BOARD OF WATER AND SOIL RESOURCES

Condition of Wetland Banks Following Initial Establishment and Active Management

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Introduction

Wetlands in Minnesota are protected and restored through conservation and regulatory programs. The 1991 Wetland Conservation Act (WCA) is the basis for Minnesota's wetland regulatory program. The WCA is administered by the Minnesota Board of Water and Soil Resources (BWSR) in conjunction with local government units. Replacement of the lost functions and values of wetlands due to unavoidable impacts is intended to help achieve WCA's goal of no net loss in the quantity, quality, and biological diversity of wetlands. WCA's wetland replacement standards and review/approval procedures are like those associated with federal implementation of Section 404 of the Clean Water Act by the U.S. Army Corps of Engineers. Most wetland replacement in Minnesota is achieved through the establishment of wetland banks and the generation and use of wetland credits. Wetland banks in Minnesota, currently consisting of over 400 sites, are approved by both state (WCA local government units) and federal (St. Paul District Army Corps of Engineers) regulatory entities. Additionally, BWSR develops wetland banks throughout the state to meet its obligation to replace wetland impacts for certain qualifying public road projects.

Wetland banks typically go through a 5 to 7-year establishment and active management period conducted by the bank sponsor in which performance standards are met and replacement credits are released for use. Following that period, wetland banks enter "long-term monitoring" phase during which the BWSR monitors the bank site for compliance with a state-held conservation easement.

Because data is not collected during the monitoring activities described above, there is limited information available on the condition of Minnesota wetland banks years after establishment and active management activities to meet performance standards as compared to data on overall statewide trends (Bourdaghs et al. 2019). Additional information on the condition of wetland banks related to age since restoration, hydrogeomorphic (HGM) class, seeding, management frequency, and human disturbance factors could be useful in site selection and restoration approaches for future wetland banks. To that end, the purpose of this study was to evaluate:

- The condition of wetland banks years after initial establishment/active management activities.
- The condition of wetland banks as compared to other wetlands in the state.
- The effect of human disturbance on wetland bank condition; and
- The effect of different restoration approaches and HGM class on wetland bank condition.

The results of this study will be used to inform future decisions on site selection and restoration approaches for wetland banks in Minnesota.

Methods

The condition of wetlands within 68 wetland bank sites were assessed. These wetlands were restored 6-15 years ago and are no longer being actively managed to meet performance standards and credit release requirements.

Sampled wetland bank sites were limited to those with adequate administrative records to determine restoration practices used during establishment. Sites were selected from all HGM categories and from within all three Level II Omernik ecoregions in Minnesota (Mixed Wood Shield, Mixed Wood Plains, and Temperate Prairies - ***Figure 1***). A total of 105 wetlands within the 68 wetland bank sites were assessed (Assessment Areas or AAs) for wetland condition. Each AA was limited to 60 acres of wetland. A total of 236 wetland plant communities were identified and assessed individually among the 105 AAs (***Figure 2***).

Figure 1. Level II Omernik ecoregions and wetland bank site sample locations.

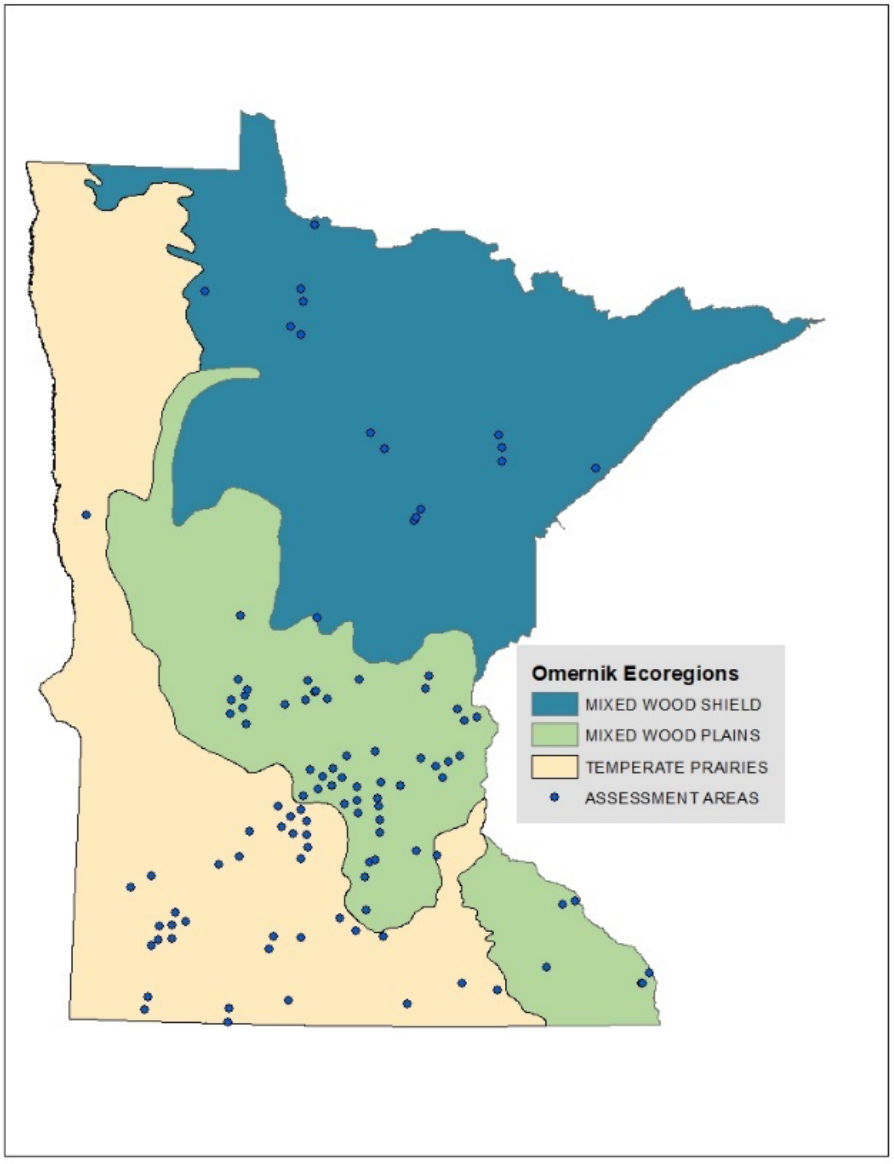
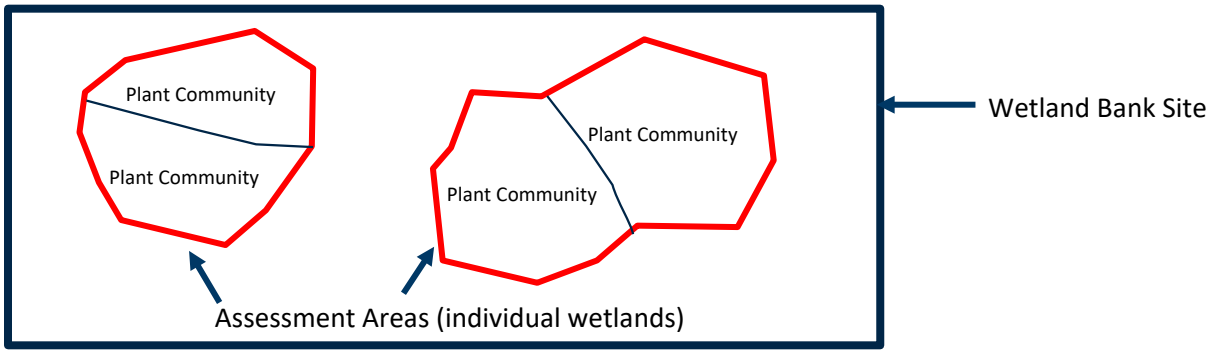


