Minnesota Department of Natural Resources Calcareous Fen Field Assessment Procedures

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Introduction

This is a technical guidance document that describes the MNDNR's preferred field methods and procedures for initial, identification, and status check assessments of calcareous fens in the state of Minnesota. The goal of this document is to provide clear procedures for MNDNR technical staff and qualified contractors for collecting, submitting, and managing data to support fen identification and assessment.

The technical criteria currently used by the Minnesota Department of Natural Resources (DNR) for identifying calcareous fens under Minnesota Statutes 103G.223 and associated Minnesota Rules Chapter 8420.0935 have been used by the DNR since 2005, when they were published in the following report:

> 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 by Jeanette H. Leete, MN DNR with Welby R. Smith, MN DNR; Joannes A. Janssens, Lambda Max; Norm Aaseng, MN DNR, April 13, 2005. Available at: Test of the Technical Criteria for Identifying Calcareous Fens in MN

The technical criteria have since been excerpted directly from that document for ease of reference and should be cited as follows:

> Leete, J.H., Smith, W.R., Janssens, J.A., Aaseng, N. 2016. Technical criteria for identifying calcareous fens in Minnesota. Excerpted from *"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, 2005."* Minnesota Department of Natural Resources. 7 pp. Available at: Technical Criteria for Identifying Calcareous Fens in MN

The procedures described in this document may vary depending on the type of assessment being conducted:

- Initial assessments -- are focused on determining whether or not a site has the potential to meet the calcareous fen technical criteria. These are sites that are not on the Commissioner's list of identified calcareous fens.
- Identification assessments -- are conducted to document that a site meets the calcareous fen technical criteria. Site visits are conducted in June and August. These visits would generally occur in sites that are not on the Commissioner's List but are known or highly likely to meet the criteria based on an initial assessment. Data are collected for each parameter of the technical criteria following the procedures described in this document.

- Status check assessments -- are conducted in known, listed fen sites to collect information about fen condition—including, but not limited to, changes in the hydrologic regime, invasive species encroachment, peat subsidence, and shifting plant communities. The status check procedures described in this document are not generally applicable to monitoring requirements under an approved Calcareous Fen Management Plan (CFMP). Because of the unique nature of each calcareous fen site, specific monitoring requirements should be addressed under each individual CFMP.

Safety and Caution

Traveling within fens can prove dangerous due to unstable ground, cold water features, and deep entrapping soils. To minimize the risks, travel methodically with a partner and notify someone about where you are and when you plan to return. In addition, calcareous fens have rare plants, sensitive soils and mineral formations--caution and restraint should be used when working within their footprint.

Calcareous fens support eight rare plant species, four of which occur almost exclusively in this community. These and other native vegetation found here are susceptible to trampling and compression of peat layers. Field staff should spread out and avoid walking the same path as well as avoid walking over areas with rare plant populations as much as possible. These areas are also vulnerable to invasive species -- clean all boots, clothes and equipment before entering.

Calcareous fen soils composed of peat or organic muck can be susceptible to erosion when their integrity is compromised, and erosion will be greater when water flows or pressures are higher. For this reason, any soils cores, piezometers, and foot travel should be limited to the minimum amount necessary to accomplish a specific task. Peat domes and peat blisters are examples of areas with high water pressure.

Calcareous fens can also contain unique mineral deposits like tufa and marl that accumulate over long periods of time. Some tufa deposits can span hundreds of square feet visible as a white-ish calcium carbonate crust that can be inches thick and is sensitive to damage from foot travel.

General field work rules:

- Travel methodically and use a walking stick
- Notify someone about your field work plan
- All footwear and equipment must be cleaned before entering a fen
- All work should be documented thoroughly to avoid repeat visits
- All work must have a specific need and goal
- When possible, avoid sensitive features and rare plants

Preliminary Office Assessment

Preliminary assessments of fens occur before an initial site visit of a fen or suspected fen. It is good practice to also perform a preliminary assessment of any fen that is unfamiliar to the field staff who will be conducting a site visit. The goal of a preliminary assessment is to: gather basic site information, note site features that could support a fen community, and identify specific locations to investigate in the field.

If a fen site is a potential new identification, a proper name should be established as early as possible in the process and distributed to staff to keep field records consistent. Follow the naming convention in Appendix 1.

The investigator should utilize geographic information systems (GIS) to identify the area(s) of interest for the field visit. Using geology, hydrology, landscape, land imagery, soils, vegetation, and rare features data sources will help identify specific target locations to visit during the initial field visit (Appendix 2). Using GIS, the investigator should look for the following conditions:

- Likely upwelling groundwater conditions e.g., trout streams, springs, groundwater levels above the land surface, artesian conditions
- Sedge-rich areas that have a signature on aerial imagery e.g., often shown with brown or green coloration
- Nearby calcareous fens situated along similar elevation(s)
- Saturated soil conditions e.g., hydric soils, organic soils, muck

A preliminary assessment checklist should be completed before each initial site visit using the referenced GIS information (Appendix 2).

Hydrology

Hydrology 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. If a calcareous fen has intact hydrology water will be present at or near the peat surface throughout the year even during periods of drought. In general, hydrologic conditions can change on a very short time scale (hours to days) when compared to criteria like vegetation (months to years), and soils (years to decades). All data collected should be handled and saved in accordance with the outline in Appendix 3 and 4.

Office Assessment

The goal of an initial hydrologic assessment is to find evidence of long periods of soil saturation by stable and typically upwelling carbonate-rich groundwater within the potential fen. Hydrologic observations will include observations related to the other criteria, such as soils. An office assessment involves a hydrologist using GIS and other resources to establish: groundwater flow direction, aquifers present, well log data (if available), and evidence of groundwater discharge.

Data sources can be found in Appendix 2 and additional novel approaches can be used as they become apparent. The following is a general checklist for a GIS hydrologic assessment:

- Identify hydric soils using web soil survey or similar data
    - Identify soils with: muck, peat, histosols, histic epipedon, etc.
    - Drainage classes of poor or very poor
    - Frequent ponding but not flooding
- Estimate or identify the depth to the water table
    - Using county well index (CWI) or county hydrogeologic atlases
- Find artesian conditions
    - Flowing wells, above land surface water levels (CWI)
    - Deeper wells having higher water levels than shallow wells (e.g. upward gradient)
- Examine spring color infrared land imagery
    - Green-up can occur earlier within fens
- Identify landscape positon
- Identify springs, trout streams, and other calcareous fens within 5 miles of the site

Initial and Identification Field Assessments

Hydrology field visits can take place any time of year, however early spring offers the best conditions to locate groundwater discharge areas because of the lack of vegetation. Site visits in late winter can also provide useful information including presence of ice domes and spring/upwelling locations. Detailed notes and photos should be taken for all observations. Field staff should note if a precipitation event occurred within a 48 hour period prior to the visit or if drought conditions are present. A general equipment list is located in Appendix 5.

Identify main discharge areas and categorize them as discreet (e.g. springs, peat domes) or diffuse (seeps). GPS point locations should be taken of discreet discharge points and polygons can be created for diffuse discharge areas. Using GPS points or polygons, the slope and aspect of the fen can be determined.

If a soil core is being documented, use that process to measure the water table depth (if below the land surface); observe saturation depth and shells present in the peat. Intact snail shells present at saturation depth in the soil indicate a circumneutral to alkaline water, as the shells would dissolve in more acidic water.

Wetland hydrology indicators from the US Army Corps of Engineers' (USACE) Wetland Delineation Manual, Midwest Regional Supplement (U.S. Army Corps of Engineers 2010, pp. 72-99) that apply to calcareous fens include:

- surface water/high water table
- soil saturation
- iron deposits
- hydrogen sulfide odor
- thin mucky soil surface
- dry season water table at or near the surface
- aquatic fauna (e.g., invertebrates)
- crayfish burrows
- gauge or well data

Wetland hydrology indicators that you should not find in a healthy calcareous fen from the USACE delineation manual, Midwest Regional Supplement (U.S. Army Corps of Engineers 2010, pp. 72-99) include:

- inundation/flooding
- high water marks
- sediment deposits
- drift deposits
- algal mats (extensive)

- inundation visible on aerial imagery
- sparsely vegetated concave surface
- surface soil cracks
- drainage patterns

Status Check Assessment

Status checks for hydrologic conditions can be done any time of year, but early spring provides the most ideal conditions for hydrology observations. In a healthy fen, water levels should be at or very near the peat surface. Field staff should note impacts to fens, which can include too much or too little water. Too much water could be due to increased drainage or flooding conditions. Too little water can be caused by local water use from wells, irrigation, mining, ditching, tiling or some combination of these.

Soils

Soil 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.

Office assessment

Soil survey reports can be obtained for an area of interest by using the web soil survey website (Web Soil Survey). Soil survey information may or may not capture the peat or muck soils present at a particular fen due to the small size of most fens and the scale at which the soil survey is applied. The most recent soil survey for the area of interest should be documented in the fen file, but a field documented soil profile is necessary for a complete calcareous fen identification. If a fen is listed in the DNR's official list of calcareous fens, and the soil survey doesn't capture the proper soil type and no soil profile is documented in the fen files, one should be obtained.

Initial and Identification Assessments

Only one soil core is needed to document soil conditions at a suspected or known calcareous fen site. This can be taken during any field visit and any time of year when the soil is not frozen.

Field soil methods are adapted from the US Army Corps of Engineers' *Wetland Delineation Manual, Midwest Regional Supplement* (USACE 2010, pp. 32-67). The most obvious modification is that this assessment is not delineating the wetland boundary, but rather documenting the presence or absence of soils that meet the calcareous fen criteria (i.e. histosol or histic epipedon). The peat edge along with the edge of the distribution of calcareous fen indicator plant species can be used to draw a working boundary around the fen community. However, this boundary does not necessarily represent the limits of the DNR's regulatory jurisdiction for a calcareous fen.

