did show germination. These results suggest the need for further work to determine if and where the plant will develop viable seed.

Table 4. Miscanthus seed analysis as conducted by Michigan Department of Agriculture Laboratory Division.

Growing Location	Seed Production Year	Laboratory Results
Big Flats, NY	2004	No TZ test due to absence of seed. No fertile florets detected.
Big Flats, NY	2005	0% germination. All florets appeared to be sterile.
Elsberry, MO	2005	0% germination. No fertile florets detected.
Big Flats, NY	2006	0% germination. Dead seed present.

RESTORATION OR RECLAMATION OF DISTURBED AREAS

Numerous human activities have the potential to dramatically alter the natural resources in an area. Construction of roads, travel lanes or utility corridors, agricultural or mining operations, and municipal or recreational development often results in a drastic disturbance of the natural communities. Successful revegetation of these disturbed areas requires plant materials and the technology to use them.

Problems With the heightened interest and promotion of native species, the availability of regionally-sources and adapted ecotypes has not kept pace with demand. This is especially true with native grass species for use in Conservation Reserve Program plantings and restoration work. Some non-native species traditionally utilized for conservation activities have come under scrutiny due to their aggressive nature. This has generated an even greater need for native plant material and the corresponding research to replace these conventional conservation species.

Needs The states served by the Rose Lake PMC need commercially available quantities of regionally native, or adapted, non-aggressive plant species, and the technology to use them. Selected species should have proven capabilities for one or more conservation concerns.

Study No. MIPMC-P-0201-CR
Great Lakes Composite of Virginia Wildrye (*Elymus virginicus*)

Background Virginia wildrye is a native, cool-season perennial bunchgrass with erect stems that reach to 4-ft high. Leaves are flat, up to 0.5-in wide, and rough on both sides and the margins. Spikes are stiff and up to 5-in long. The lower portion of the spike is often enclosed by the sheath. Lemmas have awns that reach 1.5 inches. Auricles are claw-like and clasping. Virginia wildrye is found in moist woods, meadows, and prairies throughout the United States east of the Rockies. It has good tolerance to flooding and moderate tolerance to drought. There are approximately 96000 seeds/lb.

Description of Study A collection of Virginia wildrye was assembled from native stands in Michigan, Indiana, Ohio, and Wisconsin. Material is being evaluated and composite selected for restoration or revegetation potential as conservation cover or streambank protection in the Great Lakes and Midwest states.

Procedures Virginia wildrye was collected from native stands by field staff and partners and accessioned. Plants from each of 19 accessions were started in the greenhouse and transplanted into field plots. Field plots in Michigan were established in 2002 and in Indiana and Ohio in 2003. Each plot was evaluated for survival, vigor, plant density, height, lodging resistance, disease and insect damage, seed production, and germination. A randomized complete block advanced field trial of "finalists" with three replications was established at the PMC. Plants were established in cone-tainers and transplanted to the field on 23 June 2005. Trial entries were:

9084531
9084344
9084514
Omaha (standard)

Summary and Future Direction Data recorded in 2006 from the advanced trial established at the PMC in 2005 is summarized in Table 5. Accession 9084531 was more vigorous than Omaha, the standard, but not significantly different in vigor from 9084344 or 9084514. No other statistically significant differences were observed among entries in the advanced trial.

The advanced trial will be continued in 2007. Forage production will be evaluated. Selection decisions may be made at the end of the 2007 season.

Table 5. Virginia wildrye plant growth data, Rose Lake PMC advanced test site. 2006.[1]

Accession	Vigor[2]	Disease[2]	Insect Damage[2]	Lodging[2]	Height (ft)	Flowering Stage
9084351	1.3	2	1	1	3	Boot
Omaha	3.0	2	1	1	3	Boot
9084344	1.7	2	1	1	3	Boot
9084514	2.0	2	1	1	3	Boot
$LSD_{(0.05)}$	1.5	n.s.	n.s.	n.s.	n.s.	n.s.

[1]Evaluated on 3 July 2006.

[2]Vigor, disease, insect damage, and lodging: 1 = excellent vigor; no disease, insect damage, or lodging; 9 = poor vigor; severe disease, insect damage, or lodging

Study No. MIPMC-P-0207-CR
Increase and Release of Riverbank Wildrye (*Elymus riparius*)

Background The Wisconsin State Plant Materials Committee (WIPMC) suggested the need for native cool-season grasses for use in conservation activities, noting also the lack or unavailability of native cool season grasses from commercial growers. The WIPMC identified riverbank wildrye as a candidate for collection, study, and possible release as a conservation plant. Riverbank wildrye is an erect plant with relatively short awns compared to the awns of Canada wildrye.

Study Description A source collection was made by the WIPMC and was sent to Rose Lake PMC for study and evaluation.

Procedure Seed from the source collection was evaluated in the greenhouse for germination and early vigor during August of 2002. Germination was very high in greenhouse plantings. The remainder of the seed was planted into a seed increase field at the PMC in September of 2002. Plants grown in the greenhouse for the germination evaluation were transplanted into the same seed increase field.

Growth resumed in spring of 2003 and seed was produced from most plants in the field during that growing season. Seed from that field was harvested with a combine and cleaned with a fanning mill at the PMC. Seed cleaning was relatively easy, compared to Canada wildrye, because of the short awns on the riverbank wildrye seed.