Figure 2. Schematic showing relationship between wetland bank site, assessment area, and plant communities.



We used floristic quality as an indicator of wetland condition (DeBerry et al. 2015) as such methodology is used to monitor status and trends of wetlands statewide (Bourdaghs et al. 2019). Floristic quality assessments (FQAs) are based on coefficients of conservatism, which are a range of values (0-10) assigned to each plant species indicating that species' habitat fidelity. High numbers are assigned to species exclusive to undegraded, native habitats, and low numbers are assigned to species with the least fidelity or restriction to specific habitats (Milburn et al. 2007). All non-native species are assigned a value of zero. We assigned condition categories (***Table 1***) using thresholds developed by Bourdaghs et al. (2019).

Table 1. Wetland vegetation condition category descriptions.

Condition Category	Description
Exceptional	Community composition and structure as they exist (or likely existed) in the absence of measurable effects of anthropogenic stressors representing pre-European settlement conditions. Non-native taxa may be present at very low abundance and not causing displacement of native taxa.
Good	Community structure similar to natural community. Some additional taxa present and/or there are minor changes in the abundance distribution from the expected natural range. Extent of expected native composition for the community type remains largely intact.
Fair	Moderate changes in community structure. Sensitive taxa are replaced as the abundance distribution shifts towards more tolerant taxa. Extent of expected native composition for the community type diminished.
Poor	Large to extreme changes in community structure resulting from large abundance distribution shifts towards more tolerant taxa. Extent of expected native composition for the community type reduced to isolated pockets and/or wholesale changes in composition.

FQA data was collected for each plant community within an assessment area. Wetland plant communities were identified in the field using the wetland classes and classification key in Bourdaghs (2012). For AAs less than 2.5 acres, plant communities over 0.1 acres were identified and delineated for assessment. For AAs 2.5 acres or greater, plant communities over 0.25 acres were identified and delineated for assessment. One exception to these criteria was for a calcareous fen community mapped as 0.02 acres and part of an AA greater than 2.5 aces. This exception was made to document this rare plant community. Where available, we used the post-restoration wetland delineation boundaries to define the wetland. If wetland delineation boundaries were unavailable,

recent aerial imagery and the updated National Wetland Inventory (NWI) was used to estimate the wetland boundary and hence define each AA. Each AA was evaluated in the field to confirm the estimated boundaries and to map wetland communities within the boundary.

Timed meander and shoreline sampling were used to record species composition following *Sample Types B & D* as summarized in *Wetland Monitoring Standard Operating Procedures* (Bourdaghs 2019). All plant species were identified to the lowest taxonomic division possible. Percent absolute cover was visually assessed and categorized in one of seven cover classes: >0-1, >1-5, >5-25, >25-50, >50-75, >75-95, and >95-100.

The weighted floristic quality index ($wFQI$) was calcluated for each plant community and those values were used to assign a condition category in accordance with the *Rapid Floristic Quality Assessment Manual* (MPCA 2014). The weighted average condition for each plant community was used to assign an overall condition for each AA.

One of four levels of impact (minimal, low, moderate, severe) for each of five human disturbance assessment factors (landscape alteration, immediate upland alteration, physical alteration, hydrologic alteration, and invasive species) were assessed for each AA per Bourdaghs et al (2019). An overall *Human Disturbance Assessment Rating* (minimally, moderately, or severely impacted) based on a combination of all individual disturbance factor ratings was assigned to each AA. All AAs were either moderately or severely impacted, there were no minimally impacted AAs.

The frequency of vegetation management during restoration for each plant community was assigned into one of two categories:

- Infrequent: management occurred no more frequently than every four years
- Frequent: management occurred at regular intervals, every year, or almost every year

When it was determined that a seed mix was used on a plant community, the number of species within the seed mix was noted. The number of years that had elapsed since completion of restoration was noted for each AA. Each site was sampled once between July and September 10th of 2020 or 2021.

Prior to analyses, data were reviewed for usability through a predefined quality assurance procedure approved by the EPA. Sample sizes were too small across all variables to perform statistical analysis for significance. Data were instead summarized and averaged across different categories of variables to assess potential trends and relationships. Data were also grouped and analyzed per Bourdaghs et al (2019) for comparison with the overall condition of wetlands in the state and by ecoregion. The condition of "other wetlands" as referred to in this report is based on data from Bourdaghs et al (2019).