The second modification is that the data collection method should minimize damage within the peat soil footprint (e.g. large soil pits should never be used and only one soil core sample is needed per site). Additional soil samples can be taken for sites that include a complex of fens or at monitoring well locations. Peat extent should be documented where feasible. Peat extent can be identified manually with a tile probe and minimal soil cores, or by the use of aerial imagery/soil maps. Special care should be taken to avoid puncturing through any confining layers (e.g. high flow or pressurized zones, clay, or tufa crust) to mitigate the risk of creating a preferential flow path for upwelling groundwater.

Soil profile methods

1. Select a soil profile site. Choose a representative location for your peat core centrally located within the fen plant community and at a representative depth (avoiding high discharge areas). A narrow diameter tile probe can be used to help identify peat depths to ensure a representative sample site is selected. Soil profile locations must be located with GPS.
2. Identify the depth to mineral soil with a tile probe--resistance to the probe increases at the contact of mineral soil. At some sites, the depth to mineral soil can be greater than the probe length.
3. Lay out a measuring tape or a soil trough to hold the soil for identification.
4. Remove leaf litter and vegetation.
5. Cut a plug of soil through the root zone and place it along the measuring tape starting at 0 ft.
6. If the soil is saturated to the surface and the peat is loose, sample the near surface material with your hands and place it along the measuring tape with reference to land surface (0 ft.)
7. Next, use a gouge auger to sample the next interval of soil and place it along the measuring tape starting at the last depth sampled to the current depth sampled.
8. Continue collecting soil samples until you have reached mineral soil (ideally you should continue as far as you can into the mineral soil, while being sure to avoid artesian conditions). *In some cases, classifying the soil while it is still fixed within the auger may prove easier
9. Identify locations in the soil profile where either the color or texture changes noticeably (there may be multiple divisions within the “O horizon” containing different textures or colors of peat or carbonate deposits.
10. For each distinguishable layer (change in color or texture) record: the depth interval, color, texture, and for all peat layers, degree of humification. Also record the depth of roots, water table location, reduced or gleyed soils and the presence of tufa, marl, or shells.
    a. Peat soils should be textured using the degree of humification chart (Appendix 6).
    b. Non peat soils should be textured using the USDA soil texturing field flow chart

11. The entire sample should be laid out along the measuring tape for photo documentation (Figures 1 and 2)

Figure 1. Soil profile example. Five separate photos stitched together. Soil profile documented on 6/29/2016 from Onstad 12 Fen on Burnham WMA (creek unit), Polk County, MN.

Figure 2. Soil profile example. A single panoramic photo of the whole soil profile. Soil profile documented on 8/10/2016 at Altona WMA South Fen, pipestone county, MN.

Acid test

Soil, tufa, or marl should be tested for the presence of carbonates by performing an acid test. An acid test involves applying a small amount (several drops) of acid (5-10% HCl) to a sample of soil, tufa, or marl deposit and observing if the sample effervesces (bubbles or fizzes). If the sample reacts to the acid then there is likely a carbonate present. If possible test the different soil depths along the profile to see where there are positive results. Record the result and vigor of a test. Dated photo or video documentation is recommended.

Figure 3. Acid test example reaction and documentation. Tufa sample tested on 6/28/2016 at Tilden 28 Fen, Polk County, MN.

Status Check Assessments

Soil cores do not need to be taken during the status check assessment unless there is no documented soil profile in the fen records. Observations should be made about any noticeable peat degradation or subsidence. If subsidence rods are in place then the observers should measure the peat elevation during their visit.

Water Chemistry

Water Chemistry Criterion

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
- Specific conductance of 500 µS/cm or more.

Water samples for applying the technical criteria must come from the root zone within the fen (upper 6 inches of the peat). Additional field parameters must be collected to provide context for the fen water chemistry data (e.g. weather conditions, most recent precipitation event, water temperature, dissolved oxygen, oxidation reduction potential, etc. – see below).

Initial and Identification Assessment

Chemistry data can be taken during any time period when open water is present. However, sampling within 48 hours after a precipitation event or during spring melt can affect chemistry results. Precipitation in the sample water will reduce alkalinity, calcium, and conductivity values. Therefore, these skewed results cannot exclude a fen from meeting the criterion but can be used to confirm it meets the criterion.

Data collection involves a three level approach. The first level is to use a chemistry meter(s) or multi parameter sonde to measure field parameters -- Required: pH, conductivity, temperature; Optional: dissolved oxygen and oxidation reduction potential. This level may be used for initial assessments and is required for identification assessments, which entail additional chemical analysis.

For identification assessments, the second level of data collection is required, which entails titration of water samples to obtain concentrations of alkalinity and calcium. This should be undertaken once the site has met the soils and vascular plant criteria as more time and cost are associated with it.

The third level involves laboratory analysis. This is the most costly chemistry method and is not generally required for calcareous fen identification, but could be used to answer questions about water source and age. Lab samples require measurement of the field parameters listed above and titrations (alkalinity) of the sample source water at the time of collection. Lab sampling can include any combination of analytes that are chosen to answer specific questions. Common analytes for lab samples include major and minor groundwater constituents (listed in Appendix 7). Additional analytes used to determine water age and source include stable isotopes (deuterium and oxygen-18) and radioactive isotopes (primarily tritium). Lab samples from within a fen need to be compared to

multiple water sources outside of the fen, and where possible, to all aquifers present in the area. Sampling at multiple locations and at multiple times can strengthen the results.

Field Parameter collection

Field parameters are easy to collect and should be taken at multiple locations within a fen or fen complex. Field parameter sampling locations should be marked with GPS coordinates and site descriptions recorded. Note whether you are within or outside of the groundwater discharge area. Stabilized field parameters, using a calibrated instrument(s), should be recorded where every titration and lab sample is collected. Field parameter sites will be categorized as follows:

- Fen peat – water from marly pools, depressions, or intra peat pore spaces, (e.g. if there are no pools, springs or wells, staff may need to make a depression in the peat and allow it to fill with enough water to sample.) The samples must be collected at a depth within the plant rooting zone – approximately six inches. The calcareous fen technical criteria should be applied to the water samples obtained from these sites.
- Fen well – water pumped from a fen well (piezometer). Not used for fen identification.
- Fen spring – water from a flowing or bubbling spring originating from within the fen area. Not used for fen identification.
- Non-fen – water sampled outside of the fen area.

Titration Methods

These methods are for measuring alkalinity and calcium concentrations for the calcareous fen identification and listing process. Alkalinity titrations are also required when submitting water samples to a laboratory for analysis.

Samples for titrations should be collected from a representative location within the fen. Choose the best location(s) that will allow water sampling with minimal agitation and exposure to the atmosphere. Care should be taken to exclude floc, sediment, and other detritus from the sample collections as it could interfere with the titration methods. Using the largest clean sample vessel possible (>50 ml), rinse the vessel three times with sample water and finally fill the vessel completely with fen water being sure to leave no head space in the vessel. An ideal situation would be to open and fill the vessel completely underwater to have a wet seal, but sediment and depth often prevent this.

Field parameters must be collected at every titration sample site. Samples should be removed from the field promptly and placed in a cooler with ice until titrations can occur. Titrations should be conducted as soon as possible or within 24 hours of collection if they are stored at 33 degrees Fahrenheit. The titration procedures are adapted from methods 2320 and 3500-Ca in *Standard Methods for the Examination of Water and Wastewater* (Eaton 1998). The adaptation uses mass instead of volume to determine sample size. Using the mass of the sample allows for the process to be independent of

temperature, and allows the sample aliquots to vary in mass, which reduces the ability to guess the endpoint.

Alkalinity titration procedure

1. Wear appropriate personal protective equipment including: safety glasses, nitrile gloves, and full length clothing.
2. Assemble necessary equipment (Appendix 5). Install correct digital titration cartridge (for highly alkaline samples use Sulfuric Acid Titration Cartridge, 1.600 N) into the digital titrator and securely attach J-hook tip. Write down the concentration of the cartridge. Carefully purge the cartridge and j-hook tip of air using a paper towel to soak up acid. When complete, reset the digits to zero.
3. Clean the Erlenmeyer flask by rinsing three times with deionized water. Then shake the remaining water out and dry the outside of the flask completely.
4. Tare or zero out the digital balance with the prepared flask.
5. Pour a 50-100 ml aliquot of sample into the flask, dry the outside of the flask and obtain the mass of the sample in grams. Record the result. Be sure to record the mass of the sample before proceeding. In subsequent trials vary the mass of each aliquot by 5-10 grams from the previous trial.
6. After the mass has been recorded, add the contents of one Bromcresol Green-Methyl Red Powder Pillow to the sample and gently stir until dissolved. The solution should be greenish in color.
7. Make sure the digital titrator is zeroed out and that the J-hook tip is free of titrant (dab with paper towel).
8. Place the j-hook tip within the flask so that the tip is submerged in the sample. Begin to swirl the flask (or use a stir plate). Add titrant to the sample by turning the knob. Keep swirling the flask and slowly adding titrant until the solution turns from greenish to light pink in color.
9. Record the number of digits.
10. Use the digits and mass in the equation below to calculate the concentration of alkalinity as $CaCO_3$.

[alkalinity] as $CaCO_3$ (mg/L) = digits (1.6N sulfuric acid) / (sample mass in grams)/100)

Alternatively you can use the "combined_chemistry_template.xltx" spreadsheet to calculate this faster. This template calculates concentrations of alkalinity for each titration trial and also calculates the percent error between the trials.

11. Repeat the process with the same sample two additional times with different volumes between 50-100 ml. Calculate the concentration and the % error between the multiple trials. A set of titrations is complete when three titrations are within 2% of each other. If that standard is not reached, repeat the process until you have achieved this or have exhausted the sample.

