Integration of Wetland Monitoring and Assessment into Targeted Watershed Assessments in Wisconsin: A Pilot

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Integration of Wetland Monitoring and Assessment into Targeted Watershed Assessments in Wisconsin: A Pilot

Wisconsin Department of Natural Resources
Final Report to USEPA- Region V
Wetland Program Development Grant # CD00E02324
WDNR EGAD # TBD (Technical Report)
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Statement of Authorship and Contribution:
AMM conceptualized the study and its design, acquired funding, facilitated partnership agreements, conducted a major portion of the soil and water physicochemistry fieldwork, conceptualized reporting and data analysis strategy, and led drafting and compilation of the final report. JWH assisted in field work, compiled results for biotic, functional, and disturbance assessments, conducted statistical analyses for vegetation condition and stressor analysis, and drafted sections of the results and discussion of the report. SGJ provided vegetation and functional assessment trainings for field staff, conducted analysis and drafted reporting of functional assessment calibration results, edited the report, and provided administrative oversight of project implementation and report completion after retirement of TWB. CLN conceptualized the study and its design, prepared materials for and conducted the probabilistic site draw, and conducted vegetation fieldwork for the majority of targeted sites sampled. TWB conceptualized the study and its design, acquired funding, and provided initial administrative oversight of project implementation during its first year.

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Introduction

Over the past two decades, the Wisconsin Department of Natural Resources (WDNR) has developed a suite of wetland monitoring and assessment tools following the "Level" approach of the US EPA National Wetlands Monitoring Workgroup (USEPA 2006). This suite includes tools to assess both wetland function and wetland condition. Both Wetlands By Design (WbD; Level 1 "Landscape Assessment"; Miller et al. 2017) and the Wisconsin Rapid Assessment Methodology Version 2 (WRAM V2; Level 2 "Rapid Assessment"; WDNR 2014) were designed to assess wetland functional values, whereas the Wisconsin Floristic Quality Assessment Method (WFQA; Level 3 "intensive site assessment"; Bernthal 2003) and accompanying Provisional Wetland Floristic Quality Benchmarks for Wisconsin (Hlina et al. 2015; Marti and Bernthal 2019) were designed to assess the biotic integrity (condition) of Wisconsin's wetlands.

While many of these tools have reached a point of final or provisional completion, a large question remained as to how these tools (whether singularly or in combination) could be most effectively applied by WDNR to meet state and federal regulatory mandates as they relate to wetland monitoring and assessment and wetland water quality standards. Wetlands are recognized by WDNR as a vital water resource which form the nexus between uplands, groundwater, and "traditional" surface waters regardless of their landscape position (Mushet et al. 2015; Marton et al. 2015; Fritz et al. 2018; Lane et al. 2018; Leibowitz et al. 2018; Schofield et al. 2018; Mengistu et al. 2020), and thus development of a routine wetland monitoring approach using these tools (especially WFQA) was identified as a top program priority in Wisconsin's Water Monitoring Strategy 2015-2020 (WDNR 2015). The strategy also identified a significant gap in determining the appropriate scale for wetland monitoring and assessment—listing watershed, basin/sub-basin, and US EPA Omernik Level III ecoregions (Omernik et al. 2000) as potential scales of interest, but also a written intention to integrate wetlands within WDNR's Targeted Watershed Assessment (TWA) Approach (WDNR 2015).

Given these factors, a pilot study was needed for WDNR to begin its first attempts to integrate wetland monitoring and assessment as part of standard WDNR Water Quality Program activities. After consideration of various factors (i.e. staffing distribution and interest/expertise, existing and potential resources, feasibility of scale, transferability of results, etc.), WDNR Wetland Monitoring and Assessment Staff determined that piloting a project in conjunction with an existing WDNR TWA project had the greatest potential for programmatic/staff buy-in and for logical integration into future WDNR water quality monitoring efforts. Thus, WDNR Wetland Monitoring and Assessment staff proposed and were successful in securing support through US EPA Region 5 FY17 Wetland Program Development Grants to conduct a pilot project in conjunction with a TWA with the following goals:

Goal 1: Identify a TWA project area in conjunction with regional WDNR field monitoring staff and local conservation partners (county staff, NRCS Conservation staff, etc.) where a wetland monitoring and assessment component may add value or insight to ongoing TWA and broader water resources related conservation efforts.

Goal 2: Conduct site selection for monitoring using various accepted site selection methods, including probabilistic and targeted sampling, to evaluate strengths, weaknesses, feasibility and comparability of results.

Goal 3: Conduct monitoring using WDNR's suite of developed wetland monitoring and assessment tools at selected sites.

Goal 4: Perform additional cross-calibration and validation of existing tools using field collected data.

a. Calibrate WbD using observational field data from WRAM V2 and WFQA through comparison of results.
b. Conduct additional Level 3 monitoring (soil physicochemistry and water chemistry) for comparison with WbD and WRAM V2 results related to carbon storage and nutrient/sediment retention functions.

Goal 5: Report on wetland condition and function within the TWA project area based on monitoring efforts, also evaluating major wetland stressors, in order to inform conservation actions of WDNR and other conservation entities.

Goal 6: Integrate wetland survey results with results from lake and stream monitoring to create the first integrated water resources TWA Report in Wisconsin.

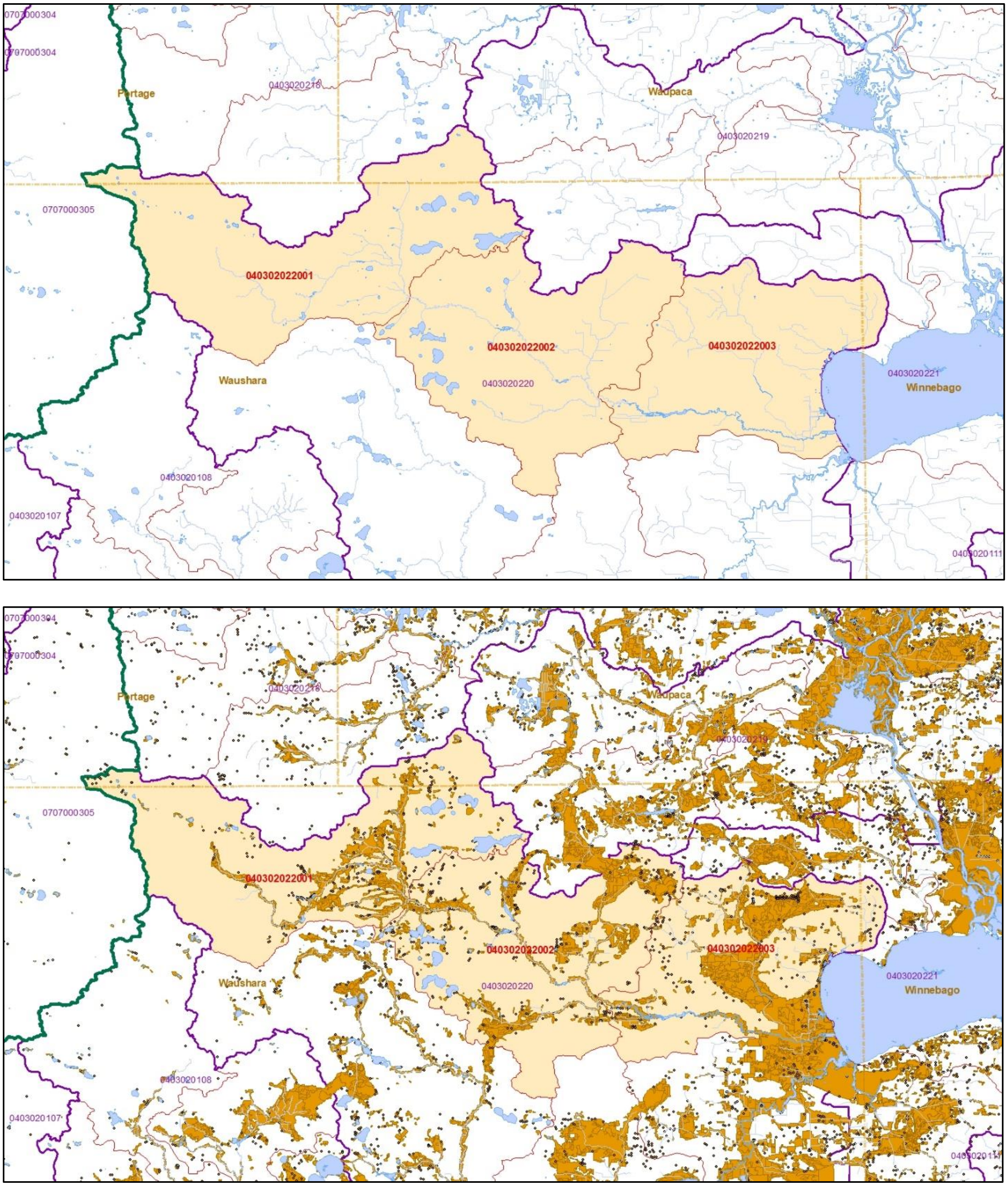

Figure 1. A map of the Pine River Watershed (study area). Features include HUC 10 boundaries (purple lines and text), HUC 12 boundaries (red lines and text- Pine HUC 12s highlighted in beige) and the Almond Terminal Moraine (approximate extent; green line)--the boundary between the Mississippi River and Lake Michigan Basins. Bottom tile shows added Wisconsin Wetland Inventory showing likely extent of wetlands in the watershed.

Methods

Study Area and TWA Selection

After consultation with regional WDNR field staff to consider a number of potential TWA project areas, WDNR wetland monitoring and assessment staff selected the Pine River Watershed as the TWA for the pilot study area. A brief synopsis of the watershed from WDNR (1998) and Bolha (2020) is provided below for context, but readers seeking further information are encouraged to review these documents.

The Pine River Watershed is located in Central Wisconsin with its uppermost headwaters occurring along the major watershed divide between the Mississippi River Basin and the Lake Michigan Basins of Wisconsin (i.e. the Almond Terminal Moraine; Figures 1 and 2). The Pine generally flows west to east, encompassing 3 of 6 HUC 12s of the Pine River-Willow Creek HUC 10 (0403020220) located mostly in the northern half of Waushara County (Figure 1).The Pine watershed is located in two major Omernik Level III Ecoregions, with the majority being part of the North Central Hardwood Forests and a small (but wetland dense) segment on the far eastern edge transitioning into the Southeastern Wisconsin Till Plains (Figure 3; Omernik et al. 2000). The river is considered part of the Upper Fox-Wolf River Basin and one of three major tributaries to Lake Poygan, which eventually flows into Lake Winnebago, the Lower Fox River Basin, and ultimately Green Bay. The area includes numerous baseflow fed coldwater and cool-coldwater trout streams of state importance (Outstanding/Exceptional Resource Waters; Bolha 2020).

The Pine has been a subject of WDNR attention since the 1990s, when WDNR and county conservation staff studied the watershed as part of the *Nonpoint Source Control Plan for the Pine River-Willow Creek Priority Watershed Project* (WDNR 1998). It was designated as a Priority Watershed Project Area in 1995 (pre-cursor to modern day US EPA 9 Key Element Plans). Nearly 2/3 (60%) of land use in the Pine-Willow HUC10 is agricultural land, with the remaining majority (30%) in woodland and wetland acreage (WDNR 1998). In-stream sedimentation and resultant habitat and water quality degradation from non-point source pollution and streambank/shoreland erosion were identified as major factors limiting aquatic life throughout the watershed. Wetlands were scarcely mentioned at all in the project/plan, and no documented overall or general evaluation of their status or condition was completed as part of the Priority Watershed efforts. However, general statements regarding the importance of wetlands and wetland functional values were stated, and "restore wetlands" was an objective listed to achieve sediment reduction goals. Best Management Practices were installed through WDNR and Wisconsin Department of Agriculture, Trade, and Consumer Protection (WDATCP) support in the watershed from 1995-2002 to address sediment, habitat, and water quality issues (Bolha 2020).

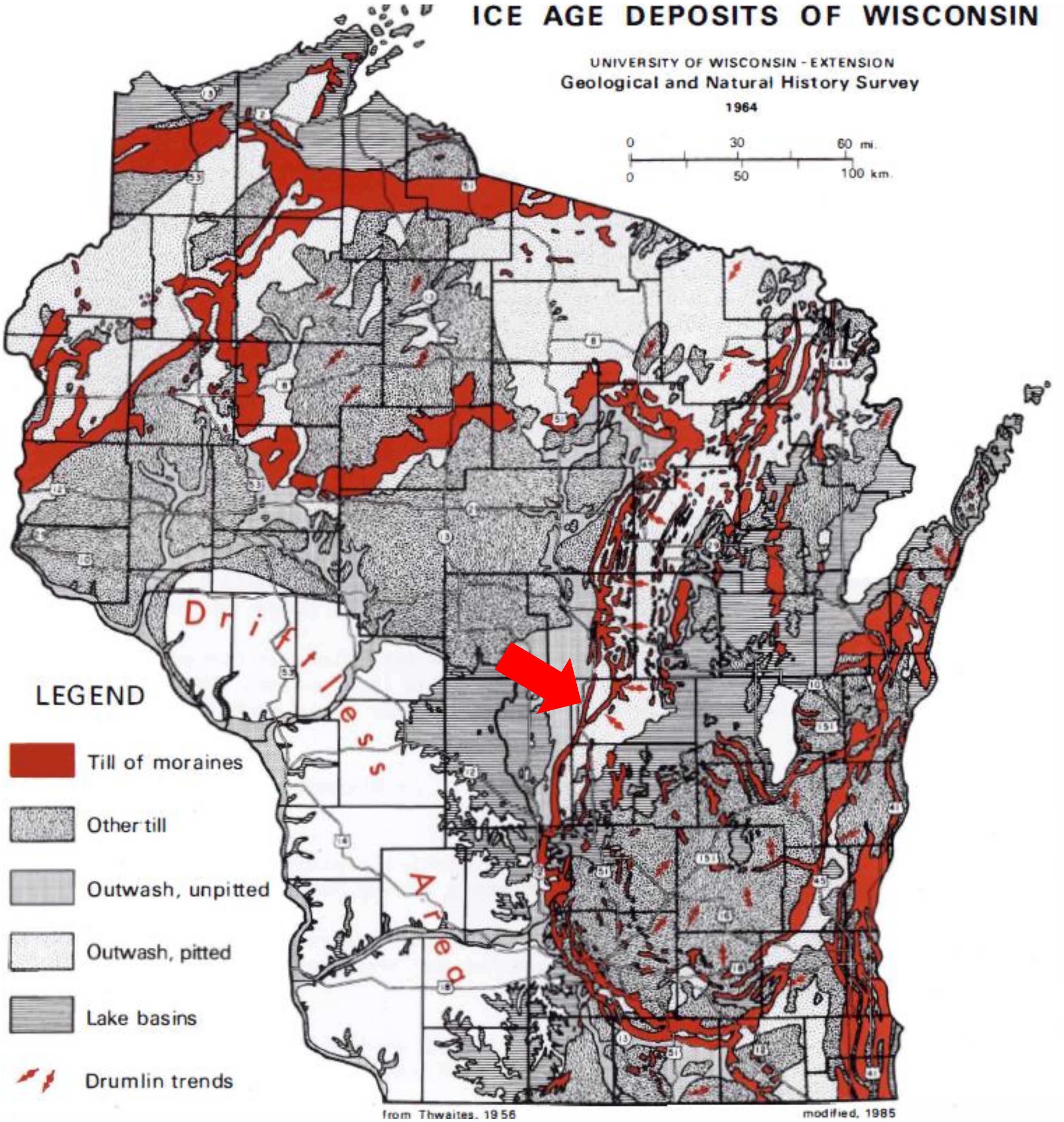

Figure 2. A map of Ice Age Deposits of Wisconsin (Reprinted and modified from Thwaites 1964). The approximate extent of the Almond Terminal Moraine in western Waushara County (which separates the Mississippi River and Lake Michigan Basins) is indicated by the red arrow.

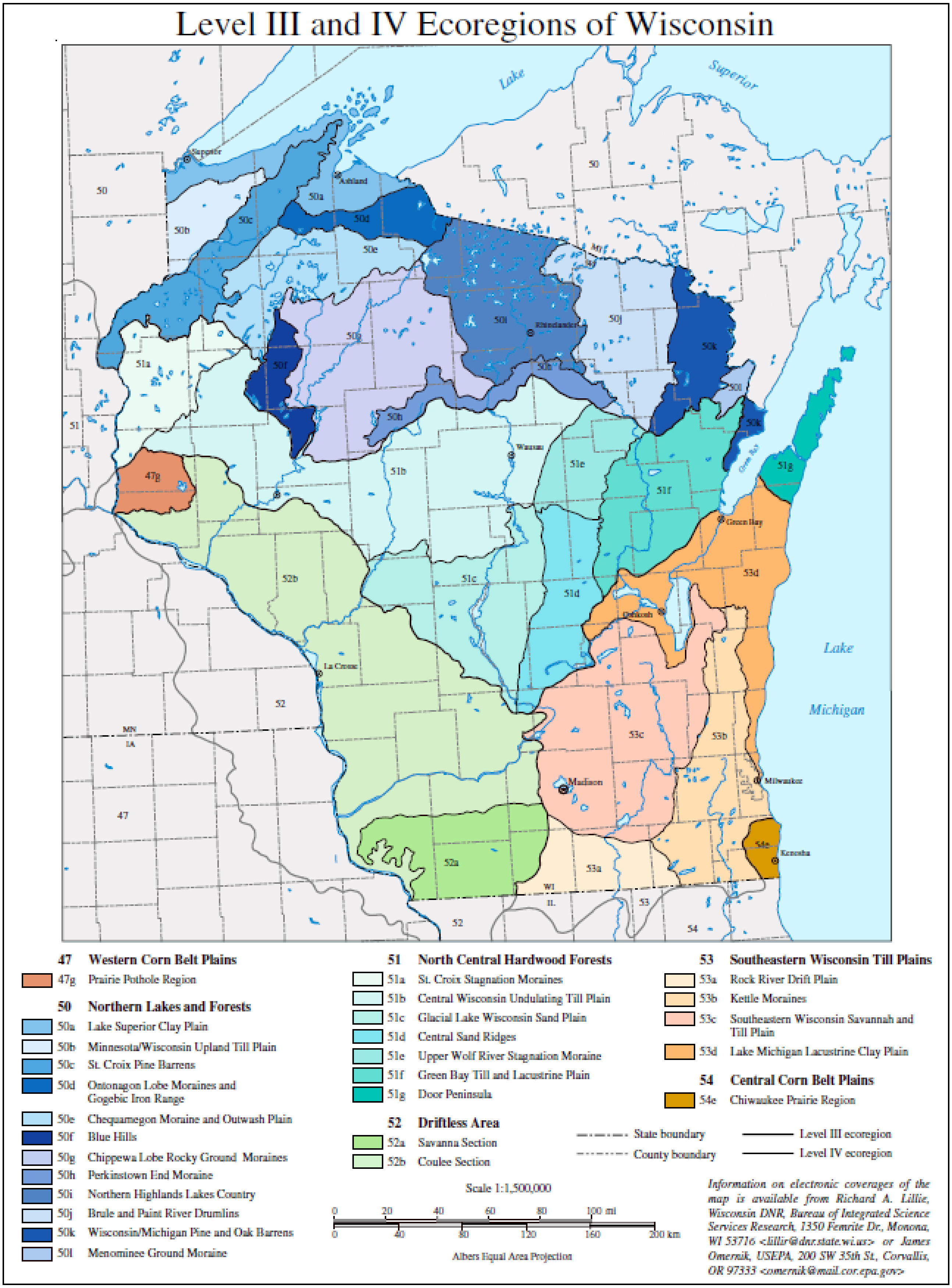

Figure 3. Level III and IV Ecoregions of Wisconsin (Reprinted from Omernik et al. 2000).