Seed was provided to PM committee members in 2004 to plant in critical area treatments to determine if riverbank wildrye can be used effectively as a conservation plant.

Results Observations in 2006 from the Wisconsin planting were "has potential" and "good growth" even where precipitation was unfavorable and reed canary grass was invading.

Study No. MIPMC-P-0204-CR
Great Lakes Composite of Bottlebrush Grass (*Elymus hystrix*)

Background Bottlebrush grass is an erect, native, cool-season, perennial bunchgrass that reaches 4 ft in height. Leaf sheaths can be smooth or hairy and leaf blades up to ½-in wide with rough texture. Spikes can be up to 10-in long with 1 – 4 spikelets per node. Spikelets spread horizontally as they mature, often becoming nearly perpendicular to the rachis. Lemmas have rough, straight awns that reach 1 ½ -in long. Bottlebrush grass is found in moist to dry woods from Nova Scotia to Quebec and North Dakota and south to Georgia and Arkansas.

Description of Study A collection of bottlebrush grass was assembled from native stands in Michigan, Indiana, Ohio and Wisconsin. Materials are being evaluated for restoration or revegetation potential as conservation cover or streambank protection in the Great Lakes and Midwest states. Seed from the breeder field will be made available to growers as a selected or tested class release.

Procedures Collections were made from native stands by field staff and partners. Each collection was accessioned and cleaned. Cone-tainerized plants from each accession were established in the greenhouse and transplanted to field sites at the PMC and in Indiana and Ohio in 2003. Plots were placed in a randomized complete block design with 3 replications and evaluated for survival, vigor, plant density, height, lodging resistance, disease and insect damage, seed production, and germination.

Based on evaluations of plots established in 2003, these "Finalists" were identified and placed in a randomized complete block field plot with 3 replicates at the Rose Lake PMC in June 2005 after having been established in greenhouse cone-tainers:

9086418

9084535

9084191

9084533

9084360

9084186

Summary Data recorded at the PMC is summarized in Table 6. Significant differences among entries were observed in vigor and height. Observations will continue. Selection decisions may be made at the end of the 2007 season.

Table 6. Bottlebrush grass plant growth data, Rose Lake PMC advanced test site. 2006.[1]

Accession	Vigor[2]	Insect Damage[2]	Height (ft)	Median Flowering Stage
9086418	3.7	1.0	2.5	Combine ripe
9084535	3.3	1.0	2.3	Soft dough
9084191	2.3	1.0	2.5	Soft dough – hard dough
9084533	5.0	1.0	1.7	Combine ripe
9084360	2.0	1.0	2.8	Soft dough
9084186	2.0	1.0	2.8	Soft dough – hard dough
Grand Mean	3.1	1.0	2.4	
$LSD_{(0.05)}$	1.0	n.s.	0.7	

[1]Established 24 June 2005. Evaluated 2 Aug 2006.

[2]Vigor and insect damage: 1 = excellent vigor or no insect damage; 9 = poor vigor or insect damage

IMPROVED WARM-SEASON FORAGE GRASS

Warm and cool-season grasses have contrasting patterns of yield distribution. Warm season grasses produce more than 60% of their yield in mid-summer, while cool-season grasses have their greatest production in spring and fall. Cool and warm-season grasses can best be used in grazing systems that utilize separate pastures for each grass type. Including warm-season grasses in a grazing system permits resting cool-season grasses in mid-summer which improves their vigor and enhances forage production in the late summer and early fall. Cool-season grasses can be grazed in spring and fall and warm-season grasses during mid-summer.

Problems Currently, there are no commercial native warm season forage grass varieties originating from the area covered by the Rose Lake PMC. Concerns are growing over the loss of native germplasm.

Needs Native warm-season grasses are needed that:

- originate from the Great Lakes/Midwest States
- have good forage yields
- have good palatability and nutrition for livestock
- persist under grazing
- establish rapidly
- have good seed production

Study No. MIPMC-T-0302-PA and MIPMC-T-0303-PA
Eastern Gamagrass (*Tripsacum dactyloides*) for Forage Production

Background Eastern gamagrass is a native warm-season perennial that can be found throughout the eastern half of the US. It is a highly productive grass that is best adapted to wet habitats. Remnant colonies are commonly found in flood plains along stream banks. Eastern gamagrass is in the same taxonomic family (Poaceae) as field corn (*Zea mays*) and is characterized by numerous short, well-developed rhizomes. Individual grass clumps can reach a diameter of 4 ft with seed heads growing on culms 3- to 9-ft tall.

Eastern gamagrass produces the majority of its growth from late spring through late September. It begins growing earlier in the spring than do other native grasses such as big bluestem (*Andropogon gerardii*) and switchgrass (*Panicum virgatum*). The distribution of eastern gamagrass yield throughout the summer makes this grass an excellent source of forage during the period of the year when cool-season grasses are relatively dormant.

Several eastern gamagrass varieties are well adapted to the central and southern United States. The Big Flats Plant Materials Center, near Corning, NY, is evaluating several eastern gamagrass accessions to determine adaptability in the northern regions of the United States. Little research has been done in Michigan to demonstrate adaptability of any eastern gamagrass releases or experimental accessions in the Great Lakes area.