12. *Average the three closest alkalinity concentration results, and convert to milliequivalents for reporting using the following equation:

    [Alkalinity] in (meq/L) = ([alkalinity] as $CaCO_3$ (mg/L)) x 0.01998

Calcium EDTA titration procedure

1. Wear appropriate personal protective equipment including: safety glasses, nitrile gloves, and full length clothing.

2. Assemble necessary equipment (Appendix 5). Install correct digital titration cartridge (for high concentrations of Ca use 0.800 M EDTA titration cartridge) into the digital titrator and securely attach J-hook tip. Write down the concertation of the cartridge. Carefully purge the cartridge and j-hook tip of air using a paper towel to soak up acid. When complete reset the digits to zero.

3. Clean the Erlenmeyer flask by rinsing 3 times with deionized water. Then shake the remaining water out and dry the outside of the flask completely.

4. Tare or zero out the digital balance with the clean and dry flask.

5. Pour a 70-100 ml aliquot of sample into the flask, dry the outside of the flask and obtain the mass of the sample in grams. Record the result. Be sure to record the mass of the sample before adding acid or the powder pillow.

6. After the mass has been recorded and the sample is close to 100 ml, add 2 ml of 8N Potassium Hydroxide standard solution to raise pH and precipitate out Mg.

7. Add the contents of one CalVer 2 Calcium Indicator Powder Pillow to the sample and gently stir until dissolved. The solution should be greenish in color.

8. Make sure the digital titrator is zeroed out and that the J-hook tip is free of titrant (dab with paper towel).

9. Place the j-hook tip within the flask so that the tip is submerged in the sample. Begin to swirl the flask (or use a stir plate). Add titrant to the sample by turning the knob. Keep swirling the flask and slowly adding titrant until the solution turns from red to pure blue.

    a. Watch the digits frequently to ensure they are counting properly

10. Record the number of digits.

11. Use the digits and mass in the equation below to calculate the concentration of Ca, as $CaCO_3$.

    [Ca] as $CaCO_3$ (mg/L) = digits (0.800M EDTA) / (sample mass in grams)/100)

    Alternatively, the "combined_chemistry_template.xltx" spreadsheet can be used to calculate this faster. This template calculates concentrations of Ca for each titration trial and also calculates the percent error between the trials.

12. Repeat the process with the same sample two additional times with different volumes between 50-100 ml. Calculate the concentration and the % error between the multiple trials. A set of titrations is complete when three titrations are within 2% of each other. If that standard is not reached, repeat the process until you have achieved this or have exhausted the sample.

13. Average the three closest Ca concentration results, and use that for reporting.

Notes on titrations

- Digital titrators are most accurate between 200 and 300 digits (after your first titration you have an idea of the best mass range).
- Sample masses should vary to avoid guessing the endpoint.
- Watch the digits carefully because some digital titrators can skip digits when adding the third digit.
- The EDTA method for determining Ca reacts more slowly than the alkalinity titration--exercise patience.

Lab samples

Samples for laboratory analysis can be collected from wells or spring flowages depending on what questions need to be answered. At least one sample should be collected from a depth corresponding to the plant rooting zone (upper 6 inches of soil) within the fen. Sampling from fen wells can be complex as the water chemistry can vary over relatively short distances (e.g. mixing water sources, exposure to the atmosphere and sample agitation. Developing a sampling plan with specific questions you want answered will help address this complexity. Fen well samples require a peristaltic pump to recover samples with minimal aeration. Laboratory instructions should include what samples need to be filtered, preserved or kept cold. In addition there should be a holding time identified for samples

and it should not be exceeded. Follow laboratory instructions, chain of custody procedures and use clean lab issued bottles for collection.

Quality control and calibration

Calibration of equipment (sonde or individual meters) should occur daily. Calibration solutions can be reused for up to one week, but should be renewed if calibration fails. Calibration procedures should follow manufacturer's instructions.

A quality control goal should be greater than 5% of titration samples taken by a field staff (alkalinity and calcium) should be duplicated annually (i.e. 1 out of 20 titrations should be a duplicate). Lab samples require the same frequency for duplicates and blanks. In other words, if an individual DNR staff member performs 18 titrations in a field season one of those should be a duplicate, and if 22 titrations are performed in a field season two of those should be duplicates.

Status Check Assessment

Chemistry data is not required for a status check assessment, unless there is no water chemistry data in the fen records. Field parameters, titrations and lab samples could be collected and compared over time, but would need to be taken from established locations with a robust water quality monitoring plan.

Vegetation

Vegetation Criterion

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 plants plus the bryophyte calcareous fen indicator species (Appendix 8). 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 to be considered a calcareous fen.

If a disturbed site has calcareous fen soil, hydrology, and water chemistry but the calciphile point total ranges from 30 to 50, the area is 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.

Vegetation assessment work should take place during the optimal time period for detecting and identifying vascular plant calcareous fen indicator species (calciphiles), which is generally when the plants are in their reproductive phase (flowers or fruit). In Minnesota, there are two optimal time periods, generally June and August, although it can vary somewhat depending on phenology for a particular year. It may be possible to meet the calcareous fen vegetation criteria based on a single site visit, but for best documentation, sites should be visited during both periods. For sites, where calciphiles are found in the first site visit, but the scoring threshold is not met, a second site visit is required. It is possible to collect and identify bryophytes outside of the normal growing season. If necessary, a bryophyte survey can be conducted at such times for initial assessment purposes or for status checks, but identification assessments must be conducted during the growing season when vascular plants can be surveyed.

Initial Assessment

For the initial assessment, field personnel should scout for sedge-rich wetland areas. Random meander surveys should be used to locate these areas. Meander surveys involve walking "randomly" through a site and noting each new species—in particular noting where calciphile indicator species occur (both vascular plant and bryophyte species). A calciphile checklist should be completed in a representative sample of the plant community (use Survey123 or see Appendix 8).

There are areas on the site that may be impassable such as deep seepage pools. When these areas are encountered on an individual's survey path, the individual will take a GPS point, note any features characteristic to calcareous fens (tufa, calcium deposits, etc.), and avoid this area.

Sites that are visited during one survey time period (early summer or early fall) and are found to support populations of vascular plant calciphiles, but do not meet the scoring requirements for a calcareous fen, should be visited in the second time period (early summer or early fall) to determine whether or not the community meets the vegetation technical criteria. Similarly, if populations of bryophyte fen indicator species are found in a site visited outside the growing season, but the scoring criteria for a calcareous fen is not met, the site should be revisited during the growing season. Any site that meets the calcareous fen vegetation criteria based on an initial assessment should be followed up with a full identification assessment including soils, hydrology and chemistry.

Sites that are visited once and fail to meet the soils, hydrology, or chemistry criteria do not need to be reassessed.

Identification Assessment

The identification assessment consists of geographically delineating the approximate boundary of the calcareous fen and creating a complete plant list, ideally including bryophytes in addition to vascular plants. First, field personnel should mark the extent of the fen areas using GPS. For mapping purposes, the boundary of a calcareous fen is marked by the extent of the combination of peat soils and populations of calciphiles. This may be evident by a change in elevation or an observable shift in plant community type. Some calcareous fens occur within larger wetland complexes. Where possible, the approximate boundaries of distinct calcareous fen communities within the overall complex should be mapped. If it's not possible or practical to determine the calcareous fen extent, these sites should be mapped as complex communities that include calcareous fens (see Appendix 1 for more mapping guidance).

Vascular Plants

After the extent of the fen is identified, a complete vascular plant list, including a calciphile checklist (Survey123 or see Appendix 8) should be completed by using a timed meander survey through the calcareous fen plant community (modified from "Rapid Floristic Quality Assessment Manual," Minnesota Pollution Control Agency, 2012). The base meander time is 30 minutes, unless the entire fen community can be covered in less time. If three or more new species are identified during the last 10 minutes of the timed meander, then an additional 10 minutes are added to the meander. This should be repeated until less than three new species are identified within the 10 minutes. The timing should be paused while identifying plants, taking photos, collecting specimens, etc.

Photos, voucher specimens, and GPS locations should be taken to document each calciphile indicator species that occurs on site. (Note: Surveyors who are not DNR employees must possess a valid collection permit for collecting state-listed threatened and endangered species and may be required to follow DNR rare plant survey procedures.) Vouchers should be processed according to the Guidelines for plant specimen collection and submission to the Bell Museum of Natural History University of

Minnesota Herbarium (MIN). Prepared specimens should be sent to the University of Minnesota's Bell Museum of Natural History.

Bryophytes

Bryophytes should be surveyed and collected for identification using the methods described in Appendix 9.

All records of calciphile indicator species require a secondary confirmation identification by a qualified professional, e.g., botanist, ecologist. Photos, vouchers, or field identification can be used for the secondary identification. Documentation of this should appear in the Identification Report.

Status Check Assessment

Prior to conducting a status check assessment, DNR field staff should review the DNR calcareous fen file and locate previous vegetation assessments and any documented concerns. A vascular plant calciphile checklist (Survey123 or see Appendix 8) should be completed by using a timed meander survey through the calcareous fen plant community (modified from "Rapid Floristic Quality Assessment Manual," Minnesota Pollution Control Agency, 2012). Calciphile indicator species should be marked with GPS and photo documented. Keep in mind that the original survey will likely encompass two time periods, whereas the status check will occur during one time period, which can account for differences in species presence. Probably even more informative is the completion of a condition rank for native plant communities following the MNDNR Ranking Guidelines for Prairie Extremely Rich Fens. Values should be accompanied by a ranking justification that explains species composition, vegetation structure, ecological processes and functions, level of human disturbance, presence of invasive species, and other factors. Invasive species presence and extent of encroachment should be documented. Invasive species encroachment should be marked with GPS and a map outlining areas of invasion should be included in the Status Check Report. The completed checklist, condition rank, invasive species encroachment, and size of fen community should be compared to the original vegetation data to see if there are any notable differences. Aerial imagery can be used to aid in an assessment of community shrinkage or expansion.