In 2018, WDNR initiated a TWA in the Pine watershed to assess what, if any, progress had been made towards achieving the goals of the Priority Watershed Project. Additionally, these data were intended to support partner efforts for proposing and implementing a future USEPA-approved Nine Key Element plan. WDNR field staff initiating the TWA indicated that information regarding wetlands would likely be an informative element for conservation and watershed planning in the area given the prevalence of wetlands along stream corridors and their important role in providing adequate groundwater infiltration and thereby baseflow to the many trout streams throughout the watershed. Additionally, ditching of wetlands for agricultural and recreational purposes were identified as a concern for water quality and aquatic habitat (D. Bolha, Pers. Comm.).

<u>Site Selection</u>

Sites were selected using two different methods (probabilistic and targeted) to compare and contrast results obtained and to elucidate any strengths or weaknesses of either approach. These site selection methods are currently used by WDNR for monitoring of other aquatic resource types. Numerous factors including number of sites, future application/practicality, and overall representativeness were taken into account and standardized (along with target population) across sampling designs to ensure as balanced and thorough of a comparison as possible could be made between designs. Details specific to each approach are subsequently noted in individual sections hereafter.

The Wetland Monitoring and Assessment Team and field staff determined that a 30-site sampling effort using each site selection method (n = 60) would likely be adequate to characterize the condition of wetlands and their stressors across the Pine watershed. This included a number of justifications. First, a central point of observation among staff was that rivers and streams generally appear to integrate cumulatively along their length and can therefore be sampled near pour points to represent stressors and status of their upgradient watersheds. But wetlands tend to have localized stressors that may occur in different areas of a given wetland complex that may yield different stressor types/combinations or overall biotic and abiotic condition. To account for this factor, the group agreed that an adequate number of sites for surveying wetland condition and functions across a watershed likely should/would be multiple times larger than the number of sites needed to adequately survey stream water quality and biotic condition. Bolha (2020) sampled 11, 20, and 25 sites for stream chemistry, fish community condition, and macroinvertebrate community condition, respectively, further justifying 30 as a reasonable number of sites. Second, this number of sites is roughly equivalent to one site per 2,800 acres of watershed land area, or one site per 540 acres of current wetland area within the Pine watershed. On average, a HUC 12 in Wisconsin encompasses approximately 35 mi^2 (22,400 ac) of area, meaning that future designs using 30 sites across 3 HUC-12s (30 sites/105 mi^2) would be equivalent to surveying one site per 3.5 mi^2 (2,240 ac) watershed area on average. Finally, staff determined it would likely be feasible for future integration of wetlands into TWAs given that surveying 30 sites within the area of three HUC12s (or similar scale) within a single field season seemed a reasonable/practicable expectation.

The target population used for both site selection designs was defined *a priori* as all areas identified on the Wisconsin Wetland Inventory (WWI; WDNR 1992) and within the study area, excluding the following:

1) Aquatic bed (submergent or floating), unvegetated wet soil, or open water class wetlands;
2) Wetlands currently in active commodity crop-based (row or bed) agriculture; and
3) Wetlands with desktop or field observed standing water depths across a majority of the assessment area greater than or equal to 1m depth.

An additional *a priori* objective was to sample 10 sites across each of three broad wetland vegetation categories (i.e. herbaceous/emergent, shrub/scrub, and forested) per site selection method to ensure general representation among wetland types to be able to draw general conclusions or make observations. All sites additionally had to display one or more wetland ecological field indicators (hydric soils, hydrologic indicators, and/or hydrophytic vegetation) for inclusion in the surveys.

Probabilistic Monitoring Design

Probabilistic monitoring designs are generally considered the "gold standard" for general unbiased monitoring of aquatic resource condition or stressors. Indeed, USEPA uses probabilistic sampling as part of the National Aquatic Resource Surveys, which includes the National Wetland Condition Assessment (NWCA; USEPA 2016a). For the purposes of this survey, we used the same R package (*spsurvey*; Kincaid and Olsen 2013) as used by US EPA NWCA for site selection, which employs a Generalized Random Tessellation Stratified (GRTS) survey design (Stevens and Olsen 1999; Stevens and Olsen 2004). The input for the *spsurvey* draw was customized WWI map clipped to reflect the study area (HUC12 boundaries) and the WWI target wetland population as previously defined. The draw included sampling 10 wetland sites per broad wetland vegetation category as previously detailed, with an overdraw of 40 additional sites per category to account for wetlands either unsampleable due to safety and/or access restrictions or found to be not part of the target population after field or desktop review. In total, 150 sites were selected and considered in the draw for potential sampling. In general, site review procedures and sampling order were completed per NWCA site assessment guidelines (USEPA 2016b). Notes were recorded if: 1) the starting location for a given site based on the draw was moved (60 m maximum) to accommodate the survey effort (a non-target wetland type and/or upland at original point), 2) if the site coordinate could not be moved to the original draw wetland type within <60 m but a survey could be completed within the given wetland for a different target wetland community, or 3) if the site was located in a non-target area and no site in a target wetland community could be established.

Targeted Monitoring Design

Wetland assessment sites for the targeted monitoring design were generally paired with existing stream and river monitoring sites from Bolha (2020). Many of these sites were at or near road crossings or near state owned lands such as fisheries access areas. In general, wetlands were selected adjacent to or near (upstream or downstream) the existing sites to allow for future comparison of biotic and abiotic data among aquatic resource types. Additionally, a handful of "geographically isolated" wetland sites were also chosen to be surveyed given their importance to watershed condition and function (Mushet et al. 2015; Marton et al. 2015; Fritz et al. 2018; Lane et al. 2018; Leibowitz et al. 2018; Schofield et al. 2018; Mengistu et al. 2020). For both stream adjacent and geographically isolated wetlands, an attempt was made *a priori* to spatially balance the sites (including by broad vegetation category) across the 3 HUC12s using overall best professional judgement to minimize spatial biases.

Wetland biotic condition assessment using WFQA

At each site, an assessment area was established for conducting a vegetation survey based on the approximate boundaries of the wetland community type present. Wetland sites were surveyed during summers 2018 and 2019 using the WDNR Timed Meander Method (Trochlell 2016). In general, probabilistic sites were surveyed by a contractor (Conservation Strategies Group), whereas targeted sites were surveyed by WDNR Wetland Monitoring and Assessment Staff. Results from the timed meander survey were used to calculate floristic quality assessment metrics (namely weighted mean coefficient of conservatism -all species) using WFQA and the Wisconsin Floristic Quality Calculator (Bernthal 2003; WDNR 2017) Calculated WFQA metrics were then compared to Provisional Wetland Floristic Quality Assessment Benchmarks (Hlina et al. 2015; Marti and Bernthal 2019) to determine the biotic condition of the wetland. Where benchmarks for a given community type were not present in the provisional benchmarks, benchmarks from an adjacent ecoregion were selected (Tables 1A and 1B). Communities which were evidently disturbed (i.e. ruderal communities-O'Connor 2018) based on presence of invasive or ruderal species or obvious human disturbance were assigned for comparison to the nearest wetland community type for which benchmarks were available.

Wetland disturbance and functional assessments

Upon completion of the timed meander survey, crews who completed the survey used field notes and observations from the survey as well as pre-/post-survey desktop resources to complete the following:

1) *Disturbance Factors Field Checklist Form* to record any potential stressors within or affecting the assessment area, including the overall estimated level of effect (low, medium or high) for each stressor Scores for "Overall Disturbance" based on the observed effect of all stressors and their estimated severity were also

determined. See Marti and Bernthal (2019) for methods and additional details, including scoring and narrative descriptions (Appendix 1).

2) WRAM V2 (WDNR 2014), to obtain a field-based rapid assessment of wetland functional values.

Additionally, the assessment area and timed meander path were used to determine the main WWI polygon(s) where the survey occurred, which were cross referenced with WbD to obtain functional assessment scores for the following attributes:

1) Flood abatement;
2) Fish and aquatic species habitat;
3) Water Quality (Sediment retention, nitrogen reduction, and phosphorus retention);
4) Floristic Integrity.

The results of the WRAM V2 field assessments were compared to the modeled functional value assessment generated in WbD to assess WbD accuracy of predicting functions at the field level. Data were pooled for this assessment given that comparison of WRAM V2 and WbD results overall was the objective rather than assessment of results potentially differing by site selection methods.

<u>Surface water characterization and water chemistry data collection</u>

Water and soil chemistry were always sampled after the WFQA timed meander survey was completed for a given site, generally weeks or longer afterwards, in order to avoid disturbance of water or the surface soil environment to be collected. This was also necessary so that the timed meander survey assessment area could serve to create overall boundaries for the site and therefore the applicable area for water and soil collection. Water chemistry samples were collected at all sites where adequate surface water was present for collection. If surface water was present at a site, regardless if sampleable, general surface water characteristics were noted on a modified US EPA NWCA water chemistry field form (Appendix 2).

Upon arrival at a site, the overall area was searched for pooled or ponded surface water. It was determined *a priori* that the minimum water depth needed to qualify for sampling at a site would be defined as standing water deep enough for water to be sampled without disturbing the sediment-water interface (further detailed below). In general, water was sampled as near to center of the assessment area established from the WFQA timed meander survey as possible. In the instance sampleable water was limited to another area of the site, water was sampled from that location. In the instance no surface water was ponded onsite, but shallow ditches or other drainage that were perceived to drain the wetland site were present within the assessment area, surface water was sampled at the edge of the drainage.

Table 1A. A list of field-identified wetland communities, as well as their determined respective benchmark community types and ecoregions selected for assessment of biotic condition at probabilistic wetland sites in the Pine River watershed. *Italics* indicate a substitution of ecoregion for a given benchmark community type.

Site Code	Field Identified Community[1]	Benchmark Community[1]	Benchmark Ecoregion[2]
SRPR002	Northern Sedge Meadow	Northern Sedge Meadow	North Central Hardwood Forests
SRPR003	Ruderal Marsh	Emergent Marsh	North Central Hardwood Forests
SRPR004	Southern Sedge Meadow	Southern Sedge Meadow	North Central Hardwood Forests
SRPR005	Southern Sedge Meadow	Southern Sedge Meadow	North Central Hardwood Forests
SRPR007	Northern Sedge Meadow	Northern Sedge Meadow	*North Central Hardwood Forests*
SRPR011	Ruderal Marsh	Emergent Marsh	Southeastern Wisconsin Till Plains
SRPR014	Ruderal Wet Meadow	Southern Sedge Meadow	Southeastern Wisconsin Till Plains
SRPR018	Ruderal Wet Meadow	Southern Sedge Meadow	Southeastern Wisconsin Till Plains
SRPR019	Southern Sedge Meadow	Southern Sedge Meadow	Southeastern Wisconsin Till Plains
SRPR023	Northern Sedge Meadow	Northern Sedge Meadow	*North Central Hardwood Forests*
SRPR053	Alder Thicket	Alder Thicket	*Driftless Area*
SRPR054	Ruderal Shrub Swamp	Southern Sedge Meadow	North Central Hardwood Forests
SRPR055	Ruderal Wet Meadow	Southern Sedge Meadow	North Central Hardwood Forests
SRPR056	Ruderal Shrub Swamp	Floodplain Forest	*Southeastern Wisconsin Till Plains*
SRPR057	Alder Thicket	Alder Thicket	*Driftless Area*
SRPR059	Alder Thicket	Alder Thicket	*Driftless Area*
SRPR063	Shrub-carr	Shrub-carr	North Central Hardwood Forests
SRPR064	Shrub-carr	Shrub-carr	Southeastern Wisconsin Till Plains
SRPR065	Shrub-carr	Shrub-carr	Southeastern Wisconsin Till Plains
SRPR066	Shrub-carr	Shrub-carr	North Central Hardwood Forests
SRPR070	Southern Hardwood Swamp	Southern Hardwood Swamp	Southeastern Wisconsin Till Plains
SRPR075	Alder Thicket	Alder Thicket	*Driftless Area*
SRPR101	Southern Tamarack Swamp	Northern Tamarack Swamp	*North Central Hardwood Forests*
SRPR105	Northern Hardwood Swamp	Northern Hardwood Swamp	North Central Hardwood Forests
SRPR107	Northern Hardwood Swamp	Northern Hardwood Swamp	North Central Hardwood Forests
SRPR109	Southern Tamarack Swamp	Northern Tamarack Swamp	North Central Hardwood Forests
SRPR110	Southern Hardwood Swamp	Southern Hardwood Swamp	*Southeastern Wisconsin Till Plains*
SRPR112	Northern Hardwood Swamp	Northern Hardwood Swamp	North Central Hardwood Forests
SRPR113	Floodplain Forest	Floodplain Forest	Southeastern Wisconsin Till Plains
SRPR114	Southern Hardwood Swamp	Southern Hardwood Swamp	Southeastern Wisconsin Till Plains
SRPR115	Southern Hardwood Swamp	Southern Hardwood Swamp	Southeastern Wisconsin Till Plains
SRPR116	Ruderal Shrub Swamp	Shrub-carr	North Central Hardwood Forests
SRPR120	Southern Hardwood Swamp	Southern Hardwood Swamp	*Southeastern Wisconsin Till Plains*

[1] From O'Connor (2018)

[2] From Hlina et al. (2015) or Marti and Bernthal (2019)

Table 1B. A list of field-identified wetland communities, as well as their determined respective benchmark community types and ecoregions selected for assessment of biotic condition at targeted wetland sites in the Pine River watershed. *Italics* indicate a substitution of ecoregion for a given benchmark community type.

Site Code	Field Identified Community[1]	Benchmark Community[1]	Benchmark Ecoregion[2]
TWPR01	Northern Hardwood Swamp	Northern Hardwood Swamp	North Central Hardwood Forests
TWPR02	Ruderal Shrub Swamp	Alder Thicket	*Driftless Area*
TWPR03	Ruderal Marsh	Emergent Marsh	North Central Hardwood Forests
TWPR04	Wet Prairie	Northern Hardwood Swamp	North Central Hardwood Forests
TWPR05	Ruderal Wet Meadow	Southern Sedge Meadow	North Central Hardwood Forests
TWPR06	Northern Hardwood Swamp	Northern Hardwood Swamp	North Central Hardwood Forests
TWPR07	Ruderal Wet Meadow	Southern Sedge Meadow	North Central Hardwood Forests
TWPR08	Northern Hardwood Swamp	Northern Hardwood Swamp	North Central Hardwood Forests
TWPR09	Northern Sedge Meadow	Northern Sedge Meadow	North Central Hardwood Forests
TWPR10	Alder Thicket	Alder Thicket	*Driftless Area*
TWPR11	Ruderal Shrub Swamp	Shrub-carr	North Central Hardwood Forests
TWPR12	Alder Thicket	Alder Thicket	*Driftless Area*
TWPR13	Northern Hardwood Swamp	Northern Hardwood Swamp	North Central Hardwood Forests
TWPR14	Northern Hardwood Swamp	Northern Hardwood Swamp	North Central Hardwood Forests
TWPR15	Northern Hardwood Swamp	Northern Hardwood Swamp	North Central Hardwood Forests
TWPR16	Alder Thicket	Alder Thicket	*Driftless Area*
TWPR17	Ruderal Shrub Swamp	Shrub-carr	North Central Hardwood Forests
TWPR18	Southern Sedge Meadow	Southern Sedge Meadow	North Central Hardwood Forests
TWPR19	Ruderal Shrub Swamp	Southern Sedge Meadow	Southeastern Wisconsin Till Plains
TWPR20	Ruderal Shrub Swamp	Shrub-carr	North Central Hardwood Forests
TWPR21	Emergent Marsh	Emergent Marsh	North Central Hardwood Forests
TWPR22	Floodplain Forest	Floodplain Forest	Southeastern Wisconsin Till Plains
TWPR23	Southern Sedge Meadow	Southern Sedge Meadow	Southeastern Wisconsin Till Plains
TWPR24	Alder Thicket	Alder Thicket	*Driftless Area*
TWPR25	Southern Sedge Meadow	Southern Sedge Meadow	North Central Hardwood Forests
TWPR26	Southern Sedge Meadow	Southern Sedge Meadow	Southeastern Wisconsin Till Plains
TWPR27	Shrub-carr	Shrub-carr	Southeastern Wisconsin Till Plains
TWPR28	Ruderal Wet Meadow	Floodplain Forest	Southeastern Wisconsin Till Plains
TWPR29	Alder Thicket	Alder Thicket	*Driftless Area*
TWPR30	Ruderal Marsh	Emergent Marsh	Southeastern Wisconsin Till Plains
TWPR31	Southern Sedge Meadow	Southern Sedge Meadow	Southeastern Wisconsin Till Plains
TWPR32	Southern Hardwood Swamp	Southern Hardwood Swamp	Southeastern Wisconsin Till Plains
TWPR33	Alder Thicket	Alder Thicket	*Driftless Area*
TWPR34	Alder Thicket	Alder Thicket	*Driftless Area*
TWPR35	Northern Sedge Meadow	Northern Sedge Meadow	*North Central Hardwood Forests*
TWPR36	Southern Sedge Meadow	Southern Sedge Meadow	Southeastern Wisconsin Till Plains
TWPR37	Wild Rice Marsh	Emergent Marsh	Southeastern Wisconsin Till Plains
TWPR38	Northern Sedge Meadow	Northern Sedge Meadow	*North Central Hardwood Forests*
TWPR39	Southern Sedge Meadow	Southern Sedge Meadow	Southeastern Wisconsin Till Plains
TWPR40	Floodplain Forest	Floodplain Forest	Southeastern Wisconsin Till Plains
TWPR41	Floodplain Forest	Floodplain Forest	*Southeastern Wisconsin Till Plains*
TWPR42	Floodplain Forest	Floodplain Forest	*Southeastern Wisconsin Till Plains*
TWPR43	Floodplain Forest	Floodplain Forest	*Southeastern Wisconsin Till Plains*
TWPR44	Southern Hardwood Swamp	Southern Hardwood Swamp	North Central Hardwood Forests

[1] From O'Connor (2018)

[2] From Hlina et al. (2015) or Marti and Bernthal (2019)

Where sampleable water was available, water was sampled using a new, sterile triple-field-rinsed 60 ml syringe. Individuals sampling water chemistry were careful to not touch the syringe with hands beyond the clear area above the 60ml graduation line to avoid contamination of samples. If surface floc, films, sheens or floating surface vegetation were present, these materials were parted as best as possible using the tip of the syringe to access the surface water below. Samples and field rinse water (when applicable) were drawn up slowly into the syringe to not disturb bottom sediments and benthic material that could affect sample results. Samples were then pressed from the syringe (and through an in-line filter, when applicable) into Wisconsin State Lab of Hygiene (WSLH) provided sample bottles. Samples were chilled on ice in the field and then stored at 4°C until they could be delivered to WSLH for analysis for pH, conductivity, alkalinity, total phosphorus, orthophosphate, and total dissolved phosphate.