Results

Most AAs (62 of 105 or 59%) were in fair condition followed by poor (35%) and good (6%) (***Figure 3***). No AAs were in exceptional condition. The percentage of AAs in poor, fair, and good condition were similar across Minnesota ecoregions. (***Figure 4***). Of the 236 plant communities sampled, 77% were fresh meadow or shallow marsh. Condition ratings by wetland plant community type are displayed in ***Table 2***.

Figure 3. Wetland condition of AAs.

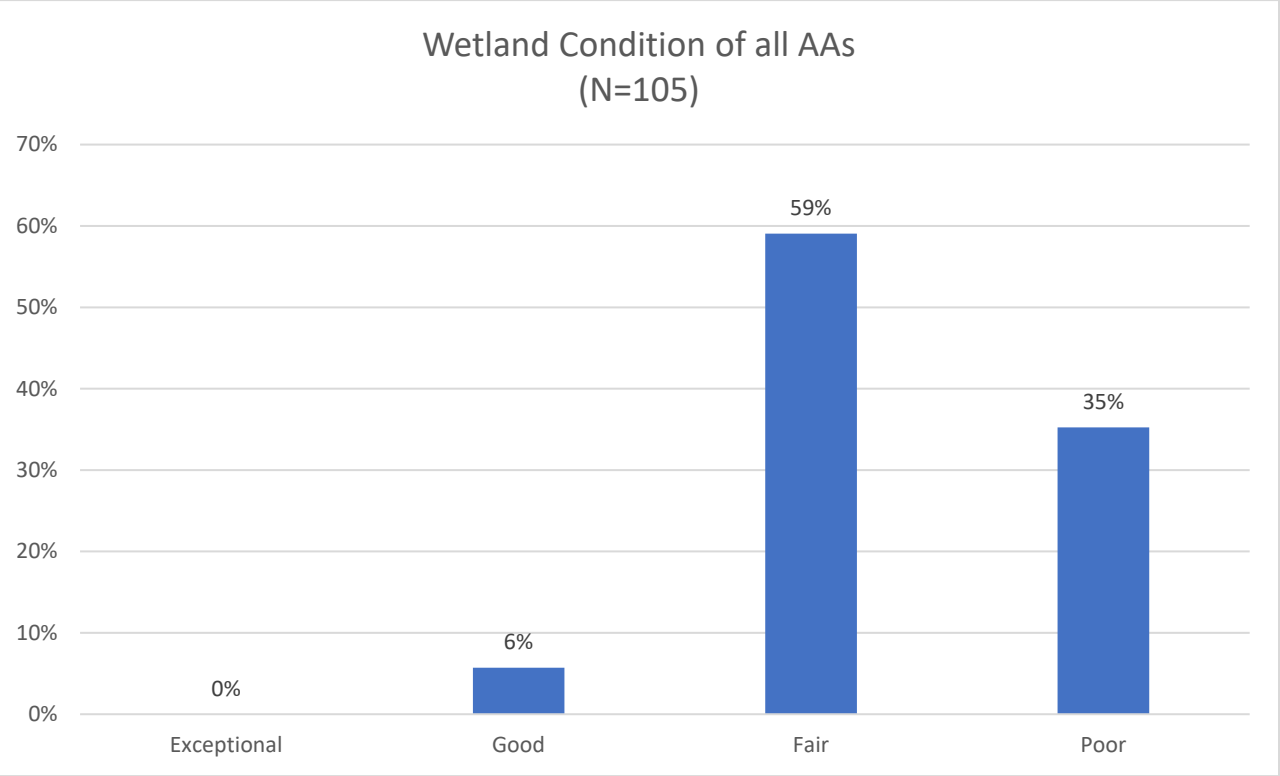


Figure 4. Wetland condition of AAs by Ecoregion.

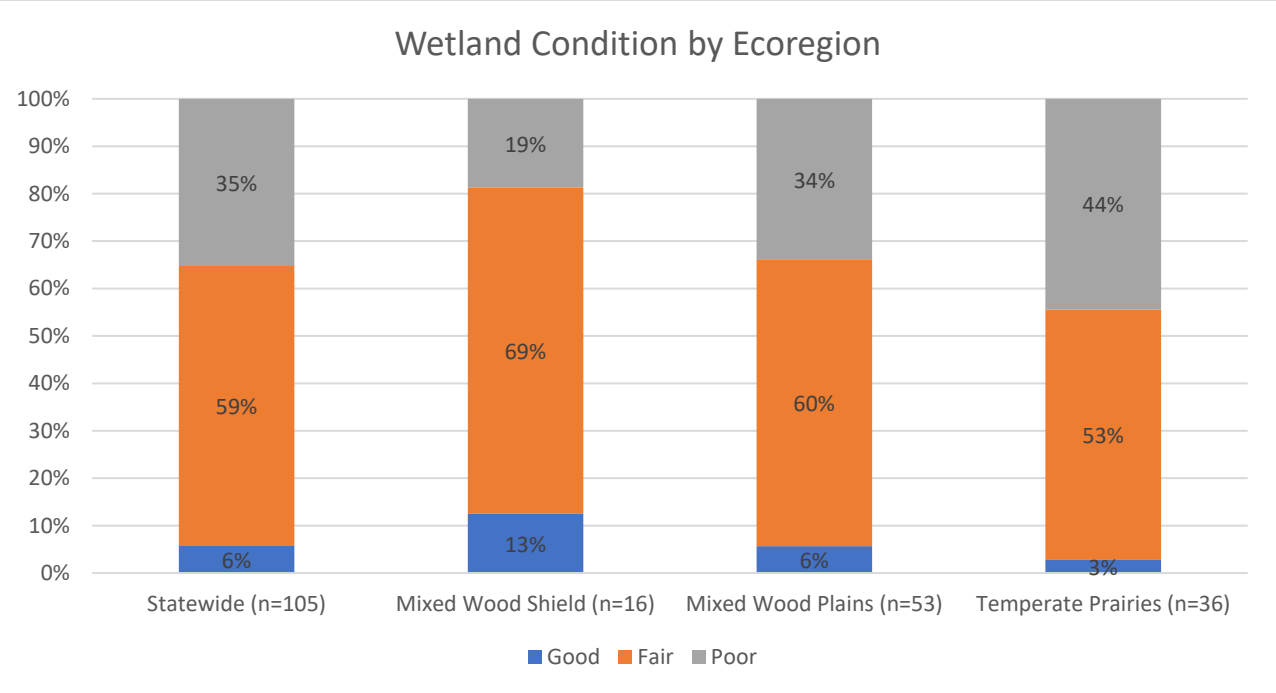


Table 2. Wetland condition ratings for each wetland plant community type sampled.

