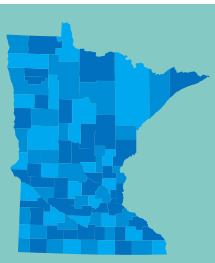
Biological monitoring

December 2019

Wetland monitoring standard operating procedures

Vegetation sampling procedures for wetland biological monitoring sites

MINNESOTA POLLUTION CONTROL AGENCY



Authors

Michael Bourdaghs

Contributors/acknowledgements

Mark Gernes

Minnesota Pollution Control Agency

520 Lafayette Road North | Saint Paul, MN 55155-4194 |

651-296-6300 | 800-657-3864 | Or use your preferred relay service. | Info.pca@state.mn.us

This report is available in alternative formats upon request, and online at www.pca.state.mn.us.

Document number: wq-bwm3-01

Contents

1. Purpose and scope

To describe the methods used by the Minnesota Pollution Control Agency (MPCA) Biological Monitoring Program to sample vegetation at wetland biological monitoring Sample Sites.

This procedure applies to vegetation sampling at all established wetland biological monitoring Sample Sites. An established Sample Site has successfully passed through MPCA wetland site evaluation procedures. Site evaluation must be implemented prior to conducting any wetland vegetation sampling.

2. General information

The Sample Site is the wetland area that is being represented by any MPCA field sampling. Sample Site boundaries need to be defined for all MPCA wetland monitoring.

Wetland Sample Sites may be selected/targeted for monitoring for a number of purposes including:

- Randomly selected sample sites as part of ongoing wetland quality status and trends surveys
- Supporting information for MPCA Intensive Watershed Monitoring and stressor identification of streams and lakes
- Sample sites selected for the development and calibration of wetland monitoring approaches and assessment criteria
- Long-term trend monitoring at designated Sample Sites
- Effectiveness monitoring of permitted activities

Different vegetation sampling approaches may be required depending on the purpose.

All MPCA wetland Sample Sites must pass through MPCA wetland site evaluation prior to being sampled for vegetation. Please refer to the MPCA procedure for evaluating Minnesota Wetland Condition Assessment sample sites if the Sample Site is part of the Minnesota Wetland Condition Assessment (MWCA) or the procedure for evaluating wetland biological monitoring sample sites for all other monitoring purposes.

The purpose of MPCA wetland vegetation sampling is to provide data to complete Floristic Quality Assessment (FQA) metrics and condition categories at wetland Sample Sites. FQA is the MPCA's primary approach to assessing wetland vegetation condition.

3. Requirements and responsibilities

3.1 General qualifications

All personnel conducting wetland vegetation monitoring must have the ability to perform rigorous physical activity in an outdoor setting. It is often necessary to hike long distances through rugged terrain to reach a wetland monitoring site. Walking and wading through wetlands for prolonged periods is required to perform field site evaluation and any wetland sampling.

3.2 Field crew leader

The field crew leader must be a professional aquatic biologist with a strong working knowledge of Minnesota's wetlands and wetland flora with a minimum of a Bachelor of Science degree. Field crew leaders should also possess excellent map reading and orienteering skills and a demonstrated proficiency with both compass and Global Positioning System (GPS). The field crew leader is responsible for implementing the action steps of the procedure and ensuring that the data generated meets the standards and objectives of the MPCA.

3.3 Field technicians/student workers

Field technicians/student workers must have at least one year of college education and coursework in environmental, natural resource, and/or biological science and an interest in becoming a natural resource professional. Field technicians/student workers are responsible for implementing the action steps of the procedure — including data recording and the maintenance, stocking, and storage of sampling equipment.

4. Training

All inexperienced personnel will receive instruction from a trainer designated by the unit supervisor. Major revisions of this protocol require that all personnel that apply this procedure be re-trained by experienced personnel. Field crew leaders will provide additional instruction to the field technicians/student workers and will be responsible for assessing their performance throughout the field season.

5. MPCA wetland vegetation sampling

MPCA wetland vegetation sampling generally consists of the following steps:

- Identify and map the plant communities that occur in the Sample Site.
- Employ a meander type survey such that a representative area of plant communities present in the Sample Site are observed.
- Identify and record the plant taxa present in each community as the meander progresses.
- Make aerial cover estimates for each taxa present by community type.

The specific sampling approach and level of taxonomic resolution required will depend on the project (i.e., monitoring purpose) the Sample Site is being monitored for over a sampling event (i.e., a sampling visit). Typically, field site evaluation is the first activity completed during a vegetation sampling visit (i.e., site evaluation and sampling are completed during the same visit). The project is designated during site evaluation.

The following sub-sections describe the detailed steps required to complete a MPCA wetland vegetation sample — with specific activities required by project as necessary.

Two types of forms will need to be completed during a wetland vegetation sampling visit:

- Visit form — information about the Sample Site and the activities completed at the time of the visit

- Community data form — information about a community present at the Sample Site during the visit and the plant taxa that occur in that community

Each sampling event at a Sample Site constitutes a visit. Wetland Sample Sites may have multiple plant communities present. An individual community data form will be required for each community present at the Sample Site during a visit (i.e., a visit may require multiple community data forms).

Both types of forms apply to all wetland MPCA vegetation sampling visits. The project and sample type will need to be specified for all visits. Forms can be provided upon request.

5.1 Equipment check

Prior to leaving on a vegetation sampling mission, check that all necessary equipment to complete this procedure is present and in proper working condition (Table 1).

Check that the field GPS has the following settings:

- Datum = NAD 83
- Coordinate format = Decimal Degrees
- Range Units = Meters
- Tracking = On

Check that the camera is fully charged, has sufficient memory to hold a week's worth of pictures, and the date/time are set properly.

Table 1. Equipment list for wetland vegetation sampling procedure.

Navigation	Personal/Safety Equipment	Data Recording	Plant Specimen Collection Equipment	Miscellaneous
Navigation GPS (w/points loaded)*	Cell phone	Site evaluation form	Aquatic veg sampler	Necessary permits
	Satellite Messenger	Site map	Hand lens	Batteries
DeLorme atlas*	Waders/knee boots	Visit form	Plastic bags	Copy of procedure
Field GPS (w/points loaded)	Rain gear	Community data form(s)	Labels	Device cords/chargers*
	First aid kit	Digital camera	Clippers	Laptop*
Access map	Drinking water/food	Clipboard	Random number table	Spray tank for invasive sp. decontamination*
Compass	Sunscreen/insect repellent	Pencils/markers	Plant press kit*	
		Field guides		

* indicates equipment that remains in the vehicle during sampling

5.2 Record visit information

Field site evaluation is typically the first activity completed during a vegetation sampling visit. Much of the information that is recorded in the visit information section of the Visit form is redundant with information recorded on the site evaluation form. This is necessary in the case of Sample Site identifiers, date, and project to properly relate all of the data forms together.