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Glossary

Alkalinity – The capacity of water to neutralize acid. The sum of all titratable bases. An aggregate property of water.

Calciphile – Plants that thrive in calcium-rich waters.

Carbonate – A salt of carbonic acid (H_2CO_3) Characterized by the presence of the carbonate ion (CO_2^{-3}). Calcium carbonate ($CaCO_3$) is the focus of fen geochemistry but Magnesium carbonate can also be present. Carbonate minerals (tufa and marl) effervesce when tested with dilute (5-10%) hydrochloric acid. (Adapted from USDA NRCS 2016)

Histosol - Organic soils where 16 in. (40 cm) or more of the upper 32 in. (80 cm) is organic soil material. Histosols also include soils that have organic soil material of any thickness over rock or fragmental soil material that has interstices filled with organic soil material. Organic soil material has an organic carbon content (by weight) of 12 to 18 percent or more, depending on the clay content of the soil. The material includes muck (sapric soil material), mucky peat (hemic soil material), or peat (fibric soil material). (Adapted from USDA NRCS 2016)

Histic epipedon – A thick (20- to 60-cm, or 8- to 24- inch) organic soil horizon that is saturated with water at some period of the year (unless the soil is artificially drained) and that is at or near the surface of a mineral soil. (USDA NRCS 2016)

Hydrogen sulfide odor –The odor of H_2S. It is similar to the smell of rotten eggs. (USDA NRCS 2016)

Gouge auger – a long, tapered stainless steel, semi-cylindrical chamber that is designed for collection of undisturbed soil samples from very soft and preferably very wet soils with minimal disturbance of soft cohesive layers. The gouge soil auger is pushed into the soil, twisted and recovered to display a full and virtually undisturbed soil profile of wet clay or peat soil.

Fen piezometers – a monitoring well type that measures the hydraulic pressure head at a discrete interval, typically below the water table and a confining material (i.e. a thin clay layer or thick peat layer). Used form monitoring water levels, establishing hydraulic gradients (minimum wells 2) and chemistry sampling.

Fen water table wells – a monitoring well type where the screen starts at or slightly above land surface and may continue to mineral soil (<5 ft. screen length) but does not penetrate a confining layer.

Observation wells – a monitoring well type that refers to deeper wells constructed using a drill rig, located outside of the fen foot print.

Marl – An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions. (USDA NRCS 2016)

Marly pool – a shallow pool occurring in fens with a substrate consisting of marl. Sparsely vegetated and groundwater fed.

Muck – Sapric organic soil material in which virtually all of the organic material is so decomposed that identification of plant forms is not possible. Bulk density is normally 0.2 or more. Muck has less than one-sixth fibers after rubbing. (USDA NRCS 2016)

Mucky peat – Hemic organic material, which is characterized by decomposition that is intermediate between that of peat (fibric material) and that of muck (sapric material). Bulk density is normally between 0.1 and 0.2 g/cm3. Mucky peat does not meet the fiber content (after rubbing) for either peat (fibric) or muck (sapric) soil material. (Modified from USDA NRCS 2016)

Peat – Fibric organic soil material. The plant forms can be identified in virtually all of the organic material. Bulk density is normally <0.1. Peat has three-fourths or more fibers after rubbing. (Modified from USDA NRCS 2016)

Sonde – Specifically a multi parameter sonde that can read field parameters of pH, Conductivity, temperature, dissolved oxygen and other optional parameters.

mEq/L – milliequivalent per liter. The amount of substance it takes to combine with 1 mole of hydrogen ions

Appendix 1. Naming, Listing, and Mapping

Naming

New calcareous fens should be named per the following conventions:

1. If the fen occurs on or adjacent to a named, permanent public land unit such as a state park, wildlife management area, USFWS Waterfowl production area, or a named lake it will be given the name of that land unit. For example: Sioux Nation WMA Fens on Sioux Nation Wildlife Management Area.
2. If the fen occurs on private land, the name will be the Township name and Section number where the majority of the fen occurs. For example: Lime 30.

Listing Process

Calcareous fens subject to regulation under Minnesota Statutes 103G.223 must be identified by the DNR via written order in the State Register. The current list of officially identified calcareous fens has previously been published in the State Register and is available on the DNR web site. As new fens are identified, they are subject to an internal DNR peer review process and, if approved, added to the official list and an update to the list is published in the State Register. Following are the procedures for adding a newly identified calcareous fen to the official list. This information can also be found on the I drive under the calcareous fen listing process document.

1. A qualified surveyor collects field data for the site per the procedures listed under "Identification Assessments" in this document (Minnesota Dept. of Natural Resources Calcareous Fen Field Assessment Procedures). The surveyor does not need to be a DNR employee, as long as they are qualified to collect the appropriate data. Regardless of who collects the field data, the data must be reviewed by a qualified DNR employee who makes a preliminary determination of whether the site meets the technical criteria for a calcareous fen. For a site to be added to the official list of calcareous fens, a qualified DNR employee must at some point conduct a site visit.
2. If the DNR employee determines that the site meets the technical criteria for a calcareous fen, the DNR employee submits the calcareous fen polygon and supporting field documentation (including observer and date(s) of observation) to the following:
    a. the Natural Heritage and Nongame Research Program Data Manager (currently Karen Cieminski) who enters it as an Element Occurrence (EO) in Biotics. The fen name will be entered in the Locator field. Supporting data is referenced and stored in the NHIS files folder under the same procedures as all other Biotics data.
    b. the DNR Ecological and Water Resources (EWR) Division Native Plant Community (NPC) Data Steward (currently Jason Johnson), who reviews the polygon (often with assistance

from other staff with appropriate expertise) and approves it for inclusion in the NPC data layer.

c. the EWR Wetlands Program Coordinator (currently Doug Norris).

3. The EWR Wetlands Program Coordinator arranges for a review of the site data by the EWR Calcareous Fen Identification Committee, which determines if the site should be added to the DNR official list of fens in the State Register. The EWR Calcareous Fen Identification Committee is currently comprised of the following:
    a. The EWR Regional Ecologist from the DNR Region containing the candidate fen;
    b. Hannah Texler, Minnesota Biological Survey (MBS) Plant Ecology Supervisor, who may appoint additional committee members having appropriate expertise for particular candidate fens;
    c. Welby Smith, MBS Botanist;
    d. Fred Harris, MBS Plant Ecologist/Botanist – for candidate fens in NW and SW Regions;
    e. Erika Rowe, MBS Plant Ecologist/Botanist
    f. Michele Walker, Groundwater Specialist;
    g. Keylor Andrews, Hydrologist.

    The members of this Committee were selected because they have specific expertise regarding to calcareous fens. The membership may be revised as needed due to staff changes and as others develop appropriate expertise.
4. If a candidate fen is approved for listing by the Identification Committee, the EWR Wetlands Program Coordinator publishes an update to the official list in the State Register. The EWR Division Director provides concurrence for the listing as part of the publication process.
5. Once the update has been published, the EWR Wetlands Program Coordinator adds the fen to the official list posted on the DNR website, updates the master calcareous fen spreadsheet, and informs the Natural Heritage and Nongame Research Program Data Manager, who adds the fen to the DNR's Calcareous Fen GIS data layer. (Note: the Calcareous Fen GIS data layer only shows officially listed fens, represented as point data. Calcareous fen polygons, if available, can be found in the NPC or NHIS GIS layer.) More information on the Calcareous Fen layer is available at: Calcareous Fen Layer

Mapping

Given that calcareous fens are natural systems, their occurrence on the landscape cannot always be precisely mapped. They may not have a clear or static boundary and frequently occur among other wetland types within a wetland complex or mosaic. Maps showing calcareous fen "boundaries" or "extents" are necessary for practical identification purposes but should not be interpreted as depicting discrete community boundaries, which can fluctuate on the landscape. Calcareous fens typically transition from a stable hydrologic regime with its associated chemistry and peat accumulation in the core of the fen community to a more variable regime in the surrounding wetland communities. For regulatory purposes, the DNR has long considered the boundary of calcareous fens to be the boundary of the wetland complex the fen is located in due to the hydrologic connectivity within wetlands.

To facilitate more consistent mapping practices the following guidelines are provided to standardize the mapping process. Previously listed fens have not strictly followed these guidelines but they could be modified to comply, if the need arises.

The lowest common divisible unit for fens is the Source Feature ID (SFID) and the next level up is the Element Occurrence ID (EOID). The EOID is called the "Fen ID" on the commissioners list of calcareous fens. Both IDs (SFID and EOID) are used to relate fen parameters over multiple databases. All discrete polygons that are part of one EO should have unique SFID's to help differentiate them for monitoring and assessments. These IDs originate from the Natural Heritage Information System (NHIS) database and are sequentially assigned. EOID's are defined as an area of land and/or water in which a native plant community is or was present. These communities should be observed at the appropriate time of year and be naturally occurring.

Calcareous Fen Layer

The calcareous fen layer should reflect the commissioners list, in that it should only show listed calcareous fens. It is a point layer only and these data are pulled from the Natural Heritage Information System database.