Project Description Seedlings of commercial cultivars 'Pete' and 'Highlander' and two experimental accessions from Big Flats Plant Materials Center, 9086456 (diploid) and 591483 (tetraploid) [cooperatively released as 'Meadowcrest' in 2006 by the U.S. Department of Agriculture, Natural Resources Conservation Service, New York State College of Agriculture and Life Sciences, Cornell University and the U.S. Department of Agriculture, Agricultural Research Service], were placed in a field comparison to determine survival, plant growth, and forage quality. A second study was established using a single cultivar to evaluate the effect of row spacing and forage harvest height (simulated grazing) on forage quality and stand survival.

Accession Study Procedures In June 2003 seedlings of Highlander and Pete eastern gamagrass were received from the J.L. Whitten PMC near Coffeeville, MS and accessions 9086456 and Meadowcrest were received from the Big Flats PMC. Seedlings were transplanted into a field study site at Rose Lake PMC. Each plot contained three rows of five plants. Plants were spaced 36 inches apart within the row and rows were spaced 30 inches apart. The study was conducted in a randomized complete block with three replicates per accession (although one replication was subsequently abandoned due to competition from adjacent vegetation). The site was irrigated to insure good survival after transplanting. All plots were fertilized and herbicides were applied as needed. Data were taken from the center row of each plot throughout the course of the study.

Forage Production Study Procedures A forage production study was initiated by planting stratified Pete eastern gamagrass seed on 17 June 2003 in plots having row spacing of 15 inches or 30 inches between rows. Plots with 15-in row spacing were planted with a seeding rate of 2 seeds/row ft. Plots with 30-in row spacing were planted with a seeding rate of 4 seeds/row ft. Seeds were planted 1 inch deep. Each plot was divided in 2004 by superimposing two cutting heights (simulated grazing). The study was conducted in a randomized complete block experimental design with four replicates per treatment. The site was irrigated to insure good survival after planting. All plots were fertilized and herbicides were applied as needed. Data is being taken from the center of each plot throughout the course of the study.

Accession Study Results Dry matter production differences were observed in 2005 with Meadowcrest NY Tetraploid and Highlander significantly out yielding Pete and NY Diploid (Table 7). Significant yield differences were not observed in 2004 or 2006. Significant differences in crude protein, acid detergent fiber, and neutral detergent fiber were not observed in 2006 – the only year for which quality data was analyzed.

Table 7. Gamagrass dry matter yield in accession trial.[1]

	2006				2005	2004
Cultivar	Dry matter yield (lbs/plot)	CP (%)	ADF (%)	NDF (%)	Dry matter yield (lbs/plot)	Dry matter yield (lbs/plot)
Pete	7.2	12.3	41.5	82.8	4.6	1.7
Highlander	13.9	11.1	42.8	81.1	6.2	2.0
NY Diploid (Accession 9086456)	7.6	11.0	41.7	82.4	3.9	2.0
Meadowcrest NY Tetraploid (Accession 591483)	7.5	10.5	42.5	80.9	6.3	2.0
Mean	9.1	11.2	42.1	81.8	5.3	1.9
LSD $_{(0.05)}$ within column	n.s.	n.s.	n.s.	n.s.	1.4	n.s.

[1]2006 harvests on 9 June, 11 July, and 17 Aug; two cuts in 2005 and 2004

Forage Study Results and Discussion Significant differences were observed in forage yield, crude protein, and acid detergent fiber (Table 8). Treatments using high-cut treatments (i.e., newest growth harvested) produced higher quality forage than low-cut treatments. This study will be continued in 2007 to observe any cumulative effect of treatment imposition.

Table 8. Effect of row width and cutting height on gamagrass forage yield and quality. Rose Lake PMC. 2006[1].

	Yield (lbs/plot)	%CP	%ADF	%NDF
Wide, high	13.8	11.7	39.6	83.1
Wide, low	17.8	10.4	40.1	83.2
Narrow, high	15.9	12.5	39.6	83.0
Narrow, low	16.6	10.8	41.1	83.5
Mean	16.0	11.4	40.1	83.2
$LSD_{(0.05)}$ within column	3.4	1.6	1.0	n.s.

[1]Harvests on 9 June, 11 July, and 17 Aug.

Study No. MIPMC-T-0502-PA Timing Eastern Gamagrass (*Tripsacum dactyloides* L.) Planting To Break Seed Dormancy

Background Eastern gamagrass is a perennial, warm-season grass that has good forage yield and quality and soil conservation characteristics. However, seed dormancy presents a barrier to on-farm establishment. Dormancy breaking techniques (e.g., premoistening and prechilling) are expensive and laborious. There is little information on timing of planting and its effect on breaking dormancy. The purpose of this study was to determine optimum planting time for breaking seed dormancy in eastern gamagrass in Michigan.

Materials and Methods Commercially available eastern gamagrass was seeded at approximate 15-day intervals starting in October 2006 in randomized complete blocks with four replicates at four locations: Rose Lake Plant Materials Center (PMC), Michigan State University Agronomy Farm (MSU), Straub Farm in Clinton County, and Michigan State University Lake City Experiment Station. Seeding depth was 1.25 in. Interval seedings was resumed in late winter or early spring as weather and soil conditions permitted. As an additional treatment variable in late winter and spring seedings, seeds were soaked for 2 hours in 30% H_2O_2. Plant emergence counts were taken through late summer.