Complete the following boxes on the Visit form:

- **Sample Site ID** — MPCA Sample Site identifier, format = 2-digit year site first established/4-letter county code/3-digit sequential number starting at 001 for the County the site is located in OR (for MWCA/DWCA projects) the 3-digit number associated with the EPA site ID
- **EPA ID** — EPA site ID for MWCA or Depressional Wetland Quality Assessment (DWQA) Sample Sites
- **Visit result:**
  - Reportable — indicates primary sample/visit for the Sample Site for the year
  - Replicate — indicates repeat sample/visit for the Sample Site for the year for quality assurance/quality control (QA/QC) purposes
  - NonReportable — sample/visit does meet quality standards, data not used in reporting
- **Crew leader** — crew leader name
- **Assistant** — crew assistant name(s)
- **Date** — visit date (mm/dd/yyyy)
- **Project** — designated MPCA wetland monitoring project (see the Site Evaluation procedure for project definitions, if other — specify the project in the space provided)

5.3 Take pictures

Pictures are required for all sampling visits, regardless of the project (i.e., monitoring purpose). An important concept for all pictures is to record the time the pictures were taken. Time will be used to properly match downloaded pictures to visits such that pictures can be saved in appropriate file directories after sampling has been completed.

5.3.1 MWCA pictures

The MWCA requires a specific set of pictures. The sequence of taking the pictures is very important. When done in proper order (without other pictures taken in between), the pictures can be rectified to a visit easily based on recording a single time on the Visit form.

Pictures of the MWCA POINT and a shifted POINT (if necessary) are normally taken during site evaluation. Taking remaining required MWCA pictures is the first activity completed during sampling. For organization, the checklist for POINT and shifted POINT (if necessary) pictures has been placed on the Visit form along with the checklist for all of the other pictures.

MWCA pictures should be taken in the following sequence:

- Overview of the original POINT
- Overview of the shifted POINT (if POINT was shifted)
- Overview of the CENTER (if a different location than the POINT or the shifted POINT)
- View from the center along each cardinal direction—starting at north and proceeding in a clockwise fashion (i.e., North/East/South/West)

Record the **time the POINT picture was taken** in the MWCA pictures section of the Visit form. Check the appropriate pictures boxes to affirm that pictures were actually taken.

5.3.2 Pictures for all other projects

Representative pictures of the plant communities present at the Sample Site are emphasized for all projects other than the MWCA. Non-MWCA Sample Sites can be much larger in size than MWCA Sample

Sites and they may not have a defined center prior to sampling. For non-MWCA project sample visits, representative community pictures is preferably done while plant communities are being determined (Section 5.4) or during meander sampling (Section 5.7).

Each community type identified during a visit is designated a community number in the Plant Community Information section of the Visit form. When a representative picture is taken for a community type, check the box to the corresponding community number in the pictures section of the Visit form, and record the time the picture was taken. Individual times are recorded for each representative community picture as there may be lags between navigating to the different communities during sampling.

Table 2. Plant community classes adapted from Eggers and Reed (2015) and brief descriptions.

Community Class	Community Class Description
Shallow Open Water	Open water aquatic communities with submergent and/or floating leaved aquatic species
Deep Marsh	Emergent vegetation rooted within the substrate that is typically inundated with > 6" of water. Submergent and floating leaved aquatic species typically a major component of community
Shallow Marsh	Emergent vegetation on saturated soils or inundated with typically < 6" of water. May consist of a floating mat. Submergent and floating leaved aquatic species typically a minor component
Fresh Meadow	Graminoid dominated, soils typically saturated
Wet Prairie	Similar to Fresh Meadow but dominated by prairie grasses
Calcareous Fen	Soils calcareous peat (i.e., organic w/high pH) due to groundwater discharge with high levels of calcium/magnesium bicarbonates. Specialized calcareous indicator species (calciphiles) present-dominant
Rich Fen	Graminoid dominated communities on circumneutral or slightly acidic peat soils. Often occurs as a floating mat and *Carex lasiocarpa* (wiregrass sedge) is often a dominant
Shrub-Carr	Tall shrub community typically dominated by Willows (*Salix* spp.). Typical understory species composition similar to Fresh Meadow
Alder Thicket	Tall shrub community typically dominated by Alder (*Alnus incana* ssp. *rugosa*)
Open Bog	Low shrub or graminoid dominated community on a mat of *Sphagnum* moss/acidic deep peat. Specialized acid tolerant (indicator) species dominant
Coniferous Bog	Forested community dominated by coniferous trees on a mat of *Sphagnum* moss/acidic deep peat. Specialized acid tolerant (indicator) species dominant
Coniferous Swamp	Forested community dominated by coniferous trees on saturated soils. Soils typically circumneutral to acidic
Hardwood Swamp	Forested community dominated by deciduous hardwood trees on saturated soils
Floodplain Forest	Forested community dominated by deciduous trees on alluvial soils associated with riverine systems

5.4 Determine and map the plant communities

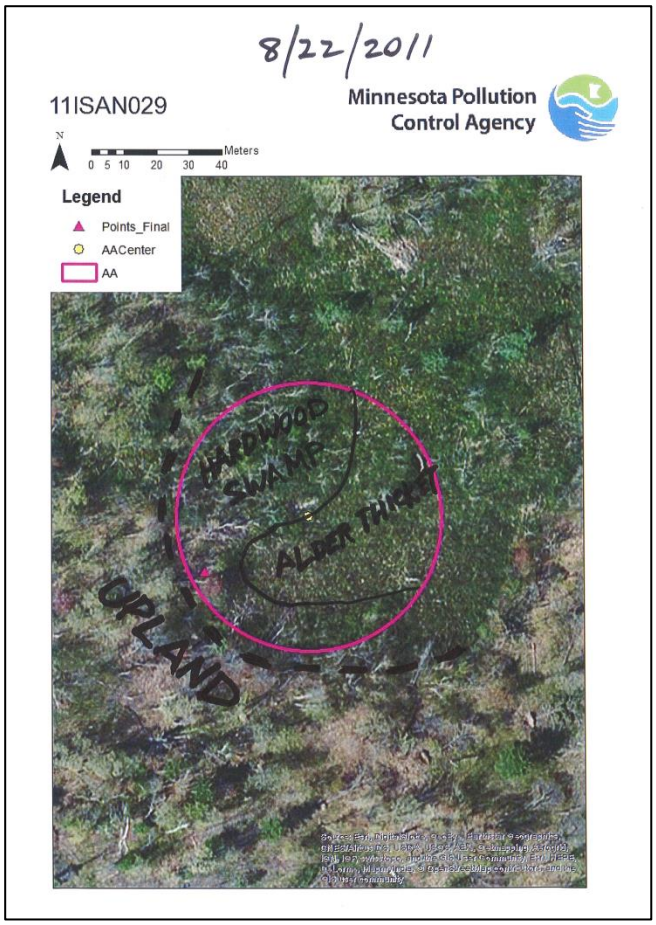
The plant community is the basic unit sampled in this procedure. Often, multiple plant communities are present within a Sample Site. Initial effort needs to be spent making plant community determinations and mapping the community extent within the Sample Site before sampling can begin. Plant community maps will be digitized after sampling has been completed.

The MPCA follows a modified version of the Eggers and Reed (2015) plant communities of Minnesota and Wisconsin (Table 2). Use the plant community key provided in Appendix 3 to make determinations based on field observations and photo interpretation of the site map.