<u>Soil profile description and soil physicochemistry data collection</u>

A moderate detail soil profile description (Appendix 3) and soil physicochemistry samples were collected to document onsite conditions as near to the source where surface water samples were collected. In the instance surface water was not collected, these activities were conducted in an area that most adequately represented overall site conditions based on vegetation or surface soil conditions, generally near the center of the WFQA timed meander survey assessment area for a given site. Sites were screened *a priori* per state and federal rules to ensure that no archeological (historic and cultural) resources would be disturbed by pit excavation.

Soil profiles (~40-50 cm depth) were excavated using hand tools including sharpshooters, bucket augers, and post holers to describe properties of the soils onsite. When standing surface water and/or slumping prevented profile description from a pit, excavated materials were sequentially obtained from the pit and laid out for description on a non-reflective, matte surface black plastic tarp (*sensu* USEPA 2016b). Profile descriptions followed NRCS standards (USDA NRCS 2012).

After description of the soil profile, whole horizon field moist samples (~2/3 gal) for physicochemical analyses were taken from the uppermost two soil horizons described, where possible. Samples were held at room temperature until return to the office, where they were stored at 4°C until they could be batch shipped to the US Army Corps of Engineers Wetlands Laboratory (Engineer Research and Development Center Environmental Laboratory) in Vicksburg, MS for lab processing/preparation and chemical analyses (Berkowitz et al. 2020). Chemical analyses were primarily related to estimation of phosphorus retention, including 1:1 Water pH, Water Soluble P, and Mehlich 3 Extractable P, Fe, and Al for calculation/estimation of Phosphorus Sorption Ratio (PSR) and Soil Phosphorus Storage Capacity (SPSC) based on the methods in Berkowitz et al. (2020).

QA/QC Measures

All field crew members completing WFQA Timed Meander Surveys and WRAM V2 assessments were provided a multi-day desktop and field training by the WDNR Wetland Water Quality Monitoring Technical Lead and Expert Botanist to ensure familiarity with protocols and methods. Additionally, individuals compared results from training exercises with one another to enable discussion and attempt to maintain consistency in interpretations and results. All field crew members also spent at least one day in the field with the contracted Conservation Strategies Group to also attempt consistency across groups.

A select subset of field crew members conducted soil and water chemistry related field tasks. These individuals were trained in-field by a seasoned wetland field ecologist (10 years experience in wetland soil profile description and biogeochemical sampling methods) at nearly two dozen sites before being allowed to conduct these field activities independently.

Statistical analyses and figures

All statistical and other data analyses were conducted either in R or Microsoft Excel. As aforementioned, the *spsurvey* package was used for probabilistic site selection and computation of area-based estimates of condition and stressors in R similar to the USEPA NWCA (USEPA 2016a; USEPA 2016b). Graphs and tables were produced in Microsoft Excel.

Results

Wetland biotic condition assessment using WFQA

Probabilistic monitoring condition estimate

A total of 33 probabilistically selected sites were surveyed for WFQA. Results for biotic condition estimated from probabilistic sites using WFQA and applicable tools are displayed in Figure 4. However, these estimates are based on uncorrected final weighting (i.e. not accounting for landowner denials, inaccessible sites, non-target sites, etc.) within *spsurvey* due to a statistical oversight that was unaccounted for until shortly before final submission of this report. Thus, while the probabilistic sites surveyed represent a truly randomized site draw that accounted for spatial density of target wetland communities and acres, the quantity of target wetland area that is unable to be accounted for and the area that was inaccessible or misclassified in the estimates is unknown at this time.

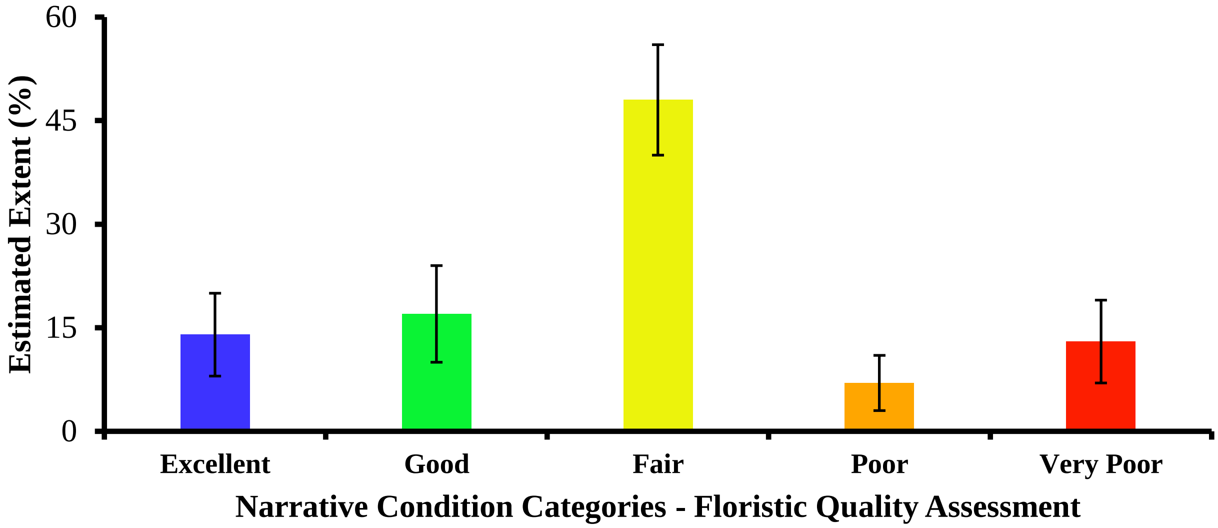

Figure 4. Estimated extent of wetland biotic condition (% wetland area) in the Pine River watershed based on the Wisconsin Floristic Quality Assessment Method (Bernthal 2003) and FQA Benchmarks (Marti and Bernthal 2019). Results were generated from 33 sites surveyed in 2019 as part of a probabilistic draw.

The vast majority of wetland acres in the study area were in “Fair” (48 ± 8%) condition based on WFQA Benchmarks (Marti and Bernthal 2019). Wetlands in both “Good” (17 ± 7%) and “Excellent” (13 ± 7%) condition comprise roughly 1/3 of the wetland area in the watershed, with the remainder in “Poor” (7 ± 4%) and “Very Poor” (13 ± 6%) condition. When probabilistic sites were plotted by timed meander survey starting coordinate on a map of the Pine watershed by condition category, no apparent directional (latitude/longitude) or watershed-based (upstream/downstream, stream order, riparian/shoreland/geographically isolated) spatial patterns in condition were evident (Figure 5).

Targeted monitoring condition estimate

A total of 44 targeted sites were surveyed for WFQA. Results for biotic condition estimated at targeted sites using WFQA and applicable tools are displayed in Figure 6. The vast majority of wetland targeted sites surveyed were in “Good” (30%) or “Fair” (32%) condition based on WFQA Benchmarks (Marti and Bernthal 2019). However, one quarter of all sites were in “Poor” (20%) and “Very Poor” (5%) condition, nearly double the amount of sites remaining in “Excellent” (14%) condition. Similar to the results for probabilistic sites, no apparent directional (latitude/longitude) or watershed-based (upstream/downstream,

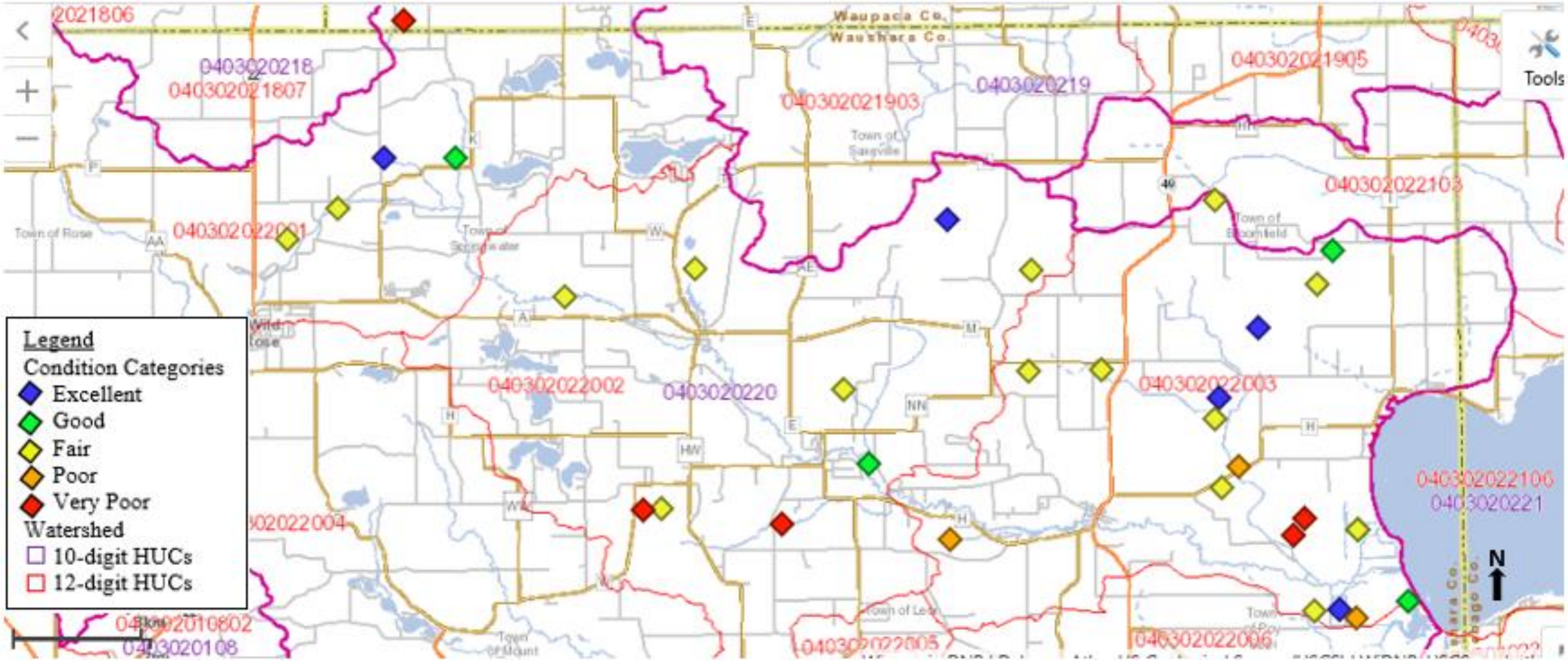

Figure 5. A map displaying wetland biotic condition of 33 probabilistically selected sites in the Pine River Watershed sampled in 2018 and 2019. Condition category based on the Wisconsin Floristic Quality Assessment Method (Bernthal 2003) and FQA Benchmarks (Marti and Bernthal 2019). Ten and twelve-digit HUCs are outlined on the map.

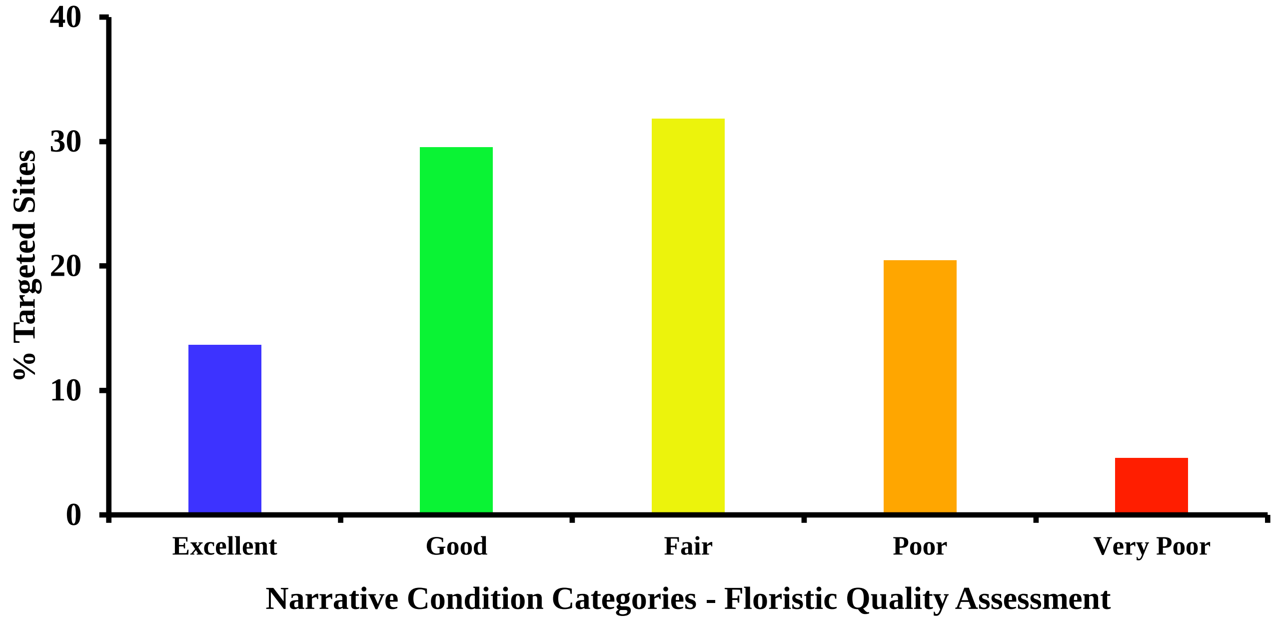

Figure 6. Condition of wetlands in the Pine River Watershed at targeted sites based on the Wisconsin Floristic Quality Assessment Method (Bernthal 2003) and FQA Benchmarks (Marti and Bernthal 2019). 44 targeted sites were surveyed during the 2018 and 2019 field seasons in the Pine River watershed.

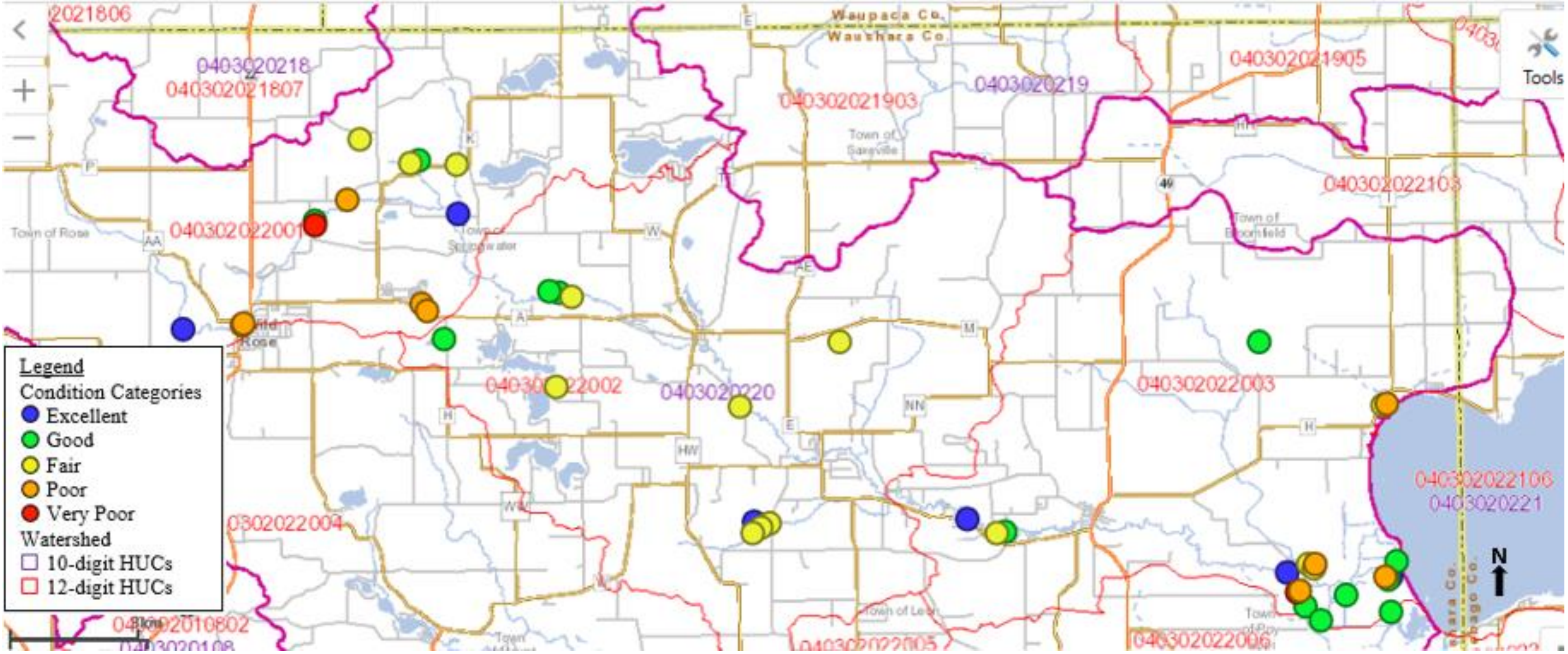

Figure 7. A map displaying wetland biotic condition of 44 targeted selected sites in the Pine River Watershed sampled in 2018 and 2019. Condition category based on the Wisconsin Floristic Quality Assessment Method (Bernthal 2003) and FQA Benchmarks (Marti and Bernthal 2019). Ten and twelve-digit HUCs are outlined on the map.

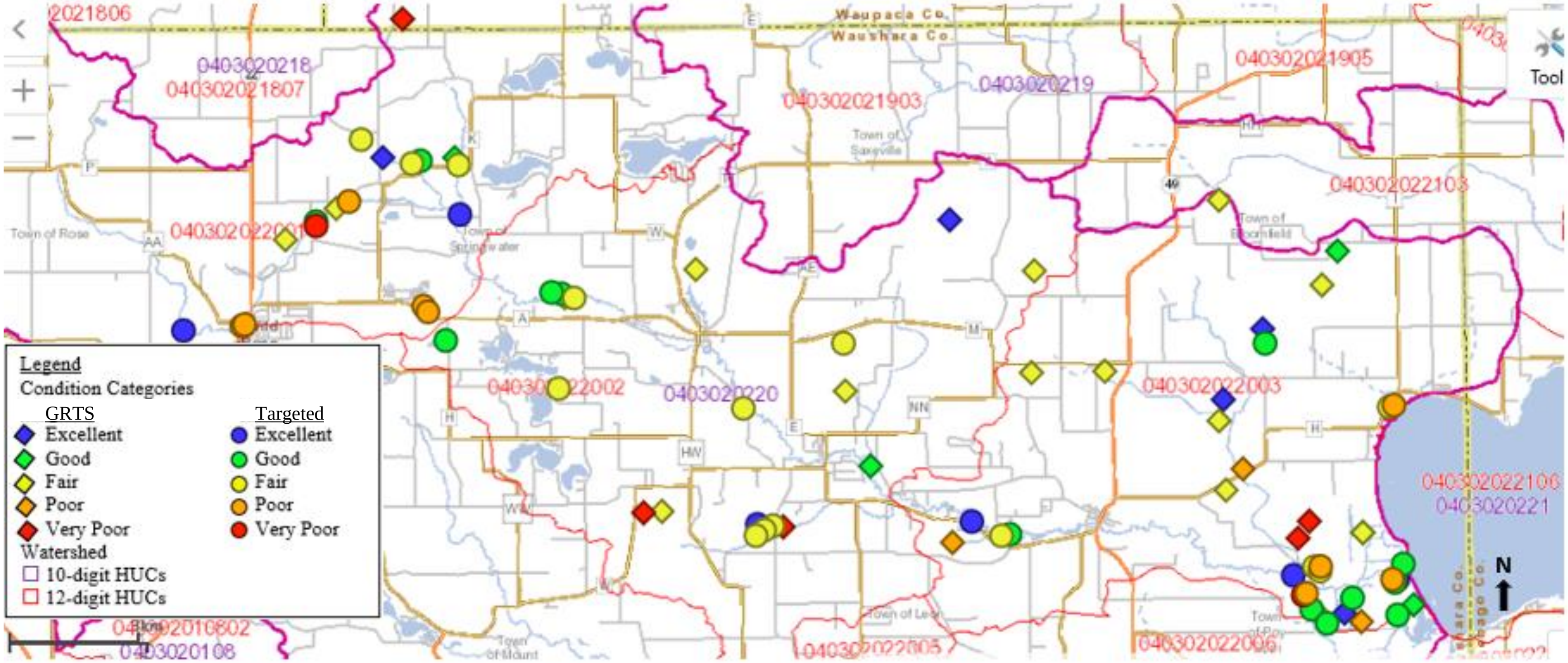

Figure 8. A map of targeted and probabilistically-selected (GRTS) sites surveyed during the 2018 and 2019 growing seasons within the Pine River watershed. Targeted-selected sites are depicted as circles and probabilistically-selected sites are depicted as diamonds. Condition categories are depicted by different colors with cool colors indicating higher quality and warmer colors indicating poorer quality. Ten and twelve-digit HUCs are outlined.

stream order, riparian/shoreland/geographically isolated) spatial patterns in condition were evident when sites were plotted by timed meander survey starting coordinate on a map of the Pine River watershed by condition category (Figure 7). Even when all sites across site selection methods were combined and mapped in this matter, no patterns were apparent (Figure 8).

