

Appendix E

Calcareous Fen Reports



MINNESOTA DEPARTMENT OF NATURAL RESOURCES
Division of Ecological and Water Resources
21371 Highway 15 South
New Ulm, MN 56073
kevin.mixon@state.mn.us
507-359-6073

May 3, 2016

Sean Flannery
Renewable Energy Systems Americas Inc.
330 2nd Avenue South, Suite 820
Minneapolis, MN 55401

Subject: Bitter Root Large Wind Energy Conversion System (LWECS)
DNR Preliminary Review
Yellow Medicine County, MN

Dear Mr. Flannery:

The Minnesota Department of Natural Resources (MNDNR) appreciates the opportunity to review and comment on the proposed Bitter Root Large Wind Energy Conversion System. When compared to most other wind projects in southern Minnesota this project area contains a significant amount of habitat within and adjacent to the project area. Native prairie, lakes, wetlands (including calcareous fens), streams, grassland, and pasture are prevalent throughout the project area. In addition, bat roosting potential exists along the forested portions of streams as well as the groves of trees found around home sites. Some of the trees are old enough for lose bark, have died, or are damaged and they have the loose bark conditions or fissures that bats use for summer roosting. As such, the MNDNR believes this site poses a high risk to wildlife, especially bats.

The MNDNR recommends the following four strategies be considered in order to minimize the potential impacts:

- 1) Consider developing a LWECS at a more appropriate location that does not contain as much habitat for birds and bats.
- 2) Consider expanding the project boundary into areas that are lower risk than some of the area that has been proposed.
- 3) Consider developing a smaller size project that is lower in MW that will result in a reduction of turbines that can be sited more appropriately.
- 4) Use higher MW rated turbines in order to reduce the number of turbines. Fewer turbines results in less access roads, transmission lines, collector lines, and crane paths. The use of fewer turbines ultimately results in a reduction in impacts to natural resources.

Please review the "DNR Guidance for Commercial Wind Energy Projects" and "Avian and Bat Survey Protocols For Wind Energy Projects" for our standard commercial wind project recommendations. Both of the guidance documents can be located at the following web link: (http://www.dnr.state.mn.us/eco/ereview/additional_resources.html). The MNDNR Guidance For Commercial Wind Energy Projects should be reviewed and considered throughout project development. The following specific sections are known to pertain to this project area: Rare Species and Native Plant Communities, Native Prairies, Public Conservation and Recreation

Lands, Properties in Government Programs or With Conservation Easements, and Lakes, Wetlands, Streams, and Rivers.

The MNDNR recommends that scientifically rigorous fatality monitoring be conducted for this project. Please review the Avian and Bat Survey Protocols on the MNDNR website (http://www.dnr.state.mn.us/eco/ereview/additional_resources.html) in order to develop a specific fatality monitoring plan. The fatality monitoring plan should be included in the PUC required Avian and Bat Protection Plan (ABPP) as it will be a key component to assess project impacts. As a high risk site, the DNR recommends a minimum of 2 years of fatality monitoring using scientifically valid protocols.

The MNDNR will be recommending that the PUC Site Permit include a requirement for feathering turbine blades when operating below the cut-in speed for the life span of the project. Arnet et al. (2013) describes one project that discovered feathering turbine blades at or below the manufacturer's cut-in speed resulted in up to 72% fewer bats killed when turbines produced no electricity into the power grid (link attached). The American Wind Energy Association (AWEA) and other states, i.e. Nebraska, have already recommended feathering of turbine blades to reduce bat fatalities. AWEA expects feathering of the blades to reduce impacts to bats from operating wind turbines by as much as 30 percent. Feathering turbine blades below the cut-in speed is likely to reduce bat fatalities/bat fatality estimates and decrease the need for additional operational mitigation.

If bat fatalities are high, despite feathering of the blades, then operational mitigation such as raising the cut-in-speed will need to be discussed as a mechanism to reduce fatalities. Raising the cut-in-speed has been shown to significantly reduce bat fatalities at numerous commercial wind facilities. Arnet et al. (2013) provided a synthesis of operational mitigation studies to reduce bat fatalities at 10 different wind projects. Most of the studies found that at least a 50% reduction in bat fatalities occurs when turbine cut-in speed was increased by 1.5 m/s above the manufacturer's cut-in speed. They also concluded that changing the cut-in speed offers an ecologically sound and economically feasible strategy for reducing bat fatalities at wind energy facilities. The MNDNR is indicating a potential need for operational mitigation early in the process so the project proponent can make decisions on turbine placement that may minimize bat fatalities and to factor in the possibility of future operational mitigation if high bat fatalities occur.

The Adaptive Management section of the PUC Site Permit should also include information on other factors that may influence the need for operational changes. Factors including but not limited to bat species killed, turbine specific fatalities, and a facility wide bat fatality estimate. The ABPP should include a specific list of options that can be deployed to reduce bat fatalities, if necessary. Monitoring for effectiveness of the operational changes would also be needed to determine their ability to reduce bat fatalities.

Calcareous fens are known to occur within the project boundary and they may occur at other unidentified locations. Calcareous fens must not be impacted or otherwise altered or degraded, wholly or partially, by any action, unless the commissioner, under an approved management plan, decides some alteration is necessary (Wetland Conservation Act Rules 8420.0935). Calcareous fens will need to be identified so they can be avoided. Avoidance would apply to all

infrastructure associated with the project including but not limited to: turbines, access roads, collector lines, transmission lines, crane paths, and temporary construction areas. Please be advised that avoidance is not only related to direct impacts, but also to any type of construction that could alter their hydrology or degrade water quality.

The MNDNR will need to be provided with the wetland delineation report and infrastructure layout map as soon as they are available. Wetland surveys need to be conducted by consultants experienced in the identification of calcareous fens and the rare plants associated with them. The consultants should be on the DNR List of Surveyors (see attached documents). The MNDNR calcareous fen identification criteria must be used and the surveyor must be able to identify rare plants associated with the scoring criteria. Surveys must occur in June and August in order to positively identify the rare plants as they are difficult to locate outside of their flowering period.

The Sioux Nation, Bohemian, Saum Memorial, Penthole, Minn-kota, Tatley, and Archerville Wildlife Management Areas (WMA) are within or adjacent to the project boundary with several of them containing multiple parcels. The MNDNR recommends that no direct impacts occur to these public recreational lands from turbine construction, transmission lines, substations, or road networks associated with the project. It is the MNDNR's responsibility to seek avoidance, minimization, and mitigation for potential impacts to Minnesota Recreation System Units (Minnesota Statutes, chapter 86A) from turbine construction, transmission lines, substations, or road networks associated with a wind project. The wind resource of State lands is protected from encroachment through the wind access buffer of 5 rotor diameters (prevailing wind direction) and 3 rotor diameters (non-prevailing wind direction) that has been established by the Public Utilities Commission (PUC) to protect non-participating landowners wind rights.

Also within the project boundary is a Waterfowl Production Area (WPA) that is managed by the United States Fish & Wildlife Service (USFWS). Further coordination should occur with the USFWS concerning potential impacts to the WPA. Rare butterflies are also known to occur within the project boundary and discussions should occur with the USFWS concerning this resource.

Issues concerning rare features should be identified and resolved prior to submitting the Site Permit Application to the PUC. To receive information regarding rare features and species in the vicinity of the proposed project, the wind developer or their consultants should submit a completed Natural Heritage Information System (NHIS) Data Request Form (http://files.dnr.state.mn.us/eco/nhnrp/nhis_data_request.pdf) to the MNDNR Endangered Species Review Coordinator. The Natural Heritage Review will identify known occurrences of rare plants, animals, and native plant communities in the vicinity of the project boundary. Please note that some NHIS data is available as GIS shapefiles and can be downloaded at no cost from the Minnesota Geospatial Commons at <http://gisdata.mn.gov>. These include the following shapefiles: MNDNR Native Plant Communities, Calcareous Fens, and MBS Sites of Biodiversity Significance. The MNDNR recommends avoidance of these significant natural areas and encourages the use of this data to identify areas within a project boundary that would not be appropriate for development. Please contact the Endangered Species Review Coordinator at 651-259-5109 for more information on the Natural Heritage Review process.

Mr. Sean Flannery
May 3, 2016
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During development of the turbine layout it is recommended that 5-6 alternate turbine locations be included. The alternate turbine locations provide an opportunity to avoid or minimize potential impacts to natural resources and to work around other issues that arise during project development.

The DNR looks forward to working in a positive and collaborative manner on this project to ensure that sustainable energy sources are developed while protecting Minnesota's natural resources. Please contact me directly at (507) 359-6073 if you have any questions about this letter.

Sincerely,



Kevin Mixon
Regional Environmental Assessment Ecologist
Division of Ecological and Water Resources

cc: Lisa Joyal, Endangered Species Review Coordinator
Jamie Schrenzel, Environmental Review
Jim Sehl, EWR Assistant Supervisor
Ryan Bjerke, Area Hydrologist
Skip Wright, North District EWR Supervisor
Wendy Krueger, Area Wildlife Manager
Jeremy Losinski, Parks and Trails
Chris Domeier, Fisheries
DNR R4 REAT
Margaret Rheude, USFWS
Richard Davis, Department of Commerce-EERA
ERDB#20080705

Links:

A Synthesis Of Operational Mitigation Studies To Reduce Bat Fatalities At Wind Energy Facilities In North America (Arnet et al. 2013):

<http://www.batsandwind.org/pdf/Operational%20Mitigation%20Synthesis%20FINAL%20REPORT%20UPDATED.pdf>

Bat Assessment Guidance for Wind Energy Facilities in Nebraska:

http://snr.unl.edu/renewableenergy/download/Bat%20Assessment%20Guidance%20for%20Wind%20Energy%20Facilities%20in%20Nebraska_August%202015.

Endangered and Threatened Species Surveyors

Minnesota Department of Natural Resources, Division of Ecological and Water Resources
March 3, 2016

The Minnesota Department of Natural Resources' Division of Ecological and Water Resources (DNR) relies upon the results of endangered and threatened species surveys to conserve these species through its conservation, management, project review, and permitting responsibilities. In order to ensure that survey results are reliable, the DNR maintains a list of individuals who are considered qualified to conduct these surveys within the state of Minnesota. Please note that the DNR evaluates individuals, not firms.

The individuals on the DNR List of Surveyors have met criteria (described below) to demonstrate that they have the skills necessary to perform high quality surveys for these species in Minnesota. High quality survey data ensures the DNR's ability to uphold the Minnesota Endangered Species Statute (*Minnesota Statutes*, section 84.0895) and associated rules (*Minnesota Rules*, part 6212.1800 to 6212.2300 and 6134), and to avoid any potential delays due to misidentified or overlooked endangered or threatened species.

Endangered or threatened species surveys may require a permit before the survey can be initiated. Choosing an individual from the List of Surveyors ensures that the individual is able to obtain a permit from the DNR.

The DNR List of Surveyors is also used by the Minnesota Department of Transportation (DOT) as **part of** their process to pre-qualify vendors for rare, endangered & threatened species identification. However, the DOT pre-qualification is a separate process and being on the DNR List of Surveyors does not constitute approval by the DOT. The DOT may have additional requirements. Pre-qualification expedites the DOT hiring process, as bidding is not required for pre-qualified vendors. Please contact DOT directly (Christopher Smith, DOT Natural Resource Program Coordinator, at 651-366-3605 or christopher.e.smith@state.mn.us) to learn more about becoming a pre-qualified vendor.

Failure to fulfill DNR contract requirements may be grounds for removal from the List. Performance ratings are also maintained by DOT and are available to the DNR. Poor DOT performance ratings may also be grounds for removal from the List.

The DNR List of Surveyors is not intended as an endorsement of any one individual over another. There may be other individuals who are qualified to do rare species surveys. Individuals who would like to be placed on the List should contact Lisa Joyal, DNR Endangered Species Environmental Review Coordinator, at 651-259-5109.

In order to be placed on the DNR List of Surveyors, an individual must meet the following criteria:

- 1) Receipt of a four-year university or college degree in a natural science
- 2) Demonstrated ability to complete rare species surveys and resulting technical reports
- 3) Previous experience with Minnesota's endangered and threatened species

To document that s/he meets these criteria, we ask that the individual submit the following supporting documents to Lisa Joyal, DNR Division of Ecological and Water Resources, 500 Lafayette Road, Box 25, St. Paul, MN 55155 or lisa.joyal@state.mn.us :

- 1) A resume
- 2) Two letters of recommendation from agency or academic staff pertaining directly to the taxa (see below) for which the individual wishes to be considered
- 3) A technical report that contains an example of the individual's previous survey work
- 4) A list of the taxa (see below) for which the individual wishes to be considered

Taxa: mammals, birds, reptiles & amphibians, fish, topeka shiner, mussels*, insects, Dakota skipper, plants, dwarf trout lily, western prairie fringed orchid, prairie bush clover, *Botrychium* spp.

*To be included on the Mussel Surveyors List, interested individuals will also need to pass a mussel identification exam. After you submit the above materials we will notify you of the next exam date.



DNR List of Surveyors Endangered and Threatened Plants

See endnote*

Surveyor	Phone Number	Email Address	Plants - General	<i>Botrychium</i> spp.	Dwarf Trout Lily	Prairie Bush Clover	Fringed Orchid	Western Prairie	Bryophytes
Barb Delaney 1038 200th Street Dresser, WI 54009									
Barb Delaney	#715-294-3635	bdelaney1@centurytel.net	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Barr Engineering Company 4700 West 77th Street, Suite 200 Minneapolis, MN 55435-4803									
Daniel DeJooode	#952-832-2919	ddejooode@barr.com	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Daniel Jones	#952-832-2875	djones@barr.com	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Daniel Tix	#952-540-7848	dtix@barr.com	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8300 Norman Center Drive Minneapolis, MN 55437									
Fred Rozumalski	#612-832-2600	.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Chris Cole 911 West 4th Street Morris, MN 56267									
Chris Cole	#320-589-6319	.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Critical Connections Ecological Services, Inc. 21150 Ozark Avenue North, PO Box 184 Scandia, MN 55073									
Jason Husveth	#651-433-4410	jhusveth@ccesinc.com	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Deb Pomroy 8143 Pequaywan Lake Road Duluth, MN 55803									
Deb Pomroy	#218-525-7502	.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Deborah Shubat 2155 Johnson Road Duluth, MN 55804									
Deborah Shubat	#218-525-3063	.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ecological Strategies, Inc. PO Box 3 Maiden Rock, WI 54750									
Cynthia Lane	#715-448-4331	clane@cannon.net	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ecosystems, llc PO Box 481 Rice Lake, WI 54868									
Tim King	#715-205-4624	tim@ecosystemscorp.com	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Emmons & Olivier Resources, Inc. 651 Hale Avenue North Oakdale, MN 55128									
Beth Nixon	#651-770-8448	bnixon@eorinc.com	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



DNR List of Surveyors Endangered and Threatened Plants

See endnote*

Surveyor	Phone Number	Email Address	Plants - General	<i>Botrychium</i> spp.	Dwarf Trout Lily	Prairie Bush Clover	Fringed Orchid	Western Prairie	Bryophytes
Environmental Resources Management, Inc. 1701 Golf Road, Suite 1-1000 Rolling Meadows, IL 60008			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Nick Owens	#847-258-8926	nick.owens@erm.com							
Gary Walton 4408 Miller Road Barnum, MN 55707			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Gary Walton	#218-389-3261	togbw@earthlink.net							
George-Ann Maxson 4235 Carver Road NE Bemidji, MN 56601			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
George-Ann Maxson	#218-586-3414	gamaxson@paulbunyan.net							
Gustavus Adolphus College 800 W College Avenue St. Peter, MN 56082			<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cindy Johnson-Groh	#507-933-7043	.							
HDR Engineering, Inc. 701 Xenia Avenue South, Suite 600 Minneapolis, MN 55416			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scott Krych	#763-591-5420	scott.krych@hdrinc.com	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tony Randazzo	#763-591-5400	anthony.randazzo@hdrinc.com							
John Moriarty 3261 Victoria Street Shoreview, MN 55126			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
John Moriarty	#651-482-8109	frogs@umn.edu							
Malcolm MacFarlane 888 East Third Street St. Paul, MN 55106			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Malcolm MacFarlane	#651-771-5609	MalcolmMacFarlan@aol.com							
Marcia Richards 1118 Lori Lane Mankato, MN 56001			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Marcia Richards	#507-388-1401	.							
Midwest Natural Resources (main contact: Scott Milburn) 744 James Avenue St. Paul, MN 55102			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Kevin Clay	#651-788-1074	kevin.clay@mnrinc.us	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Otto Gockman	#651-788-0641	otto.gockman@mnrinc.us	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rhett Johnson	#320-815-8782	rhett.johnson@mnrinc.us	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dylan Lueth	#218-343-1290	dylan.lueth@mnrinc.us	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scott Milburn	#612-310-6260	scott.milburn@mnrinc.us	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Andres Morantes	#612-483-8450	andres.morantes@mnrinc.us	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>



DNR List of Surveyors Endangered and Threatened Plants

See endnote*

Surveyor	Phone Number	Email Address	Plants - General	<i>Botrychium</i> spp.	Dwarf Trout Lily	Prairie Bush Clover	Fringed Orchid	Western Prairie	Bryophytes
MN Department of Transportation 395 John Ireland Blvd St. Paul, MN 55155			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ken Graeve	#651-366-3613	kenneth.graeve@state.mn.us							
Moorhead State University, Department of Biology Building KH, Room 206 Moorhead, MN 56560			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Richard Pemble	#218-477-5003	pemblerh@mnstate.edu							
Short Elliott Hendrickson, Inc. 418 West Superior Street, Suite 200 Duluth, MN 55802-1512			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Allyz Kramer	#218-279-3011	akramer@sehinc.com							
St. Olaf College, Department of Biology 306 St. Olaf Avenue, Apt. 0 Northfield, MN 55057			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Charles Umbanhower	#.	.							
Stantec Consulting Services Inc. 2335 West Highway 36 St. Paul, MN 55113			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Paul Bockenstedt	#651-604-4812	paul.bockenstedt@stantec.com							
The Kestrel Design Group 7101 Ohms Lane Minneapolis, MN 55439-2142			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Peter MacDonagh	#952-928-9600	pmacdonagh@tkdg.net							
University of Minnesota Herbarium 220 Biological Science Center, 1445 Gortner Avenue St. Paul, MN 55108			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Anita Cholewa	#651-625-0215	.							
University of Minnesota, Crookston Owen Hall 204 Crookston, MN 56716			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Daniel Svedarsky	#218-281-8129	dsvedars@mail.erk.umn.edu							
Vande Water Natural Resource Services 429 Ogden Avenue Escanaba, MI 49829			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Glenn Vande Water	#906-786-2141	.							
Wenck Associates, Inc. 301 1st Street NE, Suite 202 Mandan, ND 58554			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sara Simmers	#701-751-6128	ssimmers@wenck.com							
Wildlands Ecological Services 2009 Maryknoll Avenue North Maplewood, MN 55109-3645			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scott Zager	#651-261-2398	scott.zager@wildlands.biz							



DNR List of Surveyors Endangered and Threatened Plants

See endnote*

Surveyor	Phone Number	Email Address	Plants - General	Botrychium spp.	Dwarf Trout Lily	Prairie Bush Clover	Fringed Orchid	Western Prairie	Bryophytes
WSB & Associates, Inc. 701 Xenia Avenue South, Suite 300 Minneapolis, MN 55416			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Andi Moffatt	#763-287-7196	amoffatt@wsbeng.com							

*The identification of these species can be difficult; only the individuals with check marks in the corresponding boxes are considered qualified by the DNR. For Botrychium spp. and for Bryophytes, collection specimens are required; surveyor will need to obtain a collection permit from Rich Baker, at 651-259-5073 or Richard.Baker@state.mn.us, prior to any survey work.

The above is a list of individuals who are considered qualified by the Minnesota Department of Natural Resources (DNR) to conduct surveys for endangered and threatened plants within the state of Minnesota. Please note that the DNR qualifies individuals, not firms. The DNR maintains this list to ensure reliable survey results, which ensures the DNR's ability to uphold the Minnesota Endangered Species Statute (Minnesota Statutes, section 84.0895) and associated rules (Minnesota Rules, part 6212.1800 to 6212.2300 and 6134), and avoids any potential delays due to misidentified or overlooked threatened or endangered species.

This list is not intended as an endorsement of any one individual over another. There may be other individuals who are qualified to do rare species surveys. Individuals who would like to be placed on the list should contact Lisa Joyal, DNR Endangered Species Review Coordinator, at 651-259-5109.

From: [Mixon, Kevin \(DNR\)](#)
To: [Joe Sedarski](#)
Cc: [Benage, Megan \(DNR\)](#); [Joyal, Lisa \(DNR\)](#)
Subject: RE: Bitter Root Wind Project - Calcareous Fen Questions
Date: Friday, June 10, 2016 4:02:21 PM
Attachments: [image001.jpg](#)

Joe:

I inserted some quick answers to your questions (red) into your email. I will be in the office Monday-Wednesday of next week if you have additional questions. If I am not in or if you have very technical questions concerning calcareous fens you can contact Megan Benage of our staff. Megan is the Region 4 Regional Ecologist who has worked extensively with calcareous fens in recent years.

Attached are a few reference documents for your use.

Thanks,

Kevin

From: Joe Sedarski [<mailto:jsedarski@merjent.com>]
Sent: Friday, June 03, 2016 12:58 PM
To: Mixon, Kevin (DNR)
Cc: Sean Flannery; Jeff Jackson; tmattson@west-inc.com; Brie Anderson; Anne-Marie Griger
Subject: Bitter Root Wind Project - Calcareous Fen Questions

Dear Kevin,

Thanks for sending the MnDNR Preliminary Review Letter (dated May 3, 2016) regarding the Bitter Root Wind Project (Project). Regarding calcareous fens (CFs) (see bottom of page 2 in the letter) and your comments during the April 29, 2016 meeting, we have the following questions:

1. We have the current listing of 7 known CFs located within the Project boundary in Yellow Medicine County (attached pdf, page 8) and MnDNR data for such (see <https://gisdata.mn.gov/dataset/biota-nhis-calcareous-fens>), which includes CF Point Location Dataset (points on map) and MnDNR Native Plant Communities Dataset (polygons). Can you confirm this is the most current data and maps for the 7 CFs or send us the most current data/maps?
2. With the locations and boundaries of known CFs within the Project boundary, we assume there is no need to conduct further work regarding re-delineation of these known CFs. Can you confirm that?
Correct the known CF's do not need to be delineated or surveyed.
3. During the April 29th, 2016, kick-off meeting with you, you mentioned the MnDNR has a list of possible CFs (in addition to the known CFs indicated in item 1 above) within or nearby the Project boundary. After that meeting, you were going to check with your colleagues on making that information available to us for use for this Project. Can you confirm you will provide any further data to identify possible CFs for our use?

We checked and we do not have any additional locational information for CF's in the Bitter Root project area.

4. The letter indicates avoidance relates to both direct impacts and any type of construction that could alter CF hydrology or degrade water quality. What is the process or criteria we can use to determine how we should evaluate these potential indirect impacts? For your information, generally the construction activities do not extend more than 10-15 feet into the ground for turbine foundations, and much less for access roads, collection lines, etc. Surface water issues during construction will additionally be addressed with NPDES construction stormwater permitting, SWPPP, BMPs, etc.

The MNDNR would review the shapefiles for the preliminary layout of turbines, transmission lines, collector lines, crane paths, substations, access roads, and any other facilities construction in relation to CF's . We would need a map of the preliminary layout that includes the locations of CF's.

5. The letter indicates that wetland surveys need to be conducted by CF experienced consultants, and that CF identification criteria must be used. Can you clarify if this means that ALL wetlands (or potential wetlands) within the Project boundary need to be evaluated by a CF experienced consultant, or if only those potential CF wetlands (list you have) apply to this work? In other words, will RES need to make determination that any given wetland is not a CF within the Project boundary?

If a wetland has potential as a CF then it needs to be evaluated by a CF experienced consultant. The consultant would need to have direct experience in identifying CF indicator plants in order to score it. The MNDNR would review the consultants work.

You may also want to review the Wetland Conservation Act Chapter 8420.0935 in regards to Standards and Criteria For Identification, Protection, and Management of Calcareous Fens.

RES plans to avoid CFs to the extent possible, and is taking into account MnDNR concerns, data, and requirements in the siting/routing process currently underway. Your responses will assist us with finalizing the scope of work needed to address CFs regarding the Project during this field season. Since June and August are survey months for CFs, we will need your help to clarify what the MnDNR needs for this Project and appreciate your timely response to this email.

Best Regards,
Joe



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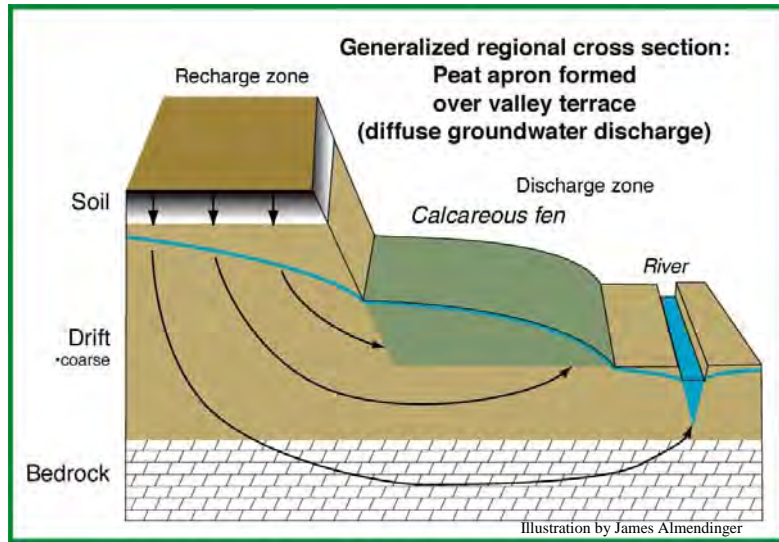
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WHAT IS A CALCAREOUS SEEPAGE FEN?

Calcareous fens are rare and distinctive wetlands characterized by a substrate of non-acidic peat and dependent on a constant supply of cold, oxygen-poor groundwater rich in calcium and magnesium bicarbonates. This calcium-rich environment supports a plant community dominated by “calciphiles,” or calcium-loving species. These fens typically occur on slight slopes where upwelling water eventually drains away and where surface water inputs are minimal. Sometimes they occur as domes of peat that grow to the

height of the hydraulic head. These settings create an unusual wetland regime where the substrate is almost always saturated to the surface, but flooding is rare and brief. Shallow pools of water in which marl precipitates are typically present surrounded by low, tussocky, grass- and sedge-dominated vegetation. The substrate is springy or quaking underfoot. The figures above and below illustrate the geologic features and groundwater flows that lead to the formation of calcareous seepage fens.

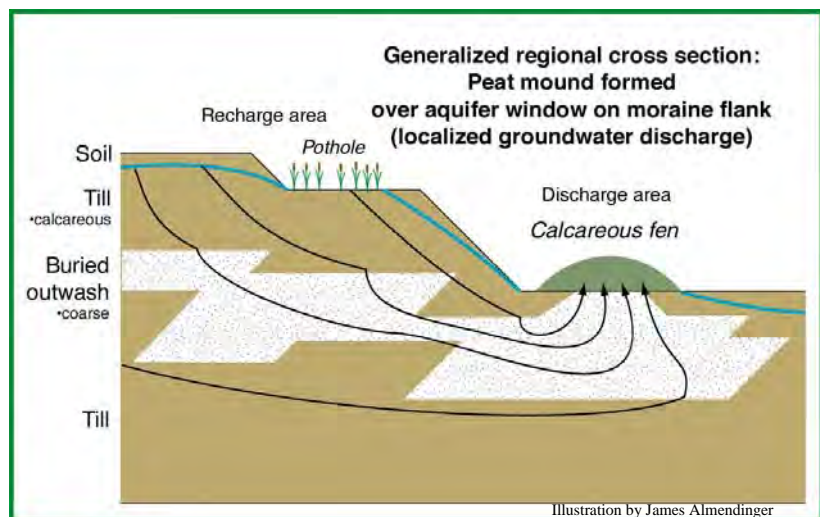


HOW RARE ARE CALCAREOUS SEEPAGE FENS?

Calcareous seepage fens are one of the rarest natural communities in the United States. These fens have been reported from 10 states, mostly in the Midwest.

Approximately 200 are known in Minnesota, most of which are only a few acres in extent. They are concentrated at the bases of terrace escarpments in river valleys in southeastern Minnesota, on the sides of morainal hills and valley

sideslopes in southern and west-central Minnesota, and on the downslope side of beach ridges in the Glacial Lake Agassiz basin in the northwest. There are also a few in northern Minnesota where upwelling groundwater reaches the surface within large, more acidic peatlands.



WHY ARE CALCAREOUS SEEPAGE FENS PROTECTED?

In addition to the rarity of the community itself, calcareous seepage fens support a disproportionately large number of rare plant species in Minnesota, four of which (*) occur almost exclusively in this community. Eight state-listed, rare plant species are known from calcareous seepage fens:

<i>Carex sterilis</i> *	Sterile sedge	State threatened
<i>Cladium mariscoides</i> *	Twig-rush	State special concern
<i>Rhynchospora capillacea</i> *	Fen beak-rush	State threatened
<i>Fimbristylis puberula</i> *	Hairy fimbristylis	State endangered
<i>Scleria verticillata</i>	Nut-rush	State threatened
<i>Eleocharis rostellata</i>	Beaked spike-rush	State threatened
<i>Valeriana edulis</i>	Valerian	State threatened
<i>Cypripedium candidum</i>	Small white lady's slipper	State special concern

Calcareous seepage fens are highly susceptible to disturbance. Reduction in the normal supply of groundwater results in oxidation of the surface peat, releasing nutrients and fostering the growth of shrubs and tall, coarse vegetation that displaces the fen plants. Nitrogen-rich surface water runoff into fens promotes the invasion of aggressive exotic plants, especially reed canary grass, that also outcompete the fen plants. Flooding drowns the fen plants. The soft, saturated character of the peat makes almost any level of activity within them, by humans or domestic livestock, highly disruptive.



Small white lady's slipper

The DNR maintains a list of known calcareous fens, which is available at the DNR's website at:

http://files.dnr.state.mn.us/publications/waters/Calcareous_Fen_List.pdf.

Landowners interested in protecting or managing a calcareous fen should contact the DNR, Ecological Resources Division at 651-259-5125.

FINAL REPORT TO THE U.S. EPA:
TEST OF THE TECHNICAL CRITERIA FOR
IDENTIFYING AND DELINEATING
CALCAREOUS FENS
IN MINNESOTA

AND

DRAFT REVISED TECHNICAL CRITERIA FOR
IDENTIFYING CALCAREOUS FENS
IN MINNESOTA

Clean Water Act Section 104(b)(3) Grant Number CD-97504601-3

JEANETTE H. LEETE, MN DNR

WITH

WELBY R. SMITH, MN DNR
JOANNES A. JANSSENS, LAMBDA MAX
NORM AASENG, MN DNR

APRIL 13, 2005

ACKNOWLEDGEMENTS to the CALCAREOUS FEN TECHNICAL COMMITTEE

The following committee, listed with their current affiliations, developed the initial technical criteria for identifying calcareous fens in Minnesota in 1994. The 1994 report summarized the published and unpublished scientific data, research findings, and literature available at that time. The committee stated in its initial report and in the 1995 revision that their effort was the start of a process to define the technical criteria for calcareous fens.

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TEST OF THE TECHNICAL CRITERIA FOR IDENTIFYING AND DELINEATING CALCAREOUS FENS IN MINNESOTA

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MINNESOTA DEPARTMENT OF NATURAL RESOURCES

TEST OF THE TECHNICAL CRITERIA FOR IDENTIFYING CALCAREOUS FENS IN MINNESOTA

SUMMARY

A test of the Calcareous Fen Technical Criteria as revised in 1995 was conducted. The technical criteria consider vegetation, water chemistry, soil and hydrology attributes. The results show that the statewide Technical Criterion for vegetation is too restrictive and may lead to false negatives, while the remaining criteria are so inclusive that they may lead to false positives. Revised sets of criteria are herewith proposed that refine the vegetation criterion with the addition of bryophytes and regionalizes the vascular plant list. In our opinion this will reduce the tendency toward false negatives without resulting in false positives.