Wetland Plant Community Type	Exceptional Condition	Good Condition	Fair Condition	Poor Condition	Total Sampled
Fresh Meadow	0	5	83	10	**98**
Shallow Marsh	1	2	16	65	**84**
Shallow Open Water	0	3	22	0	**25**
Shrub-Carr	0	1	5	4	**10**
Wet Prairie	0	0	6	0	**6**
Deep Marsh	0	1	3	0	**4**
Hardwood Swamp	0	1	0	3	**4**
Open Bog	0	0	1	1	**2**
Calcareous Fen	0	1	0	0	**1**
Floodplain Forest	0	0	0	1	**1**
Sedge Mat	0	0	1	0	**1**
TOTAL	**1**	**14**	**137**	**84**	**236**

Condition of Wetland Banks vs Other Wetlands

The percentage of AAs in poor (35%) and fair (59%) condition were higher than other wetlands statewide (1% and 39%, respectively) (***Figure 5***). When grouped by ecoregion, the distribution of good, fair, and poor condition AAs was similar to other wetlands in the Mixed Wood Plains and Temperate Prairies ecoregions (***Figures 6 and 7***). In the Mixed Wood Shield ecoregion, a much higher percentage of AAs were in poor (17% more) and fair (44% more) condition as compared to other wetlands (***Figure 8***).

Figure 5. Wetland condition of AAs statewide vs other wetlands.

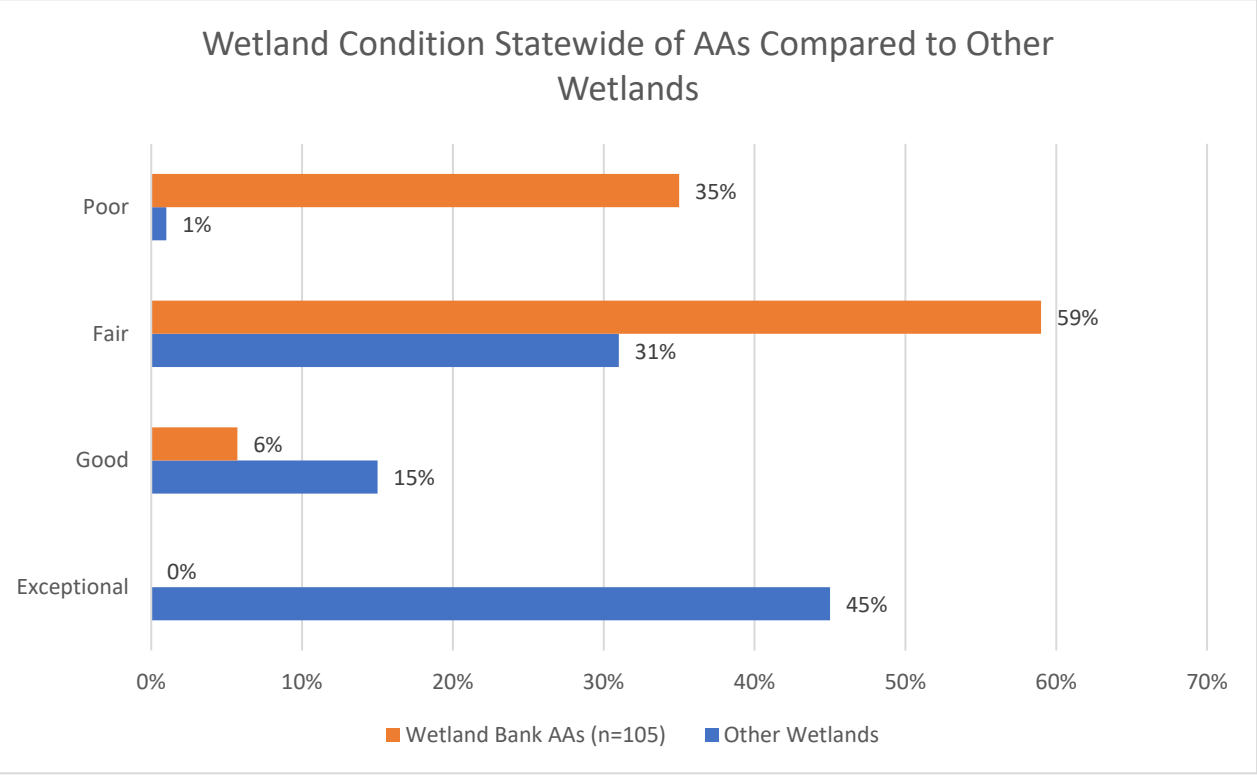


Figure 6. Wetland condition of AAs in Mixed Wood Plains ecoregion vs other wetlands.