Wetland disturbance and stressor assessment

Probabilistic monitoring estimates of Overall Disturbance and corresponding stressors

Based on the 33 probabilistic sites surveyed, over half of the wetlands in the Pine River watershed are estimated to have a “Moderate” (38 ± 8%), “Major” (14 ± 6 %) or “Severe” (1 ± 1%) level of Overall Disturbance (Scores = 3, 4, and 5, respectively; Figure 9; Appendix 1). Conversely, nearly one-fifth (18 ± 7 %) of the wetlands are estimated as being “Non-disturbed” and approximately one-third (30 ± 7%) of the wetlands are estimated as having “Minimal” Overall Disturbance.

The presence of roads/railroads/trails and disturbance from clear/selective cutting were the most common stressors observed overall, occurring at 40 ± 9% and 37 ± 8% of wetlands in the study area, respectively (Figure 10; Table 2). Invasive animals (22 ± 8%), mowing/grazing (20 ± 4%), and ditches (20 ± 6%) were also common disturbances (Figure 10; Table 2).

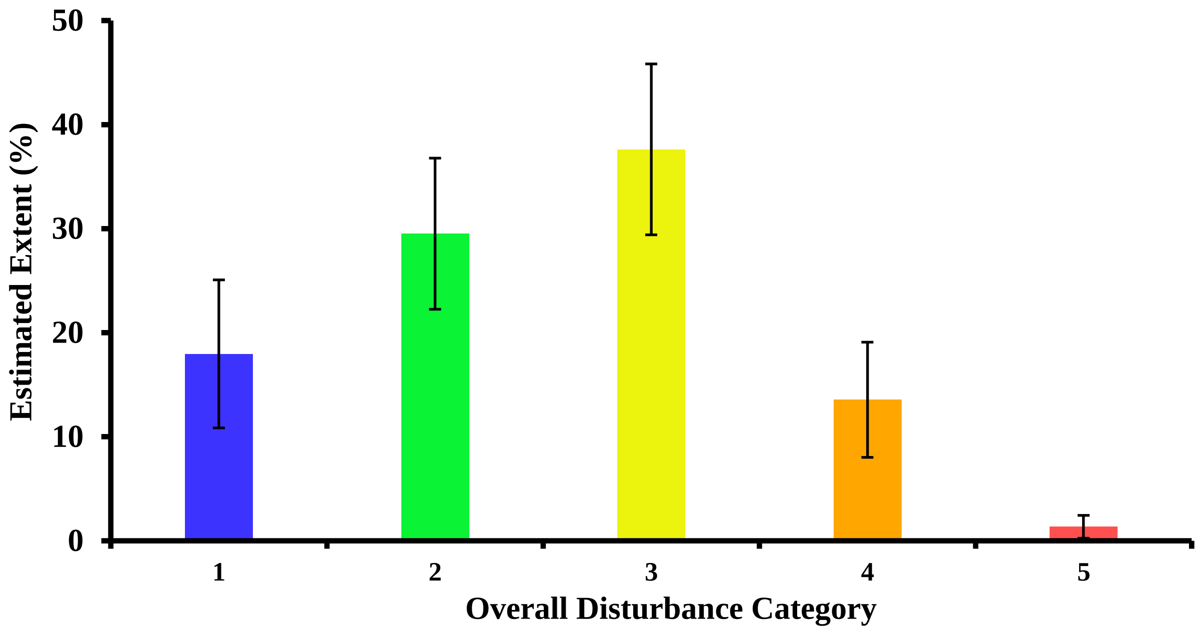

Figure 9. Estimated extent (Mean ± SE) of wetland area within each overall disturbance category in the Pine River Watershed based on 2019 field surveys of sites selected using probabilistic selection methods.

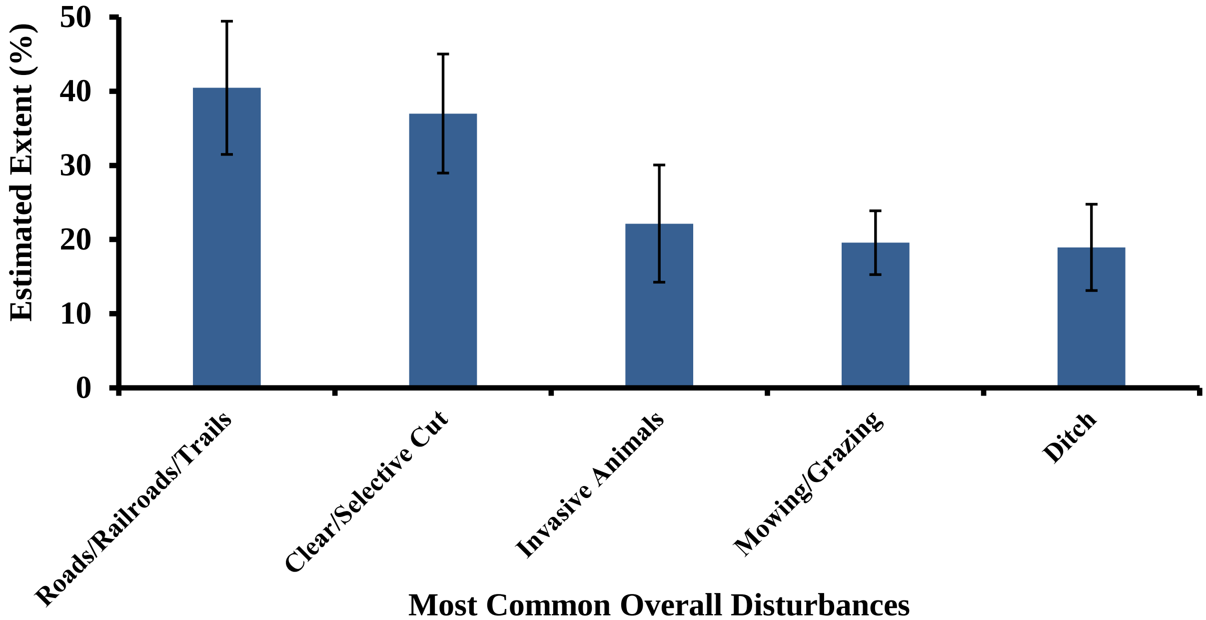

Figure 10. Percentage of wetlands affected (estimated extent ± SE) by the five most common overall disturbances observed in probabilistically selected wetlands sampled in the Pine River watershed during 2019.

Table 2. Overall disturbance factors observed in wetlands sampled in the Pine River watershed using probabilistic methods during 2019. Numbers indicate the estimated extent of wetlands with that disturbance and disturbance intensity (estimated extent ± SE).

All Disturbances	Low (%)	Medium (%)	High (%)	Total Disturbance (%)
Clear/Selective Cut	13 ± 6	23 ± 7	1 ± 1	37 ± 8
Dike	0	1 ± 1	3 ± 2	4 ± 3
Ditch	8 ± 4	11 ± 5	0	19 ± 6
Dredging	1 ± 1	4 ± 3	0	6 ± 3
Entire Vegetation	0	6 ± 4	1 ± 1	8 ± 4
Eutrophication	0	0	0	0
Excavation	6 ± 4	0	0	6 ± 4
Filling/grading	6 ± 4	4 ± 3	0	11 ± 5
Herb Removal	0	0	0	0
Invasive Animals	7 ± 3	15 ± 6	0	22 ± 8
Motor Vehicle Use	17 ± 7	1 ± 1	0	18 ± 7
Mowing/Grazing	11 ± 4	4 ± 3	4 ± 3	20 ± 4
Plowing/Ag	3 ± 2	8 ± 5	3 ± 3	14 ± 6
Road/RR/Trails	36 ± 9	1 ± 1	3 ± 2	40 ± 9
Sedimentation	6 ± 3	5 ± 5	5 ± 4	16 ± 6
Stormwater Input	4 ± 3	5 ± 5	0	9 ± 5
Tile	0	5 ± 4	0	5 ± 4
Water Control	4 ± 3	4 ± 3	0	8 ± 4

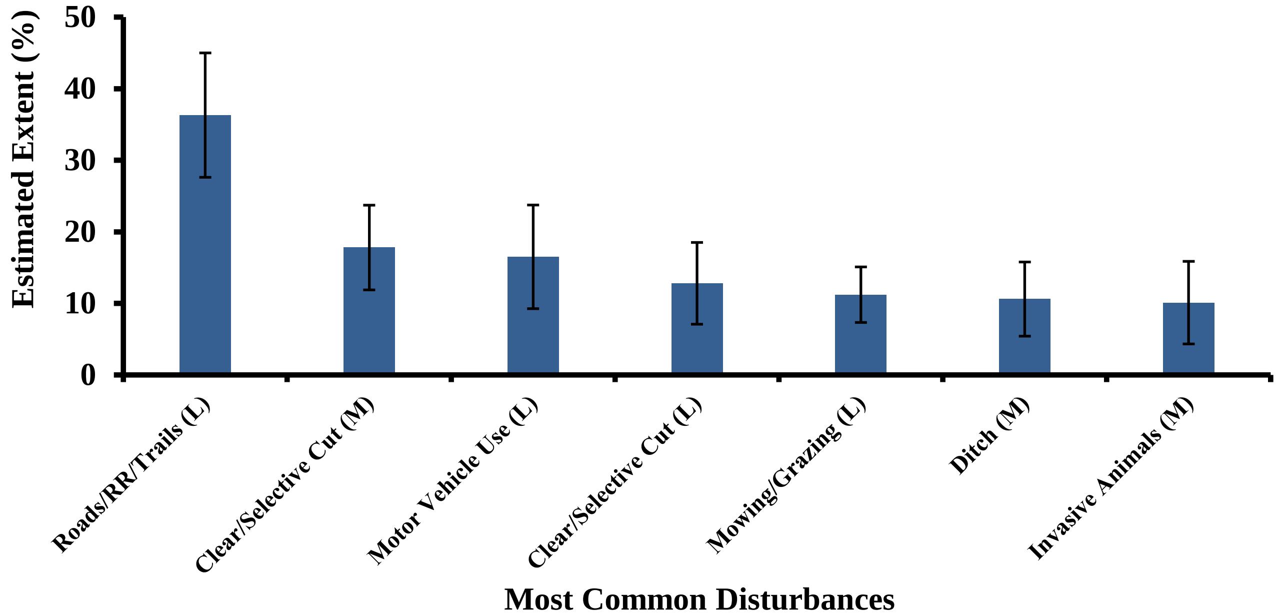

Figure 11. Percentage (estimated extent ± SE) of Pine River Watershed wetlands affected by the most commonly observed overall disturbances and by level of disturbance based on wetlands surveyed during 2019 using a probabilistic selection. L = Low intensity disturbance, M = Medium intensity disturbance, and H = High intensity disturbance.

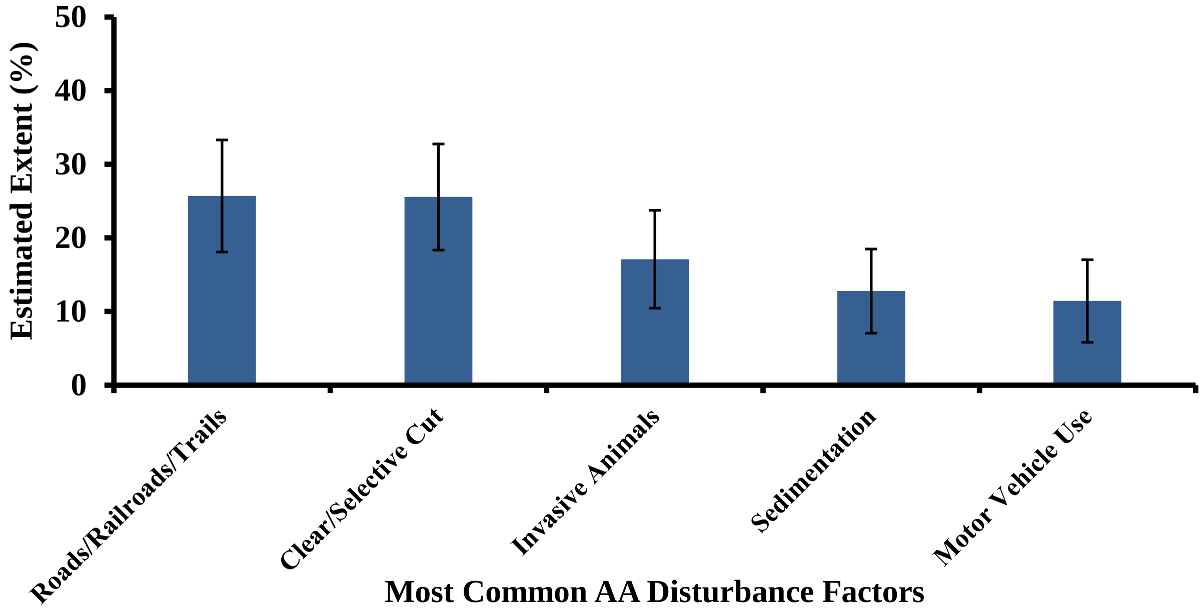

Figure 12. Percentage (estimated extent ± SE) of Pine River Watershed wetlands affected by the five most common disturbance factors (summed across impact levels) identified within the assessment areas of probabilistically selected wetlands surveyed during 2019.

Table 3. Disturbance factors observed within the assessment areas of probabilistically selected wetlands sampled in the Pine River watershed during 2019. Numbers indicate the area of wetlands with that disturbance and disturbance intensity (estimated extent ± SE).

AA Disturbances	Low (%)	Medium (%)	High (%)	Total Disturbance (%)
Clear/Selective Cut	8 ± 5	18 ± 6	0	26 ± 7
Dike	0	0	0	0
Ditch	3 ± 3	4 ± 3	0	7 ± 4
Dredging	0	1 ± 1	0	1 ± 1
Entire Vegetation	0	1 ± 1	0	1 ± 1
Eutrophication	0	0	0	0
Excavation	5 ± 4	0	0	5 ± 4
Filling/grading	5 ± 4	1 ± 1	0	6 ± 4
Herb Removal				
Invasive Animals	7 ± 3	10 ± 6	0	17 ± 7
Motor Vehicle Use	10 ± 5	1 ± 1	0	11 ± 6
Mowing/Grazing	0	4 ± 3	4 ± 3	8 ± 4
Plowing/Ag	0	0	3 ± 3	3 ± 3
Road/RR/Trails	24 ± 8	1 ± 1	0	26 ± 8
Sedimentation	0	0	0	0
Stormwater Input	0	0	0	0
Tile	0	0	0	0
Water Control	3 ± 3	1 ± 1	0	4 ± 3

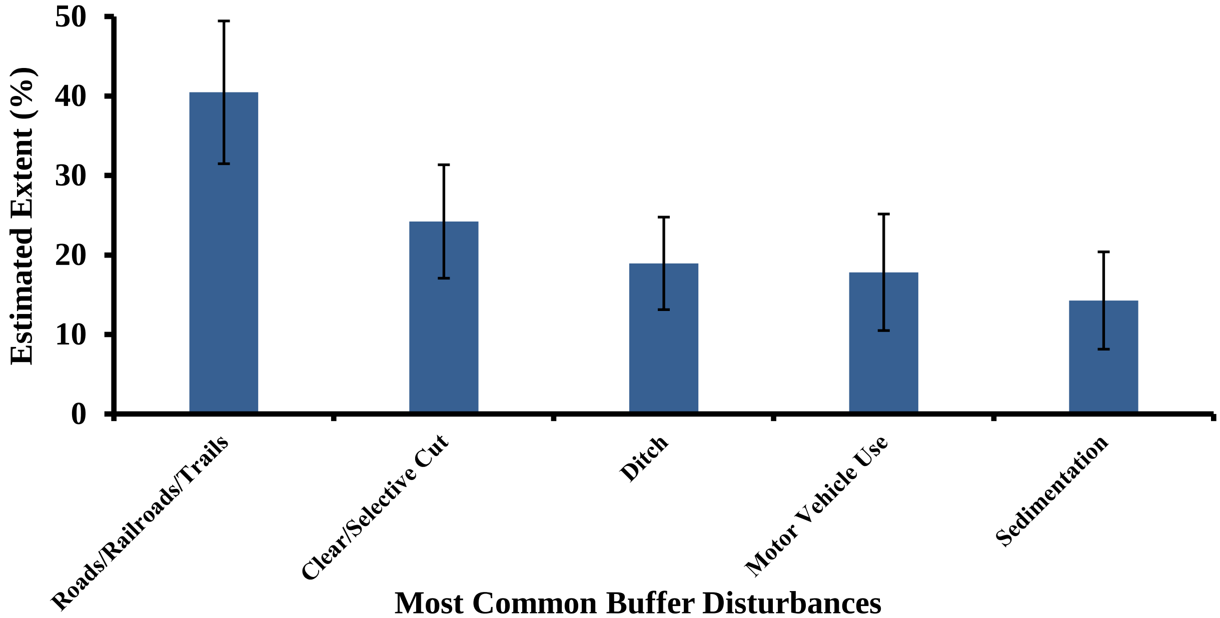

Figure 13. Percentage (estimated extent ± SE) of Pine River Watershed wetlands affected by the five most common disturbance factors (summed across impact levels) identified within the 30m buffer of probabilistically selected wetlands surveyed during 2019.

Table 4. Disturbance factors observed within the 30m buffer of probabilistically selected wetlands sampled in the Pine River watershed during 2019. Numbers indicate the area of wetlands with that disturbance and disturbance intensity (estimated extent ± SE).