Results:

The habitat for the calcareous fen plant community is often larger than the area within a wetland complex that the calcareous fen plant community currently occupies. This difference is particularly often observed when the wetland has suffered anthropogenic impacts and the calcareous fen plant community has retreated from the boundaries of its potential habitat. Thus the boundaries of the calcareous fen must be defined as the boundaries of that part of the wetland complex that meets the soils and/or hydrology criteria.

The water chemistry, soil, and hydrology attributes of calcareous fens are characteristic but not on their own definitive because all can be met in certain non-fen wetlands. Of 53 known calcareous fens included in the water chemistry, soil, and hydrology portion of the study, none failed the pH criterion, 14 (29%) failed the conductivity criterion, 1 (2%) failed the alkalinity criterion, and none failed the calcium, soils, and hydrology criteria. Of 19 known non-fen sites included in the water chemistry, soil, and hydrology portion of the study, all (100%) passed the pH criterion, 11 (55%) passed the conductivity criterion, 18 (90%) passed the calcium criterion, 19 (95%) passed the alkalinity criterion, 4 (20%) passed the hydrology criterion, and 8 (40%) passed the soils criterion.

The vegetation criterion alone has the potential to adequately and definitively identify calcareous fens in unimpacted and undegraded wetlands with the addition of bryophytes to the calciphile plant list. Of 26 known calcareous fens included in the vegetation portion of the study 6 (23%) failed the vegetation criterion. Of 7 known non-fen sites included in the vegetation portion of the study, none passed the vegetation criterion.

The gathering of data about the vegetation of calcareous fens under the 1995 technical criteria is dependent upon the season of the year. This interferes with responsive customer service when the Minnesota Department of Natural Resources is asked to determine if a specific wetland is a calcareous fen. We attempt to resolve this issue by including Minnesota's calciphile bryophyte species in the revised vegetation criterion. Mosses are collectible in all seasons, impacted typically only by the hardness of the wetland scientist.

Regionalizing the vegetation criterion for vascular plants and including bryophyte calciphiles will eliminate most if not all false positive determinations that a site is a calcareous fen.

We continue to believe, as did the original committee, that technical criteria and guidelines for identifying calcareous fens will continue to evolve with continued field surveys and repeated applications. In particular we acknowledge the need for a more work on the soils, water chemistry, and bryophytes of Minnesota's calcareous fens. We believe that regionalization of these criteria, after collection of adequate data, will further improve identification of calcareous fens.

INTRODUCTION

Legal references to Calcareous Fens are found in Minnesota Statutes and Rules. These references imply that it is possible to know definitively that an activity is occurring in or near an area that is 'a calcareous fen'. The Wetland Conservation Act of 1991, M.S. 103G.223, and Minnesota Rules 8420 expressly direct the Commissioner of Natural Resources to protect "calcareous fens". M.R. 8420.1010 establishes the purpose "...to provide minimum standards and criteria for the identification, protection, and management of calcareous fens as authorized by Minnesota Statutes, section 103G.223. Calcareous fens may not be drained or filled or otherwise altered or degraded except as provided for in a management plan approved by the commissioner", where 'commissioner' is the Commissioner of the Department of Natural Resources (DNR).

Calcareous Fens and other Outstanding Resource Value Waters are also protected by the Minnesota Pollution Control Agency (M.R. 7050.0180) from any new discharges of sewage or other waste. The listing of calcareous fens in the Rules of the Minnesota Pollution Control Agency is derived from the Minnesota DNR Natural Heritage Database Listing of Calcareous Fens. Clearly, it is the responsibility of the DNR to identify calcareous fens. See Appendix 1 for the text of these regulations.

Calcareous fens as a natural community as identified by DNR are defined as follows (DNR Natural Heritage Program, 1991, "Minnesota's Native Vegetation: A Key to Natural Communities"):

Calcareous Seepage Fen

Calcareous Seepage Fen is an open sedge and rush community that occurs throughout Minnesota. The groundlayer is usually dominated by wiregrass sedge (*Carex lasiocarpa*), *Carex sterilis*, beaked sedge (*Rhynchospora capillacea*), spike-rush (*Eleocharis rostellata*), and *Scirpus cespitosus*. Marsh muhly (*Muhlenbergia glomerata*), grass of Parnassus (*Parnassia glauca*) and Kalm's lobelia (*Lobelia kalmii*) are often present in Calcareous Seepage Fens (as well as in Rich Fens). Shrubs, including bog birch, sage-leaved willow, and shrubby cinquefoil, are common in the community. Mosses range in cover from abundant to scarce.

Calcareous Seepage Fens occur on shallow or deep peaty soils in areas of calcareous groundwater discharge. The surface water is usually circumneutral (pH 6.8 - 8.0) with high concentrations of dissolved salts ($[Ca^{2+}] = 10-100 \text{ mg/l}$) that often form a visible marl precipitate. The discharge water is low in oxygen (anoxic), which is believed to be important in inhibiting dense vegetation growth, thereby promoting the occurrence of several rare heliophytic vascular and bryophyte plant species in the community.

There are two subtypes of Calcareous Seepage Fen, a Prairie Subtype and a Boreal Subtype. The Prairie Subtype (which occurs in both the prairie and deciduous forest-woodland zones) contains many characteristically prairie species, including big bluestem (*Andropogon gerardi*), yellow stargrass (*Hypoxis hirsuta*), Virginia mountain-mint (*Pycnanthemum virginianum*), starry false Solomon's-seal (*Smilacina stellata*), and golden alexanders (*Zizia aurea*). The Prairie Subtype also commonly contains patches of emergent aquatic species such as broad-leaved cattail (*Typha latifolia*), hard-stemmed bulrush (*Scirpus acutus*), *Scirpus americanus*, and common reed grass (*Phragmites australis*). The Prairie Subtype is divided into three geographic sections, a Southeast Section, a Southwest Section, and a Northwest Section. The Boreal Subtype occurs in the Conifer-Hardwood Forest Zone and contains species characteristic of high-boreal peatlands, including bog-rosemary (*Andromeda glaucophylla*), small cranberry (*Vaccinium oxycoccos*), and pitcher plant (*Sarracenia purpurea*). The Boreal Subtype has no recognized geographic sections.

Community names/designations will be changed as the DNR moves to a classification of natural communities that starts at the landscape level. There will then be several geographic sections because calcareous fens occur in several Ecological Classification System (ECS) regions/subregions. In order to conform with the terminology in use in other countries, professional ecologists and other scientists will begin referring to these very same communities as "extremely rich fens".

A draft of this new description is found in an Appendix.

Calcareous Fen plant communities as defined above are highly diverse, contain an unusual proportion of uncommon, even threatened species, and it is concern for these communities that led to the Statutes and Rules previously mentioned.

The 1994 Calcareous Fen Technical Committee was convened by the DNR. The Committee established four criteria for identifying and delineating calcareous fens: hydrology, soils, water chemistry, and vegetation. These criteria were compatible with the Minnesota Rules 8420 (Appendix).

The Criteria were based on the data for Minnesota calcareous fens available at the time, which for the vegetation was primarily obtained from calcareous fens in the northwestern part of the state, and which for the other criteria was primarily obtained in the southwestern part of the state and in the Minnesota River Valley. This report shares the results of an effort to test the criteria on known fens in all areas of the state where fens occur and presents the resulting refined Calcareous Fen Technical Criteria.

Use of the Calcareous Fen Technical Criteria as revised in 1995 during the intervening years had made DNR staff aware of several issues with their use that we attempt to improve with this revision.

1. The habitat for the calcareous fen plant community is not exclusively the area within a wetland complex that the calcareous fen plant community currently occupies. This difference is often observed when the wetland has suffered anthropogenic impacts or natural disturbance and the calcareous fen plant community retreats from the boundaries of its potential habitat. Thus the delineation of a "calcareous fen" as a separate entity from any wetland complex within which it exists is not possible; the boundaries of the calcareous fen must be defined as the boundaries of the wetland complex within which a calcareous fen plant community exists.
2. The water chemistry, soil, and hydrology attributes of calcareous fens are characteristic but not on their own definitive because other types of wetlands can meet each of these criteria under certain circumstances.
3. The gathering of data about the vegetation of calcareous fens under the 1995 technical criteria is dependent upon the season of the year. This interferes with responsive customer service when the Minnesota Department of Natural Resources is asked to determine if a specific wetland is a calcareous fen. We have come a long way toward resolving this issue by including Minnesota's calciphile bryophyte species in the revised vegetation criterion. Mosses are collectible in all seasons, impacted typically only by the hardness of the wetland scientist.
4. Regionalizing the vegetation criterion for vascular plants, whereby the resultant regions include a distinct category for site in the Minnesota River Valley, and including bryophyte calciphiles will eliminate most if not all false positive determinations that a site is a calcareous fen.
5. We continue to believe, as did the original committee, that technical criteria and guidelines for identifying calcareous fens will continue to evolve with continued field surveys and repeated applications. In particular we acknowledge the need for a more work on the soils of Minnesota's calcareous fens and on the bryophytes of Minnesota's calcareous fens. We believe that regionalization of the bryophyte calciphiles list will further improve identification of calcareous fens.

RESTATEMENT OF CRITERIA TESTED

Descriptive characteristics and technical criteria for the hydrology, soils, water chemistry, and vegetation of calcareous fens follow (MDNR, 1995):

HYDROLOGY TECHNICAL CRITERION

An area meets the hydrology technical criterion when the hydrology is characterized by having stable, typically upwelling groundwater inflows sufficient to maintain saturation for the development of a histosol or a histic epipedon soil.

SOILS TECHNICAL CRITERION

An area meets the soils technical criterion when the soils are characterized by the presence of either a histosol or a histic epipedon. Calcium carbonate precipitates, such as tufa deposits, may frequently be associated with calcareous fens.

WATER CHEMISTRY TECHNICAL CRITERION

Water chemistry of calcareous fens should be characterized by measurement of the following parameters: specific conductance ($\mu\text{S}/\text{cm}$), pH, dissolved oxygen (mg/l), alkalinity (mg/l CaCO_3), ratio of the concentration of calcium plus magnesium ions ($[\text{Ca}+\text{Mg}]$) to total cations ($\% \text{ meq}/\text{l}$), and alkalinity/total anions ($\% \text{ meq}/\text{l}$). Of these parameters, it is imperative that specific conductance, pH, alkalinity, and dissolved oxygen be measured in the field (*in situ*). Samples would be collected for laboratory determination of the other parameters. Standard methods should be used for sample collection techniques and sample preparation and handling.

An area meets the water chemistry technical criterion when the following conditions are met: pH of 6.7 or more; calcium of 30 mg/l or more; alkalinity of 1.65 meq/l or more; dissolved oxygen of 2.0 mg/l or less; and, specific conductance of 500 $\mu\text{S}/\text{cm}$ or more. [Data for other parameters must be collected to provide further water chemistry definition of calcareous fens.]

VEGETATION TECHNICAL CRITERION

An area meets the vegetation technical criterion when the vegetation is characterized by using a modification of the Mandatory Technical Criteria for Wetland Identification--Hydrophytic Vegetation in the *FEDERAL MANUAL FOR IDENTIFYING AND DELINEATING JURISDICTIONAL WETLANDS JANUARY 1989*. Hydrophytic vegetation is defined as macrophytic plant life growing in the soils, water, and water chemistry characteristic of calcareous fens. The Minnesota DNR has developed a list of 27 statewide calciphiles indicative of calcareous fens (Table 1). This list was further divided into vascular calciphile indicator classes of "strong", "moderate", and "weak".

Two alternative methods are available to determine the vegetation criterion. An area meets calcareous fen vegetative technical criterion when, under normal circumstances, either:

1. **50 Percent Cover Method**

More than 50 percent of the composition of the dominant species from all strata are calciphiles from any of the indicator classes,

or

2. **Calciphile Species Occurrence Method**

When the area has a natural community index value of 50 or more by summing the index values of the 27 calcareous fen indicator species. This natural community index value provides a workable floristic surrogate for a full vegetation analysis.

Plot size and shape are dependent upon the professional judgment of field personnel. Identification plots may be large (400 square meters or larger) whereas delineation plots or other techniques may be smaller to provide more definite margin boundaries.

NOTE: *If a site has calcareous fen soil, hydrology, and water chemistry but the calciphile point total ranges from 30 to 50, the area will be considered to meet calcareous fen criteria. If a disturbed site has calcareous fen soil, hydrology, and water chemistry but a calciphile point total of less than 30, the disturbed area may have the potential to support a calcareous fen plant community*

Table 1. 1995 State-wide list of 27 calciphiles distinguishing "strong" (6 species), "moderate" (11 species), and "weak" (10 species) indicators to identify and delineate calcareous fens in Minnesota (MDNR 1994). [Adapted from: *MINNESOTA LIST OF PLANTS THAT OCCUR IN WETLANDS* by Reed, P.B., Jr. 1988. National list of plant species that occur in wetlands: North Central Region (Region 3). U.S. Fish and Wildlife Service

<u>Family</u>	<u>Species Indicator Abbrev.</u>	<u>Scientific Name</u>	<u>Common Name</u>	<u>Habit</u>	<u>Status</u>
<u>Strong state-wide indicators (25 calciphile point value)</u>					
CYPERACEAE	CAPR6	CAREX PRAIREA	SEDGE, PRAIRIE	PNGL	FACW+
CYPERACEAE	CAST16	CAREX STERILIS	SEDGE, DIOECIOUS	PNGL	OBL
CYPERACEAE	ELRO2	ELEOCHARIS ROSTELLATA	SPIKERUSH, BEAKED	PNGL	OBL
CYPERACEAE	RHCA11	RHYNCHOSPORA CAPILLACEA	BEAKRUSH, NEEDLE	PNGL	OBL
CYPERACEAE	SCVE2	SCLERIA VERTICILLATA	NUTRUSH, LOW	ANGL	OBL
SCHEUCHZERIAEAE	TRPA6	TRIGLOCHIN PALUSTRE	ARROW-GRASS, MARSH	PNF	OBL
<u>Moderate state-wide indicators (5 calciphile point value)</u>					
CYPERACEAE	CAVI5	CAREX VIRIDULA	SEDGE, LITTLE GREEN	PNGL	OBL
CYPERACEAE	CLMA	CLADIUM MARISCOIDES	SAWGRASS, SMOOTH	PNEGL	OBL
JUNCACEAE	JUALAR	JUNCUS ALPINO-ARTICULATUS	RUSH, JOINTED	PNGL	OBL
JUNCACEAE	JUBR4	JUNCUS BREVICAUDATUS	RUSH, NARROW-PANICLE	PNGL	OBL
SAXIFRAGACEAE	PAGL3	PARNASSIA GLAUCA	GRASS-OF-PARNASSUS, WAXY	PNF	OBL
PRIMULACEAE	PRMI	PRIMULA MISTASSINICA	PRIMROSE, MISTASSINI	PNF	FACW+
SALICACEAE	SACA4	SALIX CANDIDA	WILLOW, HOARY	NS	OBL
SAXIFRAGACEAE	SAPE8	SAXIFRAGA PENSYLVANICA	SAXIFRAGE, SWAMP	PNF	OBL
CYPERACEAE	SCCE2	SCIRPUS CESPITOSUS	BULRUSH, TUFTED	PNGL	OBL
LILIACEAE	TOGL2	TOFIELDIA GLUTINOSA	FALSE-ASPHODEL, STICKY	PNF	OBL
VALERIANACEAE	VAED	VALERIANA EDULIS	VALERIAN, EDIBLE	PNF	FACW+
<u>Weak state-wide indicators (1 calciphile point value)</u>					
BRASSICACEAE	CABU3	CARDAMINE BULBOSA	BITTER-CRESS, BULBOUS	PNF	OBL
CYPERACEAE	CAGR3	CAREX GRANULARIS	SEDGE, MEADOW	PNGL	FACW+
CYPERACEAE	CAHY4	CAREX HYSTERICINA	SEDGE, PORCUPINE	PNEGL	OBL
CYPERACEAE	CAIN11	CAREX INTERIOR	SEDGE, INLAND	PNGL	OBL
ORCHIDACEAE	LILO	LIPARIS LOESELII	ORCHID, FEN	PNF	FACW+
CAMPANULACEAE	LOKA	LOBELIA KALMII	LOBELIA, BROOK	PNF	OBL
APIACEAE	OXRI	OXYPOLIS RIGIDIOR	COWBANE, STIFF	PNF	OBL
SAXIFRAGACEAE	PAPA8	PARNASSIA PALUSTRIS	GRASS-OF-PARNASSUS, NORTHERN	PNF	OBL
ROSACEAE	POFR4	POTENTILLA FRUTICOSA	CINQUEFOIL, SHRUBBY	NS	FACW+
SCHEUCHZERIAEAE	TRMA4	TRIGLOCHIN MARITIMA	ARROW-GRASS, SEASIDE	PNF	OBL

Table 1 (continued)

DEFINITIONS AND EXPLANATIONS

General Indicator Status

OBL	Always found in wetlands; wetland occurrence >99%
FACW	Usually found in wetlands but occasionally in non-wetlands; wetland occurrence 67-99%
FAC	Sometimes found in wetlands but also occur in non-wetlands; wetland occurrence 34-66%
FACU	Seldom found in wetlands and usually occur in non-wetlands; wetland occurrence 1-33%
UPL	May occur in wetlands; wetland occurrence <1%; unlisted species do not occur in wetlands
+	A modifier to indicate a <u>more</u> frequent occurrence in wetlands
--	A modifier to indicate a <u>less</u> frequent occurrence in wetlands
*	The indicator was derived from limited ecological information
NA	No unanimous agreement by the Review Panel as to the indicator status
NI	Species with little or no information to establish an indicator status

Habit

This is a general classification of the plant characteristics. Symbols are combined to describe the life form of the species.

A	Annual	F3	Fern	N	Native	Z	Submerged
B	Biennial	G	Grass	P	Perennial	\$	Succulent
C	Clubmoss	GL	Grasslike	+	Parasitic	T	Tree
E	Emergent	H	Partly woody	P3	Pepperwort	V	Herbaceous vine
@	Epiphytic	HS	Halfshrub	Q	Quillwort	W	Waterfern
F	Forb	H2	Horsetail	S	Shrub	WV	Woody vine
/	Floating	I	Introduced	-	Saprophytic		

STUDY METHODS

REGIONALIZATION

The Department has stratified that part of the state having calcareous fens into the following three separate regions, based on the Ecological Classification System (ECS) used by the Department (Hanson and Hargrave, 1996). Field studies were conducted in (Figure 1 and Table 2):

Red River Valley/Lake Agassiz, Aspen Parklands (NW)

North Central Glaciated Plains (SW)

Minnesota & NE Iowa Morainal/Paleozoic Plateau (SE)

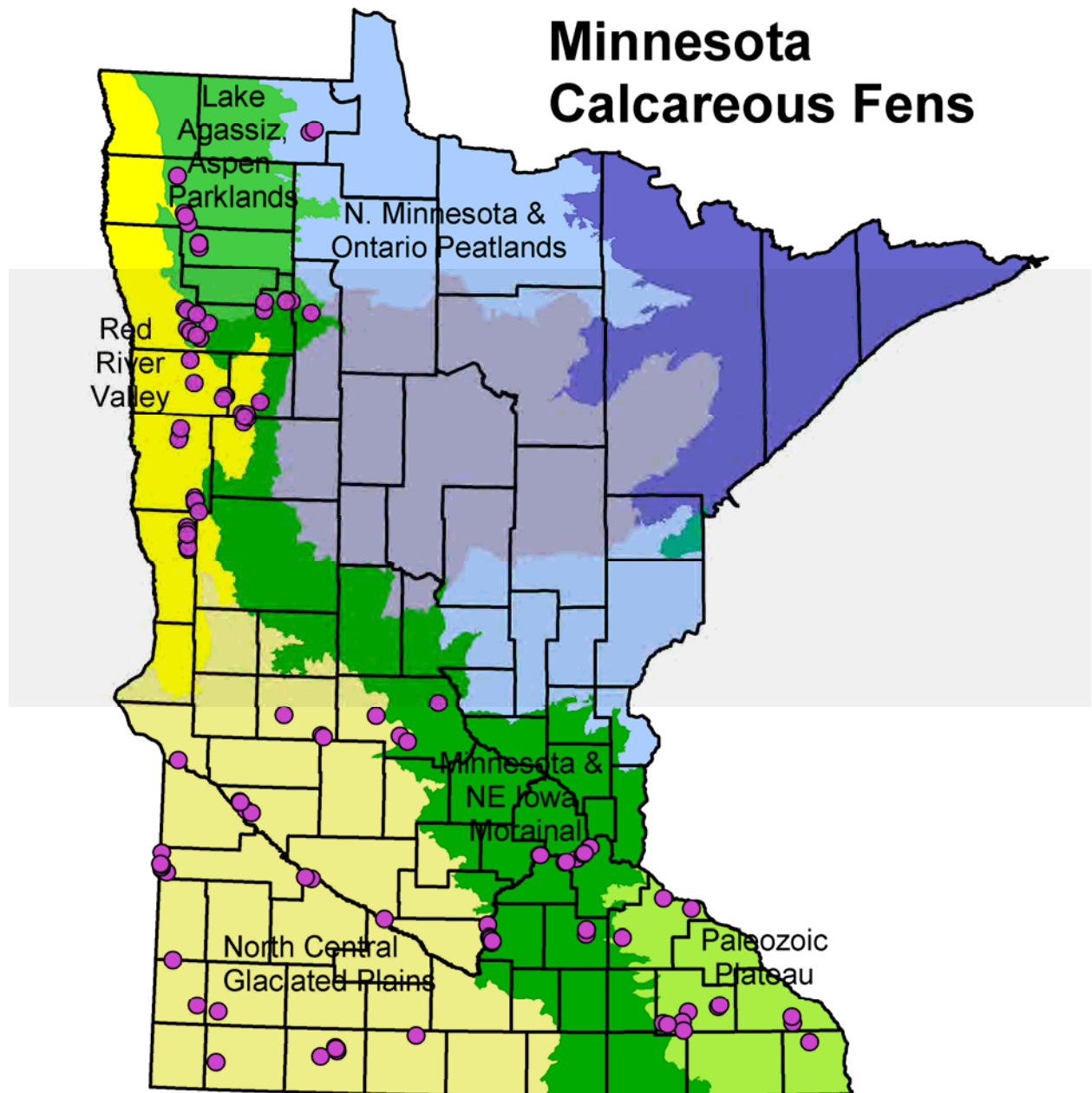


Figure 1: Calcareous Fens in the State of Minnesota overlain on ECS regions.

Table 2: Sites grouped by ECS Section

ESC Section	County	Type	Site Name	Bryo	Vasc	Hydro	Soil	Chem
Red River Valley	BEC	Fen	Ogema Spring Prairie Fen	x	x	x	X	x
Red River Valley	BEC	Control	Spring Creek WMA			x	X	x
Red River Valley	CLA	Fen	Barnesville State WMA	x	x			
Red River Valley	CLA	Control	Felton WMA	x	x	x		
Red River Valley	CLA	Fen	Felton Fen N	x	x	x	X	x
Red River Valley	CLA	Fen	Felton Fen S	x	x	x	X	x
Red River Valley	MAH	Fen	Waubun Fen	x	x	x	X	x
Red River Valley	NOR	Fen	Faith Prairie		x			
Red River Valley	NOR	Fen	Green Meadow Fen	x	x	x	X	x
Lake Agassiz, Aspen Parklands	PEN	Control	Higenbotham WMA			x	X	x
Lake Agassiz, Aspen Parklands	PEN	Control	Pembina WMA		x	x	X	x
Lake Agassiz, Aspen Parklands	PEN	Fen	Sanders 18 Fen	x	x	x	X	x
Lake Agassiz, Aspen Parklands	PEN	Fen	Sanders 7 Fen	x	x	x	X	x
Lake Agassiz, Aspen Parklands	PEN	Control	Sanders Cattail			x	X	x
Lake Agassiz, Aspen Parklands	POL	Fen	Gully Peatlands	x	x			
Lake Agassiz, Aspen Parklands	RDL	Control	Crane Wetland		x	x	X	x
N. Minnesota & Ontario Peatlands	ROS	Fen	Bemis Hill Swamp	x	x			
Red River Valley	WIL	Fen	Rothsay Prairie Fen	x	x		x	
North Central Glaciated Plains	CHI	Control	Watson WMA			x	x	x
North Central Glaciated Plains	CHP	Fen	Kragero Township Fen	x	x	x	x	x
North Central Glaciated Plains	CHP	Fen	Zion Lutheran Church Fen	x	x	x	x	x
North Central Glaciated Plains	COT	Fen	Jeffers Calcareous Fen	x		x	x	x
North Central Glaciated Plains	COT	Fen	Muller Calcareous Fen	x		x	x	x
North Central Glaciated Plains	DUE	Control	South Slough (SD/MN border)			x	x	x
North Central Glaciated Plains	JAC	Fen	Holte Prairie Fen	x	x	x	x	x
North Central Glaciated Plains	JAC	Fen	Thompson Fen		x			
North Central Glaciated Plains	JAC	Fen	Yonker Prairie Fen	x	x	x	x	x
North Central Glaciated Plains	LAC	Control	Hamlin WPA			x	x	x
North Central Glaciated Plains	LYO	Fen	Sam Tutt Fen	x	x	x	x	x
North Central Glaciated Plains	MUR	Fen	Lost Timber Fen	x	x	x	x	x
North Central Glaciated Plains	NIC	Fen	Fort Ridgely Fen	x		x	x	x
North Central Glaciated Plains	NOB	Fen	Adrian Calcareous Fen	x	x	x	x	x
North Central Glaciated Plains	NOB	Control	Adrian Spring			x	x	x
North Central Glaciated Plains	PIP	Fen	Altona Fen	x	x	x	x	x
North Central Glaciated Plains	PIP	Control	Altona Meadow	x	x	x	x	x
North Central Glaciated Plains	PIP	Fen	Burke WMA Fen	x	x	x	x	x
North Central Glaciated Plains	PIP	Control	Prairie Coteau Wetland		x	x	x	x
North Central Glaciated Plains	RED	Fen	Redwood County Fen		x	x	x	x
North Central Glaciated Plains	STR	Fen	Spring Hill Fen	x	x	x	x	x
North Central Glaciated Plains	YEL	Fen	Fairchild Calcareous Fen	x	x	x	x	x
North Central Glaciated Plains	YEL	Control	Fortier WPA			x	x	x
North Central Glaciated Plains	YEL	Fen	Sioux Nation Calcareous Fen	x	x	x	x	x
Minnesota & NE Iowa Morainal	CLE	Fen	Clearbrook Spring Fen	x	x			

Table 2 continued: Sites grouped by ECS Section and the types of activities conducted at each site.

ESC Section	County	Type	Site Name	Bryo	Vasc	Hydro	Soil	Chem
Minnesota & NE Iowa Morainal	DAK	Fen	Nichols Fen	x	x	x	x	x
Minnesota & NE Iowa Morainal	CRV	Fen	Seminary Fen	x	x	x	x	x
Minnesota & NE Iowa Morainal	DAK	Fen	Black Dog Preserve SNA	x	x	x	x	x
Minnesota & NE Iowa Morainal	DAK	Fen	Fort Snelling State Park	x	x	x	x	x
Minnesota & NE Iowa Morainal	DOD	Control	Iron Horse Prairie		x	x	x	x
Paleozoic Plateau	DOD	Fen	Pheasants Forever WMA	x	x	x	x	x
Minnesota & NE Iowa Morainal	DOD	Fen	Wasioja Calcareous Fen	x	x	x	x	x
Minnesota & NE Iowa Morainal	FIL	Control	Beaver Creek Wetland		x	x	x	x
Paleozoic Plateau	GOO	Fen	Cannon Valley Trail	x	x	x	x	x
Paleozoic Plateau	GOO	Fen	Perched Valley Calcareous Fen	x	x	x	x	x
Paleozoic Plateau	GOO	Fen	Red Wing 21 Fen	x	x	x	x	x
Paleozoic Plateau	HOU	Fen	Houston 26 Fen	x	x	x	x	x
Paleozoic Plateau	HOU	Fen	Sheldon 16 Fen	x	x	x	x	x
Minnesota & NE Iowa Morainal	LES	Fen	Ottawa Fen	x	x	x	x	x
Minnesota & NE Iowa Morainal	MEE	Control	Sucker Creek	x		x	x	x
Paleozoic Plateau	OLM	Fen	Eyota 13 Fen	x	x	x	x	x
Paleozoic Plateau	OLM	Fen	Mutchler Fen	x	x	x	x	x
Paleozoic Plateau	OLM	Fen	Nelson Fen WMA	x	x	x	x	x
Paleozoic Plateau	OLM	Fen	Stewartville Calcareous Fen	x	x	x	x	x
Paleozoic Plateau	OLM	Fen	Stonehedge Calcareous Fen	x	x	x	x	x
Minnesota & NE Iowa Morainal	RIC	Fen	Cannon River Wilderness Area	x	x	x	x	x
Minnesota & NE Iowa Morainal	SCO	Fen	Savage Spring Fen SNA	x	x	x	x	x
Minnesota & NE Iowa Morainal	SCO	Fen	Savage Spring Fen USFW	x	x	x	x	x
Minnesota & NE Iowa Morainal	STE	Fen	Pogones WMA		x	x	x	x
Paleozoic Plateau	WAB	Fen	McCarthy Lake WMA	x	x	x	x	x
Paleozoic Plateau	WIN	Fen	Kennedy Fen	x	x	x	x	x
Paleozoic Plateau	WIN	Control	Whitewater 1			x	x	x
Paleozoic Plateau	WIN	Control	Whitewater 2			x	x	x
Paleozoic Plateau	WIN	Fen	Wiscoy Valley East Fen	x	x	x	x	x
Paleozoic Plateau	WIN	Control	Wiscoy Wetland			x	x	x

Data of at least one type were collected on 52 calcareous fen sites and on 20 control sites. In some cases there are multiple sampling sites within a given fen wetland complex. For a given analysis there may be a different total number of sites. A major factor in selection of sites for study is public land ownership or landowner permission. Many of the sites are fen on private land. Permission of the landowners was obtained for access, but no new permanent monitoring sites were established on private land.

A new component has been a study to investigate the classification, indicator value, and regional differentiation of bryophyte species in Minnesota's calcareous fens. Initial work on this topic is very promising, and the revised list of calciphiles includes bryophytes. Wetland project proposals can now be reviewed for the presence of calcareous fens throughout the year.

HYDROLOGY STUDY METHODS

Upwelling conditions are typically identified by establishing that an upward ground water gradient exists and that an upward ground water flow path also exists. Methods for technically establishing upwelling conditions include installation and monitoring of a pair, or nest of water level monitoring wells: when the water level elevation is higher in the well that has the deeper screen, then an upward gradient exists and an upward flow path can occur in relation to the permeability of the intervening materials. Indeed, four of the calcareous fens we studied already had flowing wells.

In the case of a wetland where the water table is at the surface, only one well is needed to establish the ground water gradient, as the comparison in water level elevation can be made to the water table.

Well installation in calcareous fens cannot be accomplished using normal well construction methods. To avoid severe damage to the fen, all work must be done by hand and grouting and subsequent sealing cannot follow the normal Minnesota Department of Health Well Construction Code. Variances from the Code were obtained and we ultimately had water level elevation monitoring wells in a total of 18 calcareous fens.

In spring-pond or mound settings actively discharging ground water is evidence of upwelling.

In side-slope settings a downward flowpath that intersects the ground surface will also result in the emergence of groundwater at the surface, which we are also classifying as 'upwelling' for our purpose in this study.

Hydrogeologic settings were classified as: seasonally inundated or depressional, spring pond or mound, and side-slope seepage face.

SOILS STUDY METHODS

The soils of a calcareous fen have either a histic epipedon or are histosols. If the soil at a given fen or control site is an organic soil or if the soil has a histic epipedon, the following types of qualitative observations were likely to be made:

- Previously mapped as an organic soil
- Partially decomposed plant materials observable
- Black soil, greasy when rubbed between the fingers
- Very soft soil, perhaps to the point of feeling uncertain of one's footing
- A rod penetrates the soil easily
- Odor of sulfur
- Very low bulk density

If the soil at a given fen or non-fen wetland is a mineral soil, textural analysis by feel was done following the guidelines used for classification of natural plant communities (MNDNR 2003).

Soil samples from a select number of calcareous fen and non-fen wetlands sites were collected and quantitatively analyzed for bulk density, organic matter content, soil color, and carbonate content. Methods used for these analytical tests are described in the Natural Resources Conservation Service, 1996, Soil Survey Laboratory Methods Manual, Soil Survey Investigations Report No. 42.