Natural Heritage Information System Layer

SFID guidelines:

1) Each discrete fen area with a definable edge gets an SFID to denote its individual attributes.
    a. If there is a wetland complex with one fen zone there is one SFID. If there are multiple separated fen zones within the complex each one gets an SFID
    b. If a non-wetland barrier separates fen zones, but they are part of the same EOID, they will each receive unique SFIDs

EOID guidelines:

1) Fen areas should be grouped under the same EOID if one of the following is true:
    a. Distinct fen areas are connected by a wetland complex
    b. Distinct fen areas are within ½ mile of each other
    c. There is no physical barrier between the fen areas
    d. The plant communities within distinct fen areas can be considered part of the same population, i.e., plants within them can reproduce with plants in other fen pockets

2) Fen areas should be divided into different EOIDs in the following circumstances:

    a. If a connection cannot be made between the individual fen pockets to justify that they are part of one complex e.g., hydrology, slope, plant cross-pollination can occur between pockets, etc.

    b. Physical barrier (natural or manmade) separates the fen zones/wetland complexes (e.g. roadway, substantial stream channel, ditch or railroad).

    c. Are in the same wetland complex but are separated by more than ½ mile of non-fen wetland

Native Plant Community (NPC) Layer

All A-C condition rank occurrences of calcareous fens should be mapped. D-rank occurrences that support populations of State Endangered or Threatened plant species should also be mapped.

For internal DNR staff, all mapping for the native plant community layer occurs within each Division's NPC polygon candidate layer within the NPC database. Each distinct fen area (SFID from above) should be mapped as one polygon with its unique attributes. Once the shapefiles and attributes for each polygon are filled in, these then get submitted to be certified to become the final spatial representation of these communities. If alterations are needed in the future as habitats change or more is known about each site, these amendments can also be submitted through the NPC polygon candidate layer. It is a best practice to contact the original mapper/field observer and discuss changes with them so that the certification process is seamless. All changes to certified polygons are archived so there is a historical record of each plant community polygon. Each Division has their own certifier for the database. Contact your Divisional representative if you have questions about certification.

For external DNR staff, all mapping would occur by creating a shapefile around the boundaries of each native plant community. Field notes and other attributes should be submitted to the DNR for each polygon.

Appendix 2. GIS Resources

The GIS information listed below is not complete and many other data sources exist. Most of the data is available for MNDNR staff via Quick Layers (use keywords or phrases from the descriptions below in the Quick Layers search box to find them), and available to external staff via the state of Minnesota Geospatial Commons (MNDNR Geospatial Commons). Additional information like well logs, stratigraphy reports, and water level data require visiting additional web resources. Some data may be non-public and could require special training or specific data requests.

1. Land Imagery
    a. Current air photos
    b. Color Infrared
    c. historical air photos
2. Well logs
    a. County well index **(MN Dept. Of Health County Well Index)
    b. Quaternary well database
    c. Engineering bore hole logs
3. Water level data
    a. County well index
    b. MNDNR cooperative groundwater monitoring (CGM) network **(MNDNR Cooperative Groundwater Monitoring Network)
    c. USGS, National Groundwater Monitoring Network **(USGS National Groundwater Monitoring Network)
    d. Water table elevation. Minnesota Hydrogeology Atlas Series
    e. County hydrogeologic atlases
4. Soils data
    a. SSURGO Soils. (many layers)
    b. Soils of Minnesota (NRCS)
    c. Web Soil Survey reports*
    **(Web Soil Survey)
5. Surface water
    a. Designated trout streams
    b. Karst feature inventory points (Springs) **(MNDNR Spring Data)
    c. DNR Public Water Delineations
    d. Floodplain/floodway/flood frequency maps
        i. Sources: FEMA, SSURGO soils, MNDNR (perennial cropland and ecological analysis)
6. Landscape position
    a. Lidar
7. Property information
    a. Parcels in Minnesota **(some counties have external public GIS websites)
8. Vegetation

    a. Native plant communities
    b. National Wetland Inventory layers.
9. Rare species/features
    a. Natural Heritage Information System (NHIS-Enterprise Geodatabase; non-public data)
    b. NHIS Observation Database, which contains additional data including species of greatest conservation need data

*not available on MNDNR quick layers
**additional information available on the web

Appendix 3. Data Collection

The MNDNR has developed two data apps for collecting field data on calcareous fens: Survey 123 and Collector for ArcGIS. These can be used on a desktop computer, in a browser, or on a field tablet. For consistency in data collection, all MNDNR staff should use these data collection tools.

Note: A paper data sheet form can be printed out for staff who do not have access to a field tablet or other electronic data collection device.

Survey 123:

Survey123 is an electronic data sheet that uses forms to input information. There are two forms for collecting calcareous fen data: one for collecting vegetation data (Calcareous Fen - Vegetation), and one for collecting soils, water chemistry, and hydrology data (EWR Fen Survey - Chemistry Hydrology, and Soils). If you are a MNDNR employee and would like to access these forms, you will need to be added to the Calcareous Fen Group. Please contact mnitservices.dnr@state.mn.us to gain access to this group.

The MNDNR has developed other Survey123 forms that may be used during Calcareous Fen surveys to capture more information about certain features. The appropriate application based on the feature is listed below:

Feature	Application	Name
Rare Species	Survey 123	Observation DB
Invasive Species	EddMaps	EddMaps
Springs	Survey123	Spring Collector
All Vegetation Data	Survey 123	Calcareous Fen SDE

Collector for ArcGIS:

Collector for ArcGIS is a program that allows you to access maps and collect spatial data—including drawing boundary polygons, mapping invasive species encroachment, and marking features of note like indicator plant species, marly pools, and tufa. If you are a MNDNR employee and would like to access this application, you will need to be added to the Calcareous Fen Group. Please contact mnitservices.dnr@state.mn.us to gain access to this group.

Appendix 4. Data Entry and Management

This applies to DNR staff working with calcareous fens. For non-DNR calcareous fen professionals please forward your information regarding calcareous fens to a DNR staff member for archival.

The goal of data management for calcareous fens in the DNR is to use existing databases where available and create data management solutions when needed. Some existing databases work well for the types of data we gather and some do not. The biggest problem to avoid is keeping data isolated on staff hard drives or hard copy locations. Survey 123 application surveys are described in Appendix 3. All other data management is described in this section.

Shared I drive location for fen files:

I:\EWR_ALL\Calcareous Fen Files\Fen_Files_by_Location\Minnesota_Fens_by_COUNTY

** All folder paths in this section will start with the above file path*

General guidance after field work:

1) As soon as possible write a summary of field work completed, include the following;
    a. Name(s), date(s), time(s)
    b. Field work purpose
    c. Summary of work completed.
    d. General impressions of the site condition if applicable.
    e. SAVE in: COUNTY\FEN NAME – EOID#\Reports\Field Reports
    f. Title as: YYYYMMDD_discriptor
2) Label Photos by date and with a meaningful title (see photo labeling for details).
3) Scan completed field books/sheets/forms ASAP and label with a meaningful title and save in the proper shared file

Photography guidance

File path: COUNTY\FEN NAME – EOID#\Photos

The goal is to have relatively consistent naming conventions while still being flexible to many different needs. The main goal is to name photos with a meaningful title inside of a generic number/date assignment.

General guidance

1) Try not to show any **people** or **vehicles** when taking photos unless necessary*.
    a. If you do you need to obtain an Artistic Talent Release forms also located on the intranet.
2) Use the proper photo mode for the type of picture you are taking
    a. Macro – up close photos (e.g. plants, tufa, etc.)
    b. Panorama – landscape photos or linear subjects (E.g. soil core)
    c. Auto – everything else
3) Add a **Time and Date Stamp** to the photo, if possible.
4) Save the best quality photo when there are duplicates
5) Avoid saving blurry images
6) Save and name photos immediately after returning from the field

7) Use underscores for spaces

Naming convention

1) If multiple dates exist within a file OR you choose to use dates.
   Name photos in the following way
   i. "YYYYMMDD_short_title_initals"
2) If the photo(s) is in a file with date in the name
   a. Title the photo with a short description of the main subject.
      i. 1st Include at minimum one of the following:
         1. CWI well number
         2. Basin ID
         3. Parcel/ownership name if nothing with a unique number is present (e.g. Carex_WMA,)
         4. Project_name
      ii. 2nd (optional) include:
         1. Direction the camera is facing
         2. Where you are taking the photo from
         3. What is the point of the photo

*If people's faces appear in a photo, we need to obtain a signed release to use their likeness in our advertising. A release form is attached. Artistic Talent Release forms may also be found on the DNR Intranet (The formatting on the hard copy or Word document copy is preferred). Because a parent or legal guardian needs to sign a release on behalf of a minor, please do not include children/teens under the age of 18 in photographs. Also, avoid photographing the license plate of personal vehicles. There may be cases where a DNR program needs photos of people enjoying our natural resources or DNR staff working on sites for outreach purposes. Personal property that appears in the photo may also be subject to requiring a signed release. Make sure that other unwanted visitors— Mr. Shadow and Ms. Thumb—are nowhere to be seen in the photos.

Hydrology data

File Path: COUNTY\FEN NAME – EOID#\Chem_Hydgeo_Soils_Veg_(climate)\Hydrogeology\

- Spring features - If there is a distinct, definable spring feature the location and associated data should be collected and saved using the "Spring Survey" within the Survey 123 application (Refer to the Survey 123 section).
- Piezometer logs - If any peat well or piezometer is installed a well log must be generated and a unique number obtained via the Minnesota Geological Survey (MGS). The process for unique number assignment is currently under review and will be updated (as of 8/23/17).
- Well logs – if particular well logs are used for cross sections, establishing hydrology or referenced they should be saved in the hydrogeology folder for the specific fen.
- Water level data – Water level data associated to features with unique identifiers have established databases that should be utilized.
  - Basins – LakesDB (soon to be WISKI)

- Streams – Hydstra (Soon to be WISKI)
- Wells – Hydstra (Soon to be WISKI)
- Other water levels - within the fen and not associated wells do not have a database and can only be recorded with field notes, soil profiles, and the Survey 123 App. (e.g. saturated peat, marl pools, etc.)

Soils data

Soil data does not have a known universal database home. Currently soil core descriptions, and photos are stored in the fen folders on the "I" drive for each particular fen. Questions about soils meeting the technical criteria are also within the Survey 123 App.
File path: COUNTY\FEN NAME – EOID#\ Chem_Hydgeo_Soils_Veg_(climate)\Soils

- Soil profile description – hard copy field notes with textures, colors and depths
- Soil reports – created using the Web Soil Survey Application can also be saved in the same location.