Map the approximate plant community boundaries on the site map (Figure 1). Clearly label the communities according to the types in the key (Appendix 1, Table 2) on the map. In addition, annotate the site map with any other relevant information such as:

- The location of any water chemistry sampling (if necessary)
- Upland or deepwater habitat boundaries
- Natural features that may support a different suite of species compared to the matrix community (e.g., beaver lodges)
- Any local human impacts (e.g., vehicle rutting, plowing)

Figure 1. Example annotated site map for a MWCA site. The plant communities within the Sample Site have been delineated as well as the upland boundary. The visit date was also recorded.



5.4.1 Minimum mapping unit

A Minimum Mapping Unit (MMU) is the size of the map unit below which a feature can be reasonably interpreted and represented by a polygon for a given scale. MMU's are a key element in natural resource mapping. The difficulty in applying a MMU in this protocol is that MPCA Sample Sites can be variable in size, typically ranging from 0.1 ha to 250 ha. In other words, the scale of the community mapping is somewhat dependent on Sample Site size. The larger the Sample Site, the greater the community mapping will be based on aerial photo interpretation of the site map and less on direct observation.

Plant community mapping should be done according to the following MMU guidelines:

- Sample Site area = 0.1 to 1 ha:
  → MMU = 400 m^2 (based on 2011-12 MWCA polygon size distribution)
- Sample Site area = 1 to 250 ha
  → MMU = 1,000 m^2 (based on U.S. Fish and Wildlife Service National Wetland Inventory mapping standards @ ¼ acre)

The intent of the MMU guidelines is to produce greater mapping consistency between field crews. Community polygons can be smaller than the guidelines if they are readily interpretable at the scale of the site map aerial photos. However, if they are below the MMU and not readily interpretable as a separate community on the aerial photo — they should not be mapped and the feature should be treated as an inclusion within the larger matrix community.

Community polygons can also be below the MMU when a Sample Site covers a portion of a larger wetland area and a community that is clearly interpretable at the larger wetland scale is present, but only a small (< MMU size) portion lies within the Sample Site boundary. These should be mapped as separate communities and separate data should be collected for them.

5.4.2 Problematic cases

The plant communities followed here are often readily identifiable in the field; however, much variation exists which can make community interpretation challenging. When attempting to interpret types and boundaries the observer may be faced with:

- A Sample Site where the communities have recently changed or are in the process of changing from one type to another
- Adjacent communities that broadly intergrade such that significant area exists where the community characteristics are intermediate
- A wetland transition zone between the upland boundary and the predominant community in the wetland that receives enriched runoff from the upland relative to the larger wetland (i.e., a lagg zone). This is common at the margins of raised bogs and present in many other wetland community types
- Distinct but small portions of different communities within a larger matrix community
- Species composition/abundance distribution changes or wholesale type changes due to human impacts

Regardless of the situation, the observer is required to make a determination (and map the boundaries) to only one of the communities listed on Table 2. Mapping and sampling mixed communities should be avoided in this procedure as the metrics and assessment outcomes produced from the data are calibrated by community type.

When faced with difficult interpretation scenarios, the observer will have to make decisions based on the weight of evidence and may have to make broader interpretations on the ecology and site history beyond the scope of what is simply provided in the plant community key (Appendix 3). In some instances, reviewing past aerial imagery can be used to help identify changes over time.

Follow the guidelines provided below for common problematic cases:

- **For communities that have changed or are in the process of changing:** Wetlands are dynamic ecosystems where community types can change naturally due to changing conditions. They can also change due to human impacts. The goal of MPCA wetland monitoring is detect and describe vegetation condition changes due to human impacts, thus the interpretation of a community that has recently changed (or is in the process of changing) depends on whether it can be clearly attributed to a human impact. In all cases, evidence of recent change must be present. Examples include:
  - Remnant characteristic species or features (e.g., hummocks) of a former type
  - Dead or dying shrubs or trees
  - Evidence of logging or shrub removal
  - Plow furrows
  - Historic aerial photography and/or landowner accounts

  If compelling evidence of a former type exists, the next step is to determine if a human impact caused the type conversion. If the change is clearly attributable to a direct human impact (e.g., plowing, logging, hydrologic alterations from control structures/road beds/drainage) *and*

evidence of the former type is present — the community should be interpreted as the former type. If the change cannot be clearly attributed to a direct human impact — the community should be interpreted as the present type (Figure 2).

- **For communities with intergrading/intermediate characteristics:** First, look for evidence of a former type and a human impact, and (if present) follow the previous guidance. If a human impact is not apparent, then use a weight of evidence approach to interpret the best type the area falls under. Combined types (e.g. Fresh Meadow/Shrub-Carr) are prohibited in this procedure.
- **For lagg zones:** Estimate the area of the lagg zone within the Sample Site boundary. If the lagg is below the MMU guidelines (Section 5.4.1), consider the lagg as an inclusion within the larger matrix community. If the lagg is greater than the MMU guidelines and can be interpreted as a distinct community, map and sample the area as a separate community within the Sample Site.
- **For small/distinct portions of different communities within a larger matrix community:** Treat the same as laggs. If the portion(s) is smaller than the MMU, consider as an inclusion. If greater than the MMU, map and sample as a separate community.

In all cases where community interpretation is difficult, the observer should fully describe the conditions that are present and the rationale behind interpretation decisions in the comments section of the Community Data form for that community.

Figure 2. Two wetland monitoring Sample Sites that were formerly Coniferous Swamp that have been converted into Shallow Marsh due to increased water levels. Site A (where the once dominant black spruce have died and lake sedge is now dominant) was due to a beaver dam in an otherwise un-impacted setting. Site B (where the northern white cedar were flooded out and a mixture of native and invasive cattails has taken over) was due to the construction of an improperly culverted roadbed which raised the water level. Site A is considered a natural change and should be sampled and assessed as a Shallow Marsh. Site B should be sampled and assessed as an impacted Coniferous Swamp as evidence of a former type and a human impact are both present.

A

B

5.5 Start the Community Data form(s)

A Community Data form is required for each community identified and mapped in the Sample Site. For each form, first complete Visit Information section and designate the Plant Community.

Record the **Sample Type** that will be used to collect the vegetation data (Table 3). The primary sampling approach employed by the MPCA is a meander, where the observer walks a path within the Sample Site

that covers representative portions of each community present. The MPCA employs variations of the meander approach based on the taxonomic resolution that is required and whether or not meander time limits are applied. These variations are based on the Project Type that the Site is being sampled for.

The MPCA primarily employs a shoreline sampling approach for the Shallow Open Water community type, where sampling by foot is often prohibited by water and sediment depth.

Table 3. MPCA wetland vegetation Sample Types. Sample Types are based on combinations of the basic approach (meander vs. plot), the taxonomic resolution required for the sample (all species vs. rapid species), whether meander time limits are applied (no time limit vs. timed), and by wetland class. Typical Projects that employ various Sample Types are provided.

Sample Type	Approach	Taxonomic Resolution	Time Rules	Wetland Classes	Projects
A	meander	all species	no time limit	Emergent/Scrub-Shrub/ Forested	MWCA, Program Development
B	meander	all species	timed	Emergent/Scrub-Shrub/ Forested	DWCA, Trend, Program Development
C	meander	rapid species	timed	Emergent/Scrub-Shrub/ Forested	Watershed Support, Regulatory
D	shoreline	all species	NA	Open Water	MWCA, DWCA, Prog. Dev, Trend
E	shoreline	rapid species	NA	Open Water	Watershed Support, Regulatory
F	plot	all species	NA	All	Program Development, Other

In addition, the MPCA occasionally samples wetland vegetation using plots. When plot sampling is done, they will be established to represent a community type within the Sample Site. If plots are to be used, also record the plot dimensions on the Community Data form.