Buffer Disturbances	Low (%)	Medium (%)	High (%)	Total Disturbance (%)
Clear/Selective Cut	6 ± 4	18 ± 6	0	24 ± 7
Dike	0	1 ± 1	3 ± 2	4 ± 3
Ditch	8 ± 4	11 ± 5	0	19 ± 6
Dredging	1 ± 1	4 ± 3	0	6 ± 3
Entire Vegetation	0	1 ± 1	0	1 ± 1
Eutrophication	0	0	0	0
Excavation	6 ± 4	0	0	6 ± 4
Filling/grading	6 ± 4	1 ± 1	0	6 ± 3
Herb Removal	0	0	0	0
Invasive Animals	4 ± 3	5 ± 5	0	9 ± 5
Motor Vehicle Use	17 ± 7	1 ± 1	0	18 ± 7
Mowing/Grazing	4 ± 3	4 ± 3	4 ± 3	13 ± 4
Plowing/Ag	3 ± 2	0	3 ± 3	6 ± 3
Road/RR/Trails	36 ± 9	1 ± 1	3 ± 2	40 ± 9
Sedimentation	4 ± 3	5 ± 5	5 ± 4	14 ± 6
Stormwater Input	3 ± 2	5 ± 5	0	8 ± 5
Tile	0	5 ± 4	0	5 ± 4
Water Control	4 ± 3	4 ± 3	0	8 ± 4

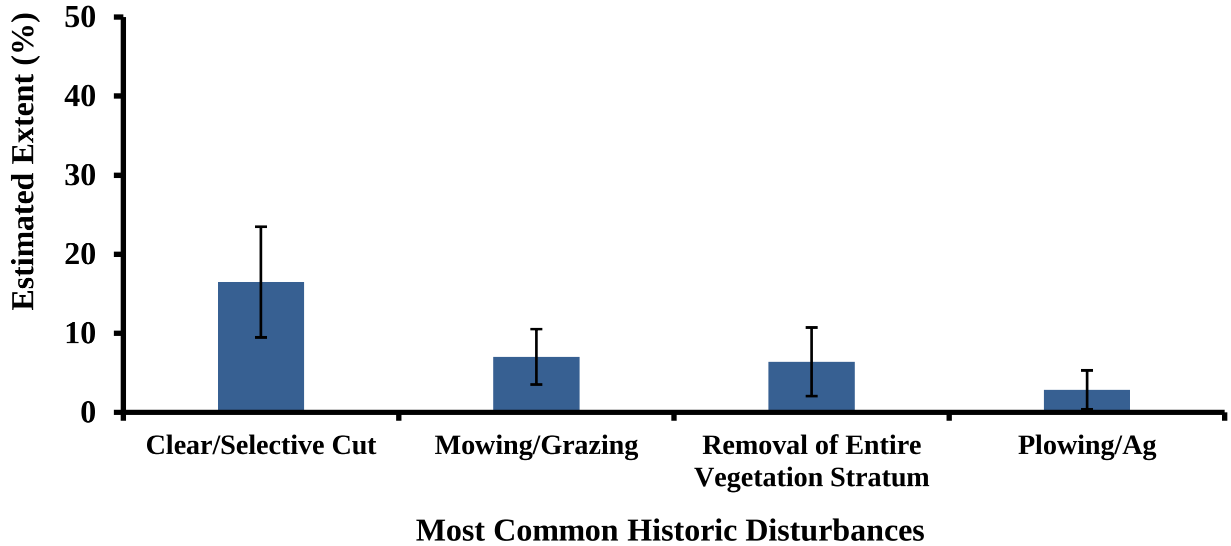

Figure 14. Percentage (estimated extent ± SE) of Pine River Watershed wetlands affected by historic disturbance factors (summed across impact levels) based on those observed at probabilistically selected wetlands surveyed during 2019

Table 5. Historic disturbance factors observed at probabilistically selected wetlands sampled in the Pine River watershed during 2019. Numbers indicate the area of wetlands in the Pine watershed with that disturbance and disturbance intensity (estimated extent ± SE).

Historic Disturbance	Low (%)	Medium (%)	High (%)	Total Disturbance (%)
Clear/Selective Cut	10 ± 5	5 ± 4	1 ± 1	16 ± 7
Dike	0	0	0	0
Ditch	0	0	0	0
Dredging	0	0	0	0
Entire Vegetation	0	5 ± 4	1 ± 1	6 ± 4
Eutrophication	0	0	0	0
Excavation	0	0	0	0
Filling/grading	0	0	0	0
Herb Removal	0	0	0	0
Invasive Animals	0	0	0	0
Motor Vehicle Use	0	0	0	0
Mowing/Grazing	7 ± 4	0	0	7 ± 4
Plowing/Ag	0	3 ± 2	0	3 ± 2
Road/RR/Trails	0	0	0	0
Sedimentation	0	0	0	0
Stormwater Input	0	0	0	0
Tile	0	0	0	0
Water Control	0	0	0	0

When overall level of disturbance was included as a factor, roads/railroads/trails at a low level of disturbance was most common (36 ± 9%), followed by disturbance from clear/selective cutting at medium (18 ± 6%) and low levels(13 ± 6%; Figure 11; Table 2). While not included in the most common overall stressors observed, motor vehicle use at a low level of disturbance was identified at 17 ± 7% of sites. Herbaceous vegetation removal and eutrophication were the only two disturbance factors not observed at any site (Table 3).

The presence of roads/railroads/trails and disturbance from clear/selective cutting (26 ± 8% and 26 ± 7%) were the most common stressors observed within the timed meander assessment area, as well as within a 30m buffer surrounding the assessment area (40 ± 9% and 24 ± 7%) when location of occurrence in relation to the wetland site being surveyed was accounted for (Figures 12 and 13; Tables 3 and 4). Motor vehicle use and sedimentation were also universally observed as a stressor across location of occurrence. Invasive animal disturbance (17 ± 7%) was somewhat commonly observed in AAs, but rarely observed in buffers, whereas ditching (19 ± 6%) was somewhat commonly observed in buffers but not within AAs. Only 4 historical disturbance factors were identified across probabilistic sites (Figure 14 and Table 5): clear/selective cutting (16 ± 7%), mowing/grazing (7 ± 4%), removal of entire vegetation stratum (6 ± 4%) and plowing/agriculture (3 ± 2%).

Targeted monitoring estimates of Overall Disturbance and corresponding stressors

Contrary to the results obtained using probabilistic site selection, the vast majority (81%) of the 44 targeted sites surveyed in the Pine had at least a “Moderate” level of disturbance or greater intensity (Figure 15). Forty-three percent of sites had an Overall Disturbance Score of 3, corresponding to a “Moderate” level of disturbance (Appendix 1). A nearly equal proportion of sites in total received scores of 4 (18%) or 5 (20%), indicating “Major” and “Severe” disturbance. Only 19% of sites were assessed with scores of 1 or 2, indicating “Non-disturbed” (5%) and “Minimal” (14%) conditions, respectively.

Mowing/grazing was observed at nearly half of all sites (48%) and was the most frequently encountered stressor overall followed by disturbance from invasive animals (34%; Figure 16 and Table 7). Stressors affecting hydrologic and physical conditions including excavation (25%), water control structures (23%), ditching (20%), and plowing/agriculture (20%) were also commonly observed.

When overall level of disturbance was included as a factor, disturbance from invasive animals (16%) and presence of roads/railroads/trails (14%) were the most common stressors observed at a low disturbance level (Figure 17 and Table 8). At a medium disturbance level, mowing/grazing (30%) and water control structures (15%) were the most common stressors observed. Mowing/Grazing was also the most common high-level disturbance, occurring at 14% of sites.

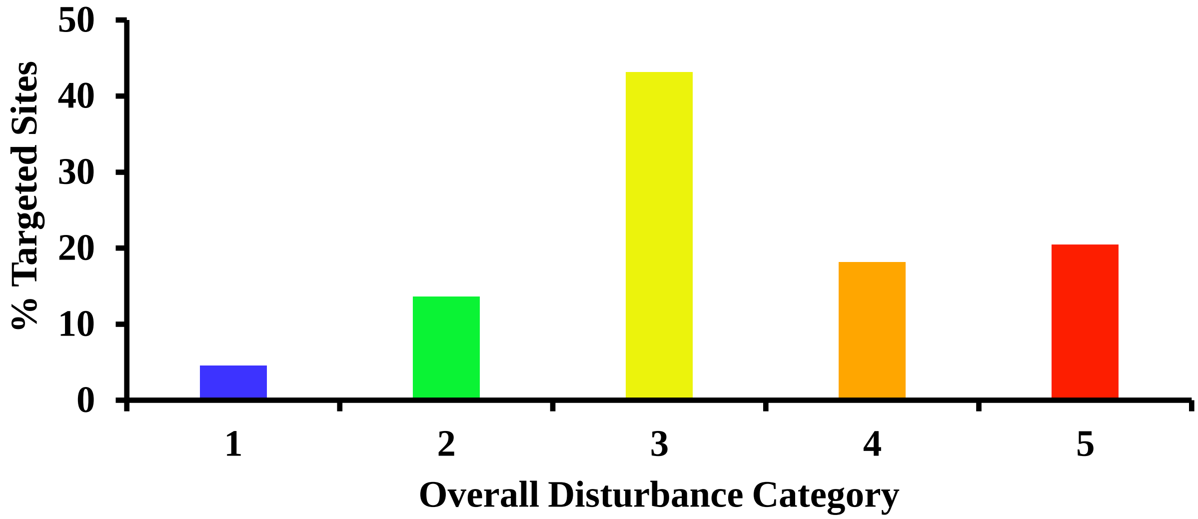

Figure 15. Percentage of wetland assessment areas within each overall disturbance category in the Pine River Watershed based on 2019 field surveys of targeted wetland sites.

Mowing/grazing (45%) and disturbance from invasive animals (32%) were the most common stressors observed within the timed meander assessment area (Figure 18 and Table 9). Within the 30m buffer around the assessment area, mowing/grazing again was the most frequently encountered stressor (25% of sites), but additional hydrologic and physical stressors such as excavation (25%),water control structures (20%), presence of roads/railroads/trails (20%), ditching (18%), filling/grading (18%) and plowing/agriculture (16%) were also observed (Figure 19 and Table 10). Historic mowing/grazing was observed at over one-third of sites (36%), but other stressors such as plowing/agriculture (16%) and removal of entire vegetation strata (11%) were also somewhat frequently encountered (Figure 20 and Table 11).

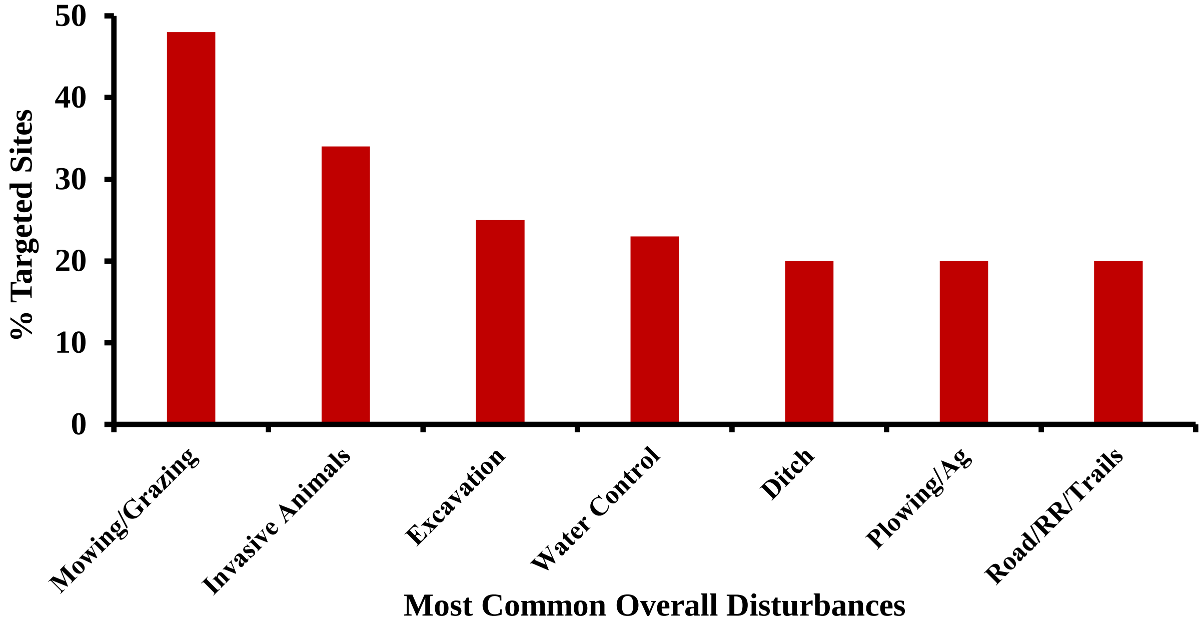

Figure 16. Seven most common overall disturbances summed across all impact intensities as observed at targeted wetland sites surveyed during 2018-2019 in the Pine River watershed.

Table 6. Overall disturbance factors observed in targeted wetland sites surveyed in the Pine River watershed during 2018 and 2019. Percentages of targeted sites impacted by disturbance factors at the low, medium, high, and total impact combined levels are indicated.

All Disturbances	Low (%)	Medium (%)	High (%)	Total Disturbance (%)
Clear/Selective Cut	0	5	2	7
Dike	5	5	0	9
Ditch	9	7	5	20
Dredging	2	7	2	11
Entire Vegetation	2	7	5	14
Eutrophication	5	5	5	14
Excavation	11	11	2	25
Filling/grading	9	7	2	18
Herb Removal	2	0	0	2
Invasive Animals	16	14	5	34
Motor Vehicle Use	5	2	0	7
Mowing/Grazing	5	30	14	48
Plowing/Ag	5	11	5	20
Road/RR/Trails	14	7	0	20
Sedimentation	7	7	2	16
Stormwater Input	5	5	0	9
Tile	0	2	0	2
Water Control	5	16	2	23

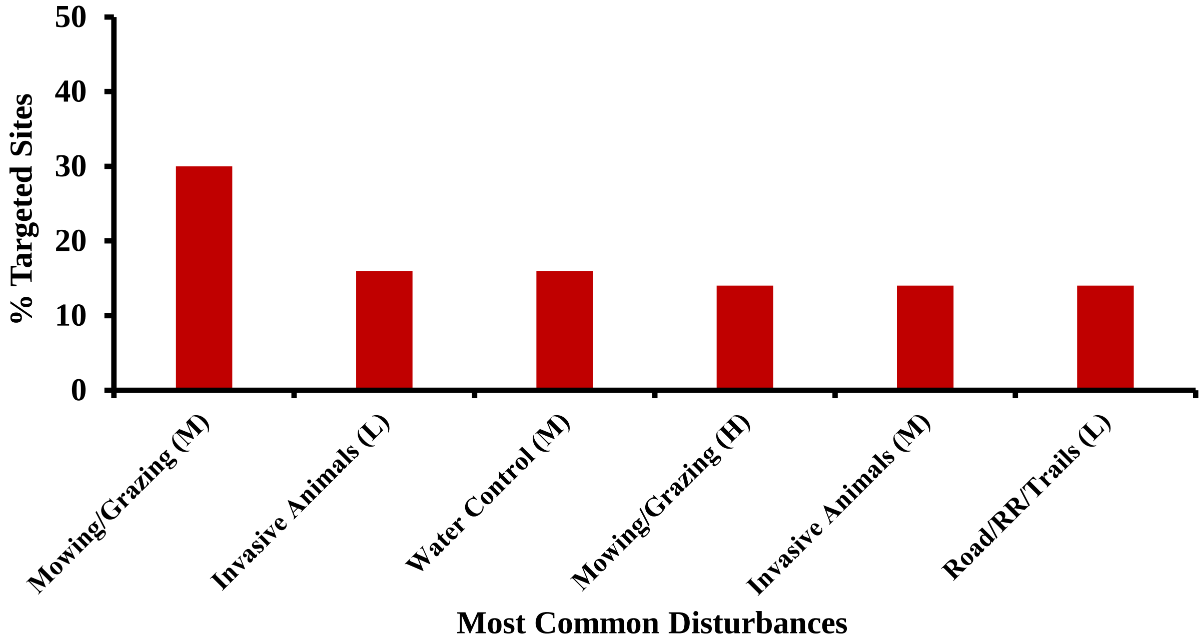

Figure 17. Percentage of targeted wetland sites affected by the most common overall disturbances by level of disturbance surveyed 2018-2019 in the Pine River Watershed. L = Low intensity disturbance, M = Medium intensity disturbance, and H = High intensity disturbance.

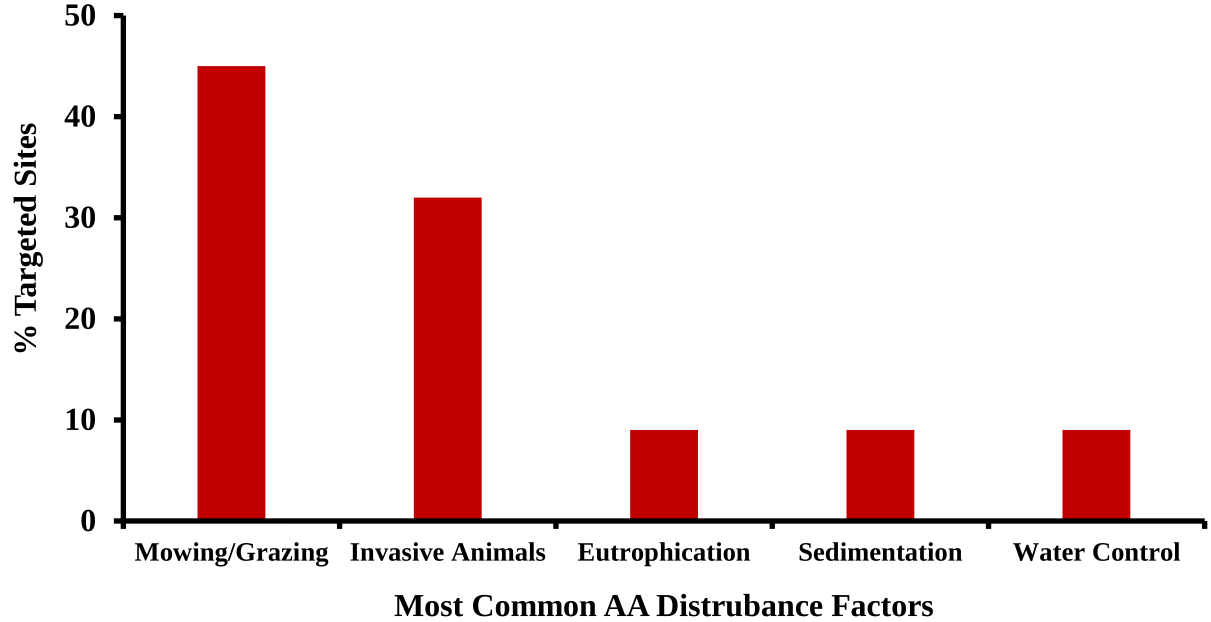

Figure 18. Percentage of targeted wetland sites surveyed 2018-2019 in the Pine River watershed affected by the five most common disturbance factors (summed across impact levels) identified within the site assessment area.

Table 7. Percentage of targeted wetland site AAs affected by disturbance factors at the low, medium, high, and total impact levels in the Pine River watershed during 2018-2019.