WATER CHEMISTRY STUDY METHODS

Field methods and sampling procedures follow guidelines in "Field and Laboratory Methods" by Scott C. Alexander and E. Calvin Alexander, University of Minnesota Hydrogeochemistry Laboratory in the Department of Geology and Geophysics. Samples were submitted to the University of Minnesota Hydrogeochemistry Laboratory.

Conductance

Conductance is measured with a Hach Senslon Conductivity Meter with automatic temperature correction. A conductivity standard is checked daily.

pH

Calibration of the pH meter is done at each sampling site by a two buffer calibration. Fresh buffers are prepared daily. Several types of meters and electrodes have been used over time. Buffers are selected to bracket the pH of the sample, in most cases pH 7 and 10 buffers are used.

Cations

The sample to be analyzed for cations is collected in a 15 ml polypropylene bottle. The sample bottles are rinsed three times with sample water before the final sample is collected. The sample is acidified with 1 drop of 6N trace metal grade HCL and stored on ice for transport. These samples are analyzed by Inductively Coupled Plasma - Mass Spectrometry Perkin-Elmer/Sciex Elan 5000 ICP-MS (EPA Method: 200.8)

Detection Limits: all values reported as $\mu\text{g/g}$. $1 \mu\text{g/g} = 1 \text{ ppm}$ ($\cong 1 \text{ mg/l}$ in dilute solutions)

Ca = 0.1	Mg = 0.1	Na = 0.1	K = 0.1
Al = 0.001	Fe = 0.02	Mn = 0.001	Sr = 0.001
Ba = 0.001	Si = 0.1	P = 0.02	

Anions

The sample to be analyzed for anions is collected in a 15 ml amber high density polyethylene bottle. The sample bottles are rinsed three times with sample water before the final sample is collected. These samples are cooled to ice water temperature for transport and storage. These samples are analyzed by Ion Chromatography Dionex Series 4000I EPA method 300.0, "The Determination of Inorganic Anions in Water by Ion Chromatography."

Detection limits: all values reported as $\mu\text{g/g}$. $1 \mu\text{g/g} = 1 \text{ ppm}$ ($\cong 1 \text{ mg/l}$, dilute solutions)

Major anions	Cl = 0.10	NO ₃ -N = 0.005	SO ₄ = 0.1
Other anions	Br = 0.010	NO ₂ -N = 0.005	S ₂ O ₃ = 1.0
	F = 0.05	PO ₄ -P = 0.02	CH ₃ COO = 0.5

Alkalinity

Alkalinity samples can be analyzed in the field, at an off-site location or in the lab within 24 hours of sample collection. Repeated measurements have indicated that holding times for refrigerated samples of several weeks show no significant degradation for carbonate saturated ground waters; this would not be true for waters with a high degree of supersaturation. Titrations are performed in triplicate with a Hach digital titrator using a 1.6N H₂SO₄ titrant to a bromocresol green-methyl red color end-point. The traditional color indicator solutions are bromocresol green and methyl red along with phenolphthalein for high pH waters.

Sample aliquots are measured in the field with a portable scale having a minimum accuracy of 0.1 g. The advantages of weighing samples are that for triplicate samples a slightly different mass is used for each titration and then normalized to 100 g thus preventing biasing the second and third values towards the first and that no particular mass is required allowing each aliquot to be easily prepared by weighing out a mass near 100 g. The normalized alkalinity is calculated using a simple proportional relationship.

Dissolved Oxygen

Dissolved Oxygen can be analyzed in the field by the Winkler Titration Method. However, results depend upon the type of sample: pools and springs can have high dissolved oxygen levels, despite the fact that the upwelling groundwater is essentially devoid of oxygen. Upwelling ground water absorbs atmospheric oxygen almost immediately – only samples drawn from wells typically result in dissolved oxygen levels under 2 mg/l, only if the sampling method is carefully devised to eliminate exposure to the atmosphere as the sample is recovered and as the sample is transferred and analyzed, all of which is difficult to ensure under field conditions. Data from a single fen site have ranged from near zero mg/l dissolved oxygen to over 8 mg/l oxygen.

On the other hand, stagnant pools in closed depressions can have low dissolved oxygen levels because of the warm water temperatures and decomposition of organic matter – which results in low dissolved oxygen levels. Dissolved oxygen cannot be used to distinguish between calcareous fens and non-fen wetlands, despite the fact that, in the subsurface, low oxygen content would be a characteristic of ground water which is upwelling into calcareous fen wetlands. For this reason, we recommend that dissolved oxygen be dropped from the technical criteria.

VEGETATION TECHNICAL CRITERION TESTING METHODOLOGY

Vascular Plants

Study sites were selected based on a number of criteria. Geographical representation, public ownership to assure repeated access, determination that the vegetation of the site is typical of undisturbed calcareous fens in the region, and whether or not there were preexisting data (species lists) that could be utilized. Criteria for selecting non-fen comparison sites were similar. Each site was visited at least twice in a year: once in late spring or early summer to be able to identify the sedges and other early-appearing species, and again in late summer or early autumn to be able to identify the grasses, composites and other late-appearing species. During each visit a list was made of all the vascular plant species seen within the boundaries of the fen. Several fens had comparable species lists from previous studies and it was not necessary to revisit those sites. This is essentially the procedure used to test method number two. Method number one was considered untestable (see results section for an explanation of this evaluation of method number one).

Bryophytes

The methods used to sample bryophytes are described in "Bryophytes of Calcareous Fens: Minimum Requirements for Submission of Collections for Identification and Suggestions on Survey Procedure", 2004, Lambda Max Ecological Research, Minneapolis, Minnesota and included here as an Appendix.

RESULTS

HYDROLOGY TECHNICAL CRITERION TESTING RESULTS

In each case we were able to show that ground water in the area of the calcareous fens we studied had the potential to emerge at the surface (Table 3), thus maintaining saturated conditions sufficient to allow organic matter to accumulate. In side slope hydrogeologic settings many non-fen wetlands will also receive ground water inputs.

Our site investigations revealed that all of the calcareous fen settings provided adequate drainage to keep the sites from being inundated. For example, none of the Minnesota River Valley calcareous fen sites were flooded during the 1993 floods. Site investigations in winter also revealed that most calcareous fens build ice sheets or domes during the winter because of the discharging ground water. Fen sites were rendered clearly visible for a few weeks between snowmelt and the melting of the accumulated ice (Figure 2). During the growing season ground water discharge may almost be equaled by evapotranspiration and thus be much less evident. These facts may help distinguish between calcareous fens and non-fen wetlands in side-slope seepage face settings.

Table 3: Hydrology Technical Criterion

Wetland Category	Site Descriptions	Number of Sites in this Category	Number of Sites Passing the Criterion
<u>Calcareous Fens</u>	Peat Domes Sustained by Upwelling Ground Water	7	7
	Seepage Face with Discharging Ground Water	26	26
	Spring Ponds with Discharging Ground Water	16	16
all 49 pass criterion			
<u>Non-Fen Wetlands</u>	Seasonally inundated wetland in a closed basin	10	
	Flowing Spring (no pond)	1	1
	Terrace wetland along creek; seasonal inundation	7	
	Seepage Face with Discharging Ground Water	2	2
3 of 20 pass criterion			

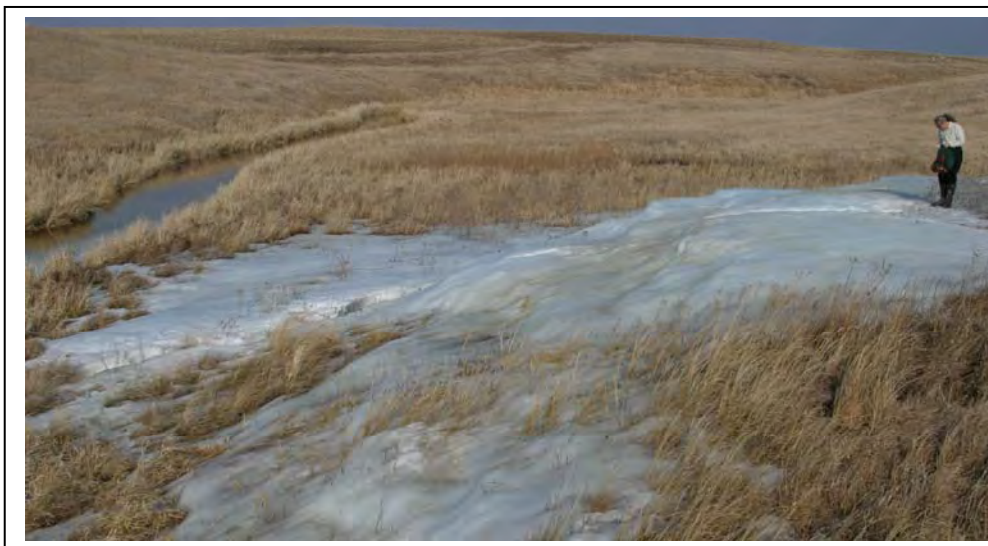


Figure 2: Winter ice dome revealed immediately after snowmelt. Shelburne 22 fen, Lyon County, MN.

SOILS TECHNICAL CRITERION TESTING RESULTS

In each case, calcareous fen sites were seen to have organic soils (Table 4). High carbonate content can lead to the perception that organic soils are less decomposed than they really are, indeed they are difficult to distinguish from mineral soils in some cases. We have termed such soils 'marly peat'.

Our site investigations revealed that 40% of the non-fen wetlands also passed the soils technical criterion.

Table 4: Soils Technical Criterion from Field Investigation

Wetland Category	Soil Descriptions	Number of Sites in this Category	Number of Sites Passing the Criterion
Calcareous Fens	Muck	23	23
	Marly Peat	7	7
all 49 pass criterion	Peat	19	19
Non-Fen Wetlands	Inorganic	12	
	Muck	6	6
8 of 20 pass criterion	Peat	2	2

Soil scientists working in the Southeastern Minnesota are quick to point out that the typical calcareous fen in their experience does not accumulate 'peat', rather the soils are typically mucks. The term 'peat' implies a presence of fibers that are only partially decomposed. True peats are identifiable by lay persons because of these identifiable fibers. In the southeast the distinction by feel or appearance between mineral soils and organic soils is more difficult for the non-soil-scientist. None-the-less, a black, soft, perennially wet soil that may also fizz with acid is a promising calcareous fen soil candidate.

Thirty-eight soil samples were submitted for determination of organic matter and carbonate content.

Table 5: Laboratory Results: Soil Bulk Density, Calcium Carbonate Equivalent and Organic Matter

	Bulk Density (g/cc)		Calcium Carbonate Equivalent (%)		O.M. (%) LOI 400C	
	Fen	Non-Fen	Fen	Non-Fen	Fen	Non-fen
Number of Samples	27	11	27	11	27	11
Minimum	0.12	0.19	1.6	0.6	15.8	0.9
Maximum	0.70	1.43	69.0	30.0	70.9	76.0
Mean	0.342	0.821	26.98	9.88	37.57	12.25
Standard Deviation	0.133	0.391	23.16	8.34	17.58	21.38

Soils of calcareous fens have higher organic matter and calcium carbonate content and lower bulk density than the soils of the non-fen sites. If an organic matter content threshold of 12% is chosen, then all of the fen site's soils are above the threshold and all but one of the non-fen site's soils are below the threshold. Calcium carbonate content varies with the depth of the sample. More work is needed before we understand the implications of these changes with depth, but preliminary results from this and previous work indicate that the carbonate/depth profile of a calcareous fen is an indicator of stability of the hydrologic regime and thus the 'health' of a calcareous fen.

WATER CHEMISTRY TECHNICAL CRITERION TESTING RESULTS

The technical criteria are meant to be used to decide if a site is indeed a calcareous fen. This implies that one could visit a site and collect limited data from which to make the determination. For many of the sites for which we have data, that is exactly what we have done. However, several of our sites have been visited many, many times and we have numerous water chemistry sampling events. To carry out this test of the criteria, it was decided to randomly select data from one site visit per distinct location to more accurately represent a calcareous fen determination. In many cases, a calcareous fen which did not pass a given criteria as shown here, may well have passed that criterion at a different location within the fen wetland complex or on a different date.

pH

All but one of the calcareous fen sites studied passed the criterion for pH, while all of the non-fen wetland sites passed the criterion (Table 6). The usefulness of this criterion is to distinguish between calcareous fens and northern (bog) peatlands, none of which were included in this study.

Table 6: pH Technical Criterion

Wetland Category	pH	Number of Sites Passing the Criterion
<u>Calcareous Fens</u>	pH \geq 6.7	48
48 of 49 pass criterion	pH < 6.7	1
<u>Non-Fen Wetlands</u>	pH \geq 6.7	20
all 20 pass criterion	pH < 6.7	0

Conductivity

The conductivity criterion is not as useful as was theoretically thought to be the case. Only 35 of 49 calcareous fens passed the criterion, while 11 of 20 non-fen wetlands passed (Table 7). The threshold of 500 mS/cm was set because the source waters sustaining calcareous fens are thought to be ground water, and ground water is characterized by a conductivity of 500 mS/cm or greater. However, calcareous fens are at the ground surface and thus receive water from at least two sources: precipitation and ground water. In addition, many fens have more than one ground water flow path that brings water to the surface at the fen's location. The shorter, local flow paths and the precipitation derived waters have much lower conductivity than the deeper ground water sources. Thus, waters within calcareous fens may vary due to antecedent conditions.

Table 7: Conductivity Technical Criterion

Wetland Category	Conductivity mS/cm	Number of Sites Passing the Criterion
<u>Calcareous Fens</u>	Conductivity \geq 500	35
35 of 49 pass criterion	Conductivity < 500	14
<u>Non-Fen Wetlands</u>	Conductivity \geq 500	11
11 of 20 pass criterion	Conductivity < 500	9

Calcium

All of the calcareous fen sites studied passed the criterion for calcium, while all but one of the non-fen wetland sites passed the criterion (Table 8). The usefulness of this criterion is to distinguish between calcareous fens and typical northern (bog) peatlands, none of which were included in this study. The results of this work reveal that field titrations of calcium hardness (Table 9), from which a representative calcium concentration value can be calculated, is just as useful and much much faster, than submittal of samples to a laboratory for testing. In addition, due to the need for field titration of alkalinities, the equipment is already at hand during site visits to calcareous fens.

Table 8: Calcium Technical Criterion

Wetland Category	Calcium ppm (\cong mg/l)	Number of Sites Passing the Criterion
<u>Calcareous Fens</u>	Calcium \geq 30	49
all 49 pass criterion	Calcium < 30	0
<u>Non-Fen Wetlands</u>	Calcium \geq 30	18
18 of 19 pass criterion	Calcium < 30	1

Table 9: Calcium Technical Criterion (Field Titration)

Wetland Category	Calcium ppm (\cong mg/l) as titrated in the field	Number of Sites Passing the Criterion
<u>Calcareous Fens</u>	Calcium \geq 30	49
all 49 pass criterion	Calcium < 30	0
<u>Non-Fen Wetlands</u>	Calcium \geq 30	19
all 19 pass criterion	Calcium < 30	0

Alkalinity

All but one of the calcareous fen sites studied passed the criterion for alkalinity and all but one of the non-fen wetland sites passed the criterion (Table 10). As with pH and calcium concentration, the usefulness of this criterion is to distinguish between calcareous fens and typical northern (bog) peatlands, none of which were included in this study. Alkalinity is always titrated in the field because the samples would tend to change too much if they were transported back to a laboratory under the field conditions usually encountered in this type of work (the samples cannot be immediately chilled to ice water temperature because there is no vehicle close by).

Table 10: Alkalinity Technical Criterion (Field Titration)

Wetland Category	Alkalinity ppm meq/l as titrated in the field	Number of Sites Passing the Criterion
<u>Calcareous Fens</u>	Alkalinity \geq 1.65	48
48 of 49 pass criterion	Alkalinity < 1.65	1
<u>Non-Fen Wetlands</u>	Alkalinity \geq 1.65	19
19 of 20 pass criterion	Alkalinity < 1.65	1

Ratio of Calcium + Magnesium to Total Cations

The original committee that created the 1995 Technical Criteria had suggested that two ratios should be examined as soon as adequate data were available. Calcium and magnesium compared to total cations and alkalinity compared to total anions were evaluated; the results are tabulated below. The number of samples is still limited, but the results are not promising. The resulting values at non-fen sites overlap the values at calcareous fen sites. Even if there should prove to be a statistically significant difference between the populations, the very sparse sampling conducted for calcareous fen identification will not distinguish between calcareous fens and non-fens using these ratios.

Table 11: Ratios				
	Ratio of Ca + Mg to Total Cations		Ratio of Alkalinity to Total Anions	
	Fen	Non-Fen	Fen	Non-Fen
Number of Samples	73	28	52	17
Mean	0.931	0.905	0.756	0.716
Minimum	0.71	0.74	0.23	0.36
Maximum	0.98	0.98	0.99	0.89
Standard Deviation	0.049	0.065	0.163	0.176

VEGETATION TECHNICAL CRITERION TESTING RESULTS

The vegetation criterion, if properly constructed, must have the potential to adequately and definitively identify calcareous fens in unimpacted and undegraded wetlands. It may also be useful in impacted areas where natural vegetation still survives.

Vascular Plants

There are two alternative testing methods in the "Vegetation Technical Criteria". The first method is called the "50% cover method", and is described as giving a positive result when "more than 50% of the composition of the dominant species from all strata are calciphiles from any of the indicator classes". The wording of this method is rather cryptic and problematic, and the original document gives no explanation. This method could easily be interpreted several ways; the four most likely ways are listed below.

- More than 50% of the species present in the plot are indicator species.
- More than 50% of the aerial cover within a plot is composed of indicator species.
- More than 50% of the cover within a plot is composed of a single species (the "dominant" species), which is an indicator species.
- The dominant species in more than 50% of the plots is an indicator species.

Since the original document gives no statistical or biological basis for this method, and no clear hypothesis is stated, it is difficult to know how to apply this method on the ground. Aside from being ambiguous, this method fails to address the fact that the plant species in a natural community are not distributed uniformly or randomly, and that any sampling scheme must take patchiness into account if subsequent analysis is to be meaningful. So without specific methodology or at least some clarification of intent, it is not possible to test this method. However, it is quite clear that in any calcareous fen it is possible to obtain a positive result using any of the four possible interpretations presented above. It would only depend on the size and placement of the plot(s).

The second method is called the "Calciphile Species Occurrence Method". This method is described as resulting in a positive determination "when the area has a natural community index value of 50 or more by summing the index values of the 27 calcareous fen indicator species" This is apparently intended to be a qualitative alternative to the preceding semi-quantitative method. In the second method each indicator species that is determined to be present is recorded regardless of its cover value or whether it is the dominant species or not. As in the first method, the relationship between sampling technique and floristic composition is not made clear. Since the supposed intent is only to determine which, if any, indicator species occur on the site, the plot size and shape was assumed to be coincident with the boundaries of the calcareous fen ecotope. Using this interpretation, the second method is not a sample but a floristic inventory, and no statistical analysis is necessary. However, this interpretation would seem to require that the boundaries of the fen be determined prior to the floristic inventory, rather than allowing the results of the inventory to determine the boundaries of the fen. It is unclear if this was the intent of the technical criteria, or even if the role of a floristic inventory as a method of delineation vs. designation was ever considered. However, it is clear that because of the non-random distribution of plant species within a community, and the inherent patchiness and discontinuity of species associations, a floristic inventory cannot serve as a useful tool for delineating community boundaries. But it does serve well as a simple and biologically-based method for comparing the floristic composition of one site to another site or to a designated type.

Comparable datasets for evaluation of the vegetation technical criteria were acquired for a total of 26 fens and 7 non-fens (Summarized in Table 12 and detailed in Table 13), where for this purpose, the Minnesota River Valley fens are treated as their own class.

Table 12: Vascular Plant Technical Criterion (Species List Scores)

Wetland Category	Calciphile score as determined from species list	Number of Sites Passing the Criterion
<u>Calcareous Fens</u>	Calciphile Score ≥ 50	21
21 of 26 pass criterion	Calciphile Score < 50	5
<u>Non-Fen Wetlands</u>	Calciphile Score ≥ 50	0
none pass criterion	Calciphile Score < 50	7

Table 13: Detailed Results of the Vegetation Criterion Test.....

Northwestern fen sites				
Faith Fen	Norman Co.	T111N R43W SW NW 25	159 points	
Waubun WMA	Mahnomen Co.	T143N R42W NW SW 25	199 points	
Spring Creek WMA	Becker Co.	T142N R42W NE NE 13	202 points	
Felton WMA	Clay Co.	T142N R45W SE NW 31	160 points	
Northwestern non-fen sites				
Crane WMA	Red Lake Co.	T151N R13W NE NW 13	1 point	
Felton WMA	Clay Co.	T142N R45W NW NE 31	29 points	
Pembina WMA	Pennington Co.	T152N R45W NE NW 18	12 points	
Southwestern fen sites				
Thompson Fen	Jackson Co.	T103N R35W NE NE 7	83 points	
Holthe SNA	Jackson Co.	T103 R 35W NW NW 8	87 points	
Altona WMA	Pipestone Co.	T108N R46W NE NW 1	87 points	
Sioux Nation WMA	Yellow Med Co	T114N R46W NW xx 17	89 points	
Burke WMA	Pipestone Co.	T106N R44W SESE 28	85 points	
Yonker's Fen	Jackson Co.	T101N R34W NW SE 27	33 points	
Adrian Fen	Nobles Co.	T102N R43W SW SW 11	58 points	
Southwestern non-fen sites				
Altona WMA	Pipestone Co.	T108N R46W NE NW 1	1 point	
Prairie Coteau SNA	Pipestone Co.	T108N R44W SW SE 32	2 points	
Southeastern fen sites				
Wiscoy Valley East	Winona Co.	T105N R7W NW SW 3	58 points	
Perched Valley WMA	Goodhue Co.	T112N R13W NW SW 8	75 points	
Rice Co. Park	Rice Co.	T111N R20W NE NE 34	67 points	
Nelson Fen WMA	Olmsted Co.	T105N R 15W SW SE 16	156 points	
Pogones WMA	Steele Co.	T105N R19W NW SE 18	29 points	
Pheasants Forever WMA	Dodge Co.	T107N R17W SW SE 24	71 points	
Wasioja WMA	Dodge Co.	T107N R17W SE SW 17	48 points	
Southeastern non-fen sites				
Beaver Creek WMA	Fillmore Co.	T101N R13W NE SW 21	11 points	
Iron Horse SNA	Dodge Co.	T105N R12W NW SE 27	7 points	
Minnesota Valley fen sites				
Redwood Co. Fen	Redwood Co.	T114N R37W NE NW 27	91 points	
Ottawa Fen	LeSueur Co.	T110N R26W NW SE 3	135 points	
St. Peter Fen	Nicollet Co.	T111 R26W NE NE 16	34 points	
Seminary Fen	Carver Co.	T116 R23W NE SW 35	156 points	
Nicols Meadow	Dakota Co.	T27N R23W NE SW 18	71 points	
Fort Snelling SP	Dakota Co.	T27N R23W SE NW 4	43 points	
Savage Fen	Scott Co.	T115N R21W SE NE 17	194 points	
Black Dog SNA	Dakota Co.	T27N R24W NW NE 34	162 points	

Highlighted Sites scored less than 50 points and thus fail the Vegetation Criterion

The average number of species recorded in each fen statewide was 61 (range 18-90), and the average number of species recorded in the non-fens statewide was 58 (range 46-71). The fens in the Minnesota Valley were the most diverse and averaged 74 species per site. The fens in the southwest were the least diverse and averaged 42 species per site.

Subjecting the species lists from each site to "method number two" resulted in 21 correct determinations and 5 incorrect determinations. Of the incorrect determinations, there was one in the southwest and two each in the

southeast and the Minnesota Valley. None of the non-fen sites were misidentified as calcareous fens. The northwest region had no incorrect determinations at all. The sites for which there were incorrect determinations had lower total species diversities than the average for their respective regions.

The regional differences in floristic diversity seen in the fens is comparable to that in non-fen wetlands, and uplands as well. It is well established in the literature that there is simply a greater number of plant species in the northwestern and southeastern portions of the state than in the southwestern portion. This is generally attributed to differences in climate and glacial history. It is also not surprising that this designation method gave adequate results in the northwest region, but not in the other 3 regions, since the method was created using data primarily from the northwest region.

Using the additional data collected during this project it is possible to create a single set of new floristic criteria that would serve to identify fens statewide. However, the sensitivity of such criteria would be greatly increased if the data were stratified regionally rather than statewide. This would result in a lesser chance of a non-fen being incorrectly identified as a fen. Designation of a calcareous fen should be based on the following regionalized, with the inclusion of a "Minnesota River Valley" category, floristic criteria. We further recommend a similar criteria for bryophytes, whereby the threshold that identifies a calcareous fen is a sum of both vegetation criteria of 50 points.

Table 14: Regionalized List of 29 Vascular Plant Indicators to Identify Calcareous Fens in Minnesota

Species	NW	MN valley	SE	SW
<i>Aster borealis</i>	1	5	5	5
<i>Berula pusila</i>	-	5	5	-
<i>Betula pumila</i>	1	5	5	-
<i>Bidens coronata</i>	-	5	5	-
<i>Bromus ciliatus</i>	1	5	5	-
<i>Cardamine bulbosa</i>	5	5	5	5
<i>Carex aquatilis</i>	1	5	25	25
<i>Carex hystericina</i>	1	5	5	25
<i>Carex interior</i>	1	5	5	5
<i>Carex prairea</i>	25	25	25	25
<i>Carex sterilis</i>	25	25	25	25
<i>Cladium mariscoides</i>	5	25	-	-
<i>Eleocharis rostellata</i>	25	25	-	-
<i>Eriophorum angustifolium</i>	1	1	5	5
<i>Gentianopsis procera</i>	1	5	25	25
<i>Liparis loeselii</i>	1	5	5	5
<i>Lobelia kalmii</i>	1	25	25	25
<i>Oxypolis rigidior</i>	-	5	5	-
<i>Parnassia glauca</i>	5	25	25	25
<i>Potentilla fruticosa</i>	1	25	25	-
<i>Primula mistassinica</i>	25	-	-	-
<i>Rhynchospora capillacea</i>	25	25	25	25
<i>Salix candida</i>	5	5	5	-
<i>Scirpus cespitosus</i>	5	25	25	-
<i>Scleria verticillata</i>	25	25	25	25
<i>Tofieldia glutinosa</i>	5	25	-	-
<i>Triglochin maritima</i>	1	25	25	25
<i>Triglochin palustris</i>	25	25	25	25
<i>Valeriana edulus</i>	-	5	5	-

Note: Where the table does not contain a value in a regional column, that plant is not expected to occur in that region. In the unlikely case that it should occur, it will receive the maximum score for that plant.

Table 15: Results of the Regionalized Scoring Method Applied to 26 Complete Lists.....

Northwestern fen sites			
Faith Fen	Norman Co.	T111N R43W SW NW 25	148 points
Waubun WMA	Mahnomen Co.	T143N R42W NW SW 25	208 points
Spring Creek WMA	Becker Co.	T142N R42W NE NE 13	215 points
Felton WMA	Clay Co.	T142N R45W SE NW 31	154 points
Northwestern non-fen sites			
Crane WMA	Red Lake Co.	T151N R13W NE NW 13	3 point
Felton WMA	Clay Co.	T142N R45W NW NE 31	35 points
Pembina WMA	Pennington Co.	T152N R45W NE NW 18	11 points
Southwestern fen sites			
Thompson Fen	Jackson Co.	T103N R35W NE NE 7	185 points
Holthe SNA	Jackson Co.	T103 R 35W NW NW 8	250 points
Altona WMA	Pipestone Co.	T108N R46W NE NW 1	250 points
Sioux Nation WMA	Yellow Med Co	T114N R46W NW xx 17	220 points
Burke WMA	Pipestone Co.	T106N R44W SESE 28	245 points
Yonker's Fen	Jackson Co.	T101N R34W NW SE 27	130 points
Adrian Fen	Nobles Co.	T102N R43W SW SW 11	160 points
Southwestern non-fen sites			
Altona WMA	Pipestone Co.	T108N R46W NE NW 1	10 point
Prairie Coteau SNA	Pipestone Co.	T108N R44W SW SE 32	15 points
Southeastern fen sites			
Wiscoy Valley East	Winona Co.	T105N R7W NW SW 3	75 points
Perched Valley WMA	Goodhue Co.	T112N R13W NW SW 8	160 points
Rice Co. Park	Rice Co.	T111N R20W NE NE 34	70 points
Nelson Fen WMA	Olmsted Co.	T105N R 15W SW SE 16	225 points
Pogones WMA	Steele Co.	T105N R19W NW SE 18	55 points
Pheasants Forever WMA	Dodge Co.	T107N R17W SW SE 24	190 points
Wasioja WMA	Dodge Co.	T107N R17W SE SW 17	85 points
Southeastern non-fen sites			
Beaver Creek WMA	Fillmore Co.	T101N R13W NE SW 21	15 points
Iron Horse SNA	Dodge Co.	T105N R12W NW SE 27	20 points
Minnesota Valley fen sites			
Redwood Co. Fen	Redwood Co.	T114N R37W NE NW 27	201 points
Ottawa Fen	LeSueur Co.	T110N R26W NW SE 3	246 points
St. Peter Fen	Nicollet Co.	T111 R26W NE NE 16	91 points
Seminary Fen	Carver Co.	T116 R23W NE SW 35	275 points
Nicols Meadow	Dakota Co.	T27N R23W NE SW 18	141 points
Fort Snelling SP	Dakota Co.	T27N R23W SE NW 4	105 points
Savage Fen	Scott Co.	T115N R21W SE NE 17	381 points
Black Dog SNA	Dakota Co.	T27N R24W NW NE 34	351 points

Highlighted Sites scored less than 50 points and thus fail the Vegetation Criterion

This analysis shows that, for the sites with the most complete data we could obtain, the new criterion provides a correct assessment for all calcareous fens without causing false positive determinations.

Because, for sites with data from only one or two visits, false negatives are a great concern, we tested the new criterion on lists in the records of other known calcareous fens.

Table 16: Results of the Regionalized Scoring Method Applied to Typical Lists in Site Records

			old	new
Northwestern fen sites				
Felton Prairie Felton WMA	Clay	T142N R46W 0ESE36	112	113
Waubun WMA East	Mahnomen	T143N R41W SWSE30	159	175
Green Meadow 35	Norman	T145N R45W SW36, SESE35	32	34
Sanders Fen North	Pennington	T153N R44W 0WNE07	64	67
Sanders Fen South	Pennington	T153N R44W SE18, NE19"	69	72
Spring Hill Fen	Stearns	T124N R33W 0N16, SE16, NWSW15	127	125
St. Wendel Swamp SW (St.Stephan)	Stearns	T125N R29W 0S17	70	77
Southwestern fen sites				
Sam Tutt Fen	Lyon	T109N R43W SE22	33	80
Lost Timber Prairie	Murray	T105N R43W SWSE02	27	100
Fairchild Fen	Yellow Medicine	T114N R46W SESWSW05	85	220
Southeastern fen sites				
Red Wing 21	Goodhue	T113N R15W 0SSE21	57	65
Houston 26	Houston	T104N R06W 0NNW26	31	35
Sheldon 16	Houston	T103N R06W NWNE16	32	35
Dover 13 (Eyota 13)	Olmsted	T106N R12W NENESW13	68	145
High Forest 35 (Stewartville)	Olmsted	T105N R14W NENESW35	5	30
Mutchler Fen	Olmsted	T106N R14W SWNW23	82	60
Stonehedge Fen	Olmsted	T107N R13W NENW19	27	35
Wisconsin 15	Winona	T105N R07W SESW15	63	100
Minnesota Valley fen sites				
Watson Sag Fen	Chippewa	T118N R41W NWNW06	33	105
Zion Lutheran Church Fen	Chippewa	T118N R41W 0NSW06	31	81
Fort Ridgely Fen	Nicollet	T111N R32W NWSE06	59	115
Savage Fen SNA	Scott	T115N R21W SENW17	147	286

Highlighted Sites scored less than 50 points and thus fail the Vegetation Criterion

The results reveal that the new scoring method improved results for Southwestern fen sites and Minnesota Valley sites. Incomplete lists from the southeastern fen sites received higher scores, but those that failed under the old criterion also failed under the new.

Plant lists created from relevé records from calcareous fen sites statewide were scored using both scoring methods. These lists represent a complete list for the date of the visit, recorded from a plot selected to be representative of the site.