Detailed Sample Type descriptions and instructions are provided in Section 5.7.

Other pieces of basic information are required for each community and recorded on Community Data form:

- **Standing water depth (cm):**
  - **Predominant** — standing water depth over the majority of the community area
  - **Max** — maximum standing water depth
  - **Min** — minimum standing water depth
- **Vegetated cover in community (%)** — aerial cover of the community when all vascular plant species are considered simultaneously
- **Floating mat** — check box if the community predominantly exists as a floating mat within the Sample Site

These observations are typically recorded after sampling has been completed. This allows the observer to have covered representative locations within each community to develop a more comprehensive observation of the community as a whole and measure various water depths throughout.

5.6 Conduct water chemistry sampling (if needed)

Water chemistry samples are occasionally taken during a wetland vegetation sampling visit in open water wetlands. When a water chemistry sample is required, refer to the Water chemistry assessment protocol for wetland monitoring sites for instruction. Space has been provided in the Vegetation Visit

form to conveniently record water chemistry monitoring results. Water chemistry sampling should be completed prior to vegetation sampling to avoid disturbing sampleable water via foot traffic.

5.7 Conduct vegetation sampling

The primary sampling approach employed for emergent, scrub-shrub, and forested wetlands by the MPCA is a meander, where the observer walks a path within the Sample Site that covers representative

portions of each community present. Plant species (or taxa at higher taxonomic divisions) are recorded by community type as the meander progresses. The observer is also required to continuously make mental observations of the areal cover of each species by community type. At the end of the meander, cover estimations are made for each species by community type.

The meander sampling approach provides great flexibility to meet the challenge of sampling wetland Sample Sites of varying size and complexity. Meander samples (when data are collected by community type) provide consistently similar results to community plot based approaches and sufficient data to produce Floristic Quality Assessment outcomes — the MPCA's wetland vegetation assessment method. Meander samples can be less complex to employ in the field as they do not require time/equipment to setup and can cover a greater area than a standardized plot (i.e., generate a more representative sample).

The MPCA primarily employs a shoreline sampling approach for the Shallow Open Water community type. Often excessive water depth and the presence of deep unconsolidated muck are prohibitive to sampling this type by foot. Shoreline sampling generally consists of establishing three stations along the emergent/aquatic vegetation interface at representative locations where species observations are made in the immediate vicinity of each station and by using aquatic rake-tows.

Finally, the MPCA occasionally samples wetland vegetation using plots. When plot sampling is done, they will typically be established to represent a community type within the Sample Site and thus producing comparable data to the meander approach described above.

Detailed vegetation **Sample Type** (Table 3) descriptions and instructions are provided in the following sub-sections.

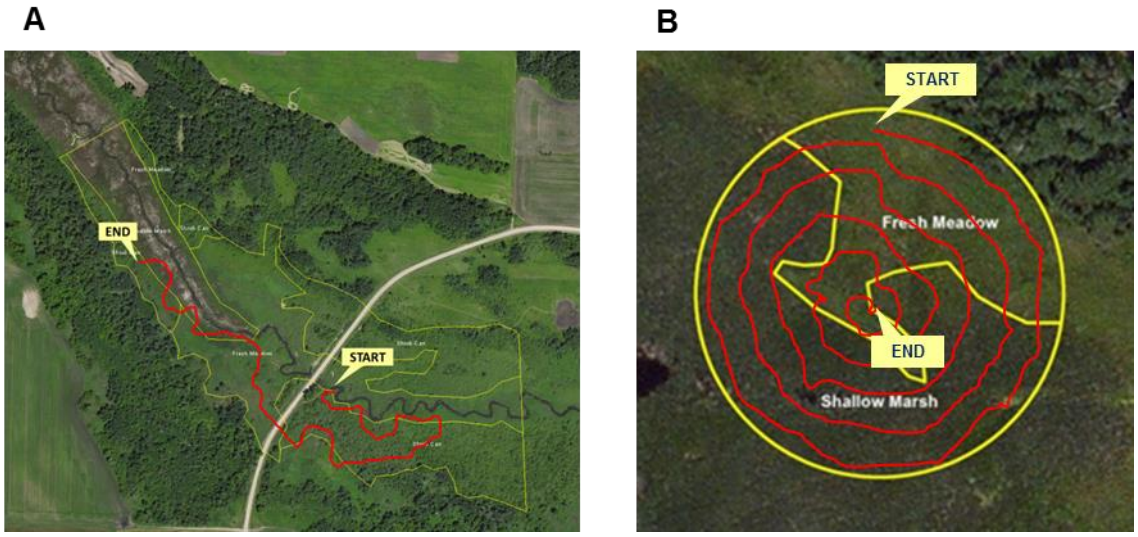
5.7.1 Sample Type A (meander/all spp./no time limit)

Sample Type A is a meander sample that captures all species/taxa observed with no time limit for the meander and is used in emergent, scrub-shrub, and forested wetlands. All communities within the Sample Site boundary are observed in a single composite meander; however, data are recorded separately by community type. Sample Type A is used in the MWCA where all Sample Sites are ≤ 0.5 ha and for program development projects that require complete vegetation data.

Complete the following steps:

1) Begin the meander in a representative area (i.e., the most typical) of community #1 (Figure 3)
2) Record **Scientific Name** of the vascular plant species/taxa observed in the Species Data section of the Community Data form. Plants must be rooted in the community to be considered present (e.g., if trees are rooted on adjacent uplands but overhang into the community, they are not counted as present)
3) Each time a community boundary is crossed, switch to the appropriate Community Data form that has been established (Section 5.4) for that type

Figure 3. Example meander sample paths. A) A moderately sized riparian wetland Sample Site (18 ha) with three different community types present (Fresh Meadow, Shrub-Carr, and Shallow Marsh). Sample Type C (timed meander/rapid spp.) was conducted. The meander was started in a representative location and was conducted such that roughly equal amounts of time were spent in each community. B) A MWCA Standard Circular Site (0.5 ha). Sample Type A (no time limit/all species) was conducted. The meander was started near northern boundary edge and proceeds in concentric circles in clockwise fashion towards the CENTER.



4) Tree species should be recorded as an aggregated group and separately by **Height Class** (Table 4). Height Class (HC) is a basic type of ecological structure data in forested wetlands. Areal cover will be estimated for all HC's of each tree species when completing Sample Type A. The aggregated HC (A) indicates the cover for the species aggregated as whole (i.e., the tree species cover when different HC's are not considered). For each tree species encountered, first create a record with HC = A. Next, create subsequent records for each predominant HC individuals of the tree species occur in.
5) Record a **Reliability Code** for each taxa record (Table 5). The Reliability Code indicates the level of certainty of the identification of the taxa record. All plant taxa observed should be identified to the lowest taxonomic division possible in the field. However, it is often not possible to identify all of the plant taxa present at a Sample Site to the species or ssp./var. level during sampling. When this occurs, record a higher taxonomic level name for the taxa (i.e., Genus, Family, etc.) and record the appropriate Reliability Code.
6) Collect specimens of unknown taxa as they are encountered (See Section 5.8)
7) As the meander proceeds, continuously make mental observations of the areal cover of each species by community type. At the end of the meander, cover estimations are made for each taxa record by community type (See Section 5.9)
8) Proceed with the meander until either the entire Sample Site has been observed or sufficient/representative portions of all communities within the Sample Site have been observed.