AA Disturbance	Low (%)	Medium (%)	High (%)	Total Disturbance (%)
Clear/Selective Cut	0	5	2	7
Dike	0	0	0	0
Ditch	0	2	0	2
Dredging	0	0	0	0
Entire Vegetation Stratum	0	5	2	7
Eutrophication	2	2	5	9
Excavation	0	2	0	2
Filling/Grading	2	0	0	2
Herb Removal	2	0	0	2
Invasive Animals	16	11	5	32
Motor Vehicle Use	0	0	0	0
Mowing/Grazing	18	16	11	45
Plowing/Ag	0	2	2	5
Road/RR/Trails	2	0	0	2
Sedimentation	5	2	2	9
Stormwater Input	5	0	0	5
Tile	0	0	0	0
Water Control	2	7	0	9

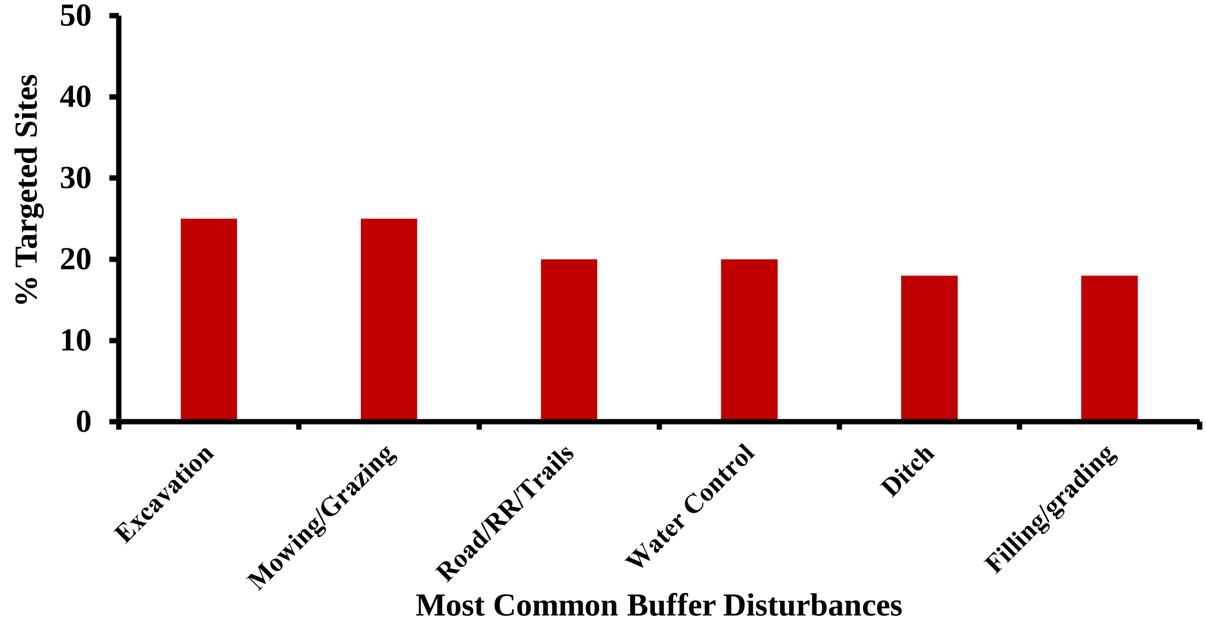

Figure 19. Percentage of targeted wetland sites surveyed 2018-2019 in the Pine River watershed affected by the five most common disturbance factors (summed across impact levels) identified within the 30m buffer surrounding the site.

Table 8. Percentage of targeted wetland sites affected by disturbance factors within the 30m buffer at the low, medium, high, and total impact levels in the Pine River watershed surveyed during 2018-2019.

Buffer Disturbance	Low (%)	Medium (%)	High (%)	Total Disturbance (%)
Clear/Selective Cut	0	5	2	7
Dike	5	5	0	9
Ditch	9	5	5	18
Dredging	2	7	2	11
Entire Vegetation	2	2	0	5
Eutrophication	2	2	5	9
Excavation	11	11	2	25
Filling/grading	9	7	2	18
Herb Removal	0	0	0	0
Invasive Animals	5	9	2	16
Motor Vehicle Use	5	2	0	7
Mowing/Grazing	0	14	11	25
Plowing/Ag	5	9	2	16
Road/RR/Trails	11	9	0	20
Sedimentation	5	2	0	7
Stormwater Input	5	5	0	9
Tile	0	0	0	0
Water Control	2	16	2	20

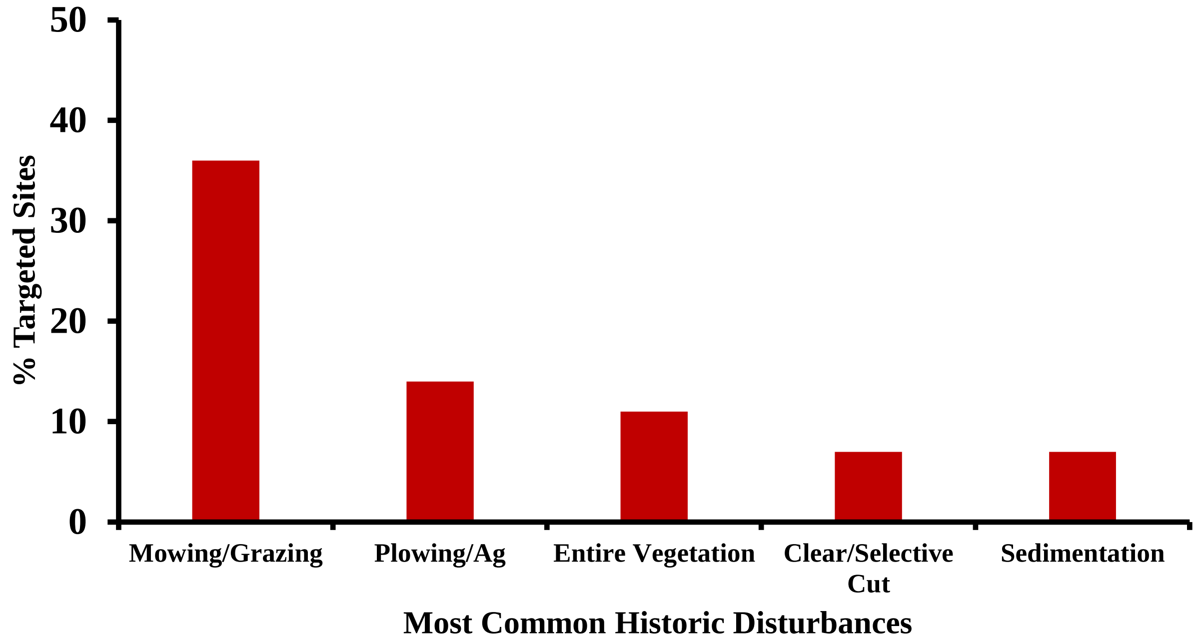

Figure 20. 5 most commonly observed historic disturbances summed across all impact intensities at targeted wetland sites surveyed during 2018-2019 in the Pine River watershed.

Table 9. Historic disturbance factors observed at targeted wetland sites surveyed in the Pine River watershed during 2018 and 2019. Percentages of targeted sites impacted by disturbance factors at the low, medium, high, and total impact combined levels are indicated.

Historic Disturbance	Low (%)	Medium (%)	High (%)	Total Disturbance (%)
Clear/Selective Cut	0	5	2	7
Dike	0	0	0	0
Ditch	2	0	0	2
Dredging	0	0	0	0
Entire Vegetation	2	5	5	11
Eutrophication	0	0	2	2
Excavation	2	0	0	2
Filling/grading	0	0	0	0
Herb Removal	0	0	0	0
Invasive Animals	0	2	0	2
Motor Vehicle Use	0	0	0	0
Mowing/Grazing	2	25	9	36
Plowing/Ag	2	7	5	14
Road/RR/Trails	2	0	0	2
Sedimentation	2	5	0	7
Stormwater Input	2	0	0	2
Tile	0	2	0	2
Water Control	2	2	0	5

Cross-comparison and calibration of WbD and WRAM V2

At the time of writing this report, there were unanticipated insurmountable data discrepancies (including omitted and uninterpretable data) that resulted in low confidence in the accuracy of the WRAM V2 data generated by field crews. Thus, while results and discussion have been included in Appendix 4, it is cautioned that these data should be interpreted as general information rather than the initially designed and intended comprehensive calibration among methods. Generally, it was found that WbD was not able to accurately predict wetland functions assessed in the field using WRAM V2.

Surface water characterization and water chemistry

Surface water characterization and water chemistry sampling was limited to field season 2019. Out of abundance of caution in relation to global COVID-19 Pandemic, a collaborative wetland monitoring and assessment staff decision was made to cancel sampling during 2020. An understandably high bar to meet both agency and personal requirements/expectations for travel and overall safety was determined to be neither logistically nor financially feasible for completion of this segment of the project within the grant or project timeline.

Despite these obstacles, data and samples were collected at approximately 32 sites in the Pine River watershed in 2019. The vast majority of samples were collected at targeted sites, as surveying for WFQA and WRAM V2 at probabilistic sites was occurring concurrently. Surface water was present on 22 of 32 sites surveyed, but only 16 sites had deep enough water for water chemistry sampling. This was despite 2018 and 2019 being some of the wettest years on record for Wisconsin both regionally and statewide (Kaeding 2019).

Given low overall surface water chemistry sample size (and even smaller sample sizes within the data for certain variables due to non-detections at the lab), exploratory data analyses were conducted but ultimately did not reveal justifiable and defensible patterns for reporting at the time of final grant submission. While a comparison of these results with functional assessment tools was also an initial intended project goal, aforementioned concerns with the accuracy of WRAM V2 and WbD results, as well as the fact that water physicochemsitry was only able to be sampled during one event (where/when available) made this comparison unwarranted.

Soil profile characterization and soil physicochemistry

Similar to surface water characterization and water chemistry sampling, soil profile description and soil physicochemistry sampling was limited to field season 2019 due to the global COVID-19 Pandemic and aforementioned associated concerns/constraints.

Despite these obstacles, soil profile data and 51 soil physicochemistry samples were collected at 26 sites in the Pine River watershed in 2019. The vast majority of samples were collected at targeted sites, as surveying for WFQA and WRAM V2 at probabilistic sites was occurring concurrently. Approximately 8 additional sites were also surveyed and sampled for soils during 2019, but logistical constraints and restrictions on office access due to COVID 19 prevented shipment of the samples to the lab for final analyses.

Preliminary data analyses related to PSR and SPSC were conducted in coordination with the US Army Corps of Engineers Wetlands Laboratory (Engineer Research and Development Center Environmental Laboratory) in Vicksburg, MS. At the time of this report, the collaborative WDNR-USACE team noticed a potential anomaly with these data as well as other data collected by USACE across Great Lakes Basin watersheds in comparison to published literature and thresholds regarding PSR and SPSC (e.g. Currie et al. 2017; Dari et al. 2018;). Thus, continued investigation is ongoing and any reports or results generated will be associated with this report and submitted to USEPA at that time.

Given the preliminary nature of these data and estimated P sorption metrics, as well aforementioned concerns with the accuracy of WRAM V2 and WbD results and overall low soil physicochemistry sample size, comparisons amongst these tools and measurements were not warranted at the time of this report. However, this may be justified for general inquiry in the future as time and resources allow.

Discussion

<u>Wetland biotic condition assessment using WFQA</u>

A primary goal of this study was to obtain an in-depth look at the current condition of wetlands in the Pine River watershed for reporting in conjunction with the existing TWA report (Bolha 2020). Another goal was to compare and contrast condition results obtained using various site selection methods. Using WDNR's available WFQA Tools (Bernthal 2003; Hlina et al. 2015; Trochlell 2016; Marti and Bernthal 2019), results indicate that **the majority of wetlands in the Pine River watershed are in "Fair" condition, regardless of which site selection method was used to generate the condition estimate**. However, probabilistic estimates of "Fair" wetland condition were one-and-a-half times greater than estimates generated by targeted site selection methods (48 ± 8% vs 32%, respectively; Figures 4 and 6). Probabilistic estimates of wetlands in "Good" condition (17 ± 7%) were nearly two-fold lower than those estimated using targeted site selection methods (30%; Figures 4 and 6). If probabilistic surveys are considered the "gold standard" by which other survey methods should be compared for accuracy, this suggests that **targeted site selection methods for surveying wetland condition in the Pine watershed generally tended to overestimate the overall condition of wetlands in the watershed despite best efforts to minimize all known (and somewhat controllable) biases.**

However, there are a number of additional considerations and caveats that should be noted that may have affected the observed differences in condition results—many of which can be summarized as factors that were unintentionally not controlled for that may have yielded a more “apples to apples” comparison. Some general aspects as related to site selection will be further discussed in a later section as they also apply to disturbance and stressor assessment (see “Site selection methods: considerations and lessons learned”), but two (arguably three) notable factors specific to WFQA due to misunderstandings among data analysts for this study that were not discovered until final drafting of this report should be considered:

1) Selection of WFQA benchmarks (i.e. Marti and Bernthal 2019) by which to compare study area site WFQA scores spanned multiple Omernik Level III Ecoregions (Figure 3), and it was decided to select benchmarks for a given site based on location (Tables 1A and 1B). Thus, if a southern sedge meadow was surveyed in the western-most HUC12 of the study area, benchmarks for the North Central Hardwood Forests were selected for comparison, and if a southern sedge meadow near Lake Poygan at the easternmost edge of the HUC12 was surveyed, benchmarks for the Southeastern Wisconsin Till Plains were selected. While this initially would seem logical, preferentially always choosing benchmarks from the North Central Hardwood Forests rather than the Southeastern Wisconsin Till Plains for wetland community types occurring in both ecoregions whenever possible would have created a more standardized comparison for condition across the entire watershed. Given that the study area watersheds are predominantly in the North Central Hardwood Forests, wetlands occurring in the far eastern portion of the study area generally share more inherent (e.g. abiotic, edaphic) ecological characteristics with North Central Hardwood Forests wetlands than they do Southeastern Wisconsin Till Plains Wetlands.

2) Secondly, when benchmarks for a given wetland community type surveyed within the study area were not available in either applicable Omernik Level III Ecoregion, benchmarks from either the Northern Lakes and Forests or the Driftless Area were chosen. While choosing benchmarks from another ecoregion not within the study area in and of itself represents an additional factor that may introduce variability, choice of benchmarks were generally based on land use and proximity rather than consideration of ecological and other factors. For example, benchmark criteria from the Driftless Area were selected for comparison to alder thicket ecosystems surveyed within the study area. However, given the absence of (geologically) recent glaciation and difference in soil parent materials (loess and colluvium) inherent to the Driftless Area comparative to the North Central Hardwood Forests (Figures 2 and 3), alder thicket benchmark criteria from the Northern Lakes and Forests ecoregion (and other benchmarks from this ecoregion as whole as a whole) may have been more appropriate because of similarity in glacial history and soil parent materials.

It is highly suggested that the above factors be considered and decisions thoroughly documented *a priori* if/when future wetland TWA assessment projects (or other projects assessing wetland condition in general) are planned and completed. Additionally, further future comparative assessment of the Pine TWA WFQA condition results using the suggested alterations noted above may be warranted to understand the effect of these decisions on condition result outcomes under multiple scenarios. When these factors are understood, future work to compare condition results among wetlands and other aquatic resources may be better supported and justified.

Wetland disturbance and stressor assessments

Similar to results obtained for estimates of wetland condition, results indicate that **the majority of wetlands in the Pine River watershed are estimated to be disturbed by probable stressors at a "Moderate" level (Disturbance Factor Checklist Score = 3), regardless of which site selection method was used to generate the disturbance estimate.** In addition, estimates of "Moderate" disturbance for probabilistic (38 ± 8%) and targeted (43%) surveys were within a few percentage points of one another (Figures 9 and 15).

However, similarity among results generated from targeted versus probabilistic site selection methods largely stopped beyond dominant disturbance level and when looking at specific stressors. When considering Overall Disturbance among survey methods, the remaining majority of targeted sites were assessed to be at more severe levels of disturbance than "moderate"—opposite the pattern of probabilistically surveyed sites, where over half of the wetland acres within the watershed were estimated to be at "Minimal" or "Non-disturbed" levels of disturbance (Figures 9 and 15). Additional discrepancies were also noted among the most common stressor types/categories. Targeted sites had observed disturbance from mowing/grazing and invasive animals at nearly half and one-third of sites as top stressors, whereas these stressors were of secondary prevalence (~20%) at probabilistic sites. Disturbance from the presence of roads/railroads/trails (40 ± 9%) and clear/selective cutting (37 ± 8%) were identified as top wetland stressors based on observations at probabilistic sites, but not even of secondary prevalence at targeted sites. Stressors related to hydrologic and physical disturbance of secondary prevalence (i.e. excavation, water control structures, and plowing/agriculture; est. 20-25% of wetland area) observed at targeted sites were entirely absent from top and secondary stressors of probabilistic sites, with the exception of ditching, which was estimated to affect ~20% of wetlands regardless of site selection method. If probabilistic surveys are considered the "gold standard" by which other survey methods should be compared for accuracy, this suggests that **targeted site selection methods for surveying wetland disturbance and prevalence of stressors in the Pine Watershed 1) generally tended to overestimate the Overall Disturbance of wetlands in the watershed as compared to estimates generated using probabilistic site selection methods, which estimated the vast majority of wetlands in the watershed to be at "moderate" or less severe states of**

disturbance; and additionally, **2) generally led to largely different observations of the types and/or prevalence of various stressors as compared to probabilistic site selection methods.**

Similar to reporting of condition results, a number of caveats specific to estimation of wetland disturbance and stressors exist and should be considered. These (and other disturbance and stressor related factors potentially influencing results) include the following:

1) The potential for inter-assessor variation within Disturbance Factor Checklist results, both for individual stressors and for assignment of the Overall Disturbance Score cannot be understated. As aforementioned, approximately six different individuals were responsible for completion of this assessment, similar to WRAM V2 results. While attempts for office and field cross-calibration were attempted among individuals and between WDNR and the contractor, many more individuals were completing these assessments than intended when this pilot project was originally designed. This likely compounded potential error and deviation among assessors completing the assessments. This underscores the need for longer duration training (week(s) vs. days) under a variety of potential disturbance and condition scenarios and the overall need, when possible, to have only a single assessor or two well-calibrated assessors for future assessments of this type when working in the same area or comparing amongst areas.

2) Targeted sites may have been inadvertently biased towards more anthropogenically disturbed areas in general. Because the objective of most water resources field staff conducting TWAs is to access tributary and river segments for sampling that can be representative of whole watershed or sub-watershed disturbance or condition rather than localized disturbance or condition, bridge crossings and public land access points inherently are the most common points for TWA sampling sites. Many of these lands in the Pine are designated fisheries access areas frequented by anglers, hunters, and other users. Thus, the general disturbance inherently associated with public access areas and road crossings (i.e. roads/railroads/trails, mowing, etc.) likely influenced the result of observed elevated disturbance within targeted sites even beyond what a single day of field observations could capture.

3) The role of potential "hidden stressors" among all survey types cannot be understated. A prime example may be groundwater withdrawals from agriculture resulting in water table alteration across the Pine watershed, which may be a confounding unobservable variable (by single day field assessment) that deserves further investigation and incorporation into wetland stressor identification. However, groundwater withdrawals may also be blatant and observable. For example, while conducting desktop evaluation of a number of sites, several pipes for center pivot agricultural irrigation were observed running across the ground surface from field

edges to center of large wetland complexes. In watersheds such as the Pine with cool-cold and coldwater streams that support trout and associated species, understanding groundwater withdrawal effects on wetlands is also paramount, as wetlands provide an important area for rainfall infiltration to groundwater and provide cold groundwater discharges that support of the baseflow of streams.