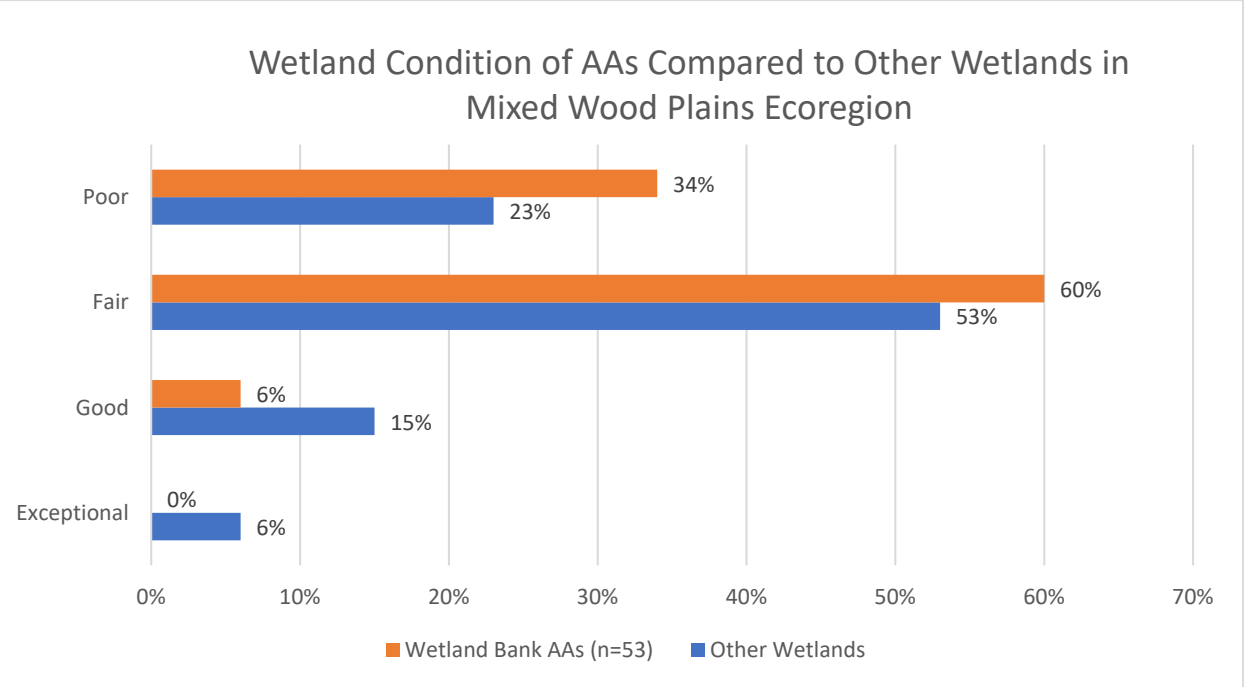


Figure 7. Wetland condition of AAs in Temperate Prairies ecoregion vs other wetlands.

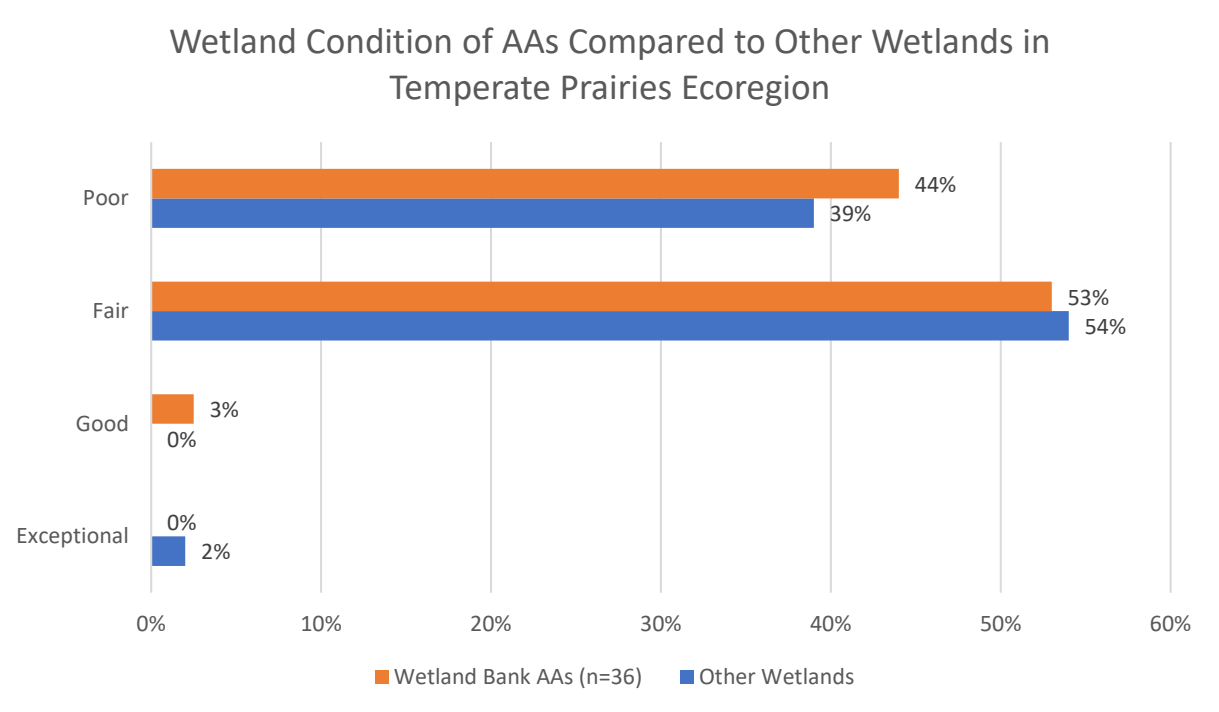
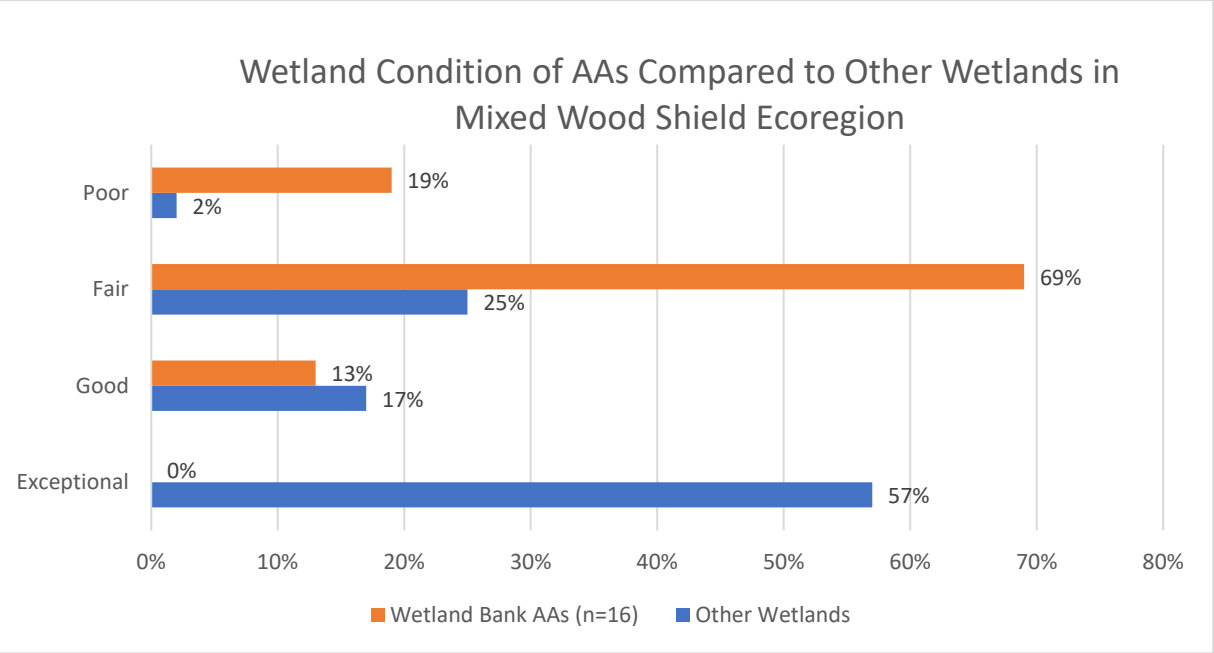