Table 9. Emergence of gamagrass as recorded in late summer 2006.

Seeding Date	Seed Treatment	PMC	MSU	Straub Farm	Lake City
		% Total Emergence			
Early October	None	3ab[†]	0a	1	0 b
Mid October		0 b	1a	0	1 b
Early November		1 b	0a	0	1 b
Mid November		0 b	1a	0	1 b
late March – early April	H_2O_2	0 b	0a	3	n.a.
	None	0 b	1a	1	n.a.
Mid April	H_2O_2	6a	4a	3	13a
	None	3ab	3a	0	3 b

[†]Means within a column followed by the same letter are not different (P>0.05) by Statistix 8.1 LSD test. LSD was not calculated at Straub Farm due to confounding.

Results are shown in Table 9. Emergence ranged from 0 - 13%. Emergence of seed planted in mid April and treated with H_2O_2 (shaded area in table) exceeded or was not significantly different from all other seeding date and treatment combinations. Straub Farm data were not analyzed because run-on water confounded results by washing away seeds in some blocks.

Conclusion and Application Summary Eastern gamagrass offers considerable forage and conservation possibilities, but establishment challenges remain. Consistent with other published reports, the H_2O_2 treatment contributed (albeit slightly) to breaking seed dormancy and increasing emergence. Over-winter weather conditions did not appear to have any dormancy-breaking effect.

Emergence rates ranged from 0 - 13%. This low emergence was partially attributable to natural seed dormancy (50% as shown on seed tag). (Previous PMC studies have shown some seeds not emerging until the second and third years following seeding.) The effect of seed dormancy on emergence was likely exacerbated by predation and seed degradation in the cold, wet soil.

Another study being considered at the PMC will focus on the cause of low emergence. Seeds from the same lot in the above study will be cold stratified and grown in the greenhouse. Further evaluation of treatments (e.g., H_2O_2, premoistening, and prechilling) and/or other commercially available or proprietary means of breaking seed dormancy will be necessary if challenges of establishing gamagrass are to be overcome.

Acknowledgements Plot space at the Michigan State University Agronomy Farm, Straub Farm, and Michigan State University Lake City Experiment Station and the cooperation of individuals at each location is gratefully acknowledged.

FOREST IMPROVEMENT AND WINDBREAK TECHNOLOGY

Forestland accounts for up to 30 percent of the agricultural land in Michigan. Considerable emphasis has been placed on establishing, maintaining, and improving forestland in Michigan. Several NRCS conservation programs encourage these practices.

In addition to forestland, trees and shrubs are used in windbreaks, riparian areas, filter strips, and wildlife corridors. Windbreak planting is practiced on almost all soil types within the PMC service area.

Problems

- Tree and shrub transplanting can be expensive and labor intensive.
- Direct seeding of tree and shrub species is not well understood in the PMC service area.
- Soil type influences tree or shrub species selection for windbreaks and other woody species plantings. Species establishment in muck soils is not as well understood as establishment in upland soils.

Study No. MIPMC-T-0404-BU
Windbreaks in Muck Soils

Background Huron County in North Central Ohio has a significant area of muck soil. Called Celeryville Marsh, this area is known for its vegetable production. However, wind erosion threatens the soils and their productivity. In the past farmers removed nearly all the trees to expand their fields because the trees exhibited undesirable characteristics. Now windbreaks are needed to protect this valuable soil. Renewed interest in establishing windbreaks has created a demand for information on which species will perform best and be accepted by farmers. Desirable characteristics include rapid growth, sufficient height for wind erosion protection, longevity, little breakage, low maintenance, and limited spread.

Description of Study Plant species were selected and evaluated for establishment and survival in windbreaks on muck soils. A series of "tall" species and a series of "short" species were planted in replicated plots to determine the effectiveness of these species as windbreak components.

Materials and Methods Twelve tree or shrub species were evaluated for effectiveness as windbreaks. "Tall" plants included arborvitae, hybrid crabapple, bald cypress, pin oak, and austree willow. "Short" plants included privet, silky willow, silky dogwood, highbush cranberry, Sargent's crabapple, black chokeberry, and lilac.

The Rose Lake Plant Materials Center provided 'Affinity' arborvitae, Riverbend Germplasm silky willow, 'Magenta' hybrid crabapple, 'Indigo' silky dogwood, and

Leelanau Germplasm highbush cranberry. Ohio DNR and OARDC provided the other species needed for the study.

OARDC planted the species in randomized, replicated field plots during spring 2004. The species will be evaluated annually for growth characteristics and general windbreak effectiveness.

Results Data were not reported in 2006.

Study No. MIPMC-T-0301-WO
Direct Seeding Tree and Shrub Establishment

Background Direct seeding of hardwoods offers an alternative to the high cost of establishing new or re-stocking existing stands of hardwood species in Michigan. Direct seeding of hardwoods is successful in Indiana, Ohio, Wisconsin, Illinois, and Missouri. The practice is generally recognized as an effective alternative to planting hardwood tree seedlings. Direct seeding of hardwoods is currently a cost-shared component in of USDA conservation programs in some states. There is little current research or written information specific to Michigan for establishing or enhancing hardwood stands by direct seeding.