4) Do upland wildlife connections to wetland condition and stressors exist? Perhaps so. The major stressor of mowing/grazing at targeted sites was often a result of white tail deer (*Odocoileus virginianus*) browse observations based on notes from the field crews. While many ecologists and the public may debate the implications of browse from a native occurring ungulate, Freker et. al. (2014) demonstrated that deer presence can greatly affect plant communities over a period of 10-20 years – specifically, areas associated with deer presence had double the abundance of exotic plants compared to areas fenced off from deer. In terms of the Pine TWA, field ecologists often assessed deer browse at low to moderate intensity, but overall, the broader impact from many years of deer browse may in fact be a higher impact disturbance that is observable in a single day's assessment.

5) Invasive animals were identified as an additional top stressor in targeted sites, which according to field notes was based on evidence of emerald ash borer, *Argilus planipennis*. While invasive animals were identified as a secondary stressor at probabilistic sites, this may be highly correlated with evidence of clear and selective cutting that was identified as a top stressor, where trees that may have suffered dieback from emerald ash borer were cut for firewood (or were pre-emptively cut anticipating dieback) to attempt to regenerate tree growth. Indeed, previous WDNR wetland monitoring and assessment studies in the Lake Michigan basin have identified this as a top concern as well, as ash trees (*Fraxinus* spp.) constitute a major canopy tree of many forested wetland types in the basin (i.e. Marti and Bernthal 2016). While the overall anticipated effects of emerald ash borer on wetlands in Wisconsin are unknown at this point, elimination or reduction of ash from wetlands in many situations may lead to additional related stressors hydrologically and myriad other aspects (e.g. Kolka et al. 2018) and conceivably would allow for semi-unregulated understory spread of current uncommon invasive species by elimination of light limitation in these systems.

Future work to compare stressors among sites surveyed by Bolha (2020) and wetlands (this study) within the Pine watershed, particularly at paired targeted sites or at sub-HUC12 scales, may yield additional further insights for holistic water resources restoration and protection. Additionally, future increased collaboration and engagement with other WDNR programs such as Wildlife Management, Forestry, Drinking and Groundwater, and Fisheries

Management to identify, alleviate and correct watershed stressors may be necessary to achieve watershed restoration goals for the health of all water resources involved.

<u>Site selection methods: considerations, lessons learned and future hurdles for implementation</u>

As aforementioned, there are a number of additional considerations and caveats regarding site selection methods that should be noted that may have affected the observed differences in condition and disturbance results between targeted and probabilistic site selection methods, as well as some anticipated hurdles for future implementation of similar surveys, including the following:

1) A discrepancy exists in number of sites surveyed and reported on using both site selection methods due to a misunderstanding among data analysts that was not identified until preparing the final draft for this report. Thus, 33 sites were selected, surveyed and reported on using probabilistic site selection methods while 44 sites were used for generating targeted site results. In general, this mismatch in numbers of sites for reporting and comparing/contrasting results was unintended because surveying and reporting an equal number of sites among methods was *a priori* identified as a method to decrease bias among methods and offer an equal ground for comparison. In contrast, it may be reasoned that reporting on 1.5x the number of targeted sites vs. probabilistic sites might be a way to increase accuracy of results of targeted surveys, and potentially, a way to overcome some of the inherent biases associated with human selection of sites. It may also be argued that inclusion of all data generated using both methods is reasonable given that all procedures for surveying sites were universal and followed. However, while inclusion of additional targeted sites may be desirable, probabilistic surveys using *spsurvey* follow a rigorous protocol for generation of potential survey sites and site evaluation. Thus, by reporting on three additional probabilistically selected sites, inherent assumptions in the original survey design may have been violated and led to misappropriation of site weights that may have affected overall final estimates.

2) Results from the probabilistic survey were generated and reported on using original unadjusted site weights due to another statistical oversight and misunderstanding on the data analysis team. While site evaluation protocols were followed and documented *sensu* US EPA NWCA (2016b), the site evaluation data was not accounted for within *spsurvey* to generate final results. Thus, while the probabilistic sites surveyed represent a truly randomized site draw that accounted for spatial density of target wetland communities and acres, the quantity of target wetland area that is unable to be accounted for and the area that was inaccessible or misclassified in the estimates is unknown at this time.

3) A general rule of thumb for probabilistic surveys using *spsurvey* is that a minimum number of 50 sites be used to minimize variation and generate statistically meaningful results and trends (*sensu* Marti and Bernthal 2016). However, given logistical concerns for both this study as well as future implementation, 30 sites was selected as an optimal number of sites based on reasons detailed within the Methods section.

4) As alluded in the previous three caveats, **extensive documentation and development of tools, resources, and trainings to facilitate probabilistic wetland surveys in the future (where appropriate) using *spsurvey* will require significant time and resources.** This need was anticipated *a priori* and funding acquired through regional monitoring initiative grant funds to procure a Wisconsin wetland-specific probabilistic site selection and data analysis customized R package (or similar product) in collaboration with US EPA Office of Research and Development in Corvallis for this pilot project and any other probabilistic wetland monitoring project in Wisconsin; however, due to personnel constraints and differing priorities, the decision was made to collaborate *ad hoc* with EPA ORD and instead have wetland monitoring staff familiar with the US EPA NWCA attempt to generate probabilistic draws and results in collaboration with other water resources monitoring staff experienced in using *spsurvey* for surveying linear resources. As evident by the Results and Discussion sections of this report, future efforts will need to draw much more heavily on EPA ORD expertise and creation of accessible, documented tools is highly recommended to avoid the issues encountered in this pilot project. Creation of a "plug and play" probabilistic wetland survey site selection and analysis tool would allow non-expert wetland ecologists at the WDNR to expand TWA (and similar) survey efforts to more watersheds throughout the state. It is the goal of the Water Quality program in future years to expand wetland monitoring efforts in an efficient and repeatable manner.

5) Three quarters of wetlands in Wisconsin occur on privately owned lands (Hagen 2008) so strictly focusing on public land available wetlands for future efforts would strongly bias results in the context of targeted surveys from an ownership, land management and potentially a disturbance perspective. Nonetheless, access to wetlands on private lands is a substantial hurdle requiring a large amount of effort (nearing hundreds of hours for a 30-site survey) in terms of obtaining permissions and maintaining communications with landowners regardless of survey type. For this pilot, a 3-person team spent multiple weeks contacting landowners for permissions by a variety of methods (phone, standard mail, e-mail, and in-person interactions) in order to conduct the probabilistic survey. The effort and time needed for private land access permissions cannot be understated for future efforts and requires significant planning.

6) Based on experience gained through this pilot, two general "rules of thumb" have been ascertained in regard to deciding on selection of wetland monitoring and assessment designs for future implementation.

   First, while **probabilistic designs** represent a "gold standard" when properly implemented, these designs are likely to be **most successfully implemented (and hurdles overcome) in rural watersheds with more public lands and potentially fewer private owners that have larger parcel sizes used for recreation or timber purposes in general**. The main limitation with recreational lands (e.g. hunting land) may be that surveys would need to accommodate seasons or anticipated times of landowner use. Probabilistic surveys **may also be successfully implemented in moderate disturbance (mixed agriculture and natural cover dominated watersheds) like the Pine but may require more extensive time and efforts for landowner contacts and permissions.**

   Second, given the discrepancies of results between survey designs for both condition and disturbance stressor analyses in this report, it is suggested that **targeted site selection designs should be used only in the instance that established and known access to wetlands due to landowner denials will be an issue, such as in dominantly urbanized watershed settings where the increased number of private landowners likely means an increased in denied access even for a single wetland assessment area**—in other words, where a probabilistic survey may be extremely difficult. This **also may occur in watersheds that are extensively agriculture and urban dominated, where private landowners may be resistant to allowing access to "working lands"**. **These limited instances would represent scenarios where the best choice may be to do a targeted design primarily focusing on public lands.** An exception to this may be targeted monitoring in relation to a known or anticipated particular stressor or set of stressors (e.g. significant water permitting activity or natural resources disturbance) or to document condition or potential stressors of wetlands within a limited scope or geographical area (sub HUC12) for various purposes such as wetland restoration or land management and conservation planning.

   While these "rules of thumb" may be helpful for future efforts, every watershed or potential study area for wetland monitoring and assessment provides a unique situation and should be assessed independently. Multiple factors should be assessed when determining which site assessment selection methodology can/should be utilized in a TWA or otherwise, including: staff availability/expertise, resources/funding, watershed size, wetland density, watershed land use, proportion of private to public wetlands, local cultural identity and trends (sociopolitical aspects), and the relative need for overall statistical confidence based on thoughtful, detailed and well documented (*a priori*) monitoring and assessment or management objectives.

Cross-comparison and calibration of WbD and WRAM V2: considerations and lessons learned

As aforementioned, while results and further discussion have been included for the cross-calibration of WbD with WRAM V2 in Appendix 4, we caution that these results be interpreted as general information rather than the initially designed and intended comprehensive calibration among methods.

A number of factors likely resulted in the unanticipated missing and low confidence data. First, WRAMs may be highly variable among field assessors if proper field and office training, cross-calibration and interpretation exercises are not completed thoroughly. While aspects of each of these factors were completed with the intent to result in a higher probability of success, a greater length of training and cross-calibration on a wider variety of sites at various states of condition and disturbance levels was needed. Second, changes in wetland monitoring and assessment staff resulted in approximately 6 different wetland field ecologists (including a contractor) conducting WRAM V2 assessments—many more than intended when this pilot project was originally designed. This likely compounded potential error and deviation among assessors completing the assessments. Finally, a number of sites were not surveyed using WRAM V2 due to the ongoing global COVID-19 pandemic which began prior to field season 2020. Out of abundance of caution for the safety of staff and the public, strict state agency restrictions on travel, overnight lodging, and other factors were enacted that rendered any potential attempt at wetland field travel and assessments (nearly) impossible.

Conclusion

This report represents the efforts of the first ever pilot study attempted by WDNR to incorporate wetlands within the Water Quality Bureau's TWA process, providing an assessment of wetland condition, disturbance, and stressors that can be compared, contrasted, and combined with results from Bolha (2020) to gain a full picture of water resources health and watershed needs within the Pine River Watershed. It also represents WDNR's first attempt to incorporate all applicable WDNR wetland monitoring and assessment tools at various levels within a single given project area—which was challenging and will remain a challenge into the future given limited time, resources, and overall expertise for designing and conducting wetland monitoring and assessment activities. While many goals were fully or partially reached as identified in the Introduction, this pilot project represents the beginning of a much longer learning and assimilation process regarding wetland monitoring and assessment into the mainstream of WDNR's Water Resources Program and beyond. This study also underscores the effort, resources, and expertise needed to successfully conduct wetland monitoring and assessment activities at a watershed scale now and in the future—much of which has been learned through direct experience and overall trial and error.

While results for general dominant biotic condition as determined by WFQA or Overall Disturbance estimates among site selection methods were similar, targeted site selection tended to skew data of remaining wetlands in analyses often opposite of results obtained using probabilistic site selection methods. Stressor identification among site selection methods was highly variable, with various stressor types and their frequency of observation/occurrence not generally corresponding among methods. Additional pilot studies are needed to investigate whether these observations are also valid in less disturbed (more natural land cover and less urbanization/agriculture) and more disturbed (urbanization and agriculture) watersheds, as well as to further develop and refine guidance for wetland monitoring and assessment integration into WDNR's Water Quality program.

The importance of training and calibration of wetland monitoring and assessment tools and personnel was also highlighted in this study, as various aspects of the project did not meet the standards proposed despite best efforts. Dedicated time and resources, training water quality field staff, and retaining trained wetland monitoring and assessment experts is crucial.

Despite overall discrepancies and caveats noted within this study, stressors identified throughout the watershed using both methods of site selection may be improved in a general sense through various grants and other resources. Additionally, many future work items for consideration including comparison of stressors and condition among water resources types within the Pine watershed have been highlighted.

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Appendices

Appendix 1: Wisconsin Department of Natural Resources Disturbance Factors Field Checklist Form

Appendix 2: Surface Water Characterization and Water Chemistry Collection Field Form

Appendix 3: Soil Profile Description Field Form

Appendix 4: Comparison of Wetlands by Design to the Wisconsin Wetland Rapid Assessment Method, Version 2.0

Appendix 1. Wisconsin Department of Natural Resources Disturbance Factors Field Checklist Form

Wisconsin Floristic Quality Assessment for Wetlands
Disturbance Factors Field Checklist Form **WFQA2017**

Project: ______________________________

Site Location Information					
Site/Assessment Area Name:		**Plant Community Type:**		**County:**	
Date:	**Time:**	**Observers:**			

Hydrological or Habitat Alteration (Stressor):	**Stressor**	**AA (Assess. Area)**	**30m Buffer**	**Historic**	**Impact Level (L, M, H)**
Is there a hydrological or habitat alteration present at the site?	Ditch				
	Tile				
Consider each Stressor. Check the box if current stressors are observed in the AA (Assessment Area) or within a 30m Buffer (around the AA).	Dike				
	Water Control				
	Dredging				
	Filling/grading				
Check the Historic box if a stressor is evident but occurred in the past.	Excavation				
	Clear/Selective cut*				
Rank the level of impact as L (low), M (medium) or H (high).	Herb removal				
	Entire Vegetation stratum removal				
	Mowing/Grazing				
	Plowing/Ag				
	Sedimentation				
	StormH20 input				
	Eutrophication				
	Motor vehicle use				
Buffer (30m): For buffer stressors, note how much of the buffer area was observed and any other explanatory notes.	Road/RR/trails				
	Invasive Animals**				
Other Stressors or Comments: Note and describe any additional stressors. Make additional comments related to disturbance (this could include how commonly the stressor occurs in the watershed/region of interest.)	Buffer Notes:				
* Tree Age class on next page * * Invasive plants on next page	Other Stressors or Comments:				

Tree Age Class: *Wooded wetlands: Estimate the degree of logging disturbance. Age is approximated by the average size (dbh) of the taller trees. Size is not always a reliable indicator of age.* ***Select only one.***	◻ Not applicable ◻ (1) Seedlings: < 2.5 cm (<1") - Very Recent, Very High Disturbance ◻ (2) Saplings: 2.5-10cm (1-4") Recent, High Disturbance ◻ (3) Middle-Age:10-25 cm (4-10") – Not Recent, Moderate Disturbance ◻ (4) Mature: >25 cm (>10") – Low Disturbance

% Coverage Invasive Plants[1]:		
Consider the entire site. List the invasive plants present at the site. What percent of the site is covered by each invasive plant? ***Select only one coverage class for each plant listed. List additional invasive plants in General Comments if needed.***	Invasive Plant 1:	◻ (1) Present: 1% or less aerial cover. ◻ (2) Sparse: 2-5% aerial cover. ◻ (3) Medium: 6-25% aerial cover. ◻ (4) Extensive: 26-50% aerial cover. ◻ (5) Very Extensive: >50% aerial cover.
	Invasive Plant 2:	◻ (1) Present: 1% or less aerial cover. ◻ (2) Sparse: 2-5% aerial cover. ◻ (3) Medium: 6-25% aerial cover. ◻ (4) Extensive: 26-50% aerial cover. ◻ (5) Very Extensive: >50% aerial cover.
	Invasive Plant 3:	◻ (1) Present: 1% or less aerial cover. ◻ (2) Sparse: 2-5% aerial cover. ◻ (3) Medium: 6-25% aerial cover. ◻ (4) Extensive: 26-50% aerial cover. ◻ (5) Very Extensive: >50% aerial cover.

[1]See the WDNR website for detailed information on invasive species: go to: dnr.wi.gov/, search "invasive plants"

Overall Disturbance: *Based on all the disturbance factors, what is the overall disturbance level at the site?* ***Select only one.***	◻ (1) Non-disturbed (Very Few alterations, none greater than low intensity) ◻ (2) Minimal (Small number of alterations of low intensity, none greater than moderate intensity) ◻ (3) Moderate (Alterations of mostly low and moderate intensity, no high intensity alterations) ◻ (4) Major (Many alterations, including at least one of high intensity) ◻ (5) Severe (Many alterations, including multiple high intensity ones)

Plant Community Condition Assessment: *Based on the vegetation survey, what is your best professional judgment of plant community condition in this Assessment Area?* ***Select only one.***	◻ (1) Natural structure & function of plant community maintained. ◻ (2) Minimal changes in structure & function. ◻ (3) Evident changes in structure & minimal changes in function. ◻ (4) Moderate changes in structure & minimal changes in function. ◻ (5) Major changes in structure & moderate changes in function. ◻ (6) Severe changes in structure & function.

General Comments:

Appendix 2. Surface Water Characterization and Water Chemistry Collection Field Form

Water-Chemistry-Sampling-Datasheet--Pine-River-TWA-Pilot-Project¶
AM-Marti--13-June-2019¶
Please-remember-to-take-pictures-of-area-where-water-sampled¶

Site-ID:- ______________________ → → **Date-of-Sampling:-** ______________________¶

Collector-Name(s):- ____________________________________¶

Presence of Surface Water in the AA: ○ Yes? Complete form. ○ No? Stop. Leave remainder of form bank.

Type of Surface Water in AA

Choose one:	Choose one:	Choose predominant feature:	
○ Freshwater	○ Tidal	○ Ponded	○ Backwater
○ Brackish	○ Non-Tidal	○ Lake	
○ Saline		○ Channel	○ Other:

Comments:

Surface Water Measurements of AA

AA contains sampleable water: ○ Yes ○ No **Surface Water > 100cm** ○ Yes ○ No

Maximum Depth of Surface Water: (cm) **% AA covered with surface water:** %

Comments:

Characteristics of AA Surface Water Body - Mark all that apply (If a water sample can be collected, characterize the surface water at the location the sample is collected. If a water sample cannot be collected, characterize the predominant surface water feature within the AA)

Substrate Color:	Water Clarity:	Substrate:	Water Smell:	Water Surface:
○ Black ○ Brown ○ Gray ○ Other:	○ Clear ○ Turbid ○ Stained ○ Milky ○ Other:	Vegetation Present?: ○ Yes ○ No ○ Sand ○ Cobble ○ Muck ○ Shellhash ○ Gravel ○ Organic ○ Mineral Soil ○ Other:	○ None ○ Chemical ○ Sulphur ○ Fishy ○ Algae Odor ○ Rotten Vegetation ○ Other:	○ Film ○ Algal Bloom ○ Floc ○ Vegetation ○ Sheen ○ Other:

Comments:

Water Chemistry Sampling (CHEM) No Sample Collected ○

Sample ID:	Chilled:	Time Collected (hhmm) 24 hr clock	Water Depth(cm)	Location of Sampling (Decimal Degrees) Latitude	Longitude
	○ Yes ○ No	:		.	— .