Chemistry data

Chemistry data has three locations where should be located. The "I drive" will hold all of the raw data files, the Survey 123 App will hold a summary of chemistry parameters, and Environmental Quality Information System (EQuIS) will hold laboratory samples. Eventually the plan is to have all chemistry data located in EQuIS, but this process is still being developed.
File path: COUNTY\FEN NAME – EOID#\ Chem_Hydgeo_Soils_Veg_(climate)\Chemistry

- Water quality field parameters – spreadsheets or hard copy scans.
- Titration results – Spread Sheet and field notes about collection.
- Laboratory results – PDF results, and collection notes.

Vegetation data

File path: COUNTY\FEN NAME – EOID#\ Chem_Hydgeo_Soils_Veg_(climate)\Vegetation

The primary repository for plant data will be the "I drive" and ArcGIS online interactive map. Clicking on a point on this map shows the species list and survey notes associated with vegetation. Data will be collected using the Survey 123 App and ArcCollector. Scans of field books or forms should be saved in the vegetation folder for each fen. Links to the ArcGIS online map and species lists will be saved in the vegetation file on the "I drive."

Appendix 5. Equipment list

General equipment
Field book/sheet
Sharpie/permanent marker
Pencil/Pen
Measuring tape
GPS device
Camera
10% HCl acid in dropper bottle
Tile probe
Knee boots/waders
Boot brush

Soils
Gouge auger
Hand auger
Soil knife
10% HCL acid bottle
Sample holder
Munsell color book
Texture chart
Sample vessel

Chemistry field parameters
Chemistry probe
Calibration standards
- Conductivity
- pH 4, 7, 10
- ORP

Deionized water
Plastic gloves
Squeeze bottle
Paper towels
pH storage solution

Chemistry Titrations
Scale
Magnetic stirrer
Digital titrator
Clean sample bottles

Calcium titration
Pipet
$CaCO_3$ standard [1,000 M]
Potassium Hydroxcide Std. Solution [8N]
CalVer 2 Calcium Indicator Powder Pillows
0.08 M EDTA cartridge
0.80 M EDTA cartridge

Alkalinity titration
0.08 M H_2SO_4 Cartridge
0.80 M H_2SO_4 Cartridge
Bromcresol Green-Methyl Red Indicator

Chemistry lab samples
Sample bottles
Inline filters
Preservatives (provided by lab)
Titration equipment
Field parameter equipment
Piezometer
Peristaltic pump
Other pump

Vegetation
Hand lens (10x)
Plant ID resources
Plant press
Sample bag
Plant list

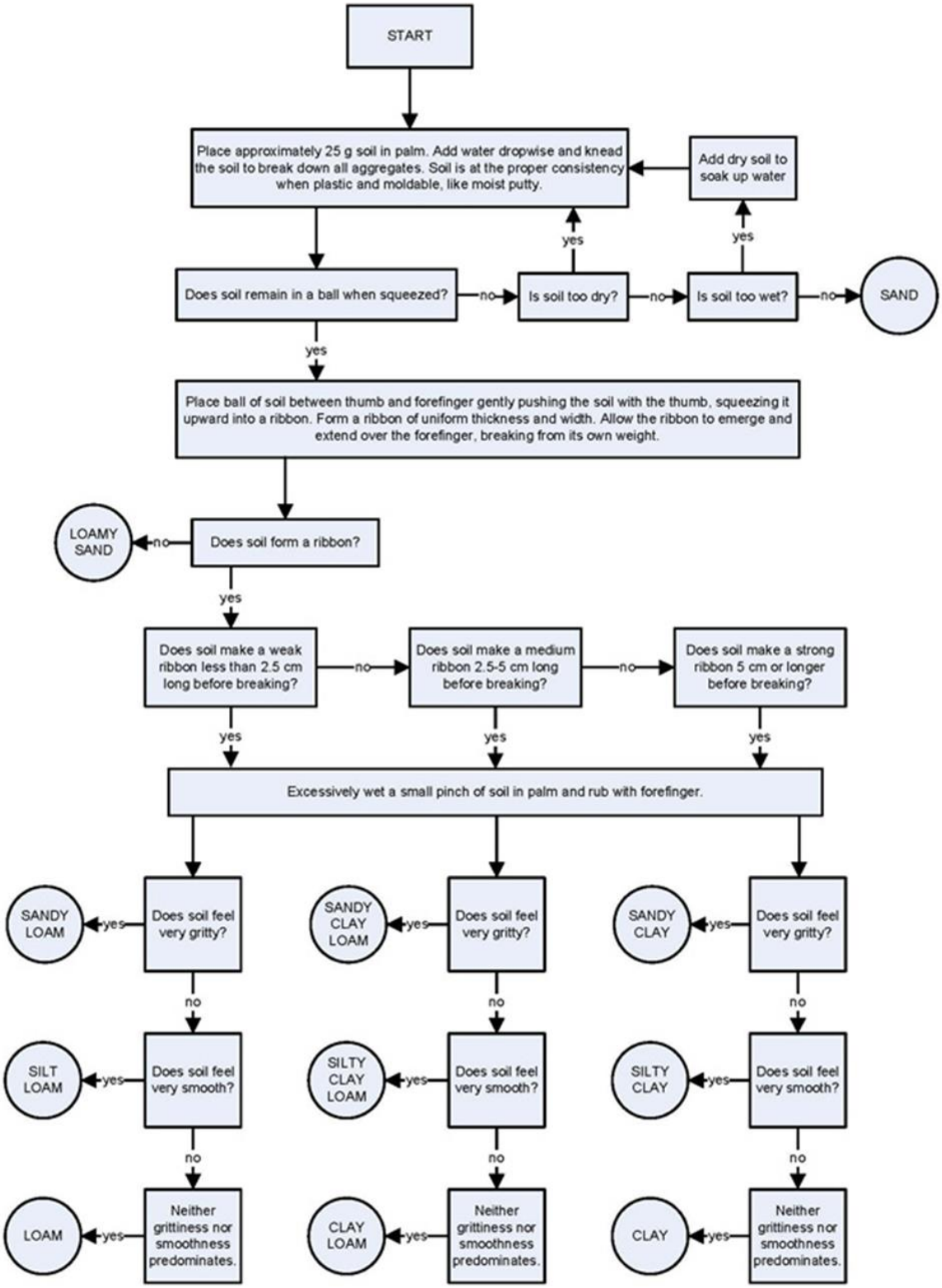
Bryophytes
Paper sample bags
Plastic bags
Hand lens (10x and 20x)
Random number chart
Measuring tape (metric)
Moss ID guide
Flags

Appendix 6. Soil Texture Charts

Table 1. Determination of degree Humification or Decomposition (adapted from ASTM 2000)

Symbol	Nature of Material Extruded on Squeezing	Nature of Pant Structure in Residue
H1 (Fibric)	Clear, colorless water; no organic solids squeezed out	Unaltered, fibrous, undecomposed
H2 (Fibric)	Yellowish water; no organic solids squeezed out	Almost unaltered, fibrous
H3 (Fibric)	Brown, turbid water; no organic solids squeezed out	Easily identifiable
H4 (Hemic)	Dark brown, turbid water; no organic solids squeezed out	Visibly altered but identifiable
H5 (Hemic)	Turbid water and some organic solids squeezed out	Recognizable but vague, difficult to identify
H6 (Hemic)	Turbid water; 1⁄3of sample squeezed out	Indistinct, pasty
H7 (Sapric)	Very turbid water; 1⁄2of sample squeezed out	Faintly recognizable; few remains identifiable, mostly amorphous
H8 (Sapric)	Thick and pasty; 2⁄3of sample squeezed out	Very indistinct
H9 (Sapric)	No free water; nearly all of sample squeezed out	No identifiable remains
H10 (Sapric)	No free water; all of sample squeezed out	Completely amorphous
B1	Dry peat	No moisture
B2	Low moisture content	Not glistening
B3	Moderate moisture content	Moist
B4	High moisture content	Saturated
B5	Very high moisture content	Water is holding up the structure of the peat

Table 2. USDA soil texture chart for non-peat soils.



Appendix 7. Chemistry laboratory analytes

Table 3. Suggested analytes for the characterization of groundwater at a fen and from surrounding wells and aquifers. This suite of analytes is not required for calcareous fen identification and this suite doesn't include isotope analysis.