Table 4. Height classes and ranges (m) for tree species.

Height Class	Range (m)
A	Aggregated
6	> 30 m
5	> 15 - 30 m
4	> 5 - 15 m
3	> 2 - 5 m
2	> 0.5 - 2 m
1	> 0 - 0.5 m

Use the following meander path for Standard Circular and Standard Circular-Shifted MWCA Sample Sites (Figure 3B):

- Use the range finder on the field GPS to navigate approximately 35 m due north from the CENTER
- Proceed in a circular pattern around the CENTER staying at an approximate 35 m radius (using the GPS to indicate the distance from the CENTER) for a complete circle
- Move approximately 5 m closer to the CENTER and complete another circle in the same fashion
- Repeat the pattern at 5 m increments until the CENTER has been reached
- The meander is now complete

Table 5. Plant identification reliability codes.

Code	Description
7	Unknown
6	cf. Genus
5	Genus certain
4	cf. species
3	species complex
2	species certain
1	cf. var/ssp.
0	var/ssp. certain

5.7.2 Sample Type B (meander/all spp./timed)

Sample Type B is similar to Type A, except that there is a time limit. The time limit indicates when sufficient sampling has been completed such that further sampling typically does not change the assessment outcome. Sample Type B is used in the DWCA, Trend, and program development projects where the Sample Sites have a large range of area (0.1 – 250 ha).

To conduct a Sample Type B, complete steps 1-9 of Sample Type A (Section 5.7.1) **and** apply the following time rules:

1) Determine the base meander time. The base meander time is the minimum amount of required sampling time for a Sample Site. It varies according to the number of different communities present. The base meander time is determined as:
   - 30 minutes for the first community
   - Add 20 minutes for each additional community

   For example, if the Sample Site includes: Fresh Meadow, Shrub-Carr, and Shallow Marsh communities—the base meander time = 30 + 20 + 20 minutes.
2) Begin the meander in a representative area (i.e., the most typical) of community #1 and proceed in a path such that approximately equal amounts of time are spent in each community (Figure 3A).
3) The meander ends (or continues) based on the number of new taxa observed near the end of the base meander time:
   - During the final 10 minutes of the base meander time begin keeping track of any new taxa encountered
   - If < 6 new taxa are observed—stop the meander, sampling is complete
   - If ≥ 6 new taxa are observed—continue the meander for an additional 10 minute period
   - Continue adding 10 minute periods to the meander until < 6 new taxa are observed in a 10 minute period
   - Once this occurs, sampling is complete

5.7.3 Sample Type C (meander/rapid spp./timed)

The MPCA has developed a novel rapid sampling approach that relies on the timed meander sampling and a simplified plant species checklist of the most common and easier to identify wetland plant species in Minnesota (i.e., the rapid species list). This approach (the Rapid Floristic Quality Assessment) was

designed for natural resource professionals that have a moderate level of botanical expertise to produce scientifically based wetland vegetation condition assessments within a reasonable timeframe.

Sample Type C is the Rapid Floristic Quality Assessment (FQA) and is used in Watershed Support and Regulatory monitoring projects. It is similar to Sample Type B except that only the species that are on the Rapid Species List are recorded when they are observed. Please refer (and follow) the Rapid FQA Manual and use the Rapid FQA data form to complete Sample Type C.

5.7.4 Sample Type D (shoreline/all spp.)

Sample Types A-C are employed in emergent, shrub-scrub, and forested wetland types. In open water/aquatic wetlands, water depth and/or the presence of deep unconsolidated muck often prohibit sampling by foot. A shoreline sampling approach has been developed to reliably sample vegetation in open water/aquatic wetlands adapted from rake-tow aquatic vegetation surveys typically done by boat.

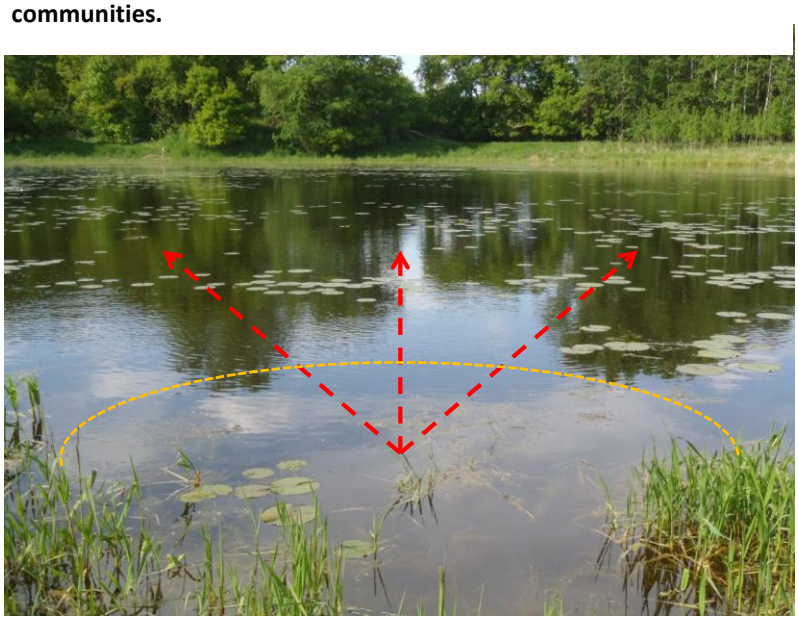
In this case the rake is a garden hand-cultivator (with the tines bent towards the handle) tied to a 20' length of rope that can easily be carried while conducting meander sampling.

Shoreline sampling consists of establishing three shoreline sampling stations at representative locations along the emergent vegetation/open water interface (Figure 4). At each station:

- Aquatic plant taxa (floating, floating-leaved, and submergent) that are observed within visual range are recorded
- The rake is tossed and retrieved three times at each station: once perpendicular from the shore and both (+/-) 45° from perpendicular
- Record any new aquatic taxa found on the rake tosses
- Take note of the abundance of each aquatic taxa throughout. Areal cover estimates will be made for each taxa (Section 5.9)

Sample Type D considers all aquatic taxa and is paired with Sample Types A-B when the Shallow Open Water community type (Table 2) is present at a Sample Site.

Figure 4. An example shoreline sampling station. Record aquatic species occurring within visual range (orange dashed line) and from three retrieves of the garden cultivator tows (red arrows). Three separate shoreline sampling stations are established at representative locations for sampling Shallow Open Water communities.



5.7.5 Sample Type E (shoreline/rapid spp.)

Sample Type E is similar to Type D, except that only the aquatic species on the Rapid Species List are recorded when observed. Type E is associated with the Rapid FQA (Type C) when the Shallow Open Water community type (Table 2) is present at a Sample Site. Please refer (and follow) the Rapid FQA Manual and use the Rapid FQA data form to complete Sample Type E.