Table 17: Results of the Regionalized Scoring Method Applied to All Calcareous Fen Relevés

Region	Calciphile score as determined from 'species list' (plants recorded in relevé plot)	Number of Sites	
		Number of Sites Scored under the Old Criterion	Scored under the New Criterion
<u>Minnesota River Valley</u>	Calciphile Score \geq 50	13	14
	Calciphile Score < 50	1	0
<u>Northwest</u>	Calciphile Score \geq 50	38	38
	Calciphile Score < 50	19	19
<u>Southeast</u>	Calciphile Score \geq 50	1	2
	Calciphile Score < 50	2	1
<u>Southwest</u>	Calciphile Score \geq 50	3	8
	Calciphile Score < 50	6	1

The new vegetation criterion does improve the sensitivity of our technical criteria when applied to calcareous fen sites outside of Northwestern Minnesota, but a significant risk of false negative still exists where site information is not exhaustive or must be obtained within a limited time frame (and thus cannot adequately assess the plant community).

As detailed above, the physical criteria can assess the suitability of a site for a calcareous fen community, but cannot verify its existence. Thus assessment of the presence of calciphile bryophytes, a frequent component of calcareous fen communities, has been added to the technical criteria for the designation of calcareous fens in Minnesota.

Bryophytes

An analysis (Janssens, 2002, updated 2004) of all bryophytes collected in wetland habitats compared the frequency of occurrence in calcareous fens to the frequency of occurrence in non-calcareous fen habitats to determine which species are calcareous fen indicators based on a ranking of their importance value (IPV = frequency of occurrence in CF times the quotient of the frequency in CF with the frequency in non-CF ecotopes).

Figure 3 and perusal of the species list (Table 18) suggests there is a reasonable division in **obligate and near-obligate** calcareous fen indicators (OB) with an IPV above 1.000 (17 species), **facultative** (FA) calcareous fen species with an IPV between 0.100 and 1.000 (15 species), and the remaining 96 species with an **occasional** (OC) occurrence and an IPV of <0.100.

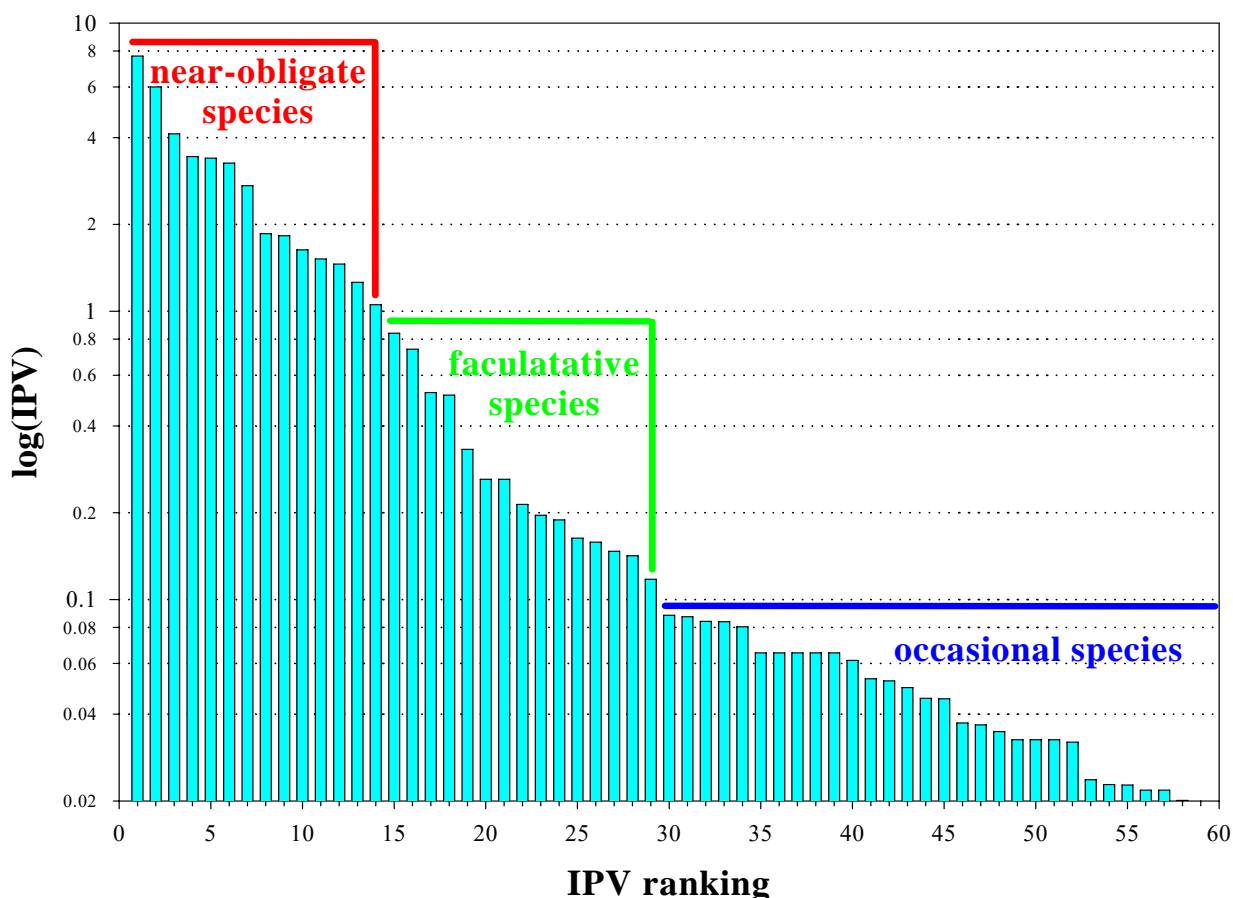


Figure 3. Ranking of bryophytes occurring in calcareous fens. Only those with an IPV (see text) above 0.200 are shown.

Table 18. Bryophyte species occurring in Minnesota's calcareous fens in order of descending IPV.

The species with an IPV >1.000 are **obligate and near-obligate** indicators, with and IPV >0.100 and <1.000 are **facultative** indicators, and those with an IPV <0.100 are **occasional** species. The column labeled 'n CF' lists the number of calcareous - fen ecotopes in which the species occurs (out of a total of 128), 'n tot' the total number of ecotopes in Minnesota where the species has been found (out of a total of 1128). The values in the columns labeled 'CFB', 'CFPnw', 'CFPsw', and 'CFPse' are the relative abundance of the species in the extreme rich fens of boreal forested region, and the calcareous fens of the NW, SW, and SE prairie sub-regions. The relative abundance is calculated as the 100 times quotient of the number of vouchers collected for the species over the total number of vouchers within the regions or sub-region (total number of vouchers for CFB = 928, CFPnw = 1806, CFPse = 1332, and CFPsw = 2339).

			boreal		-----prairie-----			
acronym	species name	IPV	n CF	n tot	CFB	CFPnw	CFPse	CFPsw
obligate and near-obligate species (OB)								
BRYUULIG	<i>Bryum uliginosum</i>	inf.	1	1		0.06		
CATONIGR	<i>Catoscopium nigrutum</i>	inf.	5	5	0.86	0.06		
PALUSQUA	<i>Paludella squarrosa</i>	inf.	3	3	1.29			
ANEUPING	<i>Aneura pinguis</i>	7.6766	52	75	1.62	4.26	3.53	7.52

					boreal		-----prairie-----		
acronym	species name	IPV	n	CF	n tot	CFB	CFPnw	CFPse	CFPsw
LIMPCOSS	<i>Limprichtia cossonii</i>	6.0073	46	69		11.96	13.95	0.23	11.59
CAMPSTEL	<i>Campylium stellatum</i>	4.1284	67	138		15.52	39.76	9.53	15.82
DREPADUN	<i>Drepanocladus aduncus</i>	3.4381	74	178		4.09	2.60	14.04	16.84
BRYUPSEU	<i>Bryum pseudotriquetrum</i>	3.3978	76	187		6.68	18.22	3.60	10.94
BRACRIVU	<i>Brachythecium rivulare</i>	3.2648	50	100		2.48	1.94	15.24	3.72
CALRCUSP	<i>Calliergonella cuspidata</i>	2.7283	31	54		2.05	0.61	2.33	5.69
SCORSCOR	<i>Scorpidium scorpioides</i>	1.8590	22	39		4.74	5.09		
CINCSTYG	<i>Cinclidium stygium</i>	1.8283	14	21		3.13			
MOERHIBE	<i>Moerckia hibernica</i>	1.6324	15	24		2.59	0.55		
CALLTRIF	<i>Calliergon trifarium</i>	1.5196	16	27		3.34	1.33		
PLAGELLI	<i>Plagiomnium ellipticum</i>	1.4570	59	215		2.91	1.38	14.19	7.48
CAMPPOLY	<i>Campylium polygamum</i>	1.2612	26	61		4.09	1.05	1.88	3.33
FISSADIA	<i>Fissidens adianthoides</i>	1.0535	22	52		4.85	0.50	1.13	
facultative species (FA)									
AMBLVARI	<i>Amblystegium varium</i>	0.8392	28	89		0.54	0.28	3.90	1.07
TOMENITE	<i>Tomenthypnum nitens</i>	0.7384	21	60		2.37	0.72	0.15	
EURHHIAN	<i>Eurhynchium hians</i>	0.5224	12	30		0.43		1.50	
AMBLSEJU	<i>Amblystegium serpens</i> var. <i>juratzkanum</i>	0.5119	14	39		0.86	1.72	0.53	3.51
BRACSALE	<i>Brachythecium salebrosum</i>	0.3318	25	148		0.32	0.11	4.65	8.85
HAMALAPP	<i>Hamatocaulis lapponicus</i>	0.2612	2	3		0.32			
MEESTRIQ	<i>Meesia triquetra</i>	0.2612	4	8		0.65			
HELOBLAN	<i>Helodium blandowii</i>	0.2137	12	56		0.22	0.39	0.53	0.21
PSEATURG	<i>Pseudo-calliergon turgescens</i>	0.1959	3	6		0.11	0.89		
CRATFILI	<i>Cratoneuron filicinum</i>	0.1889	9	37		0.86	0.89	2.10	
CONACOMP	<i>Conardia compacta</i>	0.1632	5	15			0.06		0.43
HYPNLIND	<i>Hypnum lindbergii</i>	0.1582	19	168		0.86	0.72	2.85	0.09
CAMPSTPR	<i>Campylium stellatum</i> var. <i>protensum</i>	0.1469	3	7			0.83		1.71
DREPADPO	<i>Drepanocladus aduncus</i> var. <i>polycarpus</i>	0.1419	10	56		0.22	0.06	1.35	0.13
RICDLATI	<i>Riccardia latifrons</i>	0.1175	6	26		0.97			
occasional species (OC)									
PLAGCUSP	<i>Plagiomnium cuspidatum</i>	0.0882	17	231		0.54	0.22	1.73	0.09
DREPSEND	<i>Drepanocladus sendmeri</i>	0.0871	2	5		0.11	0.22		
RICDPALM	<i>Riccardia palmata</i>	0.0840	3	10		0.43			
HYPNPRAT	<i>Hypnum pratense</i>	0.0837	10	88		0.22		2.18	0.09
LEPDHUMI	<i>Leptodictyum humile</i>	0.0804	4	17				0.45	0.13
ATRIUNDU	<i>Atrichum undulatum</i>	0.0653	1	2				0.08	
DREPSORD	<i>Drepanocladus sordidus</i>	0.0653	1	2		0.11			
ORTHPUUM	<i>Orthotrichum pumilum</i>	0.0653	2	6		0.11	0.06		
PHILCAPI	<i>Philonotis capillaris</i>	0.0653	1	2				0.08	
PHILMARC	<i>Philonotis marchica</i>	0.0653	1	2				0.08	
LESKPOLY	<i>Leskea polycarpa</i>	0.0615	4	21		0.22	0.17	0.08	0.17
AULAPALU	<i>Aulacomnium palustre</i>	0.0531	14	255		1.08	0.28	0.83	
BRYULICU	<i>Bryum liseae</i> var. <i>cuspidatum</i>	0.0522	2	7				0.15	
HYGATENA	<i>Hygroamblystegium tenax</i>	0.0495	5	38		0.11		0.45	
CAMPPRADI	<i>Campylium radicale</i>	0.0454	4	27		2.05	0.06	0.08	
CALLGIGA	<i>Calliergon giganteum</i>	0.0452	6	58		0.97	0.17		
PLAHRIPA	<i>Platyhypnidium riparioides</i>	0.0373	2	9				0.23	
MYULJULA	<i>Myurella julacea</i>	0.0367	3	19		0.32			
HAMAVERN	<i>Hamatocaulis vernicosus</i>	0.0348	4	34		0.75			
BRACDIGA	<i>Brachythecium digastrum</i>	0.0326	1	3				0.08	
DICEVARI	<i>Dicranella varia</i>	0.0326	1	3					0.04
PTGEFILI	<i>Pterigynandrum filiforme</i>	0.0326	2	10		0.11		0.08	
AMBLSERP	<i>Amblystegium serpens</i>	0.0320	5	56			0.06	0.53	0.04
HELOPALU	<i>Helodium paludosum</i>	0.0237	2	13				1.65	
BRACOEDI	<i>Brachythecium oedipodium</i>	0.0228	6	109		2.16		0.60	
CAMPCHRY	<i>Campylium chrysophyllum</i>	0.0227	4	50		0.22	0.17	0.23	
HELOBLHE	<i>Helodium blandowii</i> var. <i>helodioides</i>	0.0218	1	4				0.15	
RICRNATA	<i>Ricciocarpos natans</i>	0.0218	1	4			0.06		
CLIMAMER	<i>Climacium americanum</i>	0.0201	2	15				0.23	
LESKGRAC	<i>Leskea gracilescens</i>	0.0163	3	39		0.43		0.15	
ATRIALTE	<i>Atrichum altecrisatum</i>	0.0154	2	19				0.15	
BRACPLUM	<i>Brachythecium plumosum</i>	0.0154	2	19				0.15	
SPHAWARN	<i>Sphagnum warnstorffii</i>	0.0146	5	117		2.26			

BRACACUM acronym	<i>Brachythecium acuminatum</i> species name	0.0143 IPV	4 n CF	77 n tot				0.23 CFPse	0.13 CFPsw
ENTOSEDU	<i>Entodon seductrix</i>	0.0137	2	21				0.08	0.04
THUIRECO	<i>Thuidium recognitum</i>	0.0137	5	124	0.97			0.08	
PLATDENT	<i>Plagiothecium denticulatum</i>	0.0134	4	82	0.11	0.06		0.45	
CEPHPLSP	<i>Cephalozia pleniceps ssp. sphagnum</i>	0.0131	1	6	0.11				
FISSDUBI	<i>Fissidens dubius</i>	0.0131	2	22				0.30	
FRULINFL	<i>Frullania inflata</i>	0.0131	1	6	0.11				
PYLLSELW	<i>Pylaisiella selwynii</i>	0.0122	3	51	0.32			0.08	
LOPCHETE	<i>Lophocolea heterophylla</i>	0.0118	5	143	0.11	0.11		0.30	0.04
MARCPOLY	<i>Marchantia polymorpha</i>	0.0104	2	27		0.06		0.15	
WARNEXAN	<i>Warnstorfia exannulata</i>	0.0104	2	27		0.06		0.08	
CAMPHISP	<i>Campylium hispidulum</i>	0.0095	3	65	0.54			0.08	
BRACOXYC	<i>Brachythecium oxycladon</i>	0.0093	2	30				0.15	
PHYTPYRI	<i>Physcomitrium pyriforme</i>	0.0093	1	8				0.08	
SPHAFUSC	<i>Sphagnum fuscum</i>	0.0084	4	129	0.65				
CEPHCOCO	<i>Cephalozia connivens var. compacta</i>	0.0082	1	9	0.32				
PHILFONT	<i>Philonotis fontana</i>	0.0082	1	9				0.53	
PLADJUNG	<i>Platydictya jungermannioides</i>	0.0082	1	9					0.09
RHIZGRAC	<i>Rhizomnium gracile</i>	0.0082	1	9	0.11				
FISSOSMU	<i>Fissidens osmundioides</i>	0.0077	2	36	0.43				
LEPDRIPI	<i>Leptodictyum riparium</i>	0.0077	2	36				0.08	0.04
SPHAFIMB	<i>Sphagnum fimbriatum</i>	0.0069	2	40				0.75	
FRULOAKE	<i>Frullania oakesiana</i>	0.0065	1	11	0.11				
CONCCONI	<i>Conocephalum conicum</i>	0.0061	2	45	0.11			0.08	
THUIDELI	<i>Thuidium delicatulum</i>	0.0060	3	101				0.38	
PLACASPL	<i>Plagiochila asplenoides</i>	0.0053	2	51	0.22				
BRACOPU	<i>Brachythecium populeum</i>	0.0038	1	18				0.23	
MYLIANOM	<i>Mylia anomala</i>	0.0036	1	19	0.11				
TORLFRAG	<i>Tortella fragilis</i>	0.0036	1	19	0.22				
CHILPALL	<i>Chiloscyphus pallescens</i>	0.0034	1	20				0.08	
POLYSTRI	<i>Polytrichum strictum</i>	0.0032	3	187	0.43				
ATRIOERS	<i>Atrichum oerstedianum</i>	0.0028	1	24				0.08	
DISTCAPI	<i>Distichium capillaceum</i>	0.0028	1	24	0.11				
LEPTPYRI	<i>Leptobryum pyriforme</i>	0.0028	1	24	0.11				
TAXIDEPL	<i>Taxiphyllum deplanatum</i>	0.0027	1	25				0.08	
SPHAANGU	<i>Sphagnum angustifolium</i>	0.0026	3	227	0.22			0.08	
BRACERYT	<i>Brachythecium erythrorrhizon</i>	0.0026	2	104	0.11	0.06			
BRYERECU	<i>Bryoerythrophyllum recurvirostre</i>	0.0023	1	30		0.06			
SPHACAPI	<i>Sphagnum capillifolium</i>	0.0018	2	146	0.11			0.15	
STEESERR	<i>Steerecleus serrulatus</i>	0.0017	1	39				0.08	
CLIMDEND	<i>Climacium dendroides</i>	0.0015	2	175				0.75	
ORTHOBTU	<i>Orthotrichum obtusifolium</i>	0.0015	1	45	0.11				
PLAGCILI	<i>Plagiomnium ciliare</i>	0.0014	1	47					0.17
SPHASUSS	<i>Sphagnum subsecundum s.s.</i>	0.0013	1	50				0.08	
SPHASQUA	<i>Sphagnum squarrosum</i>	0.0013	1	51				0.08	
CEPHCONN	<i>Cephalozia connivens</i>	0.0012	1	56	0.11				
ORTHELEG	<i>Orthotrichum elegans</i>	0.0011	1	61	0.11				
POLYCOMM	<i>Polytrichum commune</i>	0.0011	1	63				0.08	
BRACREFL	<i>Brachythecium reflexum</i>	0.0010	1	64				0.08	
ENTOCLAD	<i>Entodon cladorrhizans</i>	0.0010	1	66				0.08	
PLEUSCHR	<i>Pleurozium schreberi</i>	0.0009	2	297	0.22				
PYLLPOLY	<i>Pylaisiella polyantha</i>	0.0009	1	76		0.17			
DICRUNDU	<i>Dicranum undulatum</i>	0.0008	1	79	0.11				
CERAPURP	<i>Ceratodon purpureus</i>	0.0008	1	83				0.08	
EURHPULC	<i>Eurhynchium pulchellum</i>	0.0008	1	84				0.30	
SPHACENT	<i>Sphagnum centrale</i>	0.0008	1	87				0.15	
ANOMMINO	<i>Anomodon minor</i>	0.0007	1	95	0.11				
HYLOSPLE	<i>Hylocomium splendens</i>	0.0007	1	96	0.11				
CALLCORD	<i>Calliergon cordifolium</i>	0.0007	1	101				0.15	
PLAYREPE	<i>Platygyrium repens</i>	0.0004	1	162	0.11				
PTIDPULC	<i>Ptilidium pulcherrimum</i>	0.0004	1	168	0.11				
DICRPOLY	<i>Dicranum polysetum</i>	0.0004	1	176	0.11				
SPHAMAGE	<i>Sphagnum magellanicum</i>	0.0003	1	241	0.11				

Validation of the Calcareous Fens of the Prairie Region

Assigning an arbitrary value of 25 points to the obligate and near-obligate bryophyte calcareous fen indicators, 5 to the facultative species, and 1 to the occasional species, the following validation is obtained of the calcareous fens of the prairie region (Table 19, the localities are mapped in Figure 4):

Table 19. Validation of the calcareous fen localities of the prairie region of Minnesota, based on the presence of calcareous fen indicators among the bryophyte flora. The *a priori* list of calcareous prairie fens studied has been provided by the Minnesota Department of Natural Resources (Aaseng *et al.* 1993 and pers. comm.) and the typing of the sites as calcareous fens is based on an independent assessment using vascular-plant indicators, and soil and water-chemistry characteristics (J.H. Leete and W.R. Smith, pers. comm.). This table can be used as part of the assessment to evaluate non-listed sites in the prairie region for their identification and potential as calcareous fens. Some of the localities listed consist of a complex of adjacent ecotopes.

value	locality name
Northwestern sub-region	
329	Ogema Spring
243	Barnesville State Wildlife Management Area
241	Felton State Wildlife Management Area
226	Gully
205	Sanders 18
125	Holt Meadow
105	Green Meadow
105	Waubun
Southeastern sub-region	
253	Ottawa
249	Cannon River Wilderness Area County Park
202	Perched Valley WMA
196	Wasioja
192	Pheasants Forever WMA
191	McCarthy WMA
169	Fort Snelling State Park
156	Stewartville
153	Savage
114	Nelson WMA
113	Stonehedge
106	Kennedy
100	Nelson
100	Red Wing 21
87	Perched Valley
85	Mutchler
85	Wiscoy Valley East
81	Eyota 13
75	Houston 26
70	Sheldon 16
59	Cannon Valley Trail
51	Nicols
26	Black Dog Preserve SNA
Southwestern sub-region	
235	Sioux Nation
186	Holte Prairie
185	Fairchild
180	Zion Lutheran Church
175	Burke WMA
150	Watson Sag Fen (Kragero Township)
105	Altoona Fen
100	Adrian
89	Fort Ridgely
80	Yonker
76	Jeffers
55	Sam Tutt
50	Fort Ridgely State Park
31	Lost Timber

Use of information about the bryophyte component of the calcareous fen community, where a bryophyte population exists at the site, will reduce false negatives due to inadequate data as bryophytes can be collected in all seasons. The sum of the vascular plant score and the bryophyte score will be used and the passing score will remain at 50 points. When bryophyte scores are added to the vascular plant scores of calcareous fen sites with partial data that did not initially pass the criterion, all then met the 50 point threshold (Table 20).

Table 20: Results of the New Scoring Method Including Bryophytes Applied to Typical Lists in Site Records.....

Northwestern fen sites			new	+byro
Felton Prairie Felton WMA	Clay	T142N R46W 0ESE36	113	no data
Waubun WMA East	Mahnomen	T143N R41W SWSE30	175	280
Green Meadow 35	Norman	T145N R45W SW36, SESE35	34	139
Sanders Fen North	Pennington	T153N R44W 0WNE07	67	no data
Sanders Fen South	Pennington	T153N R44W SE18, NE19"	72	277
Spring Hill Fen	Stearns	T124N R33W 0N16, SE16, NWSW15	125	pending
St. Wendel Swamp SW (St.Stephan)	Stearns	T125N R29W 0S17	77	pending
Southwestern fen sites				
Shelburne 22 Fen	Lyon	T109N R43W SE22	80	135
Lost Timber Prairie	Murray	T105N R43W SWSE02	100	131
Fairchild Fen	Yellow Medicine	T114N R46W SESWSW05	220	405
Southeastern fen sites				
Red Wing 21	Goodhue	T113N R15W 0SSE21	65	165
Houston 26	Houston	T104N R06W 0NNW26	35	110
Sheldon 16	Houston	T103N R06W NWNE16	35	105
Dover 13 (Eyota 13)	Olmsted	T106N R12W NENESW13	145	226
High Forest 35 (Stewartville)	Olmsted	T105N R14W NENESW35	30	186
Mutchler Fen	Olmsted	T106N R14W SWNW23	60	85
Stonehedge Fen	Olmsted	T107N R13W NENW19	35	148
Wisconsin 15	Winona	T105N R07W SESW15	100	206
Minnesota Valley fen sites				
Watson Sag Fen	Chippewa	T118N R41W NWNW06	105	255
Zion Lutheran Church Fen	Chippewa	T118N R41W 0NSW06	81	261
Fort Ridgely Fen	Nicollet	T111N R32W NWSE06	115	204
Savage Fen SNA	Scott	T115N R21W SENW17	286	439

Highlighted Sites scored less than 50 points and thus fail the Vegetation Criterion

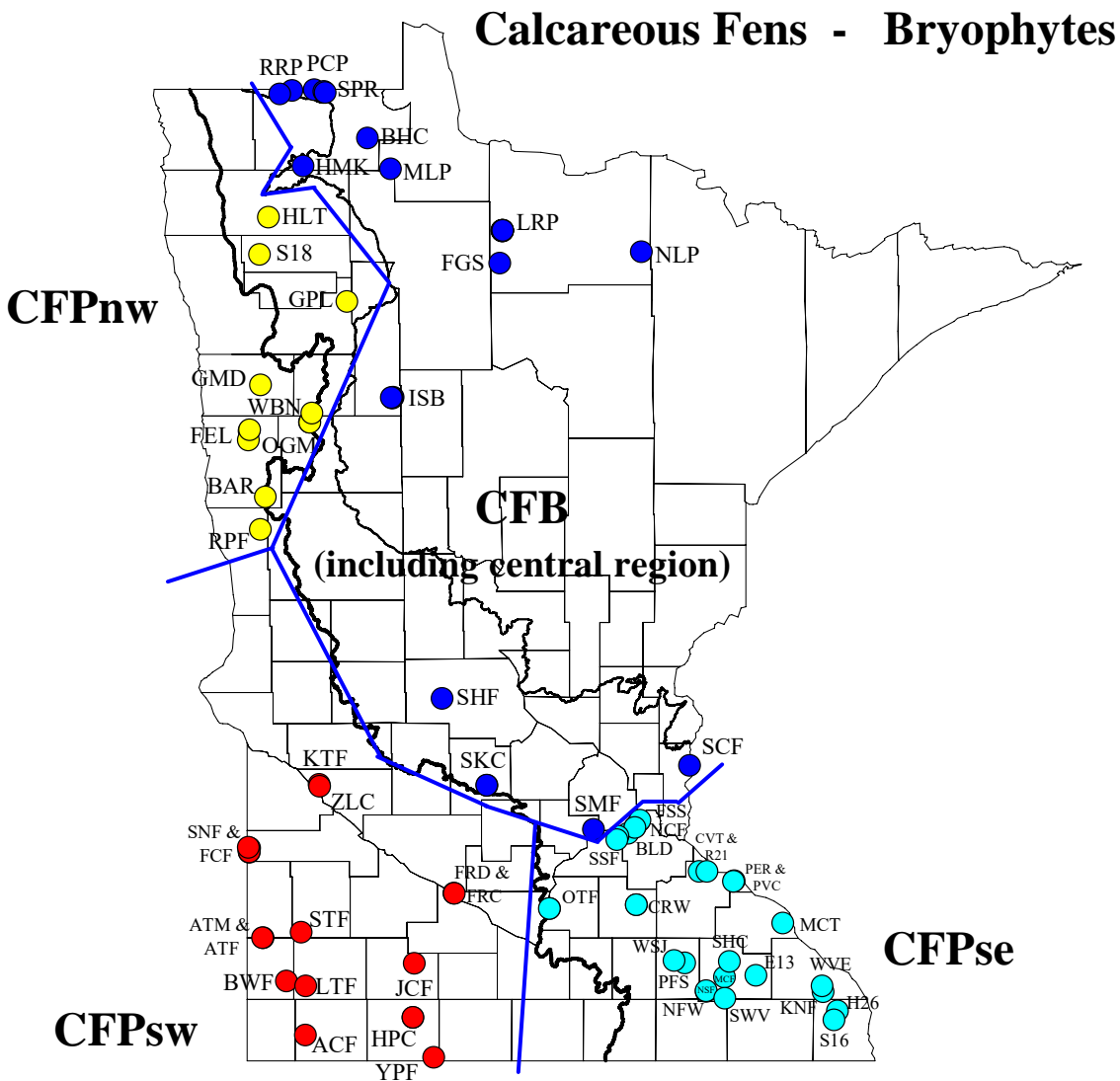


Figure 4. Localities of calcareous and extreme rich-fens in Minnesota studied for bryophytes. The localities are not yet regionalized pending collection of data from additional sites. Classification of a site as a calcareous fen was based on the 1995 criteria discussed above. The key to the site codes is provided in an Appendix.

A logical concern following this analysis would be whether these increased scores would also be recorded in non-fen wetlands. Investigation of this possibility was conducted by using these criteria to score all (n=240) non-calcareous fen wetland relevés for which proximate bryophyte data were available. None of these sites scored over 31 points based on vascular plants alone. Forty-six sites scored over 50 points based on the sum of bryophyte and vascular plant scores (these are false positives). Almost all of the false positives occur above 47 degrees latitude and have insignificant vascular plant scores. Thus, the criteria for scoring a site at a latitude above 47 degrees for which both vascular plant and bryophyte data are available should be 80 points.

DRAFT REVISED TECHNICAL CRITERIA FOR IDENTIFYING CALCAREOUS FENS IN MINNESOTA

HYDROLOGY TECHNICAL CRITERION

An area meets the hydrology technical criterion when the hydrology is characterized by having stable, typically upwelling groundwater inflows sufficient to maintain saturation for the development of a histosol or a histic epipedon soil.

SOILS TECHNICAL CRITERION

An area meets the soils technical criteria when the soils are characterized by the presence of either a histosol or a histic epipedon. Calcium carbonate precipitates, such as tufa deposits, may frequently be associated with calcareous fens and high carbonate content in this case is not indicative of a mineral soil.

WATER CHEMISTRY TECHNICAL CRITERION

Water chemistry of calcareous fens should be characterized by measurement of the following parameters: specific conductance ($\mu\text{S}/\text{cm}$), pH, alkalinity ($\text{mg}/\text{l CaCO}_3$), ratio of the concentration of calcium plus magnesium ions ($[\text{Ca}+\text{Mg}]$) to total cations ($\% \text{ meq}/\text{l}$), and alkalinity/total anions ($\% \text{ meq}/\text{l}$). Of these parameters, it is imperative that specific conductance, pH, and alkalinity be measured in the field (*in situ*). Samples would be collected for laboratory determination of the other parameters. Standard methods should be used for sample collection techniques and sample preparation and handling.

An area meets the water chemistry technical criterion when the following conditions are met: pH of 6.7 or more; calcium of 30 mg/l or more; alkalinity of 1.65 meq/l or more; and, specific conductance of 500 $\mu\text{S}/\text{cm}$ or more. [Data for other parameters must be collected to provide further water chemistry definition of calcareous fens.]

VEGETATION TECHNICAL CRITERION

The Minnesota DNR has developed a regionalized list of vascular plant calciphiles (Table 14) and a statewide list of bryophyte calciphiles (Table 18) indicative of calcareous fens of the State.

An area meets the calcareous fen vegetation technical criterion when, under normal circumstances, the area has a natural community index value of 50 or more by summing the appropriate regional index values of the vascular plant plus the bryophyte calcareous fen indicator species. Where both bryophyte and vascular plant data are available and the site's latitude is greater than 47 degrees, the natural community index value must exceed 80. Plot size and shape are dependent upon the professional judgment of field personnel.

NOTE: *If a site has calcareous fen soil, hydrology, and water chemistry but the calciphile point total ranges from 30 to 50, the area will be considered to meet calcareous fen criteria. If a disturbed site has calcareous fen soil, hydrology, and water chemistry but a calciphile point total of less than 30, the disturbed area may have the potential to support a calcareous fen plant community*

GLOSSARY

Acid

A chemical term for a water condition whereby there are more hydrogen ions (H^+) than hydroxyl ions (OH^-) and the pH is less than 7.

Alkaline

A chemical term for a water condition whereby there are more hydroxyl ions (OH^-) than hydrogen ions (H^+) and the pH is greater than 7.