Test	Test Code	Reporting limit	Method Reference
Bromide	Br	**0.005 mg/L**	EPA 300.1
Chloride	Cl	0.50 mg / L	EPA 300.0, Rev 2.1
Fluoride	Fl	0.50 mg/L	EPA 300.0, Rev 2.1
Nitrate/Nitrite		0.01 mg/L	SM 4500 - NO3 F
Total Phosphorus	TP	0.01 mg/L	EPA 365.1
Sulfate	SO4	0.50 mg / L	EPA 300.0, Rev 2.1
Aluminum	Al	*0.005 ppm*	EPA 200.7
Barium	Ba	*0.005 ppm*	EPA 200.7
Calcium	Ca	*0.5 ppm*	EPA 200.7
Iron	Fe	*0.10 ppm*	EPA 200.7
Magnesium	Mg	*0.2 ppm*	EPA 200.7
Manganese	Mn	*0.010 ppm*	EPA 200.7
Potassium	K	*0.3 ppm*	EPA 200.7
Sodium	Na	*0.2 ppm*	EPA 200.7
Strontium	Sr	*0.005 ppm*	EPA 200.7

Appendix 8. Calcareous fen plant lists

The following plant lists and associated calcareous fen indicator scores are excerpted from:

Leete, J.H., Smith, W.R., Janssens, J.A., Aaseng, N. 2016. Technical criteria for identifying calcareous fens in Minnesota. Excerpted from "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, 2005." Minnesota Department of Natural Resources. 7 pp. Available at: http://files.dnr.state.mn.us/eco/wetlands/calfen_criteria_restatement.pdf

Vascular Plants

Scientific name	Common Name	NW	MN valley	SE	SW
Berula erecta THR	Cut-leaf Water Parsnip	-	5	5	-
Betula pumila	Bog Birch	1	5	5	-
Bidens coronata	Crowned Beggarticks	-	5	5	-
Bromus ciliatus	Fringed Brome	1	5	5	-
Cardamine bulbosa	Spring Cress	5	5	5	5
Carex aquatilis	Water Sedge	1	5	25	25
Carex hystericina	Porcupine Sedge	1	5	5	25
Carex interior	Inland Sedge	1	5	5	5
Carex prairea	Prairie Sedge	25	25	25	25
Carex sterilis THR	Sterile Sedge	25	25	25	25
Cladium mariscoides SPC	Twigrush	5	25	-	-
Dasiphora fruticosa	Shrubby Cinquefoil	1	25	25	-
Eleocharis rostellata SPC	Beaked Spikerush	25	25	-	-
Eriophorum angustifolium	Tall Cottongrass	1	1	5	5
Gentianopsis procera	Smaller Fringed Gentian	1	5	25	25
Liparis loeselii	Yellow Widelip Orchid	1	5	5	5
Lobelia kalmii	Kalm's Lobelia	1	25	25	25
Oxypolis rigidior	Cowbane	-	5	5	-
Parnassia glauca	Grass of Parnassus	5	25	25	25
Primula mistassinica	Mistassinica	25	-	-	-
Rhynchospora capillacea THR	Hair-like Beakrush	25	25	25	25
Salix candida	Safeleaf Willow	5	5	5	-
Scleria verticillata THR	Low Nutrush	25	25	25	25
Symphyotrichum boreale	Northern Bog Aster	1	5	5	5
Triantha glutinosa	Sticky Tofeldia	5	25	-	-
Trichophorum cespitosum	Tufted Bulrush	5	25	25	-
Triglochin maritima	Seaside Arrowgrass	1	25	25	25
Triglochin palustris	Marsh Arrowgrass	25	25	25	25
Valeriana edulus THR	Edible Valerian	-	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. THR – State threatened; SPC – State special concern

Bryophytes

(IPV = frequency of occurrence in CF times the quotient of the frequency in CF with the frequency in non-CF ecotopes). The species with an IPV >1.000 are obligate and near-obligate (25 point) indicators, with and IPV >0.100 and <1.000 are facultative (5 point) indicators, and those with an IPV <0.100 are occasional (1 point) 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).

Obligate and near-obligate species. Calcareous fen indicator score = 25 points

					boreal	prairie		
Acronym	**Species name**	**IPV**	**n**	**n**	**CFB**	**CFP**	**CFP**	**CFP**
			CF	**tot**		**nw**	**se**	**sw**
BRYUULIG	Bryum uliginosum	inf.	1	1		0.06		
CATONIGR	Catoscopium nigritum	inf.	5	5	0.86	0.06		
PALUSQUA	Paludella squarrosa	inf.	3	3	1.29			
ANEUPING	Aneura pinguis	7.6766	52	75	1.62	4.26	3.53	7.52
LIMPCOSS	Limprichtia cossonii	6.0073	46	69	11.96	13.95	0.23	11.59
CAMPSTEL	Campylium stellatum	4.1284	67	138	15.52	39.76	9.53	15.82
DREPADUN	Drepanocladus aduncus	3.4381	74	178	4.09	2.60	14.04	16.84
BRYUPSEU	Bryum pseudotriquetrum	3.3978	76	187	6.68	18.22	3.60	10.94
BRACRIVU	Brachythecium rivulare	3.2648	50	100	2.48	1.94	15.24	3.72
CALRCUSP	Calliergonella cuspidata	2.7283	31	54	2.05	0.61	2.33	5.69
SCORSCOR	Scorpidium scorpioides	1.8590	22	39	4.74	5.09		
CINCSTYG	Cinclidium stygium	1.8283	14	21	3.13			
MOERHIBE	Moerckia hibernica	1.6324	15	24	2.59	0.55		
CALLTRIF	Calliergon trifarium	1.5196	16	27	3.34	1.33		
PLAGELLI	Plagiomnium ellipticum	1.4570	59	215	2.91	1.38	14.19	7.48
CAMPPOLY	Campylium polygamum	1.2612	26	61	4.09	1.05	1.88	3.33
FISSADIA	Fissidens adianthoides	1.0535	22	52	4.85	0.50	1.13	

Facultative species. Calcareous fen indicator score = 5 points.

					boreal	prairie		
Acronym	**Species name**	**IPV**	**n**	**n**	**CFB**	**CFP**	**CFP**	**CFP**
			CF	**tot**		**nw**	**se**	**sw**
AMBLVARI	Amblystegium varium	0.8392	28	89	0.54	0.28	3.90	1.07
TOMENITE	Tomenthypnum nitens	0.7384	21	60	2.37	0.72	0.15	
EURHHIAN	Eurhynchium hians	0.5224	12	30	0.43		1.50	

					boreal	prairie		
Acronym	**Species name**	**IPV**	**n**	**n**	**CFB**	**CFP**	**CFP**	**CFP**
			CF	**tot**		**nw**	**se**	**sw**
AMBLSEJU	Amblystegium serpens var. juratzkanum	0.5119	14	39	0.86	1.72	0.53	3.51
BRACSALE	Brachythecium salebrosum	0.3318	25	148	0.32	0.11	4.65	8.85
HAMALAPP	Hamatocaulis lapponicus	0.2612	2	3	0.32			
MEESTRIQ	Meesia triquetra	0.2612	4	8	0.65			
HELOBLAN	Helodium blandowii	0.2137	12	56	0.22	0.39	0.53	0.21
PSEATURG	Pseudo-calliergon turgescens	0.1959	3	6	0.11	0.89		
CRATFILI	Cratoneuron filicinum	0.1889	9	37	0.86	0.89	2.10	
CONACOMP	Conardia compacta	0.1632	5	15		0.06		0.43
HYPNLIND	Hypnum lindbergii	0.1582	19	168	0.86	0.72	2.85	0.09
CAMPSTPR	Campylium stellatum var. protensum	0.1469	3	7		0.83		1.71
DREPADPO	Drepanocladus aduncus var. polycarpus	0.1419	10	56	0.22	0.06	1.35	0.13
RICDLATI	Riccardia latifrons	0.1175	6	26	0.97			

Occasional species. Calcareous fen indicator score = 1 point.

					boreal	prairie		
			n	**n**	**CFB**	**CFP**	**CFP**	**CFP**
acronym	**species name**	**IPV**	**CF**	**tot**		**nw**	**se**	**w**
PLAGCUSP	Plagiomnium cuspidatum	0.0882	17	231	0.54	0.22	1.73	0.09
DREPSEND	Drepanocladus sendtneri	0.0871	2	5	0.11	0.22		
RICDPALM	Riccardia palmata	0.0840	3	10	0.43			
HYPNPRAT	Hypnum pratense	0.0837	10	88	0.22		2.18	0.09
LEPDHUMI	Leptodictyum humile	0.0804	4	17			0.45	0.13
ATRIUNDU	Atrichum undulatum	0.0653	1	2			0.08	
DREPSORD	Drepanocladus sordidus	0.0653	1	2	0.11			
ORTHPUMI	Orthotrichum pumilum	0.0653	2	6	0.11	0.06		
PHILCAPI	Philonotis capillaris	0.0653	1	2			0.08	
PHILMARC	Philonotis marchica	0.0653	1	2			0.08	
LESKPOLY	Leskea polycarpa	0.0615	4	21	0.22	0.17	0.08	0.17
AULAPALU	Aulacomnium palustre	0.0531	14	255	1.08	0.28	0.83	
BRYULICU	Bryum lisae var. cuspidatum	0.0522	2	7			0.15	
HYGATENA	Hygroamblystegium tenax	0.0495	5	38	0.11		0.45	
CAMPRADI	Campylium radicale	0.0454	4	27	2.05	0.06	0.08	
CALLGIGA	Calliergon giganteum	0.0452	6	58	0.97	0.17		
PLAHRIPA	Platyhypnidium riparioides	0.0373	2	9			0.23	