Comments:

Appendix 3. Soil Profile Description Field Form

SITE NUMBER/ID: **Project:**

Name: **Date:**

HORIZON	DEPTH	MATRIX COLOR	REDOX (QUAN,TYPE, CONTR)	REDOX COLOR	TEXTURE	STRUCTURE GR. SZ. SH.	Consistence	BOUND.	ROOTS

LAT/LONG:
Depth to Saturation:
NOTES:

Appendix 4: Comparison of Wetlands by Design to the Wisconsin Wetland Rapid Assessment Method, Version 2.0

Background/Introduction

Beginning with pilot projects beginning as early as 2012, WDNR collaborated with The Nature Conservancy to create a GIS version of a wetland functional rapid assessment method – the result of that effort being the Wetlands By Design watershed decision support tool (hereafter "WbD"; Miller et al. 2017 and https://freshwaternetwork.org/projects/wetlands-by-design/). When WbD was envisioned, it was intended to provide a similar result to a field-based US EPA Wetland Monitoring and Assessment Level 2 or 3 functional value assessment (as defined by USEPA). While previous assessments in conjunction with production of WbD have determined that the decision support tool returns functional assessment results similar to field assessments on a large scale, validity of estimates at scales smaller than a HUC8 remained untested (Miller et al. 2017). Thus, an objective of this pilot was to compare results found in the Pine River TWA Wetland Watershed Pilot (3 HUC 12s) to WbD modeled functions.

Methods

As part of the Pine River Targeted Watershed Assessment Wetland Pilot Project (this report), the results of multiple field assessment methods including wetland floristic quality assessment from a timed meander survey and Wisconsin Wetland Rapid Assessment Method (WRAM) Version 2.0 (WRAM V2) were used to assess the condition and functions of wetlands across the Pine watershed. Timed meander surveys generally established boundaries for each site and wetland community surveyed, termed the assessment area (hereafter "AA"). These results of aforementioned field assessments in each AA were compared to the modeled functional assessment results generated in WbD.

WbD groups all values into one of the following four functional ranks: 'Very High', 'High', 'Moderate', or 'NA'. Based on discussions with developers of WbD, the assumption was made that 'Moderate' scores represented wetlands with 0-50% of sites in the watershed, 'High' scores represented wetlands with 51-75% of sites, and 'Very High' scores represented wetlands with 76-100% of scores. To subdivide WRAM V2 findings into ranks of 'Very High', 'High', and 'Moderate', the number of WRAM V2 findings with an answer of "Yes" was divided by the number of metrics in each wetland function category. For example, the Flood Abatement category had 5 sets of WRAM V2 answers per AA; if a site field WRAM had 3 of 5 "Yes" answers, that would be calculated into 3/5 of 60% score and would therefore be given a functional rank of 'High'.

While floristic integrity is an included component of WRAM V2, it is only a generalized assessment. Because field surveyors had already conducted a detailed timed meander survey of each AA, these scores (and use of the Provisional Wetland Floristic

Quality Benchmarks narrative condition rankings (Hlina et al. 2015; Marti and Bernthal 2019) were substituted for the general floristic integrity assessment in WRAM V2. Any wetland with a narrative floristic quality rank of ‘Excellent’ was assigned a comparison ranking of ‘Very High’, ‘Good’ or ‘Fair’ narrative rankings assigned a comparison ranking of ‘High’, and ‘Poor’ or ‘Very Poor’ narrative rankings assigned a comparison rank of ‘Moderate’.

Due to data concerns and limitations, functional comparisons were limited to the following WRAM V2 functions: Flood Abatement, Water Quality, Fish and Aquatic Habitat, and Floristic Integrity. WbD separates out the following three water quality variables: sediment retention, nitrogen reduction, and phosphorus retention. To remain consistent with a similar comparison completed by the developers of WbD (Miller et al. 2017), these three functional services were pooled and the highest functional rank of any of the three was utilized for the WRAM comparison. For example, if sediment retention and N reduction were both ranked by Wetlands By Design for a given AA as ‘High’ and phosphorus retention as ‘Very High’, the three were pooled together and assigned a rank of ‘Very High’ when comparing to WRAM results.

Wetland AAs generally overlapped multiple Wisconsin Wetland Inventory (WWI) wetland polygons, which are the foundation of the WbD rankings. Since each WWI polygon maintains an individual ranking based on the models used within WbD, one assessment area may be represented by WWI polygons with varying ranks or scores. For the comparison of the WbD scores to the WRAM V2 and timed meander survey assessment results, the most representative polygon of the site or, if the multiple polygons were similar in type and rankings, the rankings of the WWI polygon that intersected with the starting point of the timed meander survey were utilized. If the starting point was not located within a WWI polygon, the closest polygon was utilized for this comparison.

Results

Floristic Integrity

All 77 sites had completed timed meander surveys and therefore were compared to WbD scores. As was found by the team that developed WbD, WbD ranks did not accurately predict the quality of wetland vegetation present on the ground. Only 17 of the 77 (22%) sites had the same ranking (Figure A2). Thirty-one of the 36 sites identified in WbD as having 'Very High' floristic integrity were found to have lower narrative condition rankings. Of the 37 sites with "Moderate" WbD rankings, 27 were found to have a higher rank of Fair, Good, or Excellent narrative condition using timed meander survey results (Figures A1, A2). In general, WbD found more wetlands to be of 'Very High' (equivalent of 'Excellent') or 'Moderate' (equivalent of 'Very Poor' or 'Poor') scores (36 and 37, respectively) but on-the-ground surveys found that in reality, more wetlands were of 'Fair' or 'Good' narrative condition quality (49 of 77 wetlands assessed).

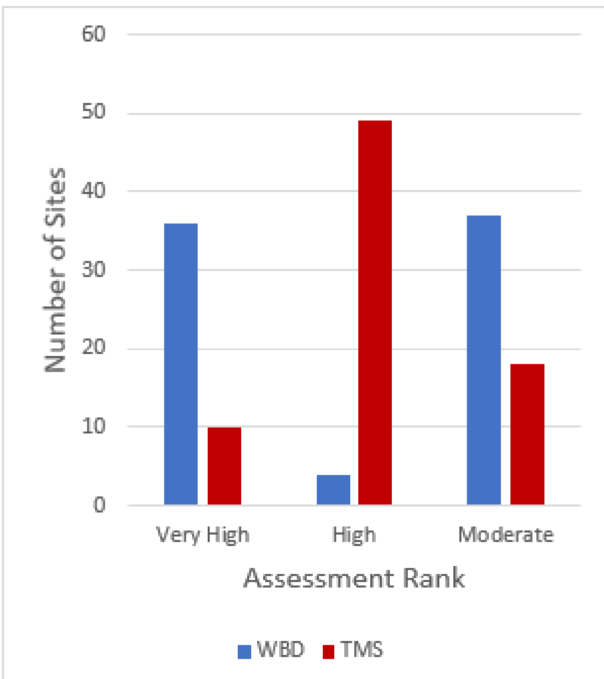


Figure A1. The distribution of floristic integrity ranks using WbD and WRAM V2 (timed meander survey results) the same sites.

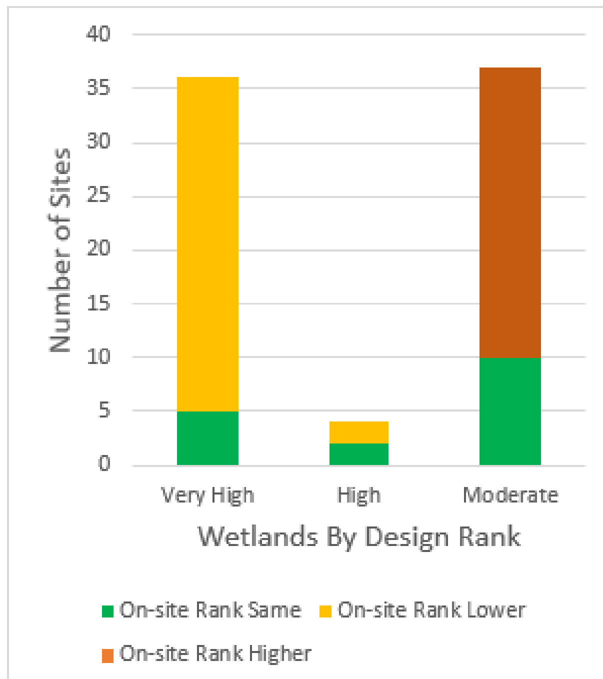
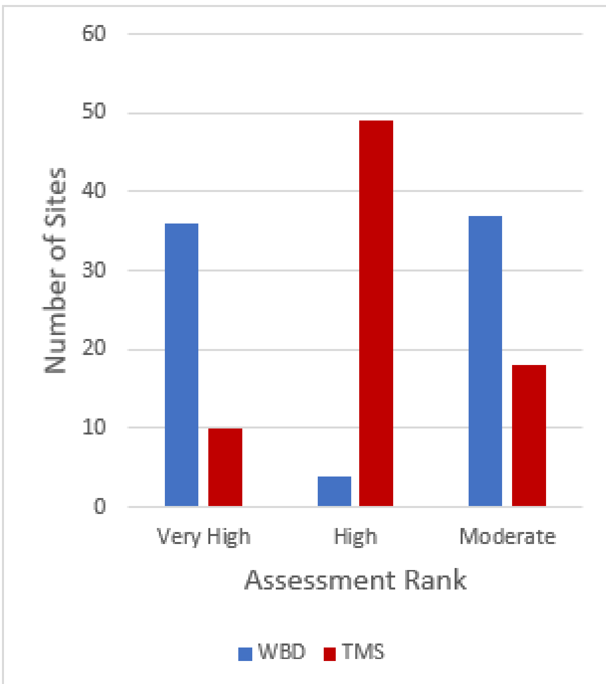


Figure A2. WbD and timed meander survey methods compared for assessing floristic integrity.

Flood abatement

Of the 63 sites where WRAM V2 was conducted to assess flood abatement, 31 sites had the same ranks among WRAM V2 and WbD (49%; Figure A4). Almost half of all wetlands surveyed were found to have 'High' Flood Abatement function according to both survey methods (Figure A3). Field crews completing WRAM V2 did not complete the watershed flood storage capacity calculations as included in a standard WRAM form.



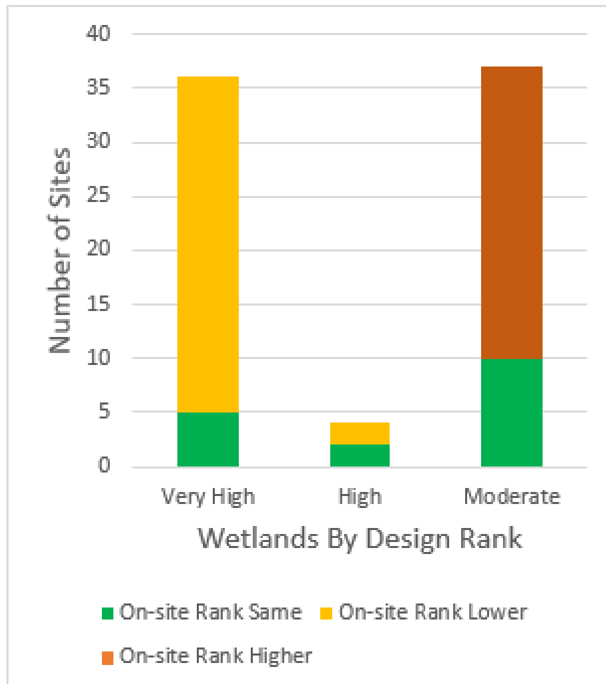
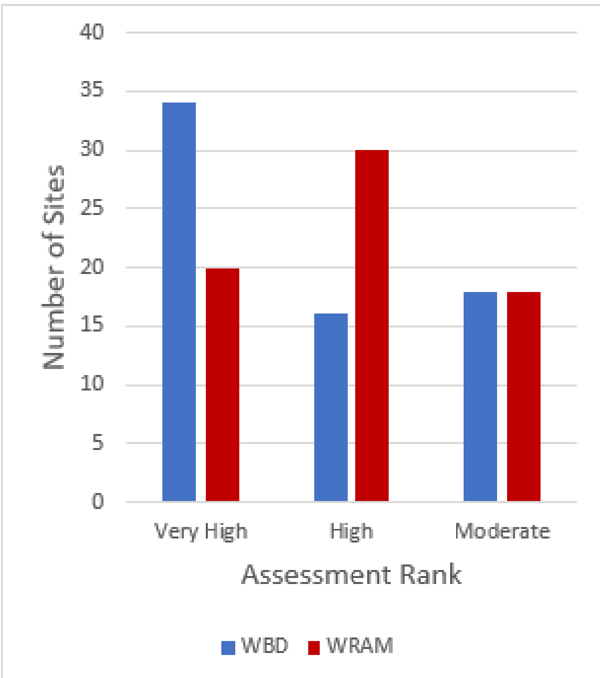


Figure A3. The distribution of flood abatement ranks using WbD and WRAM V2 at the same sites.

Figure A4. WbD and WRAM V2 compared for assessing flood abatement.

Fish and Aquatic Habitat

Of the 77 assessment areas, only 68 had completed WRAMs for the Fish and Aquatic Habitat section. Of those 68 surveys, 20 had the same rank for WRAM V2 and WbD (29%; Figure A6). WbD results skewed to higher rankings than WRAM V2 field assessments, with WRAM V2 results indicating that 30 of the 68 assessment areas had a rank of 'High' (Figure A5).



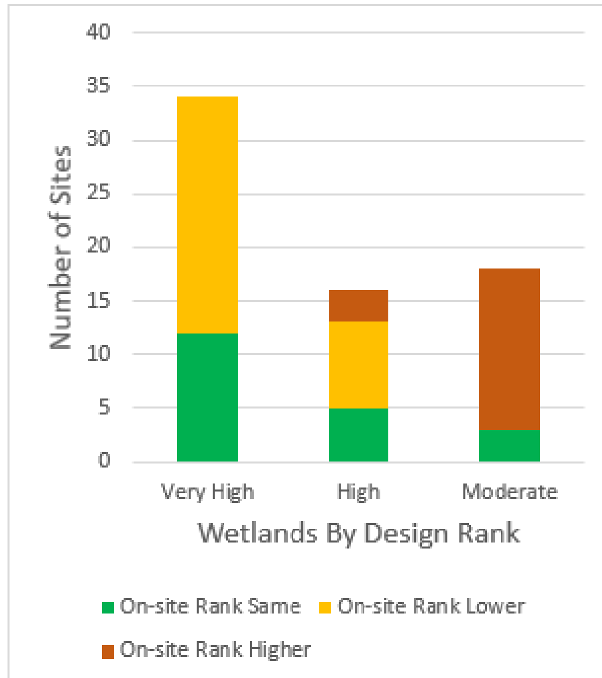


Figure A5. The distribution of fish and aquatic habitat ranks using WbD and WRAM V2 at the same sites.

Figure A6. WbD and WRAM V2 compared for assessing fish and aquatic habitat

Water Quality

Only 14% of the 63 sites assessed had the same rank between WbD and WRAM V2 (Figure A8). WRAM V2 results skewed much more to the lower rank end with 45 of 63 assessments (71%) having a score of 'Moderate' and only 2 assessments (3%) with a WRAM score of 'Very High' (Figure A7). WbD tended to indicate higher water quality function with 33 of 63 assessments (52%) having a 'Very High' rank, 29 assessments (46%) with a 'Moderate' rank, and only 1 assessment (2%) indicating a 'Moderate' rank (Figure A7).

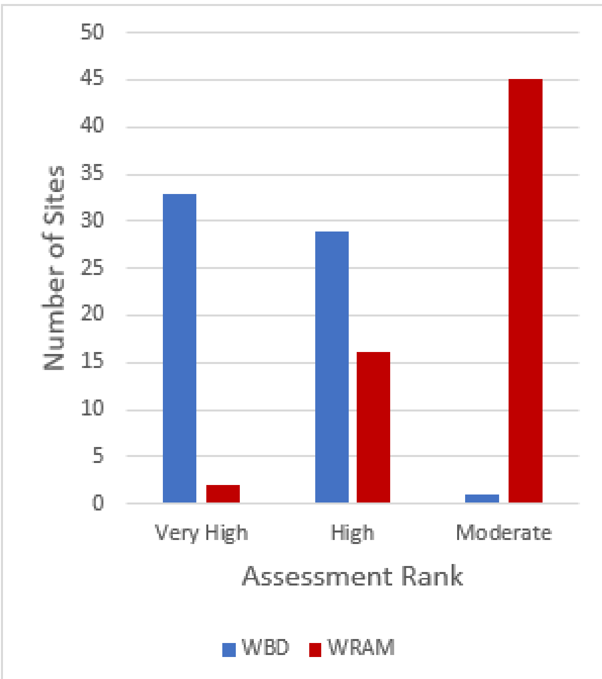


Figure A7. The distribution of water quality ranks using WbD and WRAM V2 at the same sites.

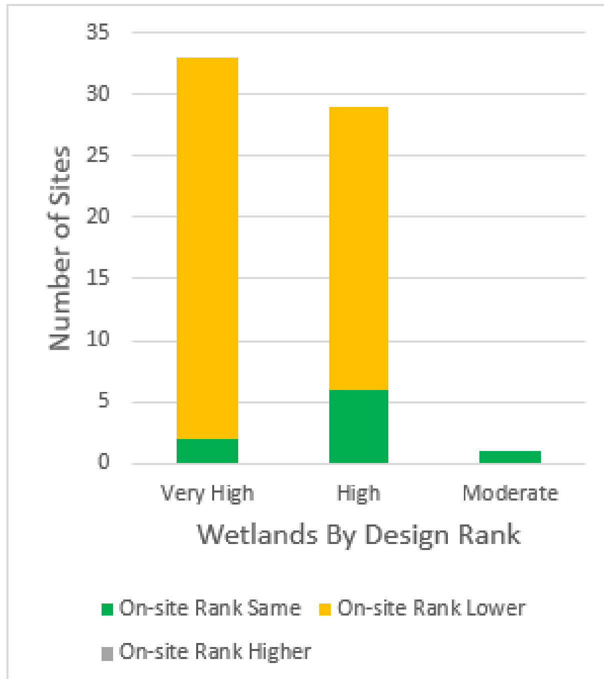


Figure A8. WbD and WRAM V2 compared for assessing water quality.

Discussion

Based on the available data utilized for this comparison, WbD was not able to accurately predict wetland functions assessed through the use of in-the-field wetland assessment tools (WRAM V2). WbD was most closely able to predict on-the-ground condition of actual flood abatement functions with 50% of on-site ranks being the same as estimated with WbD. Fish and aquatic habitat estimations by WbD were 30% accurate; WbD assigned more 'Very High' scores to the wetlands in the Pine – overvaluing the fish and aquatic habitat provided by these wetlands. Water Quality was the most inaccurate estimation in this study with WbD highly over-valuing the functions provided by the Pine watershed's wetlands with WbD only accurately estimating the functions of 14% of the wetlands. WRAM V2 assessments indicated 71% of the wetlands providing 'Moderate' water quality functions but WbD indicated that 52% of wetlands were providing these services at a 'Very High' level. Finally, WbD was only accurately able to estimate floristic integrity functions accurately 22% of the time; field assessments estimated almost half of all wetlands within 'Good' or 'Fair' narrative condition (which was categorized as 'High' in this comparison) but WbD grouped most wetlands into the 'Very High' or 'Moderate' categories.

The comparison between modeled (WbD) and field-determined (WRAM V2) wetland functions and condition assessments should be pursued in future efforts, but a single ecologist to complete the WRAM V2 assessments is encouraged to avoid inter-assessor error. These comparisons will prove to be incredibly valuable to check the accuracy of WbD or other comparable GIS tools. Without these comparisons, staff will be unable to adjust and improve these tools for future use.

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