Bog

A peatland type having 1) acidic waters (pH less than 4.2; calcium concentration less than 2 mg/l); 2) vegetation assemblages characterized by continuous coverage of mosses (e.g. *Sphagnum* spp.) and the general absence of fen-indicator species; and, most importantly, 3) largely dependent upon atmospheric sources of water and nutrients. They commonly occur as level bogs, or, lake filled depressions. An ombrotrophic bog has the above characteristics in addition to a topographically elevated crest or plateau which accentuates its rainfall dependency. (from Johnson 1985 and Glaser 1987)

Calcareous Fen

A peat-accumulating wetland dominated by distinct ground water inflows having specific chemical characteristics. The ground water is characterized as circum-neutral to alkaline, with high concentrations of calcium and low dissolved oxygen content. The chemistry provides an environment for specific and often rare hydrophytic plants. (See the definition of "Fen" and "Extremely Rich Fen") (Minnesota Rules 8420)

Calcareous Seepage Fen Prairie Subtype

A calcareous fen in the prairie/plains ecoregions of southern and western Minnesota. (See the definition of "Fen" and "Extremely Rich Fen")

Calcicole

Organisms, usually plants, that thrive in calcium-rich waters. (Hanson 1962)

Calciphile

Plants that thrive in calcium-rich waters. (Hanson 1962)

Circum-Neutral

A reference to water chemistry whereby the pH is close to 7.

Fen (adapted from Glaser 1987)

General A peatland type that receives a significant input of water and nutrients from a mineral source dominated by ground water discharge. A fen is therefore considered to be geogenous and its vegetation minerotrophic. Fens are generally characterized by 1) surface waters with pH greater than 4.2 and calcium concentration greater than 2 mg/l; and, 2) a more diverse flora including many fen indicator species. In Minnesota the division between poor, rich, and extremely rich fens is a continuum.

Poor Fen A fen containing at least one minerotrophic indicator species and weakly geogenous surface waters. Originally described in Sweden by Sjörs (1952) as having a pH range of 3.8-5.7. Minnesota poor fens have similar ranges in water chemistry with pH of 4.2-5.8 and calcium concentration of 2-10 mg/l.

Rich Fen A fen having a slightly higher range in pH (5.8-7.0) and calcium concentration (10-32 mg/l) than poor fens.

Extremely Rich Fen A fen having a very high pH (greater than 7) and calcium concentration (greater than 20 mg/l in Minnesota) and characteristic vegetative species assemblages. Extremely rich fens are generally found in discharge zones for ground water. Calcareous fens and calcareous seepage fens prairie subtype (CSFP) are generally part of the extremely rich fen type.

Geogenous

Water from a mineral source such as ground water and surface runoff from mineral soils.

Histic Epipedon

A 8- to 16-inch soil layer at or near the surface that is saturated for 30 consecutive days or more during the growing season in most years and contains a minimum of 12 percent organic matter when no clay is present or a minimum of 18 percent organic matter when 60 percent or more clay is present; generally a thin horizon of peat or muck if the soil has not been plowed.

Histosol

An order in "Soil Taxonomy" (Soil Survey Staff 1975) composed of organic soils (mucks and peats) that have organic soil materials in more than half of the upper 32 inches or that are of any thickness if overlying rock.

Hydrophytic Vegetation

Macrophytic plant life growing in water, soil, or on a substrate that is at least periodically deficient in oxygen as a

result of excessive water content. (MR8420)

Macrophyte

Any plant species that can be readily observed without the aid of optical magnification, including all vascular plant species and bryophytes (e.g. *Sphagnum* spp.) as well as large algae (e.g. *Chara* spp.). (Federal Interagency Committee for Wetland Delineation 1989)

Marl

Marl is an argillaceous, nonindurated calcium carbonate material formed partially by the action of some aquatic plants. Plants extract carbon dioxide for photosynthesis from the bicarbonate in water which locally reduces calcium carbonate solubility adjacent to the leaves and results in a precipitate formation. Moist marl has a color value of 5 or more and usually does not change color irreversibly on drying. It reacts with dilute (10%) HCl to evolve CO₂ and leave disintegrated plant remains. A layer of marl contains too little organic matter to coat the carbonate, even before it has been shrunk by drying. Most samples of marl from the U.S. studied to date have an organic matter content between 4 and 20 percent, inclusive. The horizon designation for marl is "Lca" while "Marly" is the mineralogy class modifier for characterizing subgroups or great groups of histosols. A soil would be marly if marl in the control section was 5 cm or more thick. (Soil Survey Staff 1975, Lapedes 1978)

Organic Soil

(See Histosol)

Peat Accumulating Wetland

A wetland developing a peat deposit as a result of the growth of organic matter whereby primary productivity is greater than total community respiration. (Glaser 1987)

Peat and Peatland

Peat is an organic soil deposit containing the dead remains of plants. It is distinguished from lake sediments by characteristic macro- or micro-fossils and from other terrestrial soils by the low percentage of mineral matter. A peatland is a waterlogged area containing at least 30 cm of peat in an undrained condition. (Glaser 1987)

Specific Conductivity

A measure of the ability of water to conduct electricity, affected by temperature and the type and concentration of ions present. Units are in micro-Siemens (μS; formerly micro mhos, μmhos).

Technical Criteria

Calcareous fens possess four specific characteristics: 1) calciphytic vegetation, 2) histosols or histic epipedons, 3) hydrology, and 4) water chemistry. These characteristics and their technical criteria are essential for identification and delineation purposes. The four technical criteria specified must all be met for an area to be identified as a calcareous fen.

Travertine

A dense, finely crystalline massive or concretionary limestone of white, tan, or cream color, often having a fibrous or concentric structure and splintery fracture. It is formed by rapid chemical precipitation of calcium carbonate from solution in surface and ground waters. The spongy or less compact variety is tufa. (Bates and Jackson 1987)

Tufa

Tufa is a spongy, porous calcareous material deposited from spring waters. When carbonate-rich spring waters reach the surface, carbon dioxide is released; the solubility of calcium carbonate is lowered; and, the precipitate forms. Tufa is the spongy, less porous form of travertine. (Bates and Jackson 1987 and Lapedes 1978)

Wetland

Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must 1) have a predominance of hydric soils; 2) be inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions; and 3) under normal circumstances, support a prevalence of hydrophytic vegetation.

"A wetland" or "the wetland" means a distinct hydrologic feature with the above characteristics surrounded by nonwetland and including all contiguous wetland types, except those connected solely by riverine wetlands.

"Wetland area" means a portion of "a wetland" or "the wetland." (MR8420)

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APPENDIX OF MINNESOTA REGULATIONS

The following are current references to Minnesota Statutes and Rules. For any possible updates, the Minnesota Revisor of Statutes maintains currently accurate listings at www.revisor.leg.state.mn.us.

103G.223 Calcareous fens.

Calcareous fens, as identified by the commissioner by written order published in the State Register, may not be filled, drained, or otherwise degraded, wholly or partially, by any activity, unless the commissioner, under an approved management plan, decides some alteration is necessary. Identifications made by the commissioner are not subject to the rulemaking provisions of chapter 14 and section 14.386 does not apply.

(HIST: 2004 not yet revised)

8420.1010 PURPOSE.

The purpose of parts 8420.1010 to [8420.1070](#) is to provide minimum standards and criteria for the identification, protection, and management of calcareous fens as authorized by Minnesota Statutes, section [103G.223](#). Calcareous fens may not be drained or filled or otherwise altered or degraded except as provided for in a management plan approved by the commissioner.

Part [8420.0122](#) does not apply to calcareous fens.

STAT AUTH: MS s [14.06](#); [103B.101](#); [103B.3355](#); [103G.2242](#)

HIST: 18 SR 274; 22 SR 1877; 27 SR 135

8420.1020 IDENTIFYING CALCAREOUS FENS.

A calcareous fen is a peat-accumulating wetland dominated by distinct groundwater inflows having specific chemical characteristics. The water is characterized as circumneutral to alkaline, with high concentrations of calcium and low dissolved oxygen content. The chemistry provides an environment for specific and often rare hydrophytic plants.

STAT AUTH: MS s [14.06](#); [103B.101](#); [103B.3355](#)

HIST: 18 SR 274

8420.1030 PROCEDURES TO LIST CALCAREOUS FENS.

A. The commissioner shall investigate wetlands to determine if the wetland is properly identified as a calcareous fen.

B. The commissioner shall maintain a current list of known calcareous fens in the state and their location.

C. The commissioner shall provide an updated list of calcareous fens to the board for further distribution.

STAT AUTH: MS s [14.06](#); [103B.101](#); [103B.3355](#)

HIST: 18 SR 274

8420.1040 MANAGEMENT PLANS.

Calcareous fens may not be drained or filled or otherwise altered or degraded except as provided for in a management plan approved by the commissioner. The commissioner will provide technical assistance to landowners or project sponsors in the development of management plans.

STAT AUTH: MS s [14.06](#); [103B.101](#); [103B.3355](#); [103G.2242](#)

HIST: 18 SR 274; 22 SR 1877

8420.1050 RESTORATION.

The commissioner may approve management plans to restore or upgrade a previously damaged calcareous fen.

STAT AUTH: MS s [14.06](#); [103B.101](#); [103B.3355](#)
HIST: 18 SR 274

8420.1060 APPEALS.

A. A landowner or project proposer may challenge the commissioner's determination that a wetland is a calcareous fen or the commissioner's calcareous fen management plan by demanding a hearing. The hearing will be carried out in the same manner as water permit hearings under Minnesota Statutes, chapter 103G.

B. The hearing must be demanded within 30 days after mailed notice of the commissioner's decision to the project proposer, otherwise the decision becomes final and may not be challenged by the project proposer.

C. Appeal of the commissioner's decision after the hearing must be done in the manner provided for appeals from contested case decisions in Minnesota Statutes, chapter 14.

STAT AUTH: MS s [14.06](#); [103B.101](#); [103B.3355](#)
HIST: 18 SR 274

8420.1070 ENFORCEMENT PROCEDURES.

Enforcement procedures for calcareous fens shall be conducted consistent with Minnesota Statutes, sections [103G.141](#) and [103G.2372](#), except that necessary restoration or replacement activities, if required, will be determined by the commissioner, in consultation with the local soil and water conservation district.

STAT AUTH: MS s [103B.3355](#); [103G.2242](#)
HIST: 27 SR 135

Current as of 11/14/03

7050.0180 NONDEGRADATION FOR OUTSTANDING RESOURCE VALUE WATERS.

Subpart 1. **Policy.** The agency recognizes that the maintenance of existing high quality in some waters of outstanding resource value to the state is essential to their function as exceptional recreational, cultural, aesthetic, or scientific resources. To preserve the value of these special waters, the agency will prohibit or stringently control new or expanded discharges from either point or nonpoint sources to outstanding resource value waters.

..... Subp. 6. **Restricted discharges.** No person may cause or allow a new or expanded discharge of any sewage, industrial waste, or other waste to any of the following waters unless there is not a prudent and feasible alternative to the discharge:

.....

E. calcareous fens identified in subpart 6b.

If a new or expanded discharge to these waters is permitted, the agency shall restrict the discharge to the extent necessary to preserve the existing high quality, or to preserve the wilderness, scientific, recreational, or other special characteristics that make the water an outstanding resource value water.

Subp. 6b. **Calcareous fens.** The following calcareous fens are designated outstanding resource value waters:

- A. Becker County: Spring Creek WMA NHR fen, 34 (T.142, R.42, S.13);
- B. Carver County: Seminary fen, 75 (T.116, R.23, S.35);
- C. Clay County:

- (1) Barnesville Moraine fen, 44 (T.137, R.44, S.18);
- (2) Barnesville WMA fen, 10 (T.137, R.45, S.1);
- (3) Barnesville WMA fen, 43 (T.137, R.44, S.18);
- (4) Felton Prairie fen, 28 (T.142, R.46, S.36);
- (5) Felton Prairie fen, 36 (T.141, R.46, S.13);
- (6) Felton Prairie fen, 48 (T.142, R.45, S.31);
- (7) Felton Prairie fen, 53 (T.141, R.46, S.24);
- (8) Haugtvedt WPA North Unit fen, 54 (T.137, R.44, S.28, 29); and
- (9) Spring Prairie fen, 37 (T.140, R.46, S.11);
- D. Clearwater County: Clearbrook fen, 61 (T.149, R.37, S.17);
- E. Dakota County:
 - (1) Black Dog Preserve fen, 63 (T.27, R.24, S.34);
 - (2) Fort Snelling State Park fen, 25 (T.27, R.23, S.4); and
 - (3) Nicols Meadow fen, 24 (T.27, R.23, S.18);
- F. Goodhue County:
 - (1) Holden 1 West fen, 3 (T.110, R.18, S.1);
 - (2) Perched Valley Wetlands fen, 2 (T.112, R.13, S.8); and
 - (3) Red Wing fen, 72 (T.113, R.15, S.21);
- G. Houston County: Houston fen, 62 (T.104, R.6, S.26);
- H. Jackson County:
 - (1) Heron Lake fen, 45 (T.103, R.36, S.29); and
 - (2) Thompson Prairie fen, 20 (T.103, R.35, S.7);
- I. Le Sueur County:
 - (1) Ottawa Bluff fen, 56 (T.110, R.26, S.3);
 - (2) Ottawa WMA fen, 7 (T.110, R.26, S.11); and
 - (3) Ottawa WMA fen, 60 (T.110, R.26, S.14);
- J. Lincoln County: Hole-in-the-Mountain Prairie fen, 6; Pipestone (T.108, R.46, S.1; T.109, R.45, S.31);
- K. Mahnomen County: Waubun WMA fen, 11 (T.143, R.42, S.25);
- L. Marshall County:
 - (1) Tamarac River fen, 71 (T.157, R.46, S.2);
 - (2) Viking fen, 68 (T.155, R.45, S.18);
 - (3) Viking fen, 70 (T.155, R.45, S.20); and
 - (4) Viking Strip fen, 69 (T.154, R.45, S.4);
- M. Martin County: Perch Creek WMA fen, 33 (T.104, R.30, S.7);
- N. Murray County: Lost Timber Prairie fen, 13 (T.105, R.43, S.2);
- O. Nicollet County:
 - (1) Fort Ridgely fen, 21 (T.111, R.32, S.6); and
 - (2) Le Sueur fen, 32 (T.111, R.26, S.16);
- P. Nobles County: Westside fen, 59 (T.102, R.43, S.11);
- Q. Norman County:
 - (1) Agassiz-Olson WMA fen, 17 (T.146, R.45, S.22);
 - (2) Faith Prairie fen, 15 (T.144, R.43, S.26);
 - (3) Faith Prairie fen, 16 (T.144, R.43, S.35);
 - (4) Faith Prairie fen, 27 (T.144, R.43, S.25); and
 - (5) Green Meadow fen, 14 (T.145, R.45, S.35, 36);
- R. Olmsted County:
 - (1) High Forest fen, 12 (T.105, R.14, S.14, 15); and
 - (2) Nelson WMA fen, 5 (T.105, R.15, S.16);
- S. Pennington County:
 - (1) Sanders East fen, 65 (T.153, R.44, S.7);
 - (2) Sanders East fen, 74 (T.153, R.44, S.7); and
 - (3) Sanders fen, 64 (T.153, R.44, S.18, 19);
- T. Pipestone County:
 - (1) Burke WMA fen, 57 (T.106, R.44, S.28); and

- (2) Hole-in-the-Mountain Prairie fen, 6 (see Lincoln County, item J);
- U. Polk County:
- (1) Chicog Prairie fen, 39 (T.148, R.45, S.28);
 - (2) Chicog Prairie fen, 40 (T.148, R.45, S.33);
 - (3) Chicog Prairie fen, 41 (T.148, R.45, S.20, 29);
 - (4) Chicog Prairie fen, 42 (T.148, R.45, S.33);
 - (5) Kittleson Creek Mire fen, 55 (T.147, R.44, S.6, 7);
 - (6) Tympanuchus Prairie fen, 26 (T.149, R.45, S.17); and
 - (7) Tympanuchus Prairie fen, 38 (T.149, R.45, S.16);
- V. Pope County:
- (1) Blue Mounds fen, 1 (T.124, R.39, S.14, 15);
 - (2) Lake Johanna fen, 4 (T.123, R.36, S.29); and
 - (3) Ordway Prairie fen, 35 (T.123, R.36, S.30);
- W. Redwood County:
- (1) Swedes Forest fen, 8 (T.114, R.37, S.19, 20); and
 - (2) Swedes Forest fen, 9 (T.114, R.37, S.22, 27);
- X. Rice County:
- (1) Cannon River Wilderness Area fen, 18 (T.111, R.20, S.34); and
 - (2) Cannon River Wilderness Area fen, 73 (T.111, R.20, S.22);
- Y. Scott County:
- (1) Savage fen, 22 (T.115, R.21, S.17);
 - (2) Savage fen, 66 (T.115, R.21, S.16); and
 - (3) Savage fen, 67 (T.115, R.21, S.17);
- Z. Wilkin County:
- (1) Anna Gronseth Prairie fen, 47 (T.134, R.45, S.15);
 - (2) Anna Gronseth Prairie fen, 49 (T.134, R.45, S.10);
 - (3) Anna Gronseth Prairie fen, 52 (T.134, R.45, S.4);
 - (4) Rothsay Prairie fen, 46 (T.136, R.45, S.33);
 - (5) Rothsay Prairie fen, 50 (T.135, R.45, S.15, 16); and
 - (6) Rothsay Prairie fen, 51 (T.135, R.45, S.9);
- AA. Winona County: Wiscoy fen, 58 (T.105, R.7, S.15); and
- BB. Yellow Medicine County:
- (1) Sioux Nation WMA NHR fen, 29 (T.114, R.46, S.17); and
 - (2) Yellow Medicine fen, 30 (T.115, R.46, S.18).

Subp. 7. Unlisted outstanding resource value waters. The agency shall prohibit or stringently control new or expanded discharges to outstanding resource value waters not specified in subparts 3 to 6b to the extent that this stringent protection is necessary to preserve the existing high quality, or to preserve the wilderness, scientific, recreational, or other special characteristics that make the water an outstanding resource value water.

APPENDIX OF DRAFT NATIVE PLANT COMMUNITY DESCRIPTION FOR “EXTREMELY RICH FEN”

OPp93

Prairie Extremely Rich Fen

Open graminoid-dominated fens on permanently saturated peat sustained by mineral-rich groundwater discharge, with little influence from surface water inputs. Typically on slight slopes; peat sometimes mounded or domed. Small pools and sparsely vegetated marly peat areas commonly present. Occurs throughout the prairie region of the state.

Vegetation Structure & Composition

Description is based on summary of vegetation data from 78 plots (relevés).

- **Moss** cover variable; almost entirely “brown” mosses, *Sphagnum* spp. very rare. Characteristic species are *Limprichtia cossonii*, *Campylium stellatum*, *Bryum pseudotriquetrum*, *Drepanocladus aduncus*, *Brachythecium rivulare*, and *Plagiomnium ellipticum*. The last three are less common northward, the last two being mainly southeastern.
- **Graminoid** species dominate, usually constituting more than 75% of total plant cover. Of the most distinctive species, prairie sedge (*Carex prairea*) is important throughout the range of OPp93; sterile sedge (*Carex sterilis*) is typically a major component except in the southwest; tufted bulrush (*Scirpus cespitosus*) is fairly common from central Minnesota northward; and hair-like beak rush (*Rhynchospora capillacea*), absent from the southeast, is often abundant, especially on the margins of marly pools. Important components shared with wet meadows are hard-stemmed bulrush (*Scirpus acutus*), tussock sedge (*Carex stricta*), and aquatic sedge (*Carex aquatilis*), the last apparently absent from the southeast. Several wet-prairie species are also significant components: clustered muhly grass (*Muhlenbergia glomerata*), mat muhly grass (*Muhlenbergia richardsonis*), and narrow reed grass (*Calamagrostis stricta*), the first throughout and the last two rare southeast. Big bluestem (*Andropogon gerardii*) is typically present except south of the Minnesota River Valley, where it is rare.
- **Forb** cover usually sparse (<25%). Among the more common distinctive species are American grass-of-Parnassus (*Parnassia glauca*), Kalm’s lobelia (*Lobelia kalmii*), seaside arrowgrass (*Triglochin maritima*), marsh arrowgrass (*Triglochin palustris*), lesser fringed gentian (*Gentianopsis procera*). All are rare to absent in the southeast and most are rare in the southwest. Wet-meadow species common in OPp93 are spotted Joe-pye-weed (*Eupatorium maculatum*), common boneset (*Eupatorium perfoliatum*), and swamp thistle (*Cirsium muticum*). The last is rare in the southeast and the second rare northwest. Several wet-prairie species are common: flat-topped aster (*Aster umbellatus*), swamp lousewort (*Pedicularis lanceolata*), northern bedstraw (*Galium boreale*), Riddell’s goldenrod (*Solidago riddellii*), Virginia mountain mint (*Pycnanthemum virginianum*), prairie loosestrife (*Lysimachia quadriflora*), and golden alexanders (*Zizia aurea*). Other wet prairie species such as tall meadow-rue (*Thalictrum dasycarpum*), northern plains blazing star (*Liatris ligulistylis*), and yellow stargrass (*Hypoxis hirsuta*) are often present at low densities.
- **Shrub layer** nearly absent to sparse (<25% cover). Red-osier dogwood (*Cornus sericea*) usually present. Except in the southwest, bog birch (*Betula pumila*) is often fairly common, and sage-leaved willow (*Salix candida*) typically present. Shrubby cinquefoil (*Potentilla fruticosa*) is often common in the northwest, rare to absent elsewhere.
- **Notes:** Several plant species are essentially restricted to OPp93 in Minnesota: sterile sedge, hair-like beak-rush, marsh arrowgrass, and whorled nutrush (*Scleria verticillata*), a rarer species. Beaked spikerush (*Eleocharis rostellata*) is known only from OPp93 and the closely related OPn93. Several species that occur in other classes in the northwest are confined to

OPp93 farther south: twig rush (*Cladium mariscoides*), tufted bulrush, American grass-of-Parnassus, Kalm's lobelia, seaside arrowgrass, and shrubby cinquefoil. Prairie sedge occurs in the related class WMs83, but it is otherwise a plant of OPp93. Occurrences of OPp93 are seldom homogeneous. Variations in groundwater flowpaths and in the topography of the setting can create noticeable variation in vegetation. Areas of open marly pools and low, tussocky graminoid "lawns" are most characteristic. But these may grade into denser, taller, often shrubbier vegetation where the substrate is less saturated or mineral soil is closer to the surface, or into marsh where ponding occurs below the fen.

Landscape Setting & Soils

OPp93 occurs where there is an uninterrupted discharge of mineral-rich groundwater at the surface that is neither ponded nor flows rapidly away, and where surface water inputs (rainfall, runoff) are minor relative to groundwater input. Such conditions occur where surface slopes intersect groundwater-bearing layers perched above less-permeable layers or where permeable formations penetrate confining beds overlying aquifers with above-surface heads. Fens of the first type are most commonly found along down-gradient slopes of Glacial Lake Agassiz beach ridges, on side-slopes of large erosional features such as the Minnesota and Mississippi River valleys, of smaller glacial meltwater valleys in southwestern Minnesota, and of stream valleys in the dissected bedrock region of southeastern Minnesota. Fens of the second type are concentrated in the southwest, but occur sporadically northward. OPp93 is limited to regions of calcareous glacial drift or bedrock. Soils are histosols (more than half of the upper 80 cm is organic material) or have a histic epipedon (20-60 cm organic material).

Natural History

Having flowed through calcareous glacial drift or bedrock the groundwater supply is alkaline (pH > 6.7) with a high calcium concentration (> 30mg/l). The constantly upwelling cold, anoxic water creates ideal conditions for peat formation provided it doesn't drain rapidly away, and peat formation further retards drainage. Conditions at the surface promote the precipitation of calcium carbonate as marl or tufa, which is incorporated into the accumulating peat. This material may give the peat a high mineral content. The elevated mineral concentrations and cold, anoxic substrate conditions exclude or suppress the growth of most wetland plants, allowing a few specialists to thrive. OPp93 does not occur in situations subject to flooding as none of the characteristic dominants can survive prolonged inundation.

Similar Native Plant Community Classes

• OPn93 Northern Extremely Rich Fen

OPn93 and OPp93 have similar hydrology and water chemistry. OPn93 occurs within patterned peatlands or other settings within the northern forest, and has species from this pool that are absent from OPp93. Conversely, OPp93 has a number of species from the prairie that are absent from OPn93. Because of its prairie setting, OPp93 probably burned frequently, whereas fire return times in OPn93 would have been much longer.

Species	Frequency (%)	
	OPp93	OPn93*
Spotted Joe pye weed (<i>Eupatorium maculatum</i>)	71	0
Mat muhly grass (<i>Muhlenbergia richardsonis</i>)	69	0
Flat-topped aster (<i>Aster umbellatus</i>)	67	0
Narrow reed grass (<i>Calamagrostis stricta</i>)	54	0

Big bluestem (<i>Andropogon gerardii</i>)	49	0
Northern bedstraw (<i>Galium boreale</i>)	47	0
Riddell's goldenrod (<i>Solidago riddellii</i>)	45	0
Marsh arrowgrass (<i>Triglochin palustris</i>)	38	0
Sundews (<i>Drosera anglica</i> , <i>D. rotundifolia</i> , <i>D. intermedia</i>)	3	50
White beak rush (<i>Rhynchospora alba</i>)	0	50
Buckbean (<i>Menyanthes trifoliata</i>)	6	75
Twig rush (<i>Cladium mariscoides</i>)	4	75
White cedar (<i>Thuja occidentalis</i>) seedling/sapling	0	75
Pitcher plant (<i>Sarracenia purpurea</i>)	9	88
Bladderworts (<i>Utricularia intermedia</i> , <i>U. cornuta</i> , <i>U. minor</i>)	4	88
Bog rosemary (<i>Andromeda glaucophylla</i>)	0	88

* 8 plots

• OPp91 Prairie Rich Fen

Both OPp91 and OPp92 occur on saturated peat substrates, and while there may be some lateral flow in OPp91 there is no artesian pressure. OPp91 occupies depressional sites where the water table is persistently at or close to the surface. Shallow flooding is a regular event in OPp91, and the dominants of this type have adaptations to conduct oxygen to roots from emergent leaves. Fen wiregrass sedge (*Carex lasiocarpa*) almost always a dominant in OPp91, occasionally common in OPp93.

Species	Frequency (%)	
	OPp93	OPp91*
Sterile sedge (<i>Carex sterilis</i>)	76	0
Mat muhly grass (<i>Muhlenbergia richardsonis</i>)	69	3
American grass-of-Parnassus (<i>Parnassia glauca</i>)	58	2
Big bluestem (<i>Andropogon gerardii</i>)	49	2
Prairie sedge (<i>Carex prairea</i>)	45	3
Riddell's goldenrod (<i>Solidago riddellii</i>)	45	2
Marsh arrowgrass (<i>Triglochin palustris</i>)	38	2
Hair-like beak rush (<i>Rhynchospora capillacea</i>)	28	0
Silverweed (<i>Potentilla anserina</i>)	0	19
Northern blue flag (<i>Iris versicolor</i>)	0	19
Bog willow (<i>Salix pedicellaris</i>)	0	23
Marsh cinquefoil (<i>Potentilla palustris</i>)	0	27
Common mint (<i>Mentha arvensis</i>)	0	29
Marsh St. John's wort (<i>Triadenum fraseri</i>)	0	31
Water smartweed (<i>Polygonum amphibium</i>)	1	35
Tufted loosestrife (<i>Lysimachia thyrsiflora</i>)	1	48

* 128 plots

● WPN53 Northern Wet Prairie

The seepage type WPN53a is more subtly influenced by groundwater seepage than OPp93. There is no actual discharge; pools are absent, and the substrate is moist, not saturated. The soil is very organically enriched mineral soil, not peat. The vegetation is lush, dominated by taller species than the distinctive low tussocky lawns of OPp93.

Species	Frequency (%)	
	OPp93	WPN53a*
Sterile sedge (<i>Carex sterilis</i>)	76	0
Sage-leaved willow (<i>Salix candida</i>)	50	10
Bog aster (<i>Aster borealis</i>)	67	10
Prairie sedge (<i>Carex prairea</i>)	45	0
Hard-stemmed bulrush group (<i>Scirpus acutus</i> & <i>S. heterochaetus</i>)	42	0
Aquatic sedge (<i>Carex aquatilis</i>)	36	0
Hair-like beak rush (<i>Rhynchospora capillacea</i>)	28	0
Fen wiregrass sedge (<i>Carex lasiocarpa</i>)	28	0
Maximilian's sunflower (<i>Helianthus maximiliani</i>)	1	30
Indian grass (<i>Sorghastrum nutans</i>)	1	30
Little bluestem (<i>Schizachyrium scoparium</i>)	0	30
Purple prairie clover (<i>Dalea purpurea</i>)	0	60
Heath aster (<i>Aster ericoides</i>)	3	70
Prairie cordgrass (<i>Spartina pectinata</i>)	3	70
Heart-leaved alexanders (<i>Zizia aptera</i>)	4	80
Prairie dropseed (<i>Sporobolus heterolepis</i>)	0	80

* 10 plots

● WPs54 Southern Wet Prairie

The same similarities and differences apply to WPs54a and OPp93 as are described for WPN53a. Vegetation data are available from only one plot; no comparison table is presented, but the same contrasts in prairie and fen species are to be expected.

● WMs83 Southern Seepage Meadow/Carr

WMs83 distinctions are still under revision. From the floristic data we suspect that seepage water inputs are typically dominated by local flow systems and thus contain less carbonate. The dominants of WMs83 are more like deep meadow, with greater abundance of *Carex stricta*, *Carex lacustris*, bluejoint, and few if any fen indicators are present. Shrubs are much more important.

Species	Frequency (%)	
	OPp93	WMs83*
Sterile sedge (<i>Carex sterilis</i>)	76	0
Mat muhly grass (<i>Muhlenbergia richardsonis</i>)	69	2
American grass-of-Parnassus (<i>Parnassia glauca</i>)	58	0
Kalm's lobelia (<i>Lobelia kalmii</i>)	58	0
Seaside arrowgrass (<i>Triglochin maritima</i>)	49	3
Riddell's goldenrod (<i>Solidago riddellii</i>)	45	2
Marsh arrowgrass (<i>Triglochin palustris</i>)	38	0
Hair-like beak rush (<i>Rhynchospora capillacea</i>)	28	0
Water smartweed (<i>Polygonum amphibium</i>)	1	22

Common mint (<i>Mentha arvensis</i>)	0	28
Tufted loosestrife (<i>Lysimachia thyrsiflora</i>)	1	31
Lake sedge (<i>Carex lacustris</i>)	1	32
Fowl bluegrass (<i>Poa palustris</i>)	1	35
Touch-me-not (<i>Impatiens</i> spp.)	6	43
Bluejoint (<i>Calamagrostis canadensis</i>)	9	45
Great water dock (<i>Rumex orbiculatus</i>)	5	58

* 65 plots

Native Plant Community Types in Class

• OPp93a Calcareous Fen (Northwestern)

These fens occur primarily near the bases of Glacial Lake Agassiz beach ridges on their downgradient sides, but there are also examples of local upwellings from confined aquifers. A number are large (> 40 acres), and most are > 10 acres. This is the most species-rich type. Characteristic species in this type that are rare or absent in other types are tufted bulrush, candle-lantern sedge (*Carex limosa*), lead-colored sedge (*Carex livida*), marsh grass-of-Parnassus (*Parnassia palustris*), and sticky false asphodel (*Tofieldia glutinosa*). Bog birch, sage willow, and shrubby cinquefoil are much more common in this type than in the others.

• OPp93b Calcareous Fen (Southwestern)

Fens on local upwellings from confined aquifers and on sideslopes of erosional features. This type is the most species-poor in the class, and most are < 5 acres. Sterile sedge is absent, and the areas where this dominates in OPp93a are typically dominated instead by three species, hair-like beak rush, three-square bulrush (*Scirpus pungens*), and seaside arrowgrass (*Triglochin maritima*). Shrubs are nearly absent, with only stunted red-osier dogwood likely.

• OPp93c Calcareous Fen (Southeastern)

Fens mostly on sideslopes of erosional features, sometimes on terraces within valleys. Most small, but some in Minnesota River Valley large. Intermediate species richness; sterile sedge usually present, but other indicators rare or absent southeast of Minnesota River Valley. Several species in OPp93c rare or absent in other types are spring cress (*Cardamine bulbosa*), cowbane (*Oxypolis rigidior*), and edible valerian (*Valeriana edulis*). Bog birch and sage willow sometimes present, red-osier dogwood common.