Description of Study A selection of hardwood tree and shrub species was planted by direct seeding in 2003. A second study was established in 2003 and 2004. Plots are being evaluated for emergence, survival, and plant growth characteristics for up to five years.

Procedure Seeds of seven heavy mast and seven light mast hardwood tree and shrub species were planted in field studies at the Rose Lake Plant Materials Center. (Species are listed in Table 10.) Planting dates were May 2003 and November 2003 in the first study. Planting density was approximately 4500 seeds/acre for each species. Soil in the test area is Boyer sandy loam or loamy sand. Each species was:

1) broadcast on tilled soil, followed by dragging and cultipacking;
2) drilled in rows (rows 1.5 ft apart, seeds 8-in spacing within rows) in tilled soil, followed by cultipacking; and
3) drilled in rows (rows 1.5 ft apart, seeds 8-in spacing within rows) in non-tilled soil, followed by cultipacking

Separate heavy mast and light mast studies were established each with three replicates in a randomized complete block design. Non-tilled plots were sprayed with glyphosate herbicide to control all emerged vegetation before seeds were planted. A rodent control product was placed in several locations across the trial. No fertilizer or irrigation was applied. Stands were evaluated in 2003, 2004, and 2005. Plants were counted in rows in the drilled plots and by a transect method in the broadcast plots.

A second study was established with plantings in fall 2003 and spring 2004 and with seeds drilled into tilled and non-tilled soil. Each treatment combination was planted in rows 1.5 ft apart with 8-in seed spacing within rows (43560 seeds per acre). There were three replicates in a randomized complete block design. Species were pignut hickory (*Carya glabra*), shellbark hickory (*Carya laciniosa*), bitternut hickory (*Carya cordiformis*), common winterberry (*Ilex verticillata*), and sugar maple (*Acer saccharum*).

Results Data collected in 2005 and reported in the 2005 RLPMC Technical Report suggest that fall plantings and heavier, larger mast seeds fare better than spring plantings and lighter, smaller mast seeds. Data were not collected in 2006.

Results of the second study (Table 4) corroborated findings of the first study: Fall-plantings and heavier, larger mast seeds fare better than spring-plantings and lighter, smaller mast seeds.

Discussion Droughty soil and growing season conditions (summer of 2003) may have reduced the emergence of seedlings, especially for light-seeded species which were planted at a shallow, but appropriate depth. Fall planting dates give seeds the advantage of the earliest possible start to the growing season and an opportunity to extend roots deeper into the soil before summer heat and drought begin.

Drilled seed has the advantage of relatively accurate and consistent seed depth. Broadcast seeding produces a more natural plantation but a random seed depth; some will be deeper than ideal depth and some will be on the soil surface and subject to drying and consumption by seed-eating mammals and birds.

The trend in forest regeneration is toward increasing rates of trees planted per acre. A comparison of normal tree seedling planting practice shows that direct seeding can result in a higher number of seedlings per acre compared to seedling planting. A common seedling tree planting rate is 436/acre (10-ft X 10-ft spacing). Acceptable survival for many purposes is 80% or about 350 seedlings/acre. Several direct seeded species and techniques equaled or exceeded the typical seedling tree planting rates and survival expectations.

Although an economic analysis was not included in this study, it would appear that direct seeding could be accomplished at lower costs/acre than with seeding tree planting. Because direct seeding can result in higher numbers of seedlings per acre the cost per established seedling may be much lower with direct seeding than with seedling tree planting.

Table 10. Species planted in first direct seeding tree and shrub study in 2003.	
Common Name	**Scientific Name**
Heavy Mast Species	
Northern Red Oak	*Quercus rubra*
White Oak	*Quercus alba*
Scarlet Oak	*Quercus coccinea*
Bur Oak	*Quercus macrocarpa*
Black Walnut	*Juglans nigra*
Black Cherry	*Prunus serotina*
Shagbark Hickory	*Carya ovata*
Light Mast Species	
Arrowwood / Highbush Cranberry*	*Viburnum dentatum / Viburnum trilobum*
Staghorn Sumac	*Rhus typhina*
Green Ash	*Fraxinus pennsylvanica*
White Ash	*Fraxinus americana*
Red Maple	*Acer rubrum*
Silver Maple	*Acer saccharinum*
White Birch	*Betula papyrifera*
* Arrowwood was used in the spring 2003 planting and highbush cranberry was used in the fall 2003 planting.	

Study No. MIPMC-P-0402-WO
Direct Seeding of Northern Red Oak (*Quercus rubra*)

Background Beech bark disease causes significant defect and mortality in American beech (*Fagus grandifolia*). The disease results when bark, attacked and altered by the beech scale (*Cryptococcus fagisuga*) is invaded and killed by fungi, primarily *Nectria coccinea* var. *faginata*, and sometimes *N. galligena*.

Beech bark disease is becoming a serious pest in the Eastern Upper Peninsula (UP) and in the West Central Lower Peninsula of Michigan, threatening to destroy the beech component of these forests and spread throughout Michigan. Though not a prized wood for timber, American beech is an important heavy mast crop for wildlife. In some areas of Michigan, particularly the Eastern UP, it is the only heavy mast crop available to bear, turkey, deer, and grouse. Much interest has been generated in replacing beech as it dies off with red oak, since it is the hardiest and most northerly growing of the black oak group. There has been some discussion of whether direct seeding might be a reasonable alternative to transplanting.