5.7.6 Sample Type F (sample plot/all spp.)

The MPCA occasionally samples wetland vegetation within rectangular plots of various dimensions. Purposes may include: conducting the vegetation sampling for US EPA's National Wetland Condition Assessment; the DNR Releve method; the former MPCA depressional method; or for program development projects.

When plot sampling is done, plots will typically be established (or will be assigned) to represent a plant community type within a Sample Site and therefore will conform to the data structure and forms used for the other sample types. Use a single Community Data form to record species data for each plot within a Sample Site. The plant community type (Table 2) the plot occurs in and the **plot dimensions** should be recorded on the Community Data form.

5.7.7 Non-vascular and higher taxonomic level observations

The primary focus of MPCA vegetation sampling is to generate composition and abundance distribution data of vascular plants in wetlands. Non-vascular plants (e.g., bryophytes, macroscopic algae) can also be an important component in some wetland community types. When they are, areal cover data should be collected for higher taxonomic level records.

In addition, unknown vascular plants may be encountered that need to be recorded above the Family level. These names are infrequently used in field botany.

Table 6 provides some higher level taxonomic names that can be used to record these data. Areal cover should also be estimated for these records (See Section 5.9). Specific notes further describing the taxa should be provided in the **comment** section for the record.

Table 6. Frequently used higher taxonomic level names to record information about general groups.

Group Common Name	Group Scientific Name	Rank
Angiosperm	*Magnoliopsida*	Superorder
Monocotyledons	*Lilianae*	Class
Ferns & Horsetails	*Polypodiopsida*	Class
Clubmosses	*Lycopodiaceae*	Family
Sphagnum Mosses	*Sphagnum*	Genus
Mosses	*Bryopsida*	Class
Hornworts	*Anthocerotophyta*	Division
Liverworts	*Marchantiophyta*	Division
Macroscopic Algae	*Characeae*	Family
Green algae*	*Chlorophyta*	Division

*Most frequently used to denote the presence and cover of filamentous algae mats. Most of the MN filamentous algae belong to *Chlorophyta*

5.7.8 Save the GPS track

The field GPS should be on during the entire time during sampling with tracking feature on. When sampling is completed save the GPS track of the meander sample. Use the starting and end point selection option on the field GPS to save only the portion of the track that represents actual sampling effort. Do not save the entire track, which will typically include the route used to access the site. Name the track record as the Sample Site ID.

5.8 Collect specimens for unknown species

Often, taxa are encountered that cannot be readily identified to the species or ssp./var. level either by sight or after quick consultation with field guides/manuals. When this occurs, record the lowest

taxonomic division known (e.g., Genus, Family) and the proper Reliability Code (Table 6). If sufficient identification material is present (e.g., flower or fruit), a specimen should be collected to be pressed and ultimately identified later. Check the **Collected** box on the Community Data form for that record and indicate the **Specimen Type** as U (for Unknown).

Unknown specimens should be collected as they are encountered during sampling. If the same unknown is observed in multiple community types in the same Sample Site, use a consistent name on each Community Data form but only make a single collection. Specimens should be immediately placed into plastic bags and clearly labeled to avoid wilting and maintain organization so that they can be properly pressed.

Unknown specimens should only be collected when there is a reasonable chance of improving the taxonomic resolution through laboratory study. If diagnostic material is lacking, there is no need to collect a specimen. Indicate that no specimen was collected and the rationale in the Comment section for the record.

5.9 Estimate species cover

The MPCA relies on areal cover estimates as a general measure of abundance of each taxa observed within each community present at a Sample Site. Areal cover is defined as the percentage of the ground in the delineated community covered by the downward projection of the taxa. As cover estimates are typically made at the community scale, which can vary considerably in size — cover classes that represent ranges of cover are employed to simplify estimates and increase precision (Table 7).

Estimate the areal cover of each taxa observed by community type according to the cover classes provided in Table 7. This includes cover estimates for aquatic species that occur in the Shallow Open Water community type (if present) that were observed using Sample Types D-E. Record the **Cover Class (CC)** for each record on the appropriate Community Data form.

Table 7. Cover classes, percent cover ranges, and midpoints.

Cover Class	Cover Class Range	Midpoint
7	> 95 - 100%	97.5%
6	> 75 - 95%	85%
5	> 50 - 75%	62.5%
4	> 25 - 50%	37.5
3	> 5 - 25%	15%
2	> 1 - 5%	3%
1	> 0 - 1%	0.5%

5.10 Complete the total cover quality assurance procedure

The primary FQA metric calculated from the data and used to assess wetland vegetation condition incorporates cover. Cover estimate errors can happen and different observers may have low or high relative biases. Summed midpoint cover estimates for a community can also be high or low due to the range of the classes (e.g., several taxa in the community were estimated at CC 4, but were all actually < 30% cover). As accurate cover estimates are necessary to obtain accurate and repeatable results, effort needs to be made to double check the cover estimates.

Table 8. Inter-quantile ranges of total midpoint percent cover for all taxa with Cover Classes ≥ 2 by wetland class/type groups.

Wetland Class/Type Group	Inter-Quantile Cover Range	
	25th percentile	75th percentile
Shallow Open Water/Deep Marsh	53	88
Emergent/Open Bog	100	140
Tall Shrub Swamps	135	186
Forested Swamps/Coniferous Bogs/Floodplain Forest	138	207

Complete the following simple total cover range test for each community located on the Visit form (Appendix 1):

- Sum the *vascular* plant midpoint percent cover (Table 7) for all taxa with a Cover Class ≥ 2 *excluding* tree species at individual height classes
- Compare the community total midpoint percent cover against the inter-quantile range for the appropriate wetland class/type group (Table 8)
- If the community total midpoint percent cover is within the inter-quantile range for the group type—the total midpoint percent cover meets expectations. Proceed to Section 5.11
- If the community total midpoint percent cover is < or > the inter-quantile range for the group type—review the individual cover estimates for accuracy
- Revise individual estimates as needed OR if the initial individual estimates appear accurate—provide justification why the total midpoint percent cover are less or greater than the expected inter-quantile range in the Comments section of the appropriate Community Data form

5.11 Collect voucher specimens

Accurate plant identification is a key requirement for MPCA wetland vegetation monitoring. A crew leader is responsible for making upwards of thousands of field species identifications over the course of a summer. Verification of the field identifications is necessary to assess the accuracy of the data.

For the MWCA and DWCA projects, the MPCA regularly collects randomly selected QA voucher specimens of observed "known" species (Reliability Code ≤ 4; Table 5). Voucher specimens are independently identified at the University of Minnesota Bell Herbarium and compared against the field identifications.