OPp93 Prairie Extremely Rich Fen

based on 78 plots

•••••	>0.50
••••	0.25-0.50
•••	0.10-0.25
••	0.05-0.10
•	<0.05

Forbs, Ferns, & Fern Allies

	freq %	cover
Spotted Joe pye weed (<i>Eupatorium maculatum</i>)	71	•
Northern bog violet (<i>Viola nephrophylla</i>)	71	•
Bog aster (<i>Aster borealis</i>)	67	•
Flat-topped aster (<i>Aster umbellatus</i>)	67	•
Swamp lousewort (<i>Pedicularis lanceolata</i>)	65	•
American grass-of-Parnassus (<i>Parnassia glauca</i>)	58	••
Kalm's lobelia (<i>Lobelia kalmii</i>)	58	•

Sawtooth/Giant sunflower complex (<i>Helianthus</i> spp.)	54	••
Seaside arrowgrass (<i>Triglochin maritima</i>)	49	••
Northern bedstraw (<i>Galium boreale</i>)	47	•
Riddell's goldenrod (<i>Solidago riddellii</i>)	45	•
Swamp thistle (<i>Cirsium muticum</i>)	41	•
Marsh arrowgrass (<i>Triglochin palustris</i>)	38	•
Virginia mountain mint (<i>Pycnanthemum virginianum</i>)	32	•
Lesser fringed gentian (<i>Gentianopsis procera</i>)	32	•
Common boneset (<i>Eupatorium perfoliatum</i>)	31	•
Grass-leaved goldenrod (<i>Euthamia graminifolia</i>)	29	•
Broad-leaf cattail (<i>Typha latifolia</i>)	28	••
Canada goldenrod (<i>Solidago canadensis</i>)	28	•
Prairie loosestrife (<i>Lysimachia quadriflora</i>)	28	•
Northern bugleweed (<i>Lycopus uniflorus</i>)	28	•
Narrow-leaf and hybrid cattail complex (<i>Typha</i>)	27	••
Red-stemmed aster complex (<i>Aster puniceus</i> & <i>A. firmus</i>)	23	•
Giant goldenrod (<i>Solidago gigantea</i>)	23	•
Dwarf raspberry (<i>Rubus pubescens</i>)	22	••
Golden alexanders (<i>Zizia aurea</i>)	22	•
Sticky false asphodel (<i>Tofieldia glutinosa</i>)	22	•
New England aster (<i>Aster novae-angliae</i>)	21	•
Labrador bedstraw (<i>Galium labradoricum</i>)	21	•
Swamp milkweed (<i>Asclepias incarnata</i>)	21	•
Tall meadow-rue (<i>Thalictrum dasycarpum</i>)	19	•
Marsh bellflower (<i>Campanula aparinoides</i>)	18	•
Marsh grass-of-Parnassus (<i>Parnassia palustris</i>)	17	•
Cut-leaved bugleweed (<i>Lycopus americanus</i>)	17	•
Golden ragwort complex (<i>Senecio aureus</i> & <i>S. pseud aureus</i>)	15	•
Autumn sneezeweed (<i>Helenium autumnale</i>)	15	•
Yellow stargrass (<i>Hypoxis hirsuta</i>)	15	•
Common marsh marigold (<i>Caltha palustris</i>)	13	•
Eastern panicled aster (<i>Aster lanceolatus</i>)	13	•
Northern plains blazing star (<i>Liatris ligulistylis</i>)	13	•
Gray goldenrod (<i>Solidago nemoralis</i>)	13	•
Spring cress (<i>Cardamine bulbosa</i>)	12	•
Poor gerardia (<i>Agalinis purpurea</i>)	12	•
White camas (<i>Zigadenus elegans</i>)	12	•
White rattlesnakeroot (<i>Prenanthes alba</i>)	12	•
Black-eyed Susan (<i>Rudbeckia hirta</i>)	10	•
Spotted water hemlock (<i>Cicuta maculata</i>)	10	•
Small white lady's slipper (<i>Cypripedium candidum</i>)	10	•
Cowbane (<i>Oxypolis rigidior</i>)	8	•
Edible valerian (<i>Valeriana edulis</i>)	6	••
Grasses & sedges		
Clustered muhly grass (<i>Muhlenbergia glomerata</i>)	86	••
Sterile sedge (<i>Carex sterilis</i>)	76	•••
Mat muhly grass (<i>Muhlenbergia richardsonis</i>)	69	•••
Rigid sedge (<i>Carex tetanica</i>)	55	•

Narrow reed grass (<i>Calamagrostis stricta</i>)	54	•
Big bluestem (<i>Andropogon gerardii</i>)	49	••
Prairie sedge (<i>Carex prairea</i>)	45	•••
Tall cottongrass (<i>Eriophorum polystachion</i>)	45	•
Hard-stemmed bulrush group (<i>Scirpus acutus</i> & <i>S. heterochaetus</i>)	42	•••
Fringed brome (<i>Bromus ciliatus</i>)	41	•
Aquatic sedge (<i>Carex aquatilis</i>)	36	•
Tussock sedge (<i>Carex stricta</i>)	35	•••
Flattened spikerush (<i>Eleocharis compressa</i>)	35	•
Hair-like beak rush (<i>Rhynchospora capillacea</i>)	28	•••
Fen wiregrass sedge (<i>Carex lasiocarpa</i>)	28	•••
Interior sedge (<i>Carex interior</i>)	28	•
Fowl manna grass (<i>Glyceria striata</i>)	27	•
Tufted hair grass (<i>Deschampsia cespitosa</i>)	24	••
Tufted bulrush (<i>Scirpus cespitosus</i>)	22	••
Three-square bulrush (<i>Scirpus pungens</i>)	21	••••
Red-stalked spikerush (<i>Eleocharis palustris</i>)	21	•
Sartwell's sedge (<i>Carex sartwellii</i>)	19	••
Lead-colored sedge (<i>Carex livida</i>)	19	•
Buxbaum's sedge (<i>Carex buxbaumii</i>)	14	•
Candle-lantern sedge (<i>Carex limosa</i>)	13	•
Knotty rush (<i>Juncus nodosus</i>)	12	•
Porcupine sedge (<i>Carex hystericina</i>)	12	•
Woolly sedge (<i>Carex pellita</i>)	10	•
Green sedge (<i>Carex viridula</i>)	10	•
Beaked spikerush (<i>Eleocharis rostellata</i>)	8	••••
Whorled nutrush (<i>Scleria verticillata</i>)	8	•
Alpine rush (<i>Juncus alpinoarticulatus</i>)	8	•
Twig rush (<i>Cladium mariscoides</i>)	4	•••

Shrubs

Red-osier dogwood (<i>Cornus sericea</i>)	55	•
Bog birch (<i>Betula pumila</i>)	54	•••
Sage-leaved willow (<i>Salix candida</i>)	50	•
Shrubby cinquefoil (<i>Potentilla fruticosa</i>)	42	•••
Pussy willow (<i>Salix discolor</i>)	33	•
Bebb's willow (<i>Salix bebbiana</i>)	29	•
Autumn willow (<i>Salix serissima</i>)	28	•
Slender willow (<i>Salix petiolaris</i>)	22	•

APPENDIX OF SITE CODES

Key to the Site Codes used for Calcareous Fen Site Locations in Figure 4.

ACF	Adrian
ATF	Altoona Fen
ATM	Altoona Meadow
BAR	Barnesville State WMA
BHC	Bemis Hill
BLD	Black Dog Preserve SNA
BWF	Burke WMA
CRW	Cannon River Wilderness Area County Park
CVT	Cannon Valley Trail
E13	Eyota 13
FCF	Fairchild
FEL	Felton State WMA
FGS	Forest Grove Spring
FRC	Fort Ridgely
FRD	Fort Ridgely State Park
FSS	Fort Snelling State Park
GMD	Green Meadow
GPL	Gully
H26	Houston 26
HLT	Holt Meadow
HMK	Homolka Beach Ridge
HPC	Holte Prairie
ISB	Iron Springs Bog
JCF	Jeffers
KNF	Kennedy
KTF	Kragero Township
LRP	Lost River
LTF	Lost Timber
MCF	Mutchler
MCT	McCarthy WMA
MLP	Mulligan Lake
NCF	Nichols
NFW	Nelson WMA
NLP	Net Lake
NSF	Nelson
OGM	Ogema
OTF	Ottawa
PCP	Pine Creek
PER	Perched Valley WMA
PFS	Pheasants Forever WMA
PVC	Perched Valley
R21	Red Wing 21
RPF	Rothsay
RRP	Roseau River
S16	Sheldon 16
S18	Sanders 18
SCF	St. Croix Watershed Research Station
SHC	Stonchedge
SHF	Spring Hill
SKC	Sucker Creek
SMF	Seminary
SNF	Sioux Nation
SPR	Sprague Creek
SSF	Savage
STF	Sam Tutt
SWV	Stewartville
WBN	Waubun
WSJ	Wasioja
WVE	Wiscoy Valley East
YPF	Yonker
ZLC	Zion Lutheran Church

APPENDIX OF BRYOPHYTE COLLECTION METHODS

**Bryophytes of Calcareous Fens:
Minimum Requirements for Submission of Collections for
Identification
And
Suggestions on Survey Procedure
June 2004**

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BRYOPHYTES OF CALCAREOUS FENS: MINIMUM REQUIREMENTS FOR SUBMISSION OF COLLECTIONS FOR IDENTIFICATION AND SUGGESTIONS ON SURVEY PROCEDURE

Update June 2004

Herbarium-label information for potential calcareous fen (CF) sites

To ensure proper herbarium labels for the deposition of collections in an herbarium, the following information is needed:

date of collection

name of the primary collector

locality information

habitat information

Please provide a middle initial, if available, for the primary-collector's name. The names are linked with 3-letter acronyms in the herbarium database.

The required locality information at each collection site can consist of either a legal description (township-range to at least 1/16th section accuracy), or a copy of the 1:24,000/25,000 topo quad (mention quad name) with locality or sites marked, or GPS coordinates in either lat/long or UTM. **Make sure to indicate in which datum system the GPS receiver was calculating the fixes (*i.e.*, WGS-84).** This is particularly important for UTM coordinates.

Habitat information should include a short description and visual estimate of the proportion of shrub, pool, short-sedge lawn, and spring seepage cover at the potential CF site. Provide information about water-chemistry parameters such as pH and specific conductance, if measured. A few digital

photographs of the site and its different habitats are appreciated and will enhance the report.

Procedures for collecting and preserving bryophyte samples

Use 2-lb brown paper bags (never plastic bags!) to collect samples in the field. Make sure the field staff is aware to **dry the samples as soon as possible** (no need to remove the bryophyte collections from the bags). Drying can be done either in front of a fan (often several days needed) or in a plant dryer @ 60°C (usually a single day suffices). Do not press bryophyte samples, but remove excess substrate from the bryophytes during collecting to limit abrasion of the specimens.

A single bag should not contain more than a single individual bryophyte patch (possibly with intimately associated species: no need to separate those out). **Do not put several collections of bryophyte patches that are physically separate in the field in a single bag**, even on the same site and when it appears that they might be the same species.

Suggestions on recording: a unique collection number of 5 digits maximum for each bag would be preferable. Pre-numbering the bags and keeping track of the collection-number range for each site or habitat in the field would speed things up, as there would be no need to write on the bags during the collecting in the field. Site and habitat information should be described in the field notes with the associated collection-number ranges. Keep freshly collected bryophyte samples in a large-mesh laundry or burlap bag so that they can breathe until they are dried properly.

Measuring total bryophyte cover and calculating individual species abundance

Several techniques are employed to derive abundance measures of individual bryophyte taxa within an habitat or ecotone (Janssens 2002). I found that for potential CF sites a random-number point-intercept method is most suitable. Many of the bryophyte patches are hidden under thatch, the remaining litter of the graminoids, and are not readily apparent for visual cover estimates as used in plot and relevé methods. Line point-intercepts are easily converted into areal cover (Janssens 2002).

A random-number table (see Appendix) is employed along several 5-m long sections of a measuring tape. The tape is stretched along a line through the potential CF, intersecting its most prominent features. Do not record beyond what is clearly discernable as the fen habitat. As many 5-m long sections can be used as there is habitat available or until a suitable number of point-intercept samples are collected. In sites with sufficient bryophyte cover (>20% or bryophyte hits on average at least once every 5 intercept points), a minimum of 10 bryophyte samples should be collected (25 m of total transect in this case). If none of the linear dimensions of the habitat is long enough to accommodate such a transect, several parallel or intersecting transect lines can be laid out. Often a 15-m transect suffices if total bryophyte cover approaches 50%.

Each row in the random-number table (see Appendix) lists ten random numbers. These numbers, which range from 1 to 500, represent the distance in cm along a 5-m segment of the tape. The tape is put down as close to the surface as possible and a surface sample is taken through the thatch at each one of the 10 random-number cm marks read from the table (Figure 1). Either a plumb line

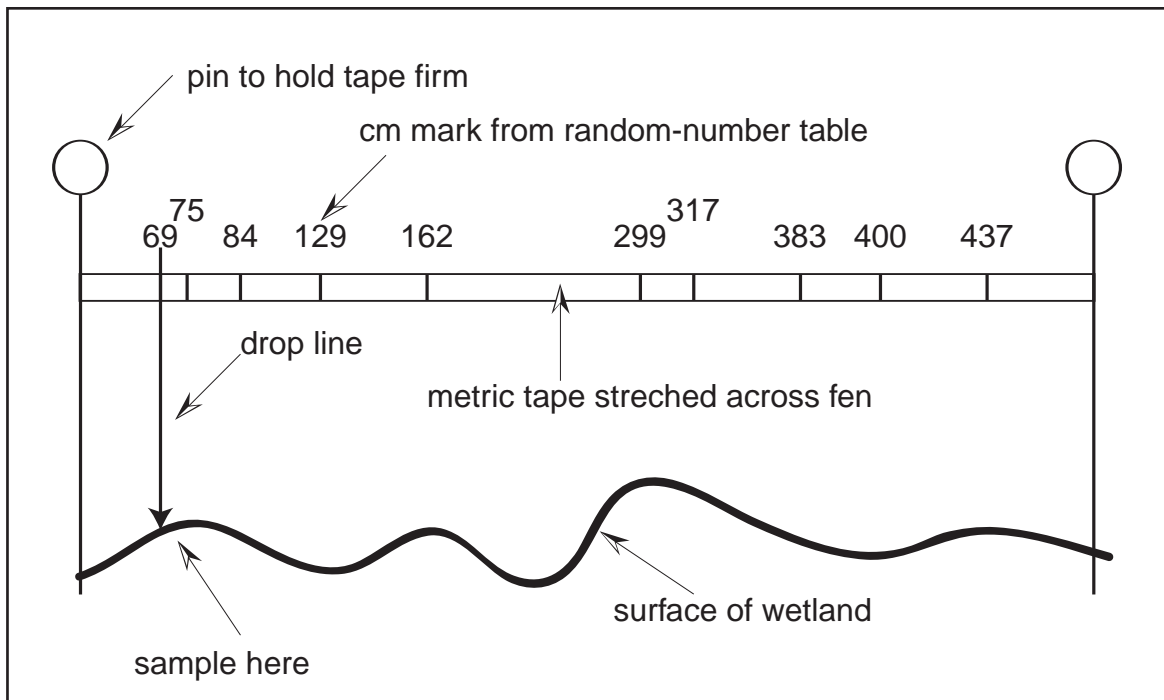


Figure 1. Point-intercept sampling. Sample at the reading along the tape (from 0 to 500 cm) that corresponds to the number in a row from the random-number table (see Appendix). In this example the sample is taken at 69 cm, 75 cm, 84 cm, etc., until 10 sample locations are identified for the 5-meter transect. Only samples with bryophytes are bagged.

or a visual drop line can be used from the tape down. A small surface sample, usually at or below the water interface, is grabbed between the thumb and forefinger of one hand and examined for the presence of bryophytes. If they are present the entire sample (minus some excess substrate if it can be removed) is dropped in a collection bag. Samples without any obvious bryophyte fragments you can discard in the field. If you are unsure if the sample contains bryophyte material, also drop it in a bag. We can easily confirm the presence or absence under the stereoscope in the lab. These bags without bryophytes will be subtracted from the total tally. [For each 5-m section use another row on the random-number sheet. For a site surveyed only once, this isn't important, but when permanent line transects are established for long-term monitoring, it is necessary to note down the random-number row that has been used to start the transect, so that future surveys can use a different starting point. The sampling method is in some degree destructive.]

In addition to the line-transect collections, some general collecting can be done in the ecotope (stay within the boundaries of the potential CF!). Those collection bags should be marked separately from those of the line transect. They are useful for (1) recording species that might have been missed along the transect, and (2) for preparing better-quality collections for herbarium deposition (vouchers), because well-developed clones of particular species can be sampled.

Recording: the following information is needed. (1) **The total length of transect** (in whole units of 5-m. (2) **The total number of collection bags used along the transect** (number of hits: either a tally of the bags, or calculated from the number range marked on the bags). Again, it is not

necessary with this method to differentiate among species in the field. **Do not separate apparent individual species from each other that occur in a single point sample: put them in the same bag!**

Calculation of total and individual bryophyte species cover: (1) The overall bryophyte cover in % on the site is simple the number of bags with bryophytes (hits) divided by the total number of points dropped (10 for each 5-m transect section surveyed). Bags that turned out to have no bryophytes in them are subtracted from the number of hits recorded in the field. (2) The cover for an individual species equals the number of times the species was recorded among the collections times the total bryophyte cover of the site in % divided by the total tally of all species records. Often this total tally is larger than the number of hits, because several bags might contain a mixture of species.

Calculating CF score

All Minnesota fen sites identified as calcareous fens and with comprehensive bryophyte analysis are ranked, both state-wide and regionally. This ranking is based on the presence of obligate, facultative, and occasional calcareous-fen species and is explained in detail in Janssens 2004a. An example of this validation is given with the Ottawa Fen report (Janssens 2004b).

Equipment needed (**absolutely necessary**)

- metric tape**, preferably at least 15-m long
- 2-lb brown paper bags**, preferably pre-numbered with your collection number
- field notebook** to record collection-number ranges, and locality and habitat information
- random-number table** (see appendix)
- waterproof pen
- handlens
- digital camera
- GPS receiver (note datum system employed!)
- stake or pole to start line transect with measuring tape
- plumb line
- laundry bag to store collections temporarily before proper drying
- rubber bands, to collate collection bags

References

- Janssens, J.A. 2002. Methods for the study of bryophyte ecology. Update April 2002. Available from the author janss008@tc.umn.edu.
- Janssens, J.A. 2004a. Classification, indicator value, and regional differentiation of bryophyte species in Minnesota's calcareous fens and validation of calcareous fens, update June 2004. Available from janss008@tc.umn.edu or jeanette.leete@dnr.state.mn.us.
- Janssens, J.A. 2004b. Bryophytes of the Ottawa Calcareous Fen, Le Sueur County, Minnesota, Preliminary Reconnaissance, update June 2004. Report to the Minnesota Department of Natural Resources, Division of Waters. Available from janss008@tc.umn.edu or jeanette.leete@dnr.state.mn.us.

APPENDIX: RANDOM NUMBER TABLE FOR POINT-INTERCEPT LINE TRANSECTS

4	7	28	43	48	153	338	415	441	452
47	81	228	236	320	377	423	436	466	478
13	25	82	88	109	193	332	371	408	444
10	54	97	212	220	237	265	328	421	441
4	32	78	121	152	203	253	296	370	489
13	48	126	152	222	293	376	392	423	483
47	73	73	77	78	167	291	382	447	477
12	72	94	98	132	193	301	409	420	481
31	65	113	167	184	251	281	299	369	370
27	30	40	203	253	296	310	346	396	412
8	48	49	96	148	222	316	325	346	420
29	77	135	211	245	319	379	407	460	478
0	56	62	91	131	134	254	265	371	467
17	66	160	180	189	256	290	401	405	458
40	91	93	95	233	249	255	256	313	490
18	24	124	175	191	257	311	335	455	486
40	41	112	189	208	260	299	336	337	364
70	248	273	286	317	330	354	410	484	495
11	57	99	124	147	171	295	312	370	464
11	28	84	116	140	224	307	421	439	481
39	99	120	166	302	360	387	389	442	454
56	65	89	126	197	240	258	285	366	413
3	123	126	147	187	197	205	241	302	354
35	56	128	138	235	236	267	390	422	450
32	82	92	174	222	307	435	437	449	479
84	256	277	304	388	402	447	459	483	499
34	89	108	118	271	300	323	381	423	465
73	133	174	187	234	253	256	317	379	482
152	236	329	339	362	394	402	449	458	484
6	49	52	126	186	284	294	340	362	485
169	182	279	282	296	306	341	364	378	407
59	64	82	152	173	193	205	270	322	360
69	75	84	129	162	299	347	383	400	437
65	155	161	285	299	326	342	395	429	496
99	161	172	214	255	256	322	367	418	430
83	109	120	123	137	191	258	278	353	357
72	277	338	351	352	411	418	419	461	464
65	68	149	183	275	326	411	451	455	469
103	280	318	336	363	380	387	389	415	467
18	30	31	51	194	263	329	371	401	413
11	53	206	207	225	297	302	337	442	469
6	14	22	85	135	261	301	361	367	472
100	164	201	215	238	363	371	471	472	485
40	104	158	209	214	216	274	342	371	389
26	93	114	129	164	227	278	355	412	447
110	144	188	243	266	277	355	386	403	471
58	84	144	190	218	263	323	329	490	491
35	64	85	194	259	294	408	413	442	443
173	191	242	318	330	340	361	396	412	473
67	124	234	264	324	365	418	438	445	452
62	109	110	114	227	244	312	344	416	448

III.D. Calcareous Fens

Calcareous fens are the rarest wetland plant community in Minnesota and Wisconsin, and probably one of the rarest in North America. These are plant communities of saturated, seepage sites that have an internal flow of groundwater rich in calcium and magnesium bicarbonates, and sometimes calcium and magnesium sulfates as well (Curtis 1971). The calcium and magnesium bicarbonates and sulfates precipitate out at the surface creating a harsh, alkaline soil condition. Only a select group of calcium-tolerant plants, referred to as **calciphiles**, can tolerate these conditions. Healthy (unaltered) calcareous fens are sedge-dominated by *Carex* species (e.g., sterile sedge (*C. sterilis*), prairie sedge (*C. prairea*), common stiff sedge (*C. tetanica*), Buxbaum's sedge (*C. buxbaumii*)) as well as beaked spike-rush (*Eleocharis rostellata*), twig-rush (*Cladium mariscoides*) and hair beak-rush (*Rhynchospora capillacea*). Characteristic grasses and forbs include wild timothy, Ohio goldenrod, Grass-of-Parnassus, common valerian, brook lobelia and lesser fringed gentian. Shrubby cinquefoil and sage willow are characteristic shrubs. Included are species disjunct from the tundra, alpine meadows and salt marshes. Therefore, calcareous fens are described as a hybrid community by Curtis (1971).

Calcareous fen communities in general have a disproportionate number of rare, threatened and endangered plant species compared to other plant communities in the Great Lakes Region.

Trout streams are often associated with calcareous fens because of the cold, pure water provided by the springs and seepages.



Steve D. Eggers

Active springs are frequently associated with calcareous fens. The example shown by the photograph is within Nicols Meadow Fen in Dakota County, Minnesota. The aquatic plant is water cress (*Rorippa nasturtium-aquaticum*).

Two Eurasian shrubs, glossy buckthorn (*Frangula alnus*) and common buckthorn (*Rhamnus cathartica*), have become established within many fen complexes in Minnesota and Wisconsin. Without control measures, buckthorns can form dense thickets that shade out calcareous fen species including the rare taxa.

CALCAREOUS FENS

VEGETATION: The calcareous fen community shown on the following page supports five species listed as threatened (T) by the State of Minnesota as well as two species listed as being of special concern (SC): sterile sedge (*Carex sterilis*) (T); beaked spike-rush (*Eleocharis rostellata*) (T); hair beak-rush (*Rhynchospora capillacea*) (T); whorled nut-rush (*Scleria verticillata*) (T); common valerian (*Valeriana edulis* var. *ciliata*) (T); twig-rush (*Cladium mariscoides*) (SC) and white lady's-slipper (*Cypripedium candidum*) (SC). Additional species present include Buxbaum's sedge (*Carex buxbaumii*), limestone meadow sedge (*Carex granularis*), common stiff sedge (*Carex tetanica*), prairie sedge (*Carex prairea*), hummock sedge (*Carex stricta*), hardstem bulrush (*Schoenoplectus acutus*), Grass-of-Parnassus (*Parnassia glauca*), lesser fringed gentian (*Gentianopsis procera*), brook lobelia (*Lobelia kalmii*), wild timothy (*Muhlenbergia glomerata*), mat muhly grass (*Muhlenbergia richardsonis*), swamp thistle (*Cirsium muticum*), blazing star (*Liatris ligulistylis*), Riddell's goldenrod (*Solidago riddellii*), great blue lobelia (*Lobelia siphilitica*), mountain mint (*Pycnanthemum virginianum*), northern bedstraw (*Galium boreale*), northern bog aster (*Symphyotrichum boreale*), giant goldenrod (*Solidago gigantea*), shrubby cinquefoil (*Dasiphora fruticosa*), sage willow (*Salix candida*), beaked willow (*Salix bebbiana*) and red-osier dogwood (*Cornus sericea*). Invasive species present include glossy buckthorn (*Frangula alnus*), common buckthorn (*Rhamnus cathartica*) and an invasive genotype of common reed (*Phragmites australis*).

SOILS: Houghton muck (Typic Borosapristis), sloping, calcareous. Muck "domes" created by upwelling groundwater pressure are present within the sloping, organic muck deposit that is up to 25 feet (7.5 m.) in depth overlaying dolomite bedrock. Radiocarbon dating of muck deposits in calcareous fens in southern Minnesota revealed them to be 4,700 to 11,000 years old (Almendinger and Leete 1998).

HYDROLOGY: Upwelling, calcareous, groundwater discharge. Small, calcareous streams originate within the fen complex due to groundwater discharges. Houghton soils (sloping) are typically saturated at or near the surface throughout the growing season.

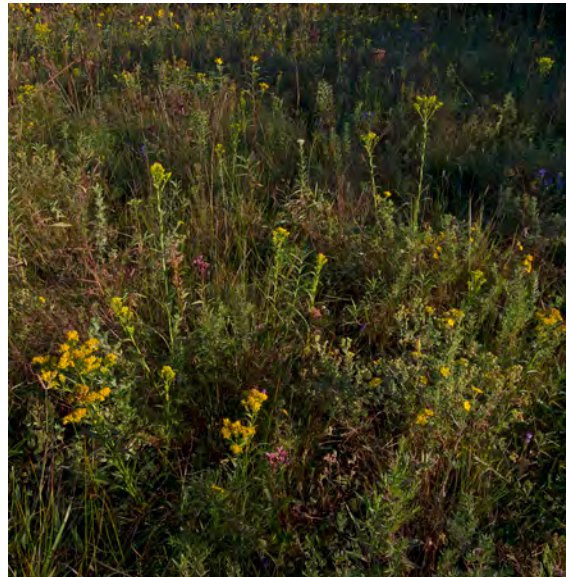
CALCAREOUS FENS



© Photos by Steve D. Eggers

The photograph above was taken from the lower edge of a muck “dome” looking towards the center high spot. This dome is approximately 2 acres in extent.

The photograph to the right illustrates a typical assemblage of sedges and forbs.



CALCAREOUS FENS



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STERILE SEDGE (*Carex sterilis* Willd.)

SEDGE FAMILY (Cyperaceae)

IND. STATUS: OBL

C of C: Native (10); listed as a threatened species in Minnesota

FIELD CHARACTERISTICS: A perennial, dioecious sedge with stems forming tufts 20-70 cm. high (Figure a on the opposing page). The many slender leaves (1-2 mm. wide) are 30 cm. or more long. Spikelets (Figure b) usually number four and are stalkless (sessile). The perigynium (Figure c) is egg-shaped, 2-4 mm. long and up to 2 mm. wide, with a double-toothed beak 0.6-1.6 mm. long. At maturity, perigynia are dark brown and often spreading or bent backward. Nutlet is shown by Figure d. In the central photograph above, the stem labeled [Fertile] has pistillate (seed-producing) spikelets, while the stem labeled [Sterile] has only staminate spikelets (pollen producing but not seed producing). Some of the tufts are all staminate giving them the appearance of being sterile.

Interior sedge (*Carex interior*) [page 384] is similar but usually has only 3 spikelets per stem and the terminal spikelet has a club-shaped mass of staminate flowers at its base. Interior sedge also occurs in a wider range of habitats including bogs and calcareous inland fresh meadows, particularly those with fluctuating water levels.

ECOLOGICAL NOTES: Sterile sedge is a characteristic sedge of calcareous fens and other inland fresh meadows supported by stable, calcareous groundwater seepages. The authors have observed that, in Minnesota and Wisconsin, sterile sedge is essentially an obligate calcareous fen species; however, it occasionally occurs on wet dolomite pavements and other calcareous seepages.

SOURCE: Fassett (1976); Gleason and Cronquist (1991); and Swink and Wilhelm (1994).



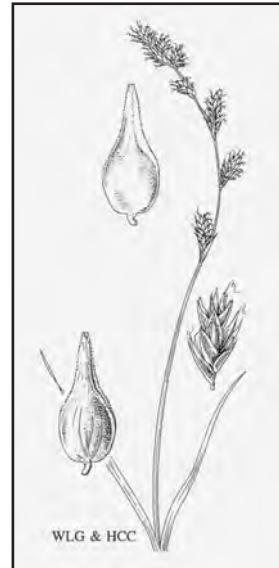
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Sterile Sedge
(*Carex sterilis*)

CALCAREOUS FENS



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PRAIRIE SEDGE

(*Carex prairea* Dewey ex Alph. Wood)

SEDGE FAMILY (Cyperaceae)

C of C: Native (10)

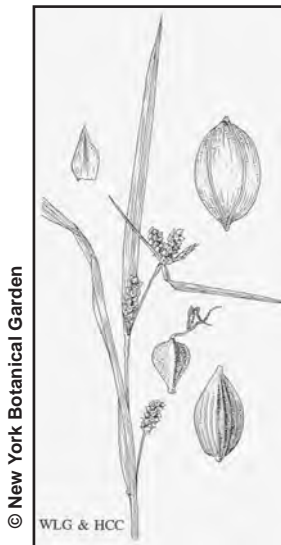
IND. STATUS: FACW

FIELD CHARACTERISTICS: A perennial sedge forming dense clusters (tussocks) of stems 50-100 cm. tall, exceeding the leaves. Leaf sheaths are prolonged 2-3 mm. beyond the leaf base and are tinged a coppery brown color on the ventral (inner) side toward the sheath summit. Numerous, small sessile spikes in a short, but loose, panicle-like arrangement are present. Reddish-brown scales conceal the perigynia. The pale brown perigynia are lance-shaped, 2.5-3 mm. long, appressed, and taper to a pale beak. Two stigmas are present and the nutlets are lens-shaped.

ECOLOGICAL NOTES: Prairie sedge is frequently found in wet prairies, calcareous fens and related wet meadows. It is most frequently seen in and south of the vegetation tension zone.

SOURCE: Fassett (1976); Gleason and Cronquist (1991); Swink and Wilhelm (1994); and Voss (1972).

CALCAREOUS FENS



LIMESTONE MEADOW SEDGE

(*Carex granularis* Muhl. ex Willd.)

SEDGE FAMILY (Cyperaceae)

C of C: Native (3)

IND. STATUS: FACW

FIELD CHARACTERISTICS: A clump-forming, perennial sedge with very short rhizomes, with stems about 30-80 cm. tall. The stems and leaves are glaucous with a bluish green tint. Mature leaves are 4-10(13) mm. wide and typically surpass the stems in height. Staminate and pistillate flowers occur in separate spikelets. The terminal spikelet is sessile, or very short-stalked, and staminate. The lateral pistillate spikelets are 1-3 cm. long. A subtending bract usually exceeds its spikelet. The tightly clustered, erect perigynia are elliptical to oval in shape, 2.2-4 mm. long, conspicuously nerved, and abruptly contracted to a short beak.

ECOLOGICAL NOTES: Limestone meadow sedge chiefly occurs in open calcareous areas, such as wet meadows and swales, calcareous fens and seepages. It also occurs in wooded swamps.

SOURCE: Gleason and Cronquist (1991); Swink and Wilhelm (1994); and Voss (1972).

CALCAREOUS FENS



© Photos by Steve D. Eggers



Fertile stem
(spikelet).

Vegetative
stem rooting at
the tip.