					boreal	prairie		
			n	n	CFB	CFP	CFP	CFP
acronym	species name	IPV	CF	tot		nw	se	w
MYULJULA	Myurella julacea	0.0367	3	19	0.32			
HAMAVERN	Hamatocaulis vernicosus	0.0348	4	34	0.75			
BRACDIGA	Brachythecium digastrum	0.0326	1	3			0.08	
DICEVARI	Dicranella varia	0.0326	1	3				0.04
PTEGFILI	Pterigynandrum filiforme	0.0326	2	10	0.11		0.08	
AMBLSERP	Amblystegium serpens	0.0320	5	56		0.06	0.53	0.04
HELOPALU	Helodium paludosum	0.0237	2	13			1.65	
BRACOEDI	Brachythecium oedipodium	0.0228	6	109	2.16		0.60	
CAMPCHRY	Campylium chrysophyllum	0.0227	4	50	0.22	0.17	0.23	
HELOBLHE	Helodium blandowii var. helodioides	0.0218	1	4			0.15	
RICRNATA	Ricciocarpos natans	0.0218	1	4		0.06		
CLIMAMER	Climacium americanum	0.0201	2	15			0.23	
LESKGRAC	Leskea gracilescens	0.0163	3	39	0.43		0.15	
ATRIALTE	Atrichum altecristatum	0.0154	2	19			0.15	
BRACPLUM	Brachythecium plumosum	0.0154	2	19			0.15	
SPHAWARN	Sphagnum warnstorfii	0.0146	5	117	2.26			
BRACACUM	Brachythecium acuminatum	0.0143	4	77			0.23	0.13
ENTOSEDU	Entodon seductrix	0.0137	2	21			0.08	0.04
THUIRECO	Thuidium recognitum	0.0137	5	124	0.97		0.08	
PLATDENT	Plagiothecium denticulatum	0.0134	4	82	0.11	0.06	0.45	
CEPHPLSP	Cephalozia pleniceps ssp. sphagnorum	0.0131	1	6	0.11			
FISSDUBI	Fissidens dubius	0.0131	2	22			0.30	
FRULINFL	Frullania inflata	0.0131	1	6	0.11			
PYLLSELW	Pylaisiella selwynii	0.0122	3	51	0.32		0.08	
LOPCHETE	Lophocolea heterophylla	0.0118	5	143	0.11	0.11	0.30	0.04
MARCPOLY	Marchantia polymorpha	0.0104	2	27		0.06	0.15	
WARNEXAN	Warnstorfia exannulata	0.0104	2	27		0.06	0.08	
CAMPHISP	Campylium hispidulum	0.0095	3	65	0.54		0.08	
BRACOXYC	Brachythecium oxycladon	0.0093	2	30			0.15	
PHYTPYRI	Physcomitrium pyriforme	0.0093	1	8			0.08	
SPHAFUSC	Sphagnum fuscum	0.0084	4	129	0.65			
CEPHCOCO	Cephalozia connivens var. compacta	0.0082	1	9	0.32			
PHILFONT	Philonotis fontana	0.0082	1	9			0.53	

					boreal	prairie		
			n	n	CFB	CFP	CFP	CFP
acronym	species name	IPV	CF	tot		nw	se	w
PLADJUNG	Platydictya jungermannioides	0.0082	1	9				0.09
RHIZGRAC	Rhizomnium gracile	0.0082	1	9	0.11			
FISSOSMU	Fissidens osmundioides	0.0077	2	36	0.43			
LEPDRIPA	Leptodictyum riparium	0.0077	2	36			0.08	0.04
SPHAFIMB	Sphagnum fimbriatum	0.0069	2	40			0.75	
FRULOAKE	Frullania oakesiana	0.0065	1	11	0.11			
CONCCONI	Conocephalum conicum	0.0061	2	45	0.11		0.08	
THUIDELI	Thuidium delicatulum	0.0060	3	101			0.38	
PLACASPL	Plagiochila asplenoides	0.0053	2	51	0.22			
BRACPOPU	Brachythecium populeum	0.0038	1	18			0.23	
MYLIANOM	Mylia anomala	0.0036	1	19	0.11			
TORLFRAG	Tortella fragilis	0.0036	1	19	0.22			
CHILPALL	Chiloscyphus pallescens	0.0034	1	20			0.08	
POLYSTRI	Polytrichum strictum	0.0032	3	187	0.43			
ATRIOERS	Atrichum oerstedianum	0.0028	1	24			0.08	
DISTCAPI	Distichium capillaceum	0.0028	1	24	0.11			
LEPTPYRI	Leptobryum pyriforme	0.0028	1	24	0.11			
TAXIDEPL	Taxiphyllum deplanatum	0.0027	1	25			0.08	
SPHAANGU	Sphagnum angustifolium	0.0026	3	227	0.22		0.08	
BRACERYT	Brachythecium erythrorrhizon	0.0026	2	104	0.11	0.06		
BRYERECU	Bryoerythrophyllum recurvirostre	0.0023	1	30		0.06		
SPHACAPI	Sphagnum capillifolium	0.0018	2	146	0.11		0.15	
STEESERR	Steerecleus serrulatus	0.0017	1	39			0.08	
CLIMDEND	Climacium dendroides	0.0015	2	175			0.75	
ORTHOBTU	Orthotrichum obtusifolium	0.0015	1	45	0.11			
PLAGCILI	Plagiomnium ciliare	0.0014	1	47				0.17
SPHASUSS	Sphagnum subsecundum s.s.	0.0013	1	50			0.08	
SPHASQUA	Sphagnum squarrosum	0.0013	1	51			0.08	
CEPHCONN	Cephalozia connivens	0.0012	1	56	0.11			
ORTHELEG	Orthotrichum elegans	0.0011	1	61	0.11			
POLYCOMM	Polytrichum commune	0.0011	1	63			0.08	
BRACREFL	Brachythecium reflexum	0.0010	1	64			0.08	
ENTOCLAD	Entodon cladorrhizans	0.0010	1	66			0.08	
PLEUSCHR	Pleurozium schreberi	0.0009	2	297	0.22			

					boreal	prairie		
			n	n	CFB	CFP	CFP	CFP
acronym	species name	IPV	CF	tot		nw	se	w
PYLLPOLY	Pylaisiella polyantha	0.0009	1	76		0.17		
DICRUNDU	Dicranum undulatum	0.0008	1	79	0.11			
CERAPURP	Ceratodon purpureus	0.0008	1	83			0.08	
EURHPULC	Eurhynchium pulchellum	0.0008	1	84			0.30	
SPHACENT	Sphagnum centrale	0.0008	1	87			0.15	
ANOMMINO	Anomodon minor	0.0007	1	95	0.11			
HYLOSPLE	Hylocomium splendens	0.0007	1	96	0.11			
CALLCORD	Calliergon cordifolium	0.0007	1	101			0.15	
PLAYREPE	Platygyrium repens	0.0004	1	162	0.11			
PTIDPULC	Ptilidium pulcherrimum	0.0004	1	168	0.11			
DICRPOLY	Dicranum polysetum	0.0004	1	176	0.11			
SPHAMAGE	Sphagnum magellanicum	0.0003	1	241	0.11			

Appendix 9. Bryophyte Survey and Collection ProceduresBRYOPHYTES OF CALCAREOUS FENS: MINIMUM REQUIREMENTS FOR SUBMISSION OF COLLECTIONS FOR IDENTIFICATION AND SUGGESTIONS ON SURVEY PROCEDURE

Joannes A. Janssens, Lambda-Max Ecological Research, 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 ecotope (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 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.

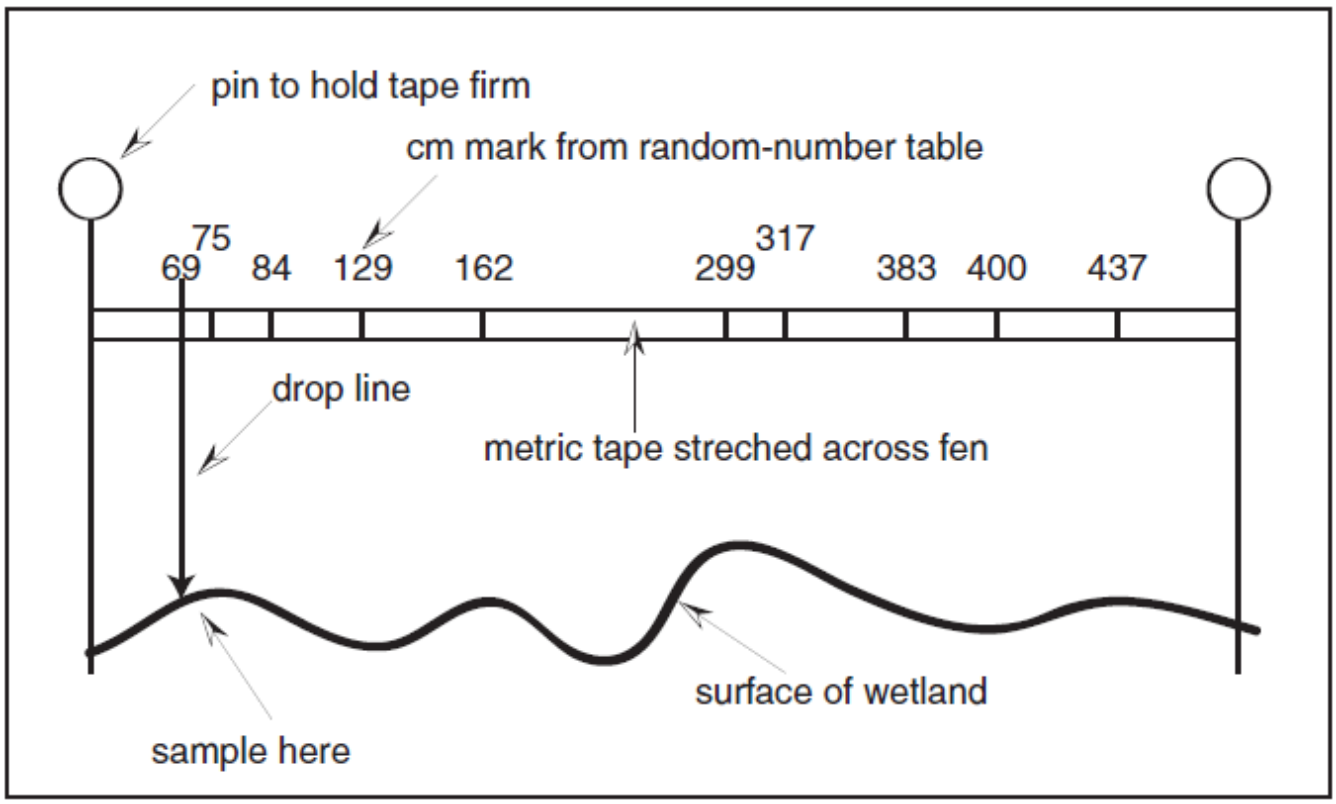


Figure 1. Point-intercept sampling. Sample at the reading along the tape (from 0 to 500 cm) that corresponds to the number in a row from the random-number table (see Appendix). In this example the sample is taken at 69 cm, 75 cm, 84 cm, etc., until 10 sample locations are identified for the 5-meter transect.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

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

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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