Materials and Methods Side-by-side comparisons of direct-seeded and transplanted Northern red oak (*Quercus rubra*) were established in the Eastern UP in 2004. Site selection was based on proximity of broken canopy and open sunlight so oak seedling performance could be evaluated in both environments. Acorns and seedlings were supplied by the Rose Lake PMC to cooperators representing nine sites in the Upper

Peninsula. Suggested field design was a row of 100 red oak acorns to be planted next to a row of 25 red oak seedlings with three rows of each treatment per test site. Broken canopy and open sunlight sites were to be paired and in close proximity. Acorns were to be planted 1.5-in deep (2 times the diameter of the acorn) approximately 1 ft apart within a row with rows spaced 5 ft apart. Seedlings were to be spaced 4 ft apart within a row with rows spaced 5 ft apart.

Planting date was in spring 2004. Data were collected in 2004, 2005, and 2006 on oak survival and average plant height. Data were also to be collected on other species that establish in the test site, including species name, density, and height.

Results and Discussion Survival and height data are presented in Table 11. Survival and height generally appeared greater in transplants than direct-seeded plants. Differences in response to broken canopy vs. open sunlight were inconsistent. Little or no increase in plant height was observed from 2004 to 2006, perhaps due to extremely dry summers.

Design differences among the eight locations rendered them not amenable to an across-all-sites statistical analysis.

Table 11. Performance of direct seeded and transplanted northern red oak in Michigan's Upper Peninsula.

Location	Site Description	Treatment	Survival (%)			Height (inches)		
			2004	2005	2006	2004	2005	2006
Luce County (site 1)	Broken canopy opening, northern hardwood stand	Direct Seeding	91	91	77	4	4	5
		Transplant	100	100	92	8.6	9.3	10.3
Luce County (site 2)	Edge open meadow, east side	Direct Seeding	40	40	36	4	4	5
		Transplant	90	86	76	7.2	8	7
Luce County (site 3)	Edge open meadow, west side	Direct Seeding	20	25	21	3	3	5.5
Luce County (site 4)	Edge open meadow, lower elevation	Direct Seeding	67	60	55	4	4	6
		Transplant	100	95	95	7.6	8.5	11.8
Luce County (site 5)	Broken canopy opening, aspen clear cut	Direct Seeding	71	82	32	3	3	3
		Transplant	67	67	22	6.5	7.5	5.5
Luce County (site 6)	Open meadow	Direct Seeding	60	40	23	4	4	4.3
		Transplant	83	83	77	7.2	8.2	6.6
Luce County (site 7)	Broken canopy opening, aspen	Direct Seeding	37	38	42	4	4	4
Mackinac County (Northern Timberland Ventures Inc., site)	old pasture reverting back to forest. sandy loam	Direct Seeding	71	31	9	3.7	4	3
		Transplant	95	77	16	8.6	9	9.3

NATIVE PLANT SPECIES TO ENHANCE WILDLIFE HABITAT

With controversy surrounding non-native species, particularly in undomesticated settings, interest in native ecotypes has risen sharply. Some non-native species historically used in wildlife plantings have been labeled aggressive or invasive or less beneficial to wildlife than many native species.

Problem Availability of Great-Lakes area native plant species for wildlife use is limited.

Needs Native species are needed for wildlife food plots, shelter, nesting, and brood rearing cover that:

- originate from the Great Lakes/Midwest States
- have good survival, vigor, and seed and foliage production
- have documented wildlife benefit
- meet the criteria for non-invasive plants

Study No. 26I080J
Tick-trefoil (*Desmodium spp*.) for Wildlife Food Plots

Background In the United States there are 30 species of *Desmodium*. All are native, perennial legumes with trifoliate (or rarely 1 to 5 foliate) leaves, purple flowers, and flat, deeply lobed or jointed pods. The joints of the pods easily separate and attach to clothing or animals by means of small hooked hairs, hence the common names tickclover, tick trefoil, and beggar's lice. These species are well distributed throughout most of the eastern and central states with several also in the southwest. Most inhabit dry, sandy, open woods or slightly shaded areas. Seeds of *Desmodium* have been found in the stomachs of masked bobwhite, lesser scaup duck, eastern ruffed grouse, slate-colored junco, ring-necked pheasant, willow ptarmigan, Gambel quail, Mearns quail, red-eyed towhee, Virginia opossum, and Bangs flying squirrel. Their seeds are also said to be eaten by the greater prairie chicken and sharp-tailed grouse in Minnesota and eastern turkey in Missouri.

Description of Study This study plans calls for assembly and evaluation of *Desmodium spp*. and selection of a superior accession for use in establishment of wildlife food plots. The development of harvesting, cleaning, and seeding procedures for seed and plant increase will be included.

Procedure In 1988, seed from 49 accessions of various *Desmodium* species was field collected from eight states and 16 MLRAs, and assembled at the Rose Lake Plant Materials Center. Each accession was grown in the greenhouse for preliminary observation the following year. In 1990, forty accessions were transplanted into field plots arranged in a randomized, complete block for an initial 2-year evaluation period. Five accessions were selected for advanced testing based on survival, vigor, foliage,

flower and seed production, and maturity date. The advanced trial was completed in 1992.