Figure 8. Wetland condition of AAs in Mixed Wood Shield ecoregion vs other wetlands.



The condition of individual plant communities and groupings of plant communities within AAs when compared to other wetlands varied depending on the plant community type. Condition ratings of deep marsh, shallow marsh, fresh meadow, wet prairie, sedge mat, and calcareous fen were combined into a single category of emergent wetlands to compare to the same category in Bourdaghs 2019. Restored emergent wetlands in our study were generally in poorer condition than other wetlands with higher percentages of poor (39% vs 16%) and fair (56% vs 30%) condition ratings (***Figure 9***). A much higher percentage of individual restored shallow marsh communities were in poor condition compared to other wetlands (77% vs 29%) and only 2% were in good condition as compared to 14% of other wetlands (***Figure 10***). A higher percentage of individual restored fresh meadow communities were in fair condition as compared to other wetlands (85% vs 46%), but a lower percentage were in poor condition (10% vs 19%) (***Figure 11***). However, the percentage of wet meadow plant communities in exceptional condition was 0% as compared to 35% of other wetlands. Grouping the plant community data among different ecoregions results in sample numbers that are too low for meaningful analysis and comparison.

Figure 9. *Wetland* ***Condition of emergent wetland plant communities for sampled AAs vs other wetlands.***

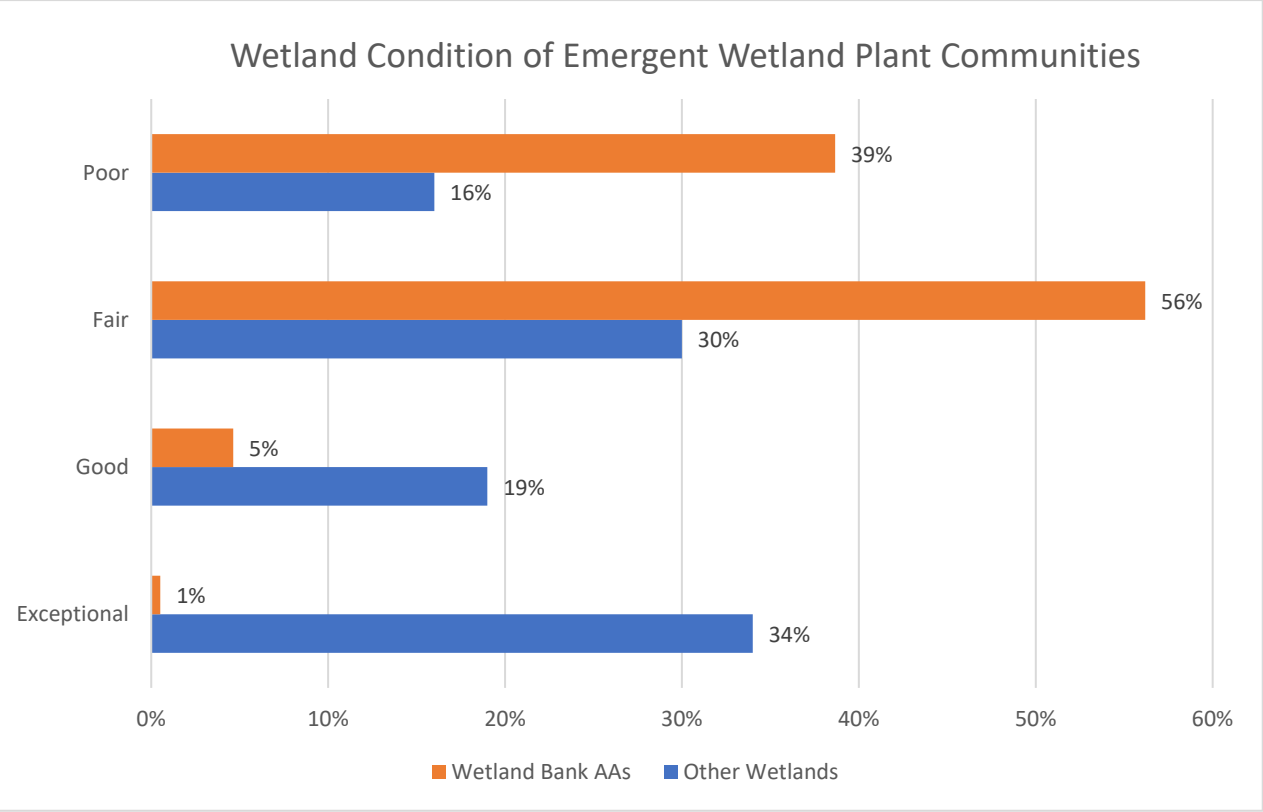


Figure 10. *Wetland* ***Condition of shallow marsh wetland plant communities for sampled AAs vs other wetlands.***