BEAKED SPIKE-RUSH

(*Eleocharis rostellata* (Torr.) Torr.)

SEDGE FAMILY (Cyperaceae)

IND. STATUS: OBL

C of C: Native (10); listed as a threatened species in both Minnesota and Wisconsin

FIELD CHARACTERISTICS: A perennial spike-rush 40-100 cm. high (Figure a on opposing page). Stems are leafless and stout, but conspicuously narrower than the spikelets (Figure b). Two stem types are present: fertile and vegetative (labeled in the photograph above). The vegetative stems are characteristically long and arching, and root at the tip. No other spike-rush (*Eleocharis* sp.) found in Minnesota and Wisconsin has this trait. The nutlet (Figure c) is 1.9-2.8 mm. long and three-sided to planoconvex.

ECOLOGICAL NOTES: This rare spike-rush is restricted to calcareous fens, spring fens in northern peatlands, and calcareous shores. It can form dense stands.

SOURCE: Gleason and Cronquist (1991); Swink and Wilhelm (1994); and Voss (1972).



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Beaked Spike-Rush
(*Eleocharis rostellata*)



© Photos by Steve D. Eggers

NARROW-LEAVED COTTONGRASS

(*Eriophorium angustifolium* Honck.)

SEDGE FAMILY (Cyperaceae)

C of C: Native (8)

IND. STATUS: OBL

FIELD CHARACTERISTICS: A colonial, perennial sedge with stems growing to a height of 20-60 cm. Stem leaf blades are generally flat for most of their length and up to 4 mm. or more wide. The 2 or 3 involucre bracts are leaf-like and often exceed the inflorescence. The summit of the leaf sheaths, as well as the base of the involucre bracts, are tinged with a dark red color. Scales are single (mid-) nerved. Nutlets are blackish in color, 2-3 mm. long and are surrounded by long, silky white bristles. In flower, and thus conspicuous, in late April to mid-May.

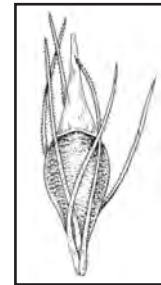
ECOLOGICAL NOTES: Narrow-leaved cottongrass is common in calcareous fens and also occurs in bogs and openings in coniferous swamps. It is a circumboreal species.

SOURCE: Gleason and Cronquist (1991); Swink and Wilhelm (1994); and Voss (1972).

CALCAREOUS FENS



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Nutlet

HAIR BEAK-RUSH (*Rhynchospora capillacea* Torr.)

SEDGE FAMILY (Cyperaceae)

IND. STATUS: OBL

C of C: Native (10), listed as a threatened species in Minnesota

FIELD CHARACTERISTICS: A perennial, tufted sedge 10-40 cm. tall. The wiry stems are erect or curved, hair-like, and leafy. Leaves are ascending, outwardly curved, and hair-like. Leaf blades are 0.2-0.4 mm. wide with inwardly rolled margins. The inflorescence consists of 1-4 spikelets in narrow, ascending clusters. Each cluster is subtended by an ascending green, scale-like leaf (involucral bract). Spikelets are pale reddish brown to brown, spindle-shaped and 6-7 mm. long. Each spikelet is usually 1-2 flowered. Nutlets are pale brown, usually 1-4 per spikelet, and surrounded by 6 bristles (perianth bristles). The nutlet body surfaces have small longitudinally marked fine lines. Each nutlet terminates with a distinct, 5 mm. or less, beak-like tubercle.

Two similar *Rhynchospora* species also occur in fens: the usually taller *R. capitellata* with wider (to 3 mm.) flat leaves and slightly shorter spikelets (3.5-4 mm. long) and *R. alba* with its distinct tan to white spikelets and 9-12 perianth bristles.

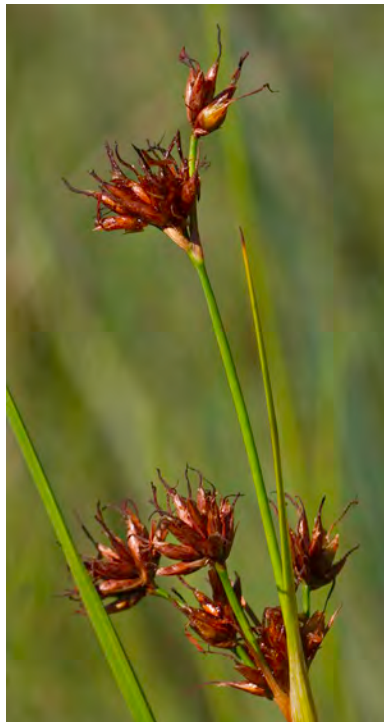
ECOLOGICAL NOTES: Hair beak-rush characteristically occurs in calcareous fens and on open, marly, sedge flats. It also occurs on seepages over dolomite pavements and on calcareous sands of interdunal swales. The similar *Rhynchospora alba* is usually found on open bog mats.

SOURCE: Crow and Hellquist (2000); Gleason and Cronquist (1991); Swink and Wilhelm (1994); and Voss (1972).

CALCAREOUS FENS



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TWIG-RUSH

(*Cladium mariscoides* (Muhl.) Torr.)

SEDGE FAMILY (Cyperaceae)

IND. STATUS: OBL

C of C: Native (10), listed as a species of special concern in Minnesota

FIELD CHARACTERISTICS: A solitary to sparsely colonial perennial sedge with stiff, slender stems growing to about 1 m. The 1-3 mm. wide stem leaf blades are folded or inrolled inward lengthwise. The compound inflorescence is much branched, each bearing a cluster of 1-2 flowered spikelets. A perianth (floral envelope) is absent. The flattish scales are in a shingle-like spiral arrangement forming a lance- to oval-shaped spikelet. Nutlets are ovoid, pointed at the summit, and whitish to pale green in color. In flower June-August.

ECOLOGICAL NOTES: Twig-rush prefers calcareous fens and calcareous watertracks of northern peatlands. In addition, it is found on floating mats, sandy seepage areas, and in interdunal swales.

SOURCE: Crow and Hellquist (2000); Gleason and Cronquist (1991); and Swink and Wilhelm (1994); and Voss (1972).

CALCAREOUS FENS



Illustration is from Hitchcock (1950).



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WILD TIMOTHY

(*Muhlenbergia glomerata* (Willd.) Trin.)

GRASS FAMILY (Gramineae or Poaceae)

C of C: Native (8)

IND. STATUS: FACW

FIELD CHARACTERISTICS: A perennial grass 50-120 cm. high. Stems usually do not branch above the base. Ligules are 0.25-0.5 mm. long. The inflorescence is a terminal, stout, condensed head of compact spikelets. The glumes are longer than the lemmas, which taper to a slender point.

ECOLOGICAL NOTES: Wild timothy is a characteristic grass of calcareous fens and is occasionally found growing on calcareous soils of wet to wet-mesic prairies and other inland fresh meadows supported by groundwater seepages.

SOURCE: Fassett (1951); Gleason and Cronquist (1991); and Swink and Wilhelm (1994).

CALCAREOUS FENS



© Photos by Steve D. Eggers

SPRING-CRESS

(*Cardamine bulbosa* (Muhl.) BSP)

MUSTARD FAMILY (Brassicaceae or Cruciferae) **C of C:** Native (6) **IND. STATUS:** OBL

FIELD CHARACTERISTICS: A perennial herb 20-45 cm. high and up to 60 cm. high when in flower. The erect stems are borne singly, or a few together, from a bulbous, tuber-like rhizome. The unbranched stems support 4-8 simple, rounded leaves. Basal leaves are rotund to heart shaped. The lower leaves are supported by petioles, while upper leaves are tapered to their bases. The upper part of the stem and inflorescence is glabrous. The showy flowers have 4 white petals 7-16 mm. long. The sepals are bright green turning yellow with age. Seed pod is a silique with a single row of seeds. In flower from late April through June.

ECOLOGICAL NOTES: Spring-cress is typically found in calcareous fens and other open, springs or seepages. It also occurs in openings of hardwood swamps.

SOURCE: Crow and Hellquist (2000); Fassett (1976); Gleason and Cronquist (1991); Swink and Wilhelm (1994); and Voss (1985).

CALCAREOUS FENS



© Photos by Steve D. Eggers

GRASS-OF-PARNASSUS

(*Parnassia glauca* Raf.)

SAXIFRAGE FAMILY (Saxifragaceae)

C of C: Native (9)

IND. STATUS: OBL

FIELD CHARACTERISTICS: A perennial herb 15-30 cm. high. The stalked basal leaves are entire, smooth, rounded, 2-7 cm. long x 1-5 cm. wide, forming a basal rosette. The stem leaf, if present, is stalkless and located at or below the middle of the stem. Flowers are white with five star-like, green-striped petals 1-2 cm. long, and solitary at the end of a single stem. The fruit is a conspicuous, terminal capsule. In flower August-October.

ECOLOGICAL NOTES: Grass-of-Parnassus is a characteristic species of calcareous fens. It also occurs along calcareous shores and on wet lake dune flats if groundwater seepages are present.

SOURCE: Gleason and Cronquist (1991).

CALCAREOUS FENS



© Photos by Steve D. Eggers



Hairs (cilia)
on leaf
margin.

COMMON VALERIAN

(*Valeriana edulis* var. *ciliata* (T. & G.) Cronq.)

VALERIAN FAMILY (Valerianaceae)

IND. STATUS: FACW

SYNONYM: *Valeriana edulis* Nutt. ex Torr. & A. Gray

C of C: Native (10); listed as a threatened species in Minnesota

FIELD CHARACTERISTICS: A perennial herb 10-50 cm. tall, occasionally to 120 cm. Leaves are generally parallel-veined with a margin of dense white hairs (ciliated). The basal leaves are linear to oblanceolate, entire or with 1-2 divisions toward the base. The stem leaves are pinnately parted. The inflorescence is an elongate panicle with creamy white flowers. In flower April-June.

ECOLOGICAL NOTES: Common valerian is characteristic of calcareous fens and calcium-rich wet to wet-mesic prairies. It is one of the first herbs to flower during the spring in these habitats. In Minnesota, railroad rights-of-way are one of the few remaining habitats where this species occurs.

SOURCE: Fassett (1976); Gleason and Cronquist (1991); and Swink and Wilhelm (1994).

CALCAREOUS FENS



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OHIO GOLDENROD

(*Oligoneuron ohioense* (Frank x Riddell) G.N. Jones)

ASTER FAMILY (Compositae or Asteraceae)

IND. STATUS: OBL

SYNONYM: *Solidago ohioensis* Riddell **C of C:** Native (9); a species of special concern in WI

FIELD CHARACTERISTICS: A perennial herb 40-90 cm. high. Leaves of the lower and upper stem are dissimilar; the lower or basal leaves are better developed than the upper, and are usually persistent. Leaves are flat, not triple-nerved, and are not dotted with glands. The inflorescence is a flat-topped corymb that is without hairs. Flowers are yellow. In flower June–October.

This species is similar to Riddell's goldenrod (*Solidago riddellii*) [page 210], which occurs in similar Wisconsin habitats. However, the leaves of *S. riddellii* are sickle-shaped, folded and triple-nerved, and its inflorescence is hairy. Refer to Appendix A for a key to wetland goldenrods.

ECOLOGICAL NOTES: In Wisconsin, Ohio goldenrod is characteristic of calcareous fens and also occurs in wet to wet-mesic prairies supported by groundwater seepages. Eastern Wisconsin is the western extent of its range. This goldenrod has not been recorded in Minnesota.

SOURCE: Gleason and Cronquist (1991); and Swink and Wilhelm (1994).

CALCAREOUS FENS



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SWAMP THISTLE (*Cirsium muticum* Michaux)

ASTER FAMILY (Compositae or Asteraceae) **C of C:** Native (8) **IND. STATUS:** OBL

FIELD CHARACTERISTICS: A biennial herb 50-200 cm. high. Leaves are pinnatifid, green beneath and have weak spines. A basal rosette is formed the first year, and an unwinged flowering stalk the second year. The flower head does not have stiff spines as in most other thistles, but instead is weakly spined and sticky because of a gummy resin. Flowers are pink to purple. In flower July-October.

ECOLOGICAL NOTES: Swamp, or fen, thistle is characteristic of calcareous fens and also occurs in wet to wet-mesic prairies and sedge meadows supported by groundwater seepages.

SOURCE: Gleason and Cronquist (1991); and Swink and Wilhelm (1994).

CALCAREOUS FENS



© Photos by Steve D. Eggers

GOLDEN RAGWORT

(*Packera aurea* (L.) A.Love & D.Love)

ASTER FAMILY (Compositae or Asteraceae)

C of C: Native (6)

IND. STATUS: FACW

SYNONYM: *Senecio aureus* L.

FIELD CHARACTERISTICS: A perennial herb to 30-80 cm. in height. Basal leaves are heart-shaped, 5-10 cm. long and as wide, on long petioles with rounded teeth. Stem leaves are much smaller and pinnately-lobed becoming sessile. Flower heads number several to many, the disc is 5-10 mm. wide. Rays are golden yellow and 6-13 mm. long. The involucre is 5-8 mm. tall, the tips often purple. Fruit is a smooth nutlet (achene). In flower May-June.

ECOLOGICAL NOTES: Golden ragwort occurs primarily in wet to wet-mesic prairies and calcareous fens.

SOURCE: Gleason and Cronquist (1991); Chadde (2002); and Black and Judziewicz (2009).

CALCAREOUS FENS



© Steve D. Eggers

SWAMP LOUSEWORT (*Pedicularis lanceolata* Michx.)

FIGWORT FAMILY (Scrophulariaceae)

C of C: Native (8)

IND. STATUS: FACW

FIELD CHARACTERISTICS: A perennial herb with stems 30-80 cm. tall. Leaves are opposite, or in part alternate, lanceolate, 4-9 cm. long and 1-2 cm. wide, pinnately-lobed with margins of rounded teeth. Flowers are in spikes 2-10 cm. long at the end of branches from the upper leaf axils. Flowers are pale yellow, two-lipped and about 2 cm. long. Fruit is a capsule. In flower July-August.

ECOLOGICAL NOTES: Swamp lousewort primarily occurs in calcareous fens and wet to wet-mesic prairies.

SOURCE: Gleason and Cronquist (1991); Chadde (2002); and Black *et al.* (2009).

CALCAREOUS FENS



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BROOK LOBELIA

(*Lobelia kalmii* L.)

BELLFLOWER FAMILY (Campanulaceae)

C of C: Native (9)

IND. STATUS: OBL

FIELD CHARACTERISTICS: A perennial herb 10-40 cm. high. Basal leaves are spatula-shaped and may be deciduous. Stem leaves are linear. The inflorescence is a loose raceme with small (7-13 mm. long) flowers that are blue with a white “eye”. The flower consists of an erect, upper, 2-lobed lip and spreading, lower, 3-lobed lip. In flower July-October.

ECOLOGICAL NOTES: Brook lobelia is characteristic of calcareous fens and shores. It also occurs on calcareous soils of wet to wet-mesic prairies and wet lake dune flats if groundwater seepages are present.

SOURCE: Gleason and Cronquist (1991).

CALCAREOUS FENS



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FEN TWAYBLADE

(*Liparis loeselii* (L.) Rich.)

ORCHID FAMILY (Orchidaceae)

C of C: Native (6 MN)(7 WI)

IND. STATUS: FACW

FIELD CHARACTERISTICS: A perennial herb 10-25 cm. tall from a bulb-like base. Two shiny leaves, lanceolate to oval and 4-15 cm. long by 1-4 cm. wide, arise from the base of the plant. Flowers number 2-15 and are arranged in an open raceme 2-10 cm. long and 1-2 cm. wide. Flowers are yellow-green with lanceolate sepals 4-6 mm. long and linear petals 3-5 mm. long. The lip is obovate, 4-5 mm. long and 2-3 mm. wide. Fruit is a capsule that is short-cylindric and 8-12 mm. long. In flower June-August.

ECOLOGICAL NOTES: Fen twayblade primarily occurs in calcareous fens but also in coniferous swamps.

SOURCE: Gleason and Cronquist (1991); Chadde (2002); and Black and Judziewicz (2009).

CALCAREOUS FENS



WHITE LADY'S-SLIPPER
(*Cypripedium candidum* Willd.)

ORCHID FAMILY (Orchidaceae)

IND. STATUS: OBL

C of C: Native (10); a threatened species in Wisconsin and a species of special concern in Minnesota

FIELD CHARACTERISTICS: A perennial herb 15-40 cm. high. Stems range in number from 1-30 per plant. Leaves on the stem number 3-5 and are curved and strongly ribbed or pleated. The leaves tend to form an erect cluster near the ground, sheathing the stem. Flowers are distinctive and solitary with a white lip (1.5-2.5 cm. long) streaked with violet. Sepals and lateral petals are 2-4 cm. long, green-yellow and streaked with purple. Lateral petals are often spirally twisted. In flower from mid-May to early June, only for a few days in hot weather.

ECOLOGICAL NOTES: White lady's-slipper is a rare orchid that occurs on calcareous, wet soils of calcareous fens and wet to wet-mesic prairies. The flowers and flower buds are eaten by white-tailed deer and eastern cottontail.

SOURCE: Gleason and Cronquist (1991); and Swink and Wilhelm (1994).

CALCAREOUS FENS



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NODDING LADIES' TRESSES ORCHID

(*Spiranthes cernua* (L.) Richard)

ORCHID FAMILY (Orchidaceae)

C of C: Native (5)

IND. STATUS: FACW

FIELD CHARACTERISTICS: A perennial herb seldom over 20 cm. high. Stem leaves are usually persistent at flowering time. Several white flowers, with lips 7-12 mm. long, form a 3-ranked, spirally twisted spike. Callosities at the base of the lip are conspicuous, projecting, and rounded. Flowers are sometimes fragrant. In flower August-October.

ECOLOGICAL NOTES: Nodding ladies' tresses is a frequent orchid of inland fresh meadows, particularly calcareous fens and wet to wet-mesic prairies that have been slightly disturbed.

SOURCE: Gleason and Cronquist (1991); and Swink and Wilhelm (1991).

CALCAREOUS FENS



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NORTHERN BOG VIOLET

(*Viola nephrophylla* Greene)

VIOLET FAMILY (Violaceae)

C of C: Native (8 MN)(7 WI)

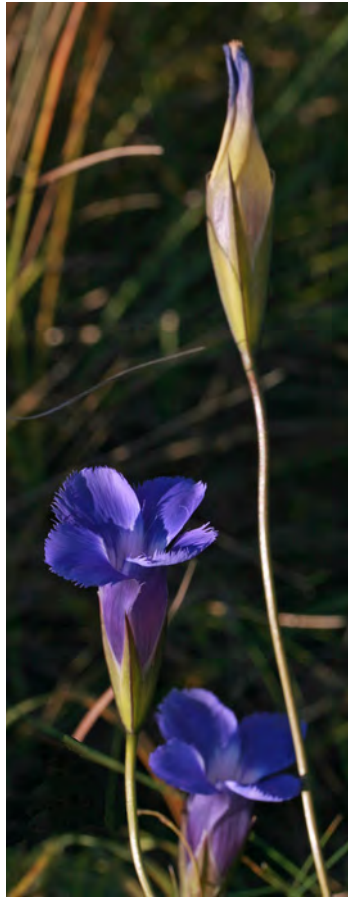
IND. STATUS: FACW

FIELD CHARACTERISTICS: A low perennial herb 10-15 cm. in height and spreading by rhizomes. Leaves are all basal, smooth, heart-shaped to kidney-shaped, 1-4 cm. long and 2-6 cm. wide, and rounded at the tip. Leaves arise from long petioles that are 2-16 cm. long. Leaf margins have rounded tips. Flowers are violet, single, nodding on slender stalks and held above the leaves. The spurred petal is densely hairy within. Fruit is a capsule 5-10 mm. long. In flower in May, but sometimes flowering again in August or September.

ECOLOGICAL NOTES: Northern bog violet prefers cold, groundwater-fed, calcareous habitats such as calcareous fens and some interdunal swales.

SOURCE: Gleason and Cronquist (1991); Chadde (2002); and Black and Judziewicz (2009).

CALCAREOUS FENS



LESSER FRINGED GENTIAN

(*Gentianopsis procera* (Holm) MA)

GENTIAN FAMILY (Gentianaceae)

IND. STATUS: OBL

SYNONYM: *Gentiana procera* Holm.

C of C: Native (8); a species of special concern in WI

FIELD CHARACTERISTICS: A biennial herb up to 80 cm. tall. Leaves are opposite, without stalks, linear to lance-shaped, and less than 1 cm. (8 mm.) wide. Flowers are blue with four fringed corolla lobes, and are solitary to numerous at the end of branches. In bloom September-October.

Greater fringed gentian (*Gentianopsis crinita*) is similar, but occurs in less calcareous habitats. *G. crinita* leaves are greater than 1 cm. wide and the flowers are more box-shaped. These two species may hybridize.

ECOLOGICAL NOTES: Lesser fringed gentian is characteristic in calcareous fens, and also occurs on calcareous soils of wet to wet-mesic prairies and along shores, particularly if groundwater seepages are present.

SOURCE: Gleason and Cronquist (1991); and Swink and Wilhelm (1994).

CALCAREOUS FENS



© Photos by Steve D. Eggers

SHRUBBY CINQUEFOIL

(*Dasiphora fruticosa* (L.) Rydb.)

ROSE FAMILY (Rosaceae)

C of C: Native (7)

IND. STATUS: FACW

SYNONYMS: *Potentilla fruticosa* L., *Pentaphylloides floribunda* (Pursh) A. Love

FIELD CHARACTERISTICS: A low, bushy, deciduous shrub with woody stems usually 20-50 cm. tall, but can be up to 1 m. high. Leaves are pinnately compound with 5-7 fuzzy leaflets that are gray-green and about 1-2 cm. long. The five-petaled flowers are yellow, 2-3 cm. wide, and solitary to few at the ends of branches. In flower May-October.

ECOLOGICAL NOTES: Shrubby cinquefoil occurs on calcareous soils, particularly in calcareous fens. Occasionally, it is found in wet to wet-mesic prairies, bogs and along shores. It tends to increase aggressively with declining water levels. A horticultural variety of this species is used for landscaping.

SOURCE: Fassett (1976); Gleason and Cronquist (1991); and Swink and Wilhelm (1994).

CALCAREOUS FENS



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Pistillate catkins.

SAGE WILLOW (*Salix candida* Willd.)

WILLOW FAMILY (Salicaceae)

C of C: Native (9)

IND. STATUS: OBL

FIELD CHARACTERISTICS: A low deciduous shrub usually up to 1 m. high. Leaves are entire with inrolled margins, have dense white-matted hairs on the undersides, and are 4-8 cm. long by 0.7-2 cm. wide (between 5-10 times as long as wide). Twigs are also covered by dense white-matted hairs, but they tend to become somewhat hairless with age. Capsules are woolly and pink-white in color (see photograph). In flower April-May.

ECOLOGICAL NOTES: In addition to calcareous fens, this small willow is found in wet to wet-mesic prairies, coniferous swamps and bogs. It usually is found growing solitary and scattered.

SOURCE: Gleason and Cronquist (1991); and Swink and Wilhelm (1994).



July 18, 2016

Mr. Sean Flannery
Permitting Director
Renewable Energy Systems Americas, Inc.
330 2nd Avenue South, Suite 820
Minneapolis, MN 55401

**Re: Calcareous Fen Survey Report
Bitter Root Wind Project**

Dear Mr. Flannery:

Midwest Natural Resources, Inc. (MNR) and Merjent Inc. (Merjent) are pleased to provide the following early season site evaluation - calcareous fen survey report for the proposed Bitter Root Wind Project (Project). The survey work was conducted to address Minnesota Department of Natural Resources (MN DNR) comments on the Project provided in the MN DNR Preliminary Review letter dated May 3, 2016.

Background

Renewable Energy Systems Americas, Inc. (RES) is proposing the Project located in southwestern Minnesota in Yellow Medicine County and a portion of Deuel County South Dakota, approximately 1.5 miles west of the City of Canby and 5 miles to the northwest of the City of Porter (**Figure 1**). The Project is a wind conversion facility with a planned capacity of approximately 145 megawatts (MW), with approximately 60-70 percent of the turbines planned to be located in Minnesota and the remaining turbines planned to be located in South Dakota. The calcareous fen survey was based on a preliminary turbine layout that included up to 42 turbine locations. The layout and design of the Project will continue to be refined, particularly to minimize to environmental effects from the Project. In addition to the turbines, facilities necessary for construction and operation of the Project in Minnesota include access roads, electrical collection lines, an operations and maintenance facility, a substation, an overhead transmission line, and temporary crane paths and laydown/staging areas. Construction in Minnesota is expected to begin in 2017.

According to the MN DNR, there are six documented calcareous fen features in the Project area. As a result, MNR and Merjent were retained by RES to investigate potential calcareous fen locations. Calcareous fens are wetland plant communities regulated by both the MN DNR and the Minnesota Pollution Control Agency. These features are groundwater-fed discharge systems rich in calcium carbonate (CaCO₃) and/or magnesium carbonates (Bergland 1995; Leete et al. 2005, Arndt et al. 2015). Calcareous fens remain saturated year-round due to continuous groundwater discharge maintaining anaerobic conditions at and near the soil surface, resulting in the accumulation of organic matter (peat). Calcareous fens typically classify into Prairie Extremely Rich Fen communities (OPp93) in the Minnesota Native Plant Community Classification system (MN DNR 2005), and host a number of unusual plants that are adapted to the calcareous fen environment. A number of these plants are state-listed species and are further protected under Minnesota's endangered species law.

Methods

Desktop Review and Selection of Potential Calcareous Fen Sites in Yellow Medicine County

The objective of the field surveys was to identify potential calcareous fens in or near the Project area in Minnesota. Targeted survey locations of possible calcareous fen sites were based on a recent desktop review conducted by Merjent staff in collaboration with MNR.

This process involved the examination of the following geospatial resources obtained for the study area and interpreted in a Geographic Information System (Google Earth Professional):

1. Recent high-resolution aerial imagery, imagery date 9/1/2015.
2. A two-foot topographic contour map created from high resolution LiDAR data available for the State of Minnesota¹.
3. National Wetlands Inventory (NWI) polygons and associated attribute data.
4. Supplemental information from the Minnesota Geospatial Commons (MGC) included MN DNR native plant community polygons and attribute data² for areas inventoried for potential biological significance by the MN County Biological Survey³ and the calcareous fen source feature points datasets.
5. A polygon created by buffering planned infrastructure associated with the Project by 500 feet to represent the area to be investigated, the “Survey Corridor.”

Dr. James Arndt of Merjent previously reviewed several listed calcareous fens in the field in Yellow Medicine County near the proposed Project. That work was conducted to support an informational document prepared for the Environmental Protection Agency (Arndt 1999), and to characterize a state listed calcareous fen potentially affected by a proposed road realignment in nearby Lincoln County (Arndt and Dejoode 2009). Calcareous fens in southwest Minnesota are associated with unique landscape positions and present unique landform features that can be used as a scoping tool to identify locations that may have calcareous fens (Arndt, J.L. 1995, 1999; Almendinger and Leete, 1998a, 1998b; Arndt and Dejoode, 2005; other references). These features include:

1. The presence of wetlands and wetland signatures on sloping ground in areas that are inconsistent with typical depression-type palustrine wetlands and are not characteristic of the topography associated with riparian wetlands adjacent to area streams. The accretion of peat in these areas presents a signature of a doubly convex, sloping apron of saturated ground in sideslope and toeslope positions typically above the floodplain of incised drainageways within the surrounding till plain.

These areas typically represent sidehill seeps of calcareous water from exposures of confined aquifers on the valley walls of incised drainageways.

2. Breaks in the confining aquitard—a relatively low permeability layer that impedes groundwater flow—that allow confined aquifers to discharge as spring-heads in nearly level till areas, resulting in an accumulation of peat forming a classic “dome” feature. Such features are typically 10-12 feet or more high, and readily appear on contour maps as approximate circular concentric contours indicative of a mounding effect.

All data was incorporated into Google Earth Pro GIS (**Figure 2**). Within the Survey Corridor, all NWI wetland areas and all NWI-designated upland areas that that presented anomalous topographic signatures

¹ (<http://arcgis.dnr.state.mn.us/maps/mntopo/>)

² <http://www.dnr.state.mn.us/eco/mcbs/maps.html>

³ <http://www.dnr.state.mn.us/eco/mcbs/maps.html>

of peat accretion were identified as sites requiring subsequent field identification for potential calcareous fen. Initial site selection based on the above information resulted in the selection of 22 potential areas to survey (**Figure 3**).

Early season site evaluations were conducted June 29 – July 1, 2016 with late season surveys planned for August 2016. The initial field approach was to collect detailed plot data at those locations having possible calcareous fen conditions. A number of field sites were readily determined not to be calcareous fens once in the field and were documented with basic site notes and representative photographs. The remainder of the sites were documented either by collecting thorough species lists or with relevés. Relevés are used as tools to document and classify native plant communities. This sampling involves the collection of species richness and abundance within a standardized plot. This method also incorporates the documentation of life form (e.g., forbs, graminoids, broadleaf evergreens etc.), and height class. Sampling by means of relevés was reserved for those sites that were intact native plant communities. These community classifications are based on Minnesota's Native Plant Community Classification (Version 2.0). Possible calcareous fen locations were further evaluated by means of the vegetation technical criterion as described in the "Test of the Technical Criteria for Identifying and Delineating Calcareous Fens in Minnesota" document (Leete et al. 2005).

Results

All but one of the 22 predetermined sites were evaluated during the initial field visit with one additional site added based on the field reconnaissance. The site that was not evaluated (BR07) had been determined to be on federal land. However, since no Project infrastructure will be placed on federal land it was determined that this site did not require additional survey. Preliminary surveys resulted in the location of three calcareous fen locations, one of which (BR22-Fortier 5) has been previously documented by the MN DNR. This particular feature, along with the associated fen (BR23), are both outside of the Survey Corridor, while the third fen location (BR01) is within the Survey Corridor. Site BR14 is also a possible fen location, but more data is required and this will be collected during the late season survey in August 2016. All other remaining survey areas were classified as either wet meadow communities (Prairie Wet Meadow/Carr and Southern Seepage Meadow/Carr), marsh (Prairie Bulrush-Arrowhead Marsh), upland, or drainage swale. A summary table is provided in **Appendix A** and representative photos are provided in **Appendix B**.

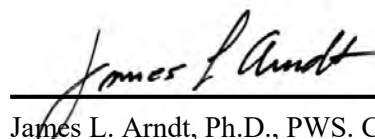
As mentioned, additional surveys are planned for sites BR01 and BR14 in order to collect additional data. Following those surveys, a more detailed document will be prepared that will include relevé data, where collected, along with final results.

Please feel free to contact us if you have any questions.

Respectfully submitted,



Scott A. Milburn, M.S., PWS
Sr. Botanist/President
Midwest Natural Resources, Inc.