Releases Three accessions were selected for increase and potential release (Table12). Two accession were issued as tested releases for the Great Lakes and upper Midwest regions and named after their county of origin. Generation 1 plants will be maintained at the Rose Lake Plant Materials Center. Foundation seed increase seed plots were established for each potential release in 2003 with additional plants added to those fields in 2004 and 2005.

Table 12. *Desmodium* species released or selected for potential release.

Accession No	Release Name	Scientific Name	State of Origin	Maturity Period	Release Date
9005087	Marion Germplasm Dillenius' tick-trefoil	*Desmodium glabellum*	IL	Mid-season	pending
9055415	Alcona Germplasm Dillenius' tick-trefoil	*Desmodium glabellum*	MI	Early-season	2006
9055428	Grant Germplasm Panicledleaf tick-trefoil	*Desmodium paniculatum*	WI	Mid-season	2006

APPENDIX A

RELEASED MATERIAL

'Affinity' (*Thuja occidentalis* L.) Northern White Cedar
Released: 1993 (FY1993)
Accession Number: 9005060 (PI Number: 477011)
Release Type: cultivar
Plant Origin: native
Collection Location: Pulaski Co., IN
Plant Type: tree
Plant Duration: perennial
Propagation: seed
Uses: field and farmstead windbreaks, screen or border planting in urban situations, and winter browse

Alcona Germplasm (*Desmodium glabellum* (Michx.) DC.) Dillenius' Tick-Trefoil
Released: 2006 (FY2006)
Accession Number: 9055415
Release Type: tested germplasm
Plant Origin: native
Collection Location: Alcona County, MI
Plant Type: legume
Plant Duration: perennial
Propagation: seed
Uses: wildlife food plots as an alternative to introduced plant species

Grant Germplasm (*Desmodium* paniculatum (L.) DC.) Panicledleaf Tick-Trefoil
Released: 2006 (FY2006)
Accession Number: 9055428
Release Type: tested germplasm
Plant Origin: native
Collection Location: Grant County, WI
Plant Type: legume
Plant Duration: perennial
Propagation: seed
Uses: wildlife food plots as an alternative to introduced plant species

Icy Blue Germplasm (*Elymus canadensis* L.) Canada Wildrye
Released: 2004 (FY2004)
Accession Number: 9084347 (PI Number 641962)
Release Type: tested germplasm
Plant Origin: native
Collection Location: LaPorte County, IN
Plant Type: cool-season grass
Plant Duration: perennial
Propagation: seed
Uses: restoration, wildlife cover, and erosion control
Registration Document: Durling, J.C., J.W. Leif, and D.W. Burgdorf. 2006. Registration of icy blue Canada wildrye germplasm. Crop Sci. 46:2330-2331.

‘Imperial’ (*Populus canadensis* Moench var. *eugenei* (Simon-Louis) Schelle) Carolina Poplar
Released: 1979 (FY1979)
Accession Number: Mich-88 (PI Number: 432347)
Release Type: cultivar
Plant Origin: introduced
Collection Location: Rice Co., MN
Plant Type: tree
Plant Duration: perennial
Propagation: vegetative
Uses: windbreaks (especially around orchards) and pulpwood

‘Indigo’ (*Cornus amomum* P. Mill.) Silky Dogwood
Released: 1982 (FY1982)
Accession Number: 9031863 (PI Number 468117)
Release Type: cultivar
Plant Origin: native
Collection Location: Clinton Co., MI
Plant Type: shrub
Plant Duration: perennial
Propagation: seed or vegetative
Uses: single row windbreak under center pivot irrigation, field and farmstead windbreak, soil bioengineering, and wildlife food

‘Lancer’ (*Lathyrus latifolius* L.) Perennial Pea
Released: 1984 (FY1984)
Accession Number: 477009 (PI Number 477009)
Release Type: cultivar
Plant Origin: naturalized
Collection Location: MI
Plant Type: legume
Plant Duration: perennial
Propagation: seed
Uses: erosion control plant, wildlife cover plant, land reclamation, brush management, roadside seeding mixtures, critical area planting where objective includes beautification

Leelanau Germplasm (*Viburnum opulus* L. var. *americanum* Ait.) Highbush Cranberry
Released: 1999 (FY1999)
Accession Number: 9031863
Release Type: selected
Plant Origin: native
Collection Location: Leelanau Co., MI
Plant Type: shrub
Plant Duration: perennial
Propagation: vegetative
Uses: windbreaks (especially on wet or organic soils) and wildlife habitat

'Magenta' (*Malus sp*.) Hybrid Crabapple
Released: 1990 (FY1990)
Accession Number: 9005032
Release Type: cultivar
Plant Origin: introduced
Collection Location: Clinton Co., MI
Plant Type: tree
Plant Duration: perennial
Propagation: seed
Uses: small tree for single row windbreaks & beautification

Prairie View Indiana Germplasm (*Andropogon gerardii* Vitman) Big Bluestem
Released: 2005 (FY2005)
Accession number: 9086588
Release Type: Selected
Plant Origin: Native
Collection Location: Indiana
Plant Type: warm-season grass
Plant Duration: perennial
Propagation: seed
Uses: wildlife food/cover, erosion control, increased species diversity, and native environment restoration