If the sampling is being completed for the MWCA or DWCA, complete the following steps to collect QA voucher vascular plant specimens for a Sample Site:

- Place the Community Data forms in order by community number indicated on the Visit form
- Using the record number on the Community Data forms, calculate the total number of records for all communities sampled at the Sample Site
- Select the appropriate random number table based on the total number of records (tables in 20 record increments are included in the MPCA training materials)

- Working from left-right, select an unused random number from the table (cross used random numbers off as you select voucher specimens)
- Using the record numbers (with the Community Data forms in order), navigate to the record number that corresponds to the random number
- If the record is has a Reliability Code ≤ 4, find an individual with appropriate diagnostic material and collect a specimen
- Repeat until the required number of QA voucher specimens have been collected:
  - MWCA = 5 specimens
  - DWCA = 3 specimens
- If the same species is selected multiple times due to the same random number, the species occurring in multiple communities at the Sample Site, or is a tree species that occurs over multiple height classes—make another selection. Do not collect the same species twice for a Sample Site
- Clearly label specimens and immediately place them in a site QA plastic bag to prevent wilting
- Check the **Collected** box for the record and indicate a Q (for QA) for the **Specimen Type** on the Community Data form

5.12 Record observed impacts

For the MWCA and DWCA projects and for occasional program development efforts, the MPCA also collects information about human impacts occurring at a Sample Site during a vegetation sampling visit. This information is used to estimate the perceived impact exposure a wetland has had and to track the overall types and trends of impacts in probabilistic surveys.

If the Sample Site is a MWCA or DWCA site, record observed impacts on the Visit form. Impacts have been arranged into three categories/sections on the form: physical alterations (e.g., plowing, grazing, logging), hydrologic alterations (i.e., the disruption of the natural wetland hydrology due to drainage, increased water directed to the wetland, and/or impoundment), and/or (for open water wetlands) eutrophication-turbid state indicators.

If any of the impacts listed in these sections are observed during the vegetation sampling visit, indicate their presence by checking the appropriate box. For every box checked, further describe the extent and severity of the impact in the Comment section of the form.

If no impacts are seen for a category/section, affirm that observation by checking the appropriate box in each section.

In addition, space is provided on the Visit form to record other observed impacts that may be affecting wetland condition but are otherwise not listed previously. If an impact is recorded here, again describe the extent and severity of the impact in the comments section of the form.

5.13 Complete the Visit Completion Checklist

A checklist is provided at the bottom of the Visit form to verify that the required steps in this procedure have been completed. This checklist needs to be filled out to finalize the sampling visit:

- No Sample Site layout or boundary changes were made during vegetation sampling (occasionally necessary changes become apparent during vegetation sampling, these changes need to be fully documented such that GIS polygons can be updated)

- If Sample Site layout or boundary was changed — the site evaluation form has been updated and the site map has been annotated
- Plant communities have been clearly delineated on the site map
- Vegetation data are complete for each community in the Sample Site
- Standing water depths/vegetated cover/floating mat data have been recorded for each community in the Sample Site
- GPS track saved (file name = Sample Site ID)
- Voucher specimens collected (5 for the MWCA, 3 for the DWCA)
- Voucher and unknown specimens have been documented on Community Data forms and are clearly labeled & securely bagged
- Observed impacts have been recorded and described

6. Data security

Complete the following activities over the appropriate time scale to ensure that the data are secure and effectively managed so that they can be used for analysis and reporting.

6.1 Daily activities

At the end of each day of MPCA wetland vegetation sampling, complete the following:

- Dry (if necessary) and securely file all Site Evaluation, Visit, and Community Data forms in the designated site files
- Press and label the collected plant specimens:
  - Each crew should have a plant press kit (Table 1) consisting of the following:
    - A plant press and straps with sufficient numbers of cardboard ventilators, blotter paper, and newsprint
    - MPCA plant specimen labels
    - A small tray, specimen mounting paper, and wax paper to press aquatic specimens
  - Press each specimen in an individual piece of newsprint following these guidelines:
    - Array the plant so that stems and leaves and any flowering or fruiting material are separated and clearly visible
    - Fold the specimens into a 'V' or 'Z' pattern (if necessary) such that no portions are outside of the newsprint but the specimen is not crowded on itself
    - Leaves should display both upper and lower surfaces in the flattened condition
    - Be cleaned of soil as much as possible
  - Label each specimen using MPCA specimen labels
  - Aquatic plants should be floated onto appropriately sized pieces of mounting paper with a piece of wax paper placed on top, prior to being placed into the newsprint
  - Specimens must be pressed within 24 hours of collection
- Assess and maintain sampling equipment as necessary for the following day (e.g., dry wet equipment, charge batteries, etc.)

6.2 Weekly activities

At the end of each week of vegetation sampling, complete the following:

- Prepare water chemistry samples for lab submission if necessary (see the wetland Water Chemistry Protocol)
- Place the loaded plant press onto the plant press dryer located in the MPCA Field Operations Center for drying over the weekend
- Download the saved GPS tracks and any points generated in the field from the field GPS unit and save the files to the designated directories on the MPCA network drives. Delete the track files from the GPS unit to avoid duplicate file downloads and free up space on the unit for the next week.
- Download digital photographs from the camera and save the files to the designated directory on the MPCA network drives. Delete these photographs from the camera to avoid duplicate file downloads and free up space on the camera for the next week
- Update the designated site tracking table
- Assess and maintain sampling equipment as necessary for the following week
- Prior to departing on new sampling missions, remove specimens from presses and file into appropriate folders. Re-pack plant press kits for the upcoming week

6.3 Annual activities

At the end of each field sampling season, complete the following:

- Enter the data from the Site Evaluation, Visit, and Community Data forms into the MPCA biological monitoring database
- Complete all geospatial updates and processing in the designated feature classes:
  - Shifted MWCA POINTS and CENTERS
  - Sample Site layouts and boundaries
  - Plant community mapping
  - GPS meander tracks
- Manage and ship voucher specimens to the University of Minnesota Bell Herbarium
- Identify collected unknown specimens
- Rename picture files and save to designated file directory
- Update identification changes in the database as needed
- Complete the Human Disturbance Assessments (if necessary)

7. Quality assurance/quality control

Proper execution of this procedure will be maintained through internal reviews by senior technical staff and the unit supervisor at appropriate intervals. Crew leaders will conduct periodic self-checks by comparing their results with other trained personnel.

The MPCA implements following additional QA/QC requirements for wetland vegetation sampling:

- Ten percent of the Sample Sites sampled in a given year are re-sampled as a means of determining sampling error and spatial variability. Replicate sampling visits must be made at least two weeks after the first sampling visit.
- For the MWCA and DWCA projects, the MPCA collects voucher specimens to assess the accuracy of field identifications (see Section 5.11). In addition, 10% of the unknown specimens collected (and subsequently identified in the lab) are randomly selected and submitted to the University of Minnesota Bell Herbarium for verification. MPCA plant identification QA/QC goals are: achieve a collection completeness rate ≥ 90% and taxonomic disagreement rates ≤ 15%.