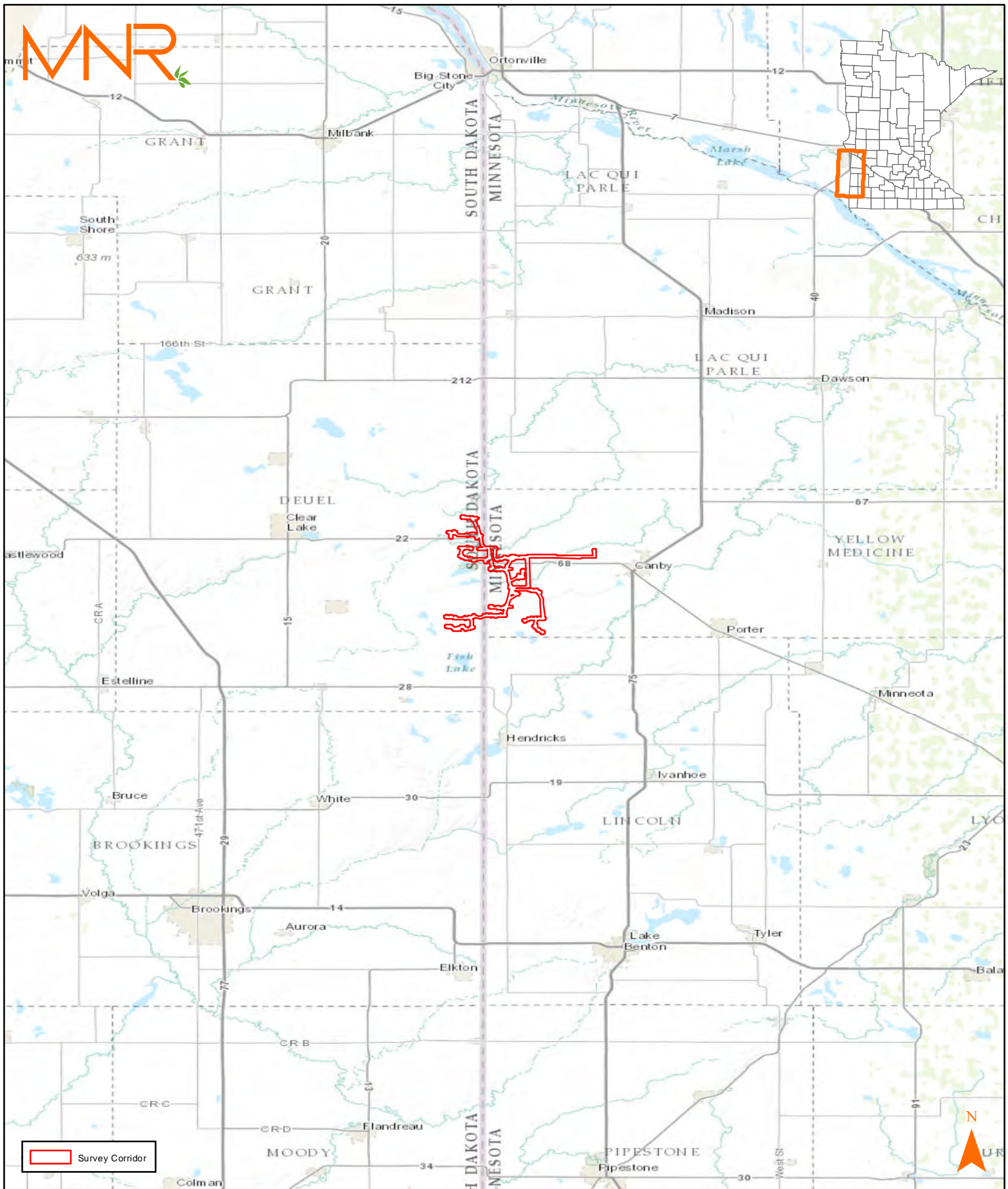


James L. Arndt, Ph.D., PWS. CPSS
Senior Analyst
Merjent Inc.

cc: Anne-Marie Griger
Jeff Jackson

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- MN DNR. 2013. A handbook for collecting vegetation plot data in Minnesota: The relevé method. 2nd ed. Minnesota Biological Survey, Minnesota Natural Heritage and Nongame Research Program, and Ecological Land Classification Program. Biological Report 92. MNDNR St. Paul.



Project Overview
Bitter Root Wind Project
Calcareous Fen Evaluation
Yellow Medicine County, MN

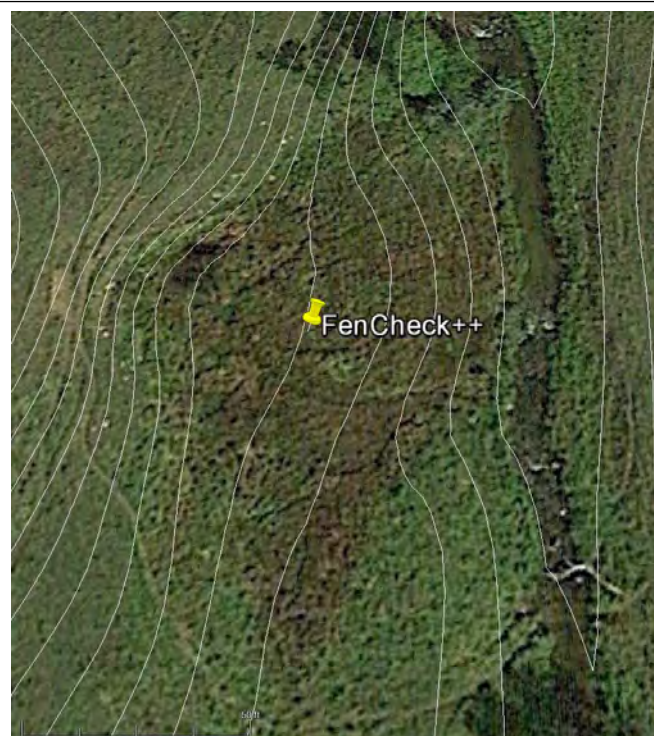
Figure 1



Part A. Portion of Project area with NWI (blue; e.g., lower left) and Sites of Biological assessment (green) added.



Part B. Portion of Project area with 2-foot contours added. Topographic anomaly circled.



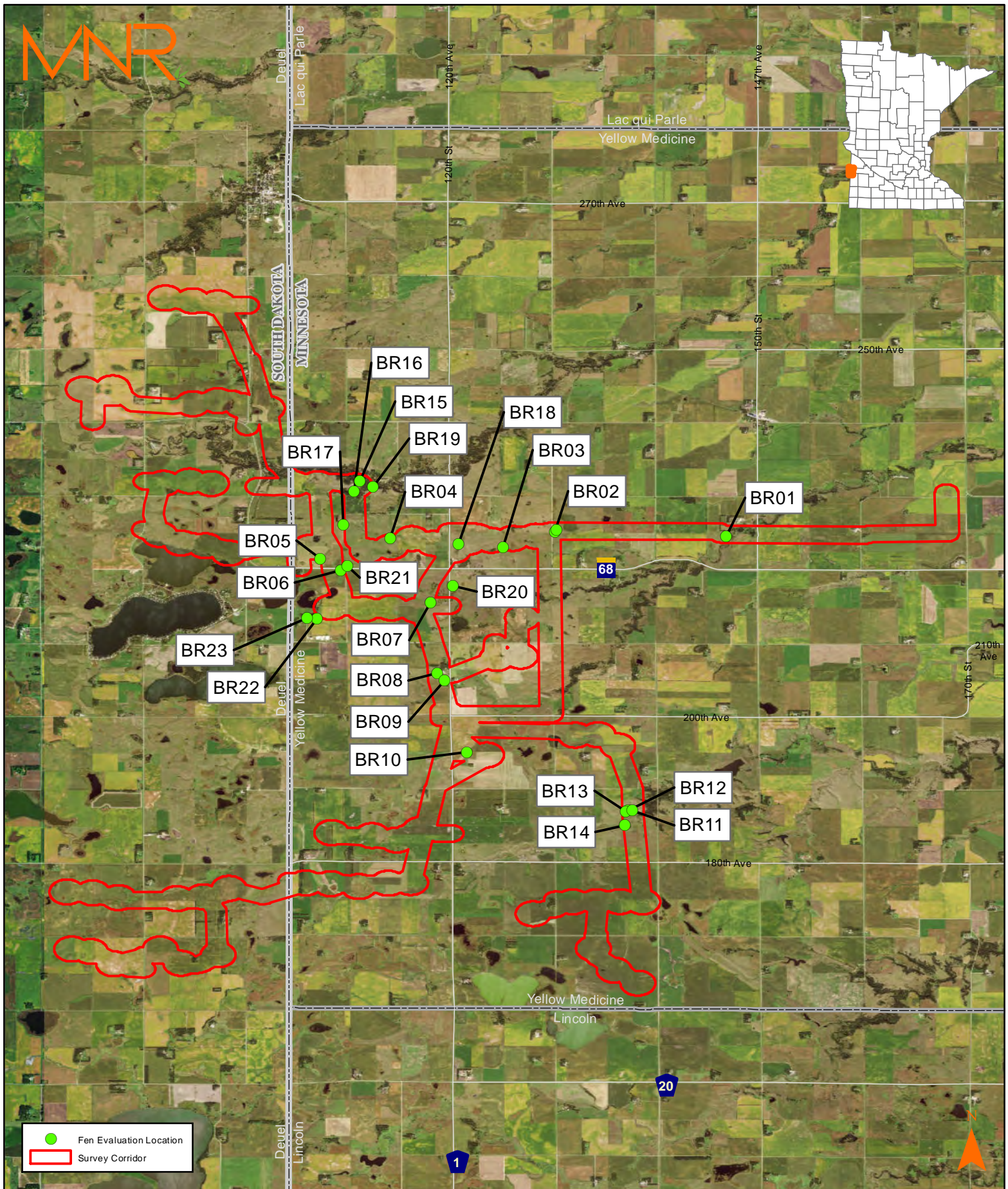
Part C. Detail of topographic anomaly shows wetland signature on a steep slope, with the topography indicative of a peat apron type landform adjacent to an incised stream but above the floodplain.



Part D. Detail of known "Dome-Type" calcareous fen – Fortier 5. Fortier 5 is not within the Survey Corridor.

Figure 2. Potential calcareous fen areas within or near the Survey Corridor of the Bitter Root Wind facilities were assessed using National Wetlands Inventory and County Biological spatial and attribute data combined with a 2-foot contour interval GIS layer overlaid onto high resolution orthorectified aerial photography (September 2015). Areas with potential for calcareous fen were identified as FenCheck. Areas identified as FenCheck++ had a better potential based on the GIS assessment than areas identified as FenCheck+ or FenCheck.

All areas within the Survey Corridor were examined.



Fen Evaluation Locations
Bitter Root Wind Project
 Calcareous Fen Evaluation
 Yellow Medicine County, MN

Figure 3

APPENDIX A

Summary Table

Survey Date	Site	Native Plant Community Code	Description
6/29/2016	BR01	OPp93	Calc Fen - Prairie Extremely Rich Fen
7/1/2016	BR02	WMp73	Prairie Wet Meadow/Carr
7/1/2016	BR02	MRp93	Prairie Bulrush-Arrowhead Marsh
6/30/2016	BR03	WMp73	Prairie Wet Meadow/Carr
6/30/2016	BR04	WMs83	Southern Seepage Meadow/Carr
6/30/2016	BR05	None	Degraded Wet Meadow/Cattail Marsh
6/30/2016	BR06	None	Drainage swale dominated by reed canary grass
N/A	BR07	N/A	Not Evaluated
6/30/2016	BR08	WM	Wet Meadow Community - no type assigned
6/30/2016	BR09	None	Upland
6/30/2016	BR10	None	Upland
6/30/2016	BR11	None	Drainage Swale
6/30/2016	BR12	WMs83	Southern Seepage Meadow/Carr
6/30/2016	BR13	WMs83	Southern Seepage Meadow/Carr
6/30/2016	BR14	WM or OP	Wet Meadow or Calc Fen
7/1/2016	BR15	None	Upland
7/1/2016	BR16	None	Upland
7/1/2016	BR17	WMp73	Prairie Wet Meadow/Carr
7/1/2016	BR18	WMp73	Prairie Wet Meadow/Carr
7/1/2016	BR19	WMs83	Southern Seepage Meadow/Carr
7/1/2016	BR20	WMs83	Southern Seepage Meadow/Carr
7/1/2016	BR21	WMp73	Prairie Wet Meadow/Carr
7/1/2016	BR22	OPp93	Calc Fen - Prairie Extremely Rich Fen
7/1/2016	BR23	OPp93	Calc Fen - Prairie Extremely Rich Fen

APPENDIX B

Site Photos



BR01



BR02 – WMp73



BR02 – MRn93



BR03



BR04



BR05



BR06



BR08



BR09



BR10



BR11



BR12



BR13



BR14



BR15



BR16



BR17



BR18



BR19



BR20



BR21



BR22



BR23



November 28, 2016

Mr. Sean Flannery
Permitting Director
Renewable Energy Systems Americas, Inc.
330 2nd Avenue South, Suite 820
Minneapolis, MN 55401

**Re: Calcareous Fen Survey Report for Early and Late Season Field Surveys
Bitter Root Wind Project**

Dear Mr. Flannery:

Midwest Natural Resources, Inc. (MNR) and Merjent Inc. (Merjent) are pleased to provide the following follow up, late season site evaluation Calcareous Fen Survey Report (Report) for the proposed Bitter Root Wind Project (Project). The survey work was conducted to address Minnesota Department of Natural Resources (MN DNR) comments on the Project provided in the MN DNR Preliminary Review letter dated May 3, 2016. The MN DNR required that early and late season field surveys be conducted for the Project to assess the potential impacts to calcareous fens.

On August 11, 2016, Merjent submitted to the MN DNR the Preliminary Calcareous Fen Survey Report (Preliminary Report, dated July 18, 2016), which provided the results of a desktop assessment of potential calcareous fen sites and results of the early season field survey conducted for the Project. To date, the MN DNR has not provided comments on the Preliminary Report. This Report includes a compilation of the early season work and results of the late season desktop and field survey efforts completed in August 2016. As required by the MN DNR, this information is being used to appropriately site Project facilities and to avoid potential Project impacts to calcareous fens and other natural resources.

Background

Flying Cow Wind, LLC (Flying Cow Wind), a subsidiary of Renewable Energy Systems Americas, Inc. (RES) is proposing the Project located in southwestern Minnesota in Yellow Medicine County and Deuel County, South Dakota, approximately 1.5 miles west of the City of Canby and 5 miles to the northwest of the City of Porter (**Figure 1**). The Project is a wind conversion facility with a planned capacity of approximately 150 megawatts (MW), with approximately 27 (60 percent) of the turbines planned to be located in Minnesota, and the remaining 19 turbines (40 percent) planned to be located in South Dakota. The layout for the Project is still very preliminary and the final number of turbines in South Dakota and Minnesota will continue to evolve as additional land and constraint information is incorporated in to the Project development.

The calcareous early season fen survey was based on a preliminary turbine layout that included up to 42 turbine locations. The late season fen survey was based upon a revised preliminary turbine layout that has 46 turbine locations. **Figures 1 and 2** illustrate the early season and late season Project layout and buffer area used for the fen surveys. The design of the Project layout will continue to be refined, particularly to avoid known and suspected environmental impacts and minimize to the extent practicable unavoidable impacts.

In addition to the turbines, facilities necessary for construction and operation of the Project in Minnesota include access roads, electrical collection lines, fiber optic communication cabling, an operations and maintenance facility, a substation, an overhead transmission line, and temporary crane paths and laydown/staging areas. Construction in Minnesota is expected to begin in 2017 or 2018.

According to the MN DNR, there are seven documented calcareous fen features in the Project area (see MN DNR Preliminary Review letter dated May 3, 2016, and **Figure 1**). As a result, MNR and Merjent were retained by Flying Cow Wind to investigate other potential calcareous fen locations.

Calcareous fens are wetland plant communities regulated by both the MN DNR and the Minnesota Pollution Control Agency. These features are groundwater-fed discharge systems rich in calcium carbonate (CaCO₃) and/or magnesium carbonates (Bergland 1995; Leete et al. 2005, Arndt et al. 2015). Calcareous fens remain saturated year-round due to continuous groundwater discharge maintaining anaerobic conditions at and near the soil surface, resulting in the accumulation of organic matter (peat).

Calcareous fens typically classify into Prairie Extremely Rich Fen communities (OPp93) in the Minnesota Native Plant Community Classification system (MN DNR 2005), and host a number of unusual plants that are adapted to the calcareous fen environment. A number of these plants are state-listed species and are further protected under Minnesota's endangered species law.

Methods

Desktop Review and Selection of Potential Calcareous Fen Sites

The objective of the field surveys was to identify potential calcareous fens in or near the Project area in Minnesota. Targeted survey locations of possible calcareous fen sites were based on a recent desktop review conducted by Merjent staff in collaboration with MNR just prior to conducting the field surveys.

Desktop review involved the examination of the following geospatial resources obtained for the study area and interpreted in a Geographic Information System (Google Earth Professional):

1. Recent high-resolution aerial imagery, imagery date 9/1/2015.
2. A two-foot topographic contour map created from high resolution LiDAR data available for the State of Minnesota¹.
3. National Wetlands Inventory (NWI) polygons and associated attribute data.
4. Supplemental information from the Minnesota Geospatial Commons (MGC) included MN DNR native plant community polygons and attribute data² for areas inventoried for potential biological significance by the MN County Biological Survey³ and the calcareous fen source feature points datasets.
5. A polygon created by buffering planned infrastructure associated with the Project by 500 feet to represent the area to be investigated, the "Survey Corridor."

On unrelated projects, Dr. James Arndt of Merjent previously reviewed several listed calcareous fens in the field in Yellow Medicine County near the proposed Project. That work was conducted to support an informational document prepared for the Environmental Protection Agency (Arndt 1995, 1999), and to characterize a state listed calcareous fen potentially affected by a proposed road realignment in nearby

¹ (<http://arcgis.dnr.state.mn.us/maps/mntopo/>)

² <http://www.dnr.state.mn.us/eco/mcbs/maps.html>

³ <http://www.dnr.state.mn.us/eco/mcbs/maps.html>

Lincoln County (Arndt and Dejoode 2009). Calcareous fens in southwest Minnesota are associated with unique landscape positions and present unique landform features that can be used as a scoping tool to identify locations that may have calcareous fens (Arndt, J.L. 1995, 1999; Almendinger and Leete, 1998a, 1998b; Arndt and Dejoode, 2005; other references) as illustrated in **Figure 3**. These features include:

1. The presence of wetlands and wetland signatures on sloping ground in areas that are inconsistent with typical depression-type palustrine wetlands, and are not characteristic of the topography associated with riparian wetlands adjacent to area streams. The accretion of peat in these areas presents a signature of a doubly convex, sloping apron of saturated ground in sideslope and toeslope positions typically located above the floodplain of incised drainageways within the surrounding till plain. These areas typically represent sidehill seeps of calcareous water from exposures of confined aquifers on the valley walls of incised drainageways.
2. Breaks in the confining aquitard⁴ that allow confined aquifers to discharge as spring-heads in nearly level till areas, resulting in an accumulation of peat forming a classic “dome” feature. Such features are typically 10 - 12 feet or more high, and readily appear on contour maps as approximate circular concentric contours indicative of a mounding effect.

All data were incorporated into Google Earth Pro GIS (**Figure 2**). Within the Survey Corridor, all NWI wetland areas and all NWI-designated upland areas that presented anomalous topographic signatures of peat accretion were identified as sites requiring subsequent field identification for potential calcareous fen. These desktop reviews preceded both early and late field surveys to account for ongoing alterations in the Project footprint.

Field Survey Methods

Using the desktop review data, Merjent engaged MNR personnel to field review each of the potential calcareous fen areas identified in the desktop review. In the event that MNR determined any of the potential calcareous fens did not meet the criteria to be a calcareous fen, Merjent’s wetland personnel would then delineate it as a wetland.

The approach included collecting detailed plot data at those locations having possible calcareous fen conditions observed in the field. A determination of potential fen status was made in the field and documented with basic site notes and representative photographs. Sites having wetlands with no observed calcareous fen features were documented either by collecting thorough species lists or with relevés.

Relevés are used as tools to document and classify native plant communities. This sampling involves the collection of species richness and abundance within a standardized plot. This method also incorporates the documentation of life form (e.g., forbs, graminoids, broadleaf evergreens etc.), and height class. Sampling by means of relevés was reserved for those sites dominated by intact native plant communities. Field-determined native plant community classifications are based on Minnesota's Native Plant Community Classification (Version 2.0). Possible calcareous fen locations were further evaluated by means of the vegetation technical criterion as described in the “Test of the Technical Criteria for Identifying and Delineating Calcareous Fens in Minnesota” document (Leete et al. 2005).

If a given wetland was determined to be a potential calcareous fen, MNR completed a survey and determination. If a given wetland was not a potential calcareous fen, MNR documented this information.

⁴ Aquitard - a relatively low permeability layer that impedes groundwater flow.

Results

Early Season Desktop Screening Analysis and Field Surveys

Early season site evaluations were conducted June 29 – July 1, 2016 within the Survey Corridor based on the most current Project footprint at the time (Survey Corridor 1). Initial site selection based on the above information resulted in the selection of 23 potential areas to survey early in the growing season.

All but one of the 23 predetermined sites were evaluated with one additional site added based on the field reconnaissance. The site that was not evaluated (BR07) is located on federal land. Since we did not have access permission for that parcel, no survey was completed. However, no Project infrastructure will be placed on federal land. **Appendix A** summarizes the field survey results, and **Appendix B** presents the scoring results used in the classification of calcareous fens. Representative photos are provided in **Appendix C**, and relevé data are provided in **Appendix D**.

Preliminary surveys resulted in the location of three areas exhibiting calcareous fen characteristics, one of which (BR22-Fortier 5) had been previously documented by the MN DNR. This particular feature, along with the associated fen (BR23), were both outside of Survey Corridor 1, while the third fen location (BR01) was located within it. Site BR14 was also identified as a possible fen location so it was surveyed again during the late season survey. All other remaining survey areas were classified as either wet meadow communities (Prairie Wet Meadow/Carr and Southern Seepage Meadow/Carr), marsh (Prairie Bulrush-Arrowhead Marsh), upland, or drainage swale.

Late Season Desktop Screening Analysis and Field Surveys

The late season surveys were conducted August 15 – 16, 2016 using the same protocols described for the early season survey. However, Survey Corridor 1 was revised based on the early season survey results and other Project constraints to avoid impacts to known sensitive resources, resulting in a Survey Corridor 2 that was used during the late season survey (see **Figures 1 and 2**).

Application of the desktop screening procedures identified 10 additional areas to be surveyed within Survey Corridor 2 for the late season survey. Sites discounted as potential fens during the early season survey were not included in the late season survey. Two potential calcareous fens were subjected to both early and late season plant surveys. In total, 33 areas were assessed during the two surveys for diagnostic calciphile plants (**Figure 2**)⁵.

The late season survey identified two potential calcareous fens within Survey Corridor 2, in addition to fen BR01, which was resurveyed. Features identified as potential fens in the early and late season surveys are summarized in **Table 1** below. Feature BR14 was also revisited during the August field review. This site would fall into the classification of a seepage wet meadow community, but meets the vegetative criterion of a calcareous fen strictly related to the point value of the feature. However, it is located outside of Survey Corridor 2. All other remaining survey areas were classified as either wet meadow communities (Prairie Wet Meadow/Carr and Southern Seepage Meadow/Carr), marsh (Prairie Bulrush-Arrowhead Marsh), upland, or drainage swale that lacked calciphiles or did not have sufficient calciphiles to be considered calcareous fen by plant criteria. In summary, the early and late season surveys identified three fen features within Survey Corridor 2—BR01, BR25, and BR32.

⁵ Several potential fen areas are outside of the Project Survey Corridor 2 as a result of interim adjustments to Survey Corridor, which was based on previous Project configurations designed by Flying Cow Wind, to avoid impacts to potentially environmentally sensitive resources, including potential fen areas.

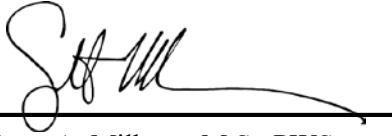
The information provided in this report will be used to refine the Project footprint. Once the final Project footprint has been identified, the hydrogeologic setting of any fen features that may be potentially impacted by the Project will be examined in the context of planned Project infrastructure to assess further avoidance options, and mitigation options that may be available for unavoidable impacts.

Table 1 Potential Calcareous Fens Identified in Field Surveys					
Site	Survey Date	Calcareous Fen Point Summary	Location		Comments
			Within Survey Corridor 1 (June/July 2016)	Within Survey Corridor 2 (August 2016)	
BR01	6/29/2016 and 8/15/2016	80	Yes	Yes	Calcareous Fen—Prairie Extremely Rich Fen
BR14	6/30/2016 and 8/15/2016	50	Yes	No	Wet Meadow or Calcareous Fen
BR22	7/1/2016	190	No	No	Calcareous Fen—Prairie Extremely Rich Fen
BR23	7/1/2016	55	No	No	Calcareous Fen—Prairie Extremely Rich Fen
BR25	8/16/2016	75	No	Yes	Calcareous Fen—Prairie Extremely Rich Fen
BR32	8/16/2016	110	No	Yes	Calcareous Fen—Prairie Extremely Rich Fen

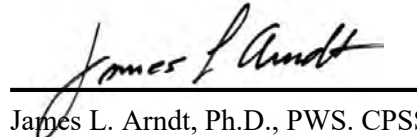
Calcareous fen surveys as described in this letter report will be conducted on any new areas subsequently identified as potentially part of future updated Project footprint, if any. Flying Cow Wind will share the results of these additional surveys in consultation with MN DNR to avoid and minimize impacts to calcareous fens to the extent practicable. When the Project configuration and footprint are finalized, Flying Cow Wind will summarize the results of all fen field surveys in a report to the MN DNR, as well as Flying Cow Wind's impact avoidance and minimization strategies. Flying Cow Wind anticipates that all impacts to identified calcareous fens can be avoided and will request DNR concurrence for these areas.

Please feel free to contact us if you have any questions. Scott can be reached at 612.310.6260 or scott.milburn@mnrinc.us, and Jim can be reached at 612.924.3987 or jarndt@merjent.com.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'Scott Milburn', written over a horizontal line.

Scott A. Milburn, M.S., PWS
Sr. Botanist/President
Midwest Natural Resources, Inc.

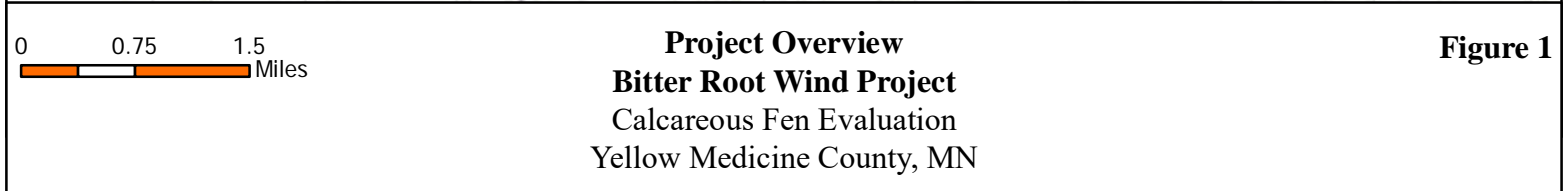
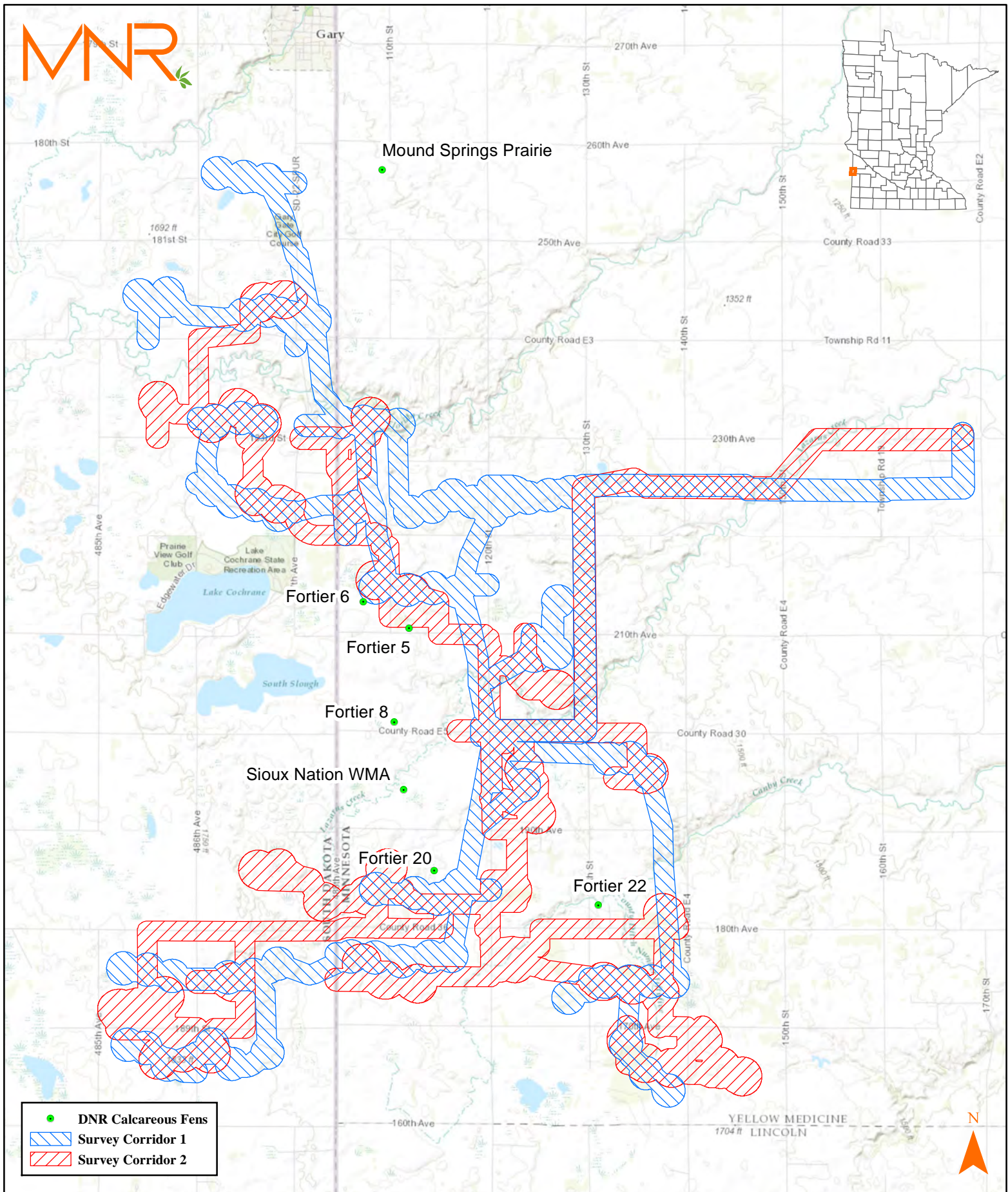
A handwritten signature in black ink, appearing to read 'James L. Arndt', written over a horizontal line.

James L. Arndt, Ph.D., PWS. CPSS
Senior Analyst
Merjent, Inc.

cc: Anne-Marie Griger, RES Americas
Jeff Jackson, RES Americas

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Fen Evaluation Locations
Bitter Root Wind Project
 Calcareous Fen Evaluation
 Yellow Medicine County, MN

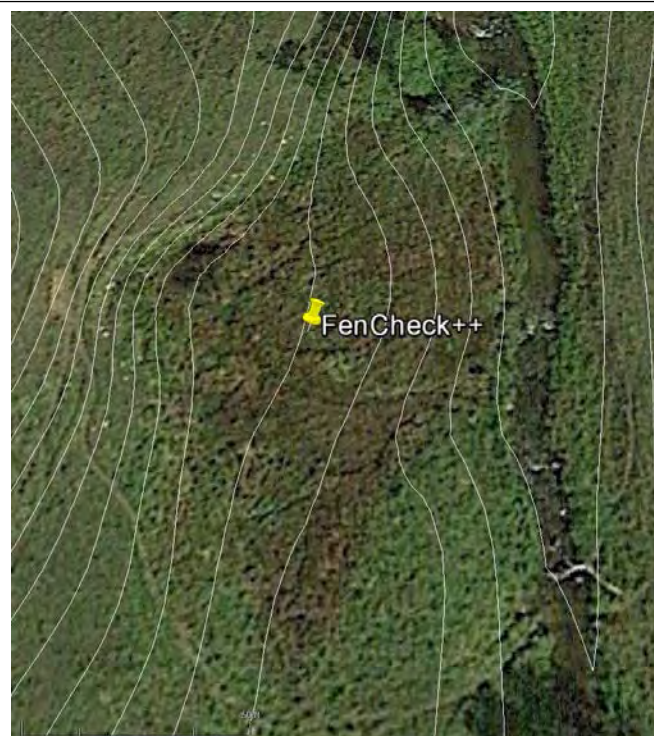
Figure 2



Part A. Portion of Project area with NWI (blue; e.g., lower left) and Sites of Biological assessment (green) added.



Part B. Portion of Project area with 2-foot contours added. Topographic anomaly circled.



Part C. Detail of topographic anomaly shows wetland signature on a steep slope, with the topography indicative of a peat apron type landform adjacent to an incised stream but above the floodplain.



Part D. Detail of known "Dome-Type" calcareous fen – Fortier 5. Fortier 5 is not within the Survey Corridor.

Figure 3. Potential calcareous fen areas within or near the Survey Corridor of the Bitter Root Wind facilities were assessed using National Wetlands Inventory and County Biological spatial and attribute data combined with a 2-foot contour interval GIS layer overlaid onto high resolution orthorectified aerial photography (September 2015). Areas with potential for calcareous fen were identified as FenCheck. Areas identified as FenCheck++ had a better potential based on the GIS assessment than areas identified as FenCheck+ or FenCheck.

All areas within the Survey Corridor were examined.