Prairie View Indiana Germplasm (*Schizachyrium scoparium* (Michx.)) Little Bluestem
Released: 2005 (FY2005)
Accession number: 9086577
Release Type: Selected
Plant Origin: Native
Collection Location: Indiana
Plant Type: warm-season grass
Plant Duration: perennial
Propagation: seed
Uses: wildlife food/cover, erosion control, increased species diversity, and native environment restoration

Prairie View Indiana Germplasm (*Sorghastrum nutans* (L.) Nash) Indiangrass
Released: 2005 (FY2005)
Accession number: 9086566
Release Type: Selected
Plant Origin: Native
Collection Location: Indiana
Plant Type: warm-season grass
Plant Duration: perennial
Propagation: seed
Uses: wildlife food/cover, erosion control, increased species diversity, and native environment restoration

Riverbend Germplasm (*Salix sericea* Marsh.) Silky Willow
Released: 2003 (FY2003)
Accession Number: 9069052
Release Type: tested
Plant Origin: native
Collection Location: Daviess County, IN
Plant Type: shrub
Plant Duration: perennial
Propagation: vegetative
Uses: streambank/shoreline restoration and riparian corridors

'Roselow' (*Malus sargentii* Rehder) Sargent's Crabapple
Released: 1978 (FY1978)
Accession Number: 9005026 (PI Number: 477986)
Release Type: cultivar
Plant Origin: introduced
Collection Location: Japan
Plant Type: tree
Plant Duration: perennial
Propagation: seed
Uses: farm and field windbreaks

Southlow Michigan Germplasm (*Andropogon gerardii* Vitman) Big Bluestem
Released: 2001 (FY2001)
Accession number: 9084510
Release Type: Source Identified
Plant Origin: Native
Collection Location: Southern Lower Michigan
Plant Type: warm-season grass
Plant Duration: perennial
Propagation: seed
Uses: wildlife cover filter strips
Registration Document: Durling, J.C., J.W. Leif, and D.W. Burgdorf. 2007. Registration of icy blue Canada wildrye germplasm. Crop Sci. 47:455.

Southlow Michigan Germplasm (*Panicum virgatum* L.) Switchgrass
Released: 2001 (FY2001)
Accession number: 9084512
Release Type: Source Identified
Plant Origin: Native
Collection Location: Southern Lower Michigan
Plant Type: warm-season grass
Plant Duration: perennial
Propagation: seed
Uses: wildlife food/cover, erosion control, increased species diversity, and native environment restoration

Southlow Michigan Germplasm (*Schizachyrium scoparium* (Michx.) Nash) Little Bluestem
Released: 2001 (FY2001)
Accession number: 9084511
Release Type: Source Identified
Plant Origin: Native
Collection Location: Southern Lower Michigan
Plant Type: warm-season grass
Plant Duration: perennial
Propagation: seed
Uses: wildlife food/cover, erosion control, increased species diversity, and native environment restoration

Southlow Michigan Germplasm (*Sorghastrum nutans* L. Nash) Indiangrass
Released: 2001 (FY2001)
Accession number: 9084513
Release Type: Source Identified
Plant Origin: Native
Collection Location: Southern Lower Michigan
Plant Type: warm-season grass
Plant Duration: perennial
Propagation: seed
Uses: wildlife food/cover, erosion control, increased species diversity, and native environment restoration

APPENDIX B

CUSTOMER ASSISTANCE SUMMARY

The Rose Lake Plant Materials Center recorded 98 customer assists during FY 2006. Time spent per assist ranged from 10 minutes to 4 hours. Assistance was provided to individuals and groups. Partners and government agencies receiving assistance included:

Apostle Island National Lakeshore
Bay Mills Community College
Clinton County Road Commission
College of DuPage/Natural & Applied Sciences Division
Ft. Custer Military Training Center
Gun Lake, Huron, and Pokagon Band of Potawatomi Indians
Indiana DNR
Jasper-Pulaski Fish & Wildlife Center
Michigan DNR
MI Dept. of Agriculture
Michigan State University
National Park Service
Saginaw Chippewa Indian Tribe
Syngenta Corporation
US Forest Service

The Rose Lake Center created 24 publications and made 26 presentations during 2006. Presentations were to groups ranging to 125 people (e.g., NRCS All-Employee Meeting and Picnic on 26 July 2006).

APPENDIX C

2006 WEATHER

Table 13. Temperature and precipitation data (deviation from long-term average) for Rose Lake PMC for 2006 growing season.[1]

	May	June	July	Aug	Sept
Average Daily Maximum (°F)	69.0 (-1.0)	78.5 (-1.5)	83.7 (-0.6)	80.4 (-2.1)	68.9 (-6.0)
Average Daily Minimum (°F)	46.3 (1.3)	51.5 (-3.9)	58.2 (-1.0)	56.6 (-0.7)	47.3 (-3.4)
Precipitation (in)	5.6 (2.6)	3.0 (-0.6)	7.1 (4.3)	3.1 (-0.1)	2.4 (-0.3)

[1]Rose Lake PMC data based on records from Michigan State University Muck Research Farm in Laingsburg, MI, about 3 miles from Rose Lake PMC. Data available on-line at http://www.agweather.geo.msu.edu/mawn/ Long-term averages as recorded in Soil Surveys of Clinton and Shiawassee Counties.

Summary At the Rose Lake PMC in 2006, growing season temperatures were lower and precipitation amounts were greater than long-term averages.

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