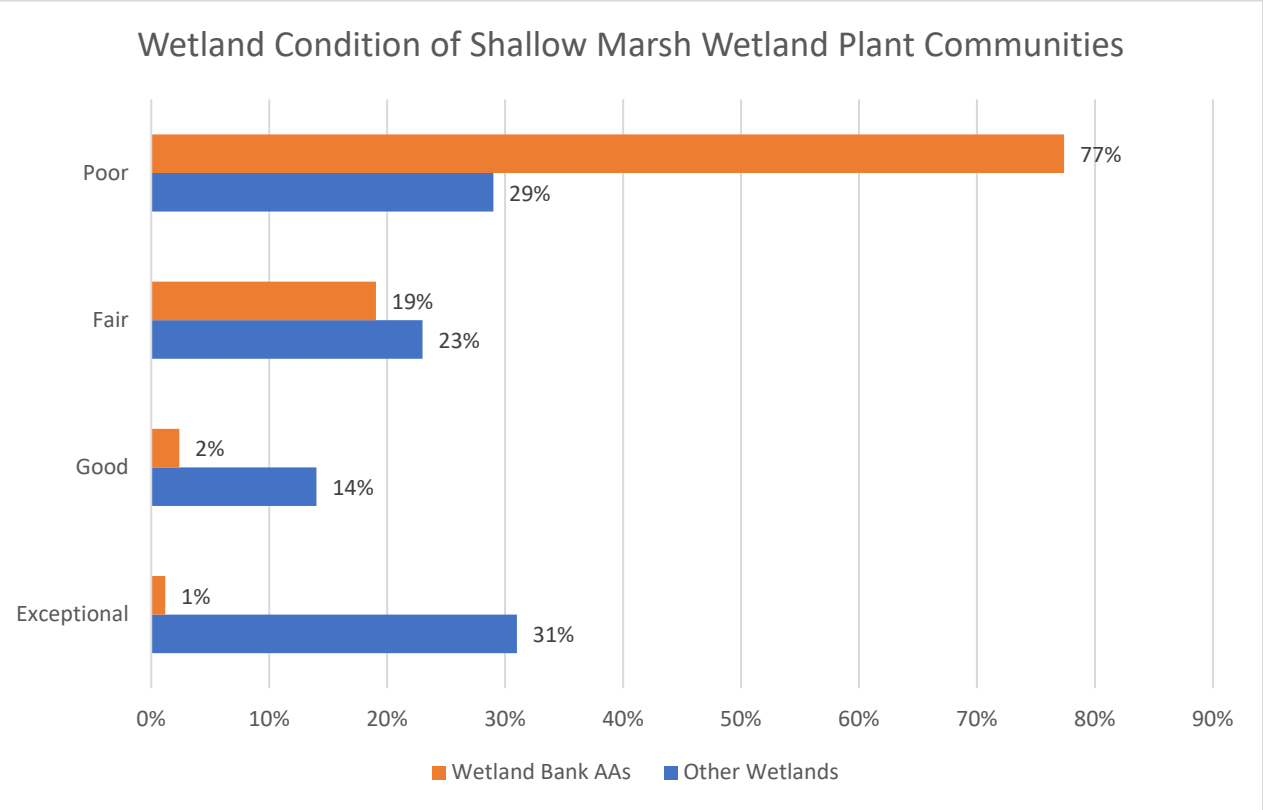
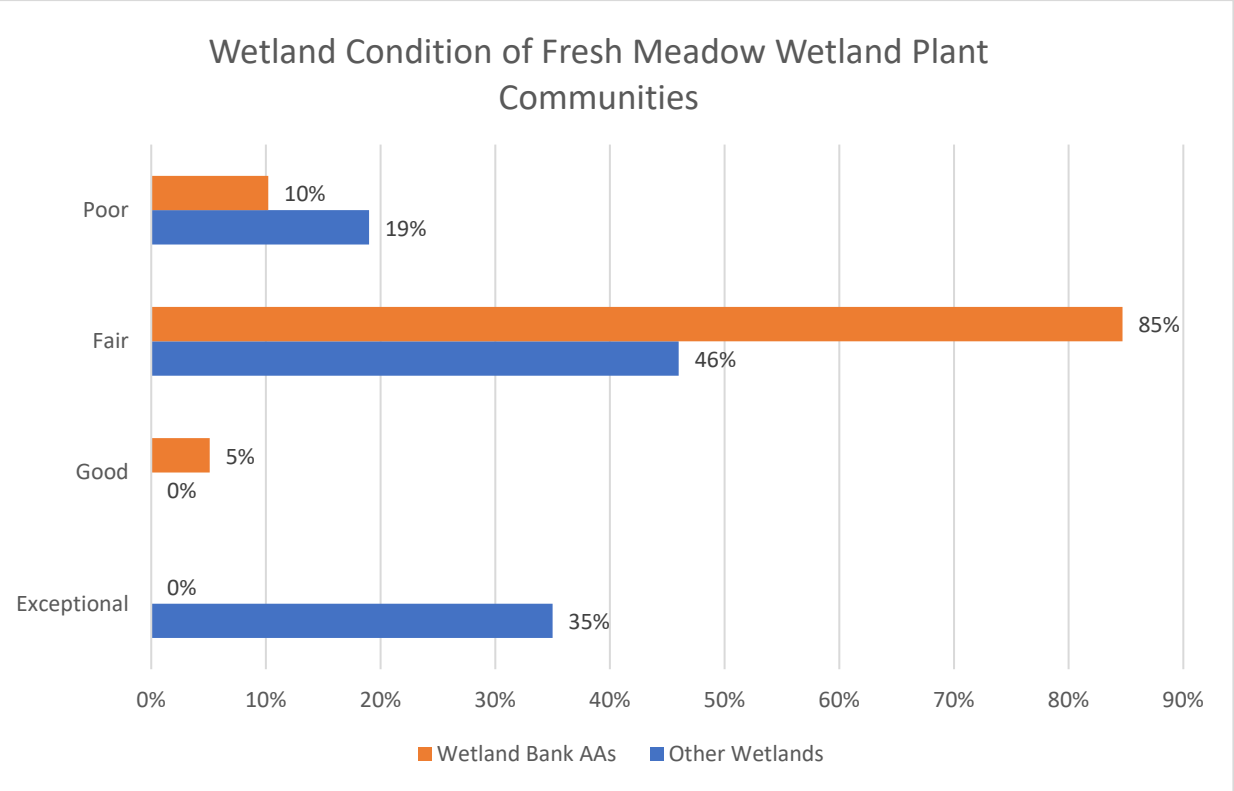