Appendix 1: Wetland Plant Community Key (pp. 17-19)

Adapted from Eggers and Reed (2015) plant communities of Minnesota and Wisconsin. Several classes have been modified from the original classification. Modifications are as follows:

- The Fresh Meadow class here combines the original Eggers & Reed classes: Sedge Meadow, Fresh (Wet) Meadow (Native Subtype), and Fresh (Wet) Meadow (Disturbed Subtype) into a single class.
    - Rationale for the change is that the soil conditions and the species composition/abundance distributions are not significantly different between the Sedge Meadow and Fresh (Wet) Meadow (Native Subtype) and that the Fresh (Wet) Meadow (Disturbed Subtype) represents a degradation of the former classes (i.e., a Fresh Meadow in fair or poor condition as indicated by the FQA).
- The Hardwood Swamp class here includes the Eggers & Reed Hardwood Swamp (Vernal Pool Subtype). The MPCA lacks the data on Hardwood Swamps that can be interpreted as the Vernal Pool Subtype and cannot confirm whether it should be treated as a distinct subtype.
- The Rich Fen class here—which is now named Sedge Meadow (Sedge Mat Subtype) in Eggers & Reed — is more consistent with what are described as Open Rich Peatlands in the MN DNR Native Plant Community classification. Our data supports that the species composition/abundance distribution of the Eggers & Reed Sedge Mat type is distinct from Sedge Meadow; thereby it is better treated as a distinct type, not merely a subtype. Also, communities where bog wiregrass sedge (*Carex oligosperma*) and a mat of *Sphagnum* are present are more appropriately grouped as an Open Bog as opposed to the Sedge Meadow (Sedge Mat Subtype) as is currently described in Eggers and Reed.
- The Seasonally Flooded class here is inclusive of a broader range of habitat settings than the Eggers & Reed Seasonally Flooded Basin. The Seasonally Flooded class includes habitats associated with lakes, streams, and open water wetlands where the water level has dropped, exposing a mudflat, that is quickly dominated by annual species. These are ephemeral habitats that are very similar to the Seasonally Flooded Basin described in Eggers & Reed. If the water level is remains lower for several consecutive years, perennial emergent species will begin to take over. Conversely, if water levels return it will revert back to open water aquatic habitats.

1A) Mature trees (dbh > 6") are present and form closed stands (> 17 trees/acre; > 50% canopy cover…….. **2**

2A) Hardwood trees are dominant (> 50% areal cover); alluvial, peaty/mucky, or poorly-drained mineral soils……**3**

3A) Silver maple, American elm, green ash, black willow, peach-leaved willow, box elder, cottonwood, and/or are dominant; growing on floodplains that are temporarily inundated during flood events, but may be well-drained for much of the growing season……..**FLOODPLAIN FOREST**

3B) Black ash, red maple, yellow birch, balsam poplar, and/or quaking aspen are dominant; green ash, tamarack, balsam fir, and/or northern white cedar may be subdominant; growing on poorly-drained peat/muck or mineral soils…….**HARDWOOD SWAMP**

2B) Coniferous trees are dominant (> 50% areal cover); soils usually peat/muck……..**4**

4A) Tamarack and/or black spruce are dominant; growing on a nearly continuous mat of *Sphagnum* moss and acidic peat soils; ericaceous (acid tolerant) shrubs dominate the understory ……..**CONIFEROUS BOG**

4B) Tamarack, black spruce, and/or northern white cedar are dominant; a continuous mat of mosses may be present but dominated by minerotrophic mosses; soils neutral-acidic; minerotrophic plant species present-abundant in the understory…….**CONIFEROUS SWAMP**

1B) Mature trees are absent or (if present) form open sparse stands; other woody plants (if present) are tall or low shrubs……..**5**

5A) Community dominated (> 50% areal cover) by woody shrubs……..**6**

6A) Low, woody shrubs (usually < 3' in height)……..**7**

7A) Shrubs are ericaceous and evergreen growing on a mat of *Sphagnum* moss; soils are acidic peat …….. **OPEN BOG**

7B) Shrubs are deciduous, typically dominated by shrubby cinquefoil and/or bog birch as a sub-dominant; often growing on sloping wetlands or extensive flats located in northwestern Minnesota that receive mineral rich groundwater discharge and alkaline peat soils; calcium-tolerant plants (calciphiles) are present; *Sphagnum* moss typically absent…… **CALCAREOUS FEN**

6B) Tall, deciduous shrubs (usually > 3' in height) are dominant……..**8**

8A) Speckled alder is dominant (comprising >50% aerial cover of the tall shrub canopy); tamarack, black spruce, black ash, and/or northern white cedar may be present but do not form a canopy; typically growing on muck/peat soils…… **ALDER THICKET**

8B) Willows, red-osier dogwood, and/or bog birch are dominant; soils mineral or muck/peat ranging from alkaline-neutral-moderately acidic……..**SHRUB-CARR**

5B) Community dominated by emergent graminoids and/or forbs; or open water wetland…… **9**

9A) Open water wetland; emergent vegetation layer absent; vegetation consisting of floating, floating-leaved, and/or submergent aquatic species……..**SHALLOW OPEN WATER**

9B) Emergent vegetation layer present; standing water may or may not be present……..**10**

10A) Seasonally to permanently inundated by water with depths up to 3' or more during most growing seasons; aquatic species often present to abundant in the understory……..**11**

11A) Typically inundated by water of depths of 6" to 3' or more throughout the growing season in most years; community a mixture emergent and aquatic vegetation;

emergent plants rooted in the sediment; common dominant emergent species include: soft stem bulrush, hardstem bulrush, river bulrush, wild rice, sessile fruited arrowhead ……..**DEEP MARSH**

11B) Inundated by water typically up to 6"; often drying down to saturated soils during the latter half of most growing seasons; dominated by emergent species such as: narrowleaf cattail, hybrid cattail, lake sedge, slough sedge, whitetop, beaked sedge, aquatic species typically a minor component; emergent dominants can form a floating mat ……**SHALLOW MARSH**

10B) Saturated soils or only temporarily inundated during most growing seasons; aquatic species typically absent or (if present) a very minor component of the community……**12**

12A) Temporarily inundated for a few weeks in spring giving way to mudflats and then typically dry for the remainder of the growing season; annuals (e.g., smartweeds, beggars ticks, wild millet) typically dominate; can occur as small shallow wetland basins or along lake shores and streams or semi-permanent open water wetlands that have dried up ……**SEASONALLY FLOODED**

12B) Saturated soils, at or below the surface during the latter half of the growing season, at most briefly inundated; typically 75-100% areal cover by perennial grasses, sedges, and/or forbs……..**13**

13A) Nearly continuous mat of *Sphagnum* moss present, acid peat soils, acid tolerant graminoids (bog wiregrass sedge, cotton grasses) are dominant……..**OPEN BOG**

13B) *Sphagnum* moss mat absent, soils alkaline-neutral –moderately acidic, communities more productive……..**14**

14A) Spring-fed supply of calcareous groundwater and calcareous peat present; calciphiles are abundant including: prairie sedge, sterile sedge, beaked spikerush, needle beakrush, low nutrush, and/or marsh arrow-grass…….**CALCAREOUS FEN**

14B) Calciphiles absent or (if present) are moderate-weak calcareous fen indicators and generally low in abundance……..**15**

15A) Prairie graminoinds and forbs are dominant including: big bluestem, prairie cordgrass, indian grass, sunflowers; soils typically mineral/saturated below the surface……**WET PRAIRIE**

15B) Prairie graminoids and forbs absent or (if present) are at moderate-low abundance……..**16**

16A) Bluejoint, tussock sedge, wooly sedge, woolgrass, narrow reedgrass, and/or reed canary grass are dominant; soils mucky/saturated at the surface or mineral/saturated below the surface…….**FRESH MEADOW**

16B) Often occurs as a floating mat of circumnuetral-slightly acidic peat; fen wiregrass sedge typically dominant, occasionally occurs as a floating mat of minerotrophic *Sphagnum* with marsh fern and/or arrowhead as dominants; impacted sites may be dominated by invasive cattail……..**RICH FEN**