Figure 11. *Wetland* ***Condition of fresh meadow wetland plant communities for sampled AAs vs other wetlands.***



Wetland Condition by HGM Class

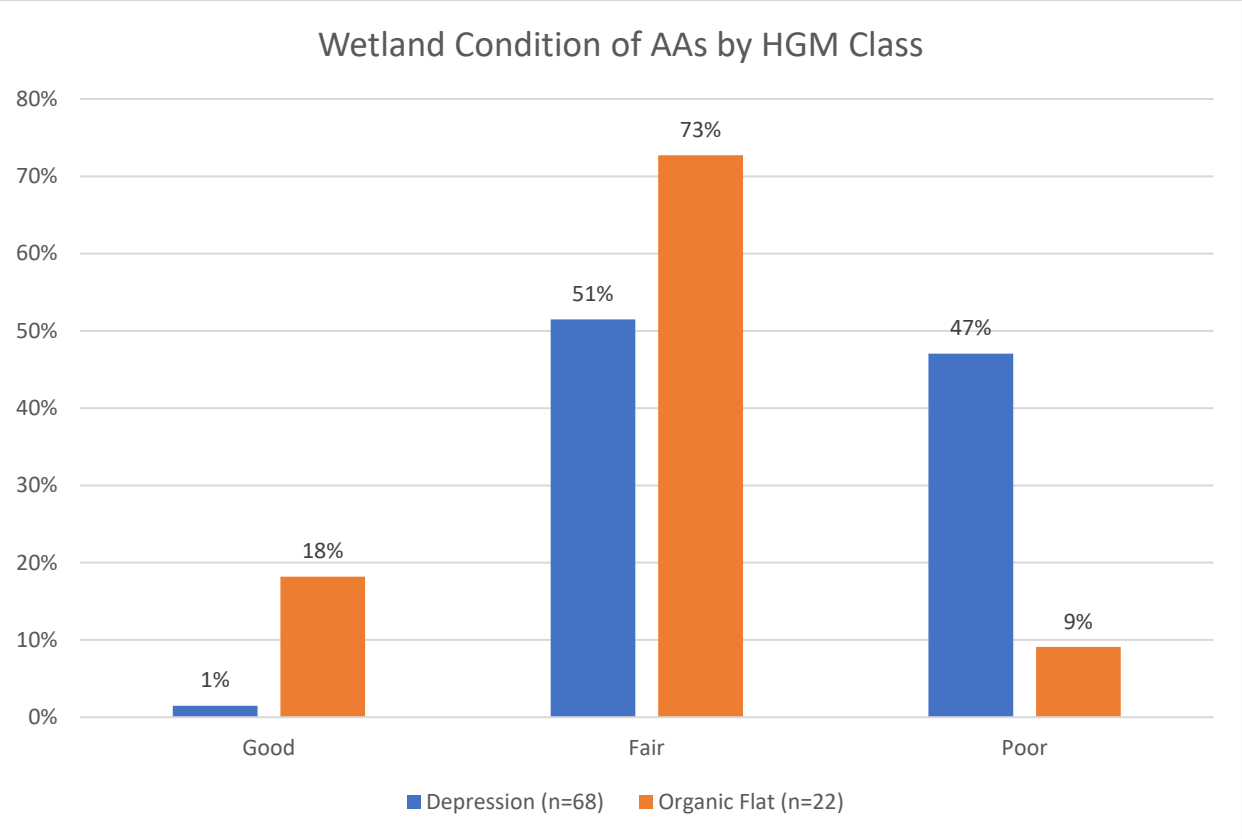
AAs were assigned an HGM class based on Smith et al. (1995). Most AAs were of the depression HGM class (65%) followed by organic flats (21%) and just a few mineral flat, riverine, and slope classes (**Table 3**).

Table 3. Number of AAs by HGM class.

HGM Class	Number of AAs
Depression	68
Organic Flat	22
Mineral Flat	8
Riverine	5
Slope	2
TOTAL	**105**

A higher percentage of organic flats were in fair and good condition and a lower percentage were in poor condition as compared to depression HGM class AAs (***Figure 12***). Other classes are underrepresented in the data, preventing any meaningful comparisons.

Figure 12. Comparison of wetland condition between HGM organic flat and depression AAs.



Wetland Condition by Age of Restoration

Each AA was classified by age since the restoration was completed as either young (6-9 years) or old (10-16 years). Young AAs had a higher percentage of good and fair condition ratings as compared to older sites (***Figure 13***). The differences were greater in depressional HGM class AAs compared to organic flat HGM class AAs (***Figures 14 and 15***). The condition of different individual plant communities within AAs followed the same pattern with younger AAs having higher percentages of good and fair ratings compared to older AAs.

Figure 13. Wetland condition of young vs old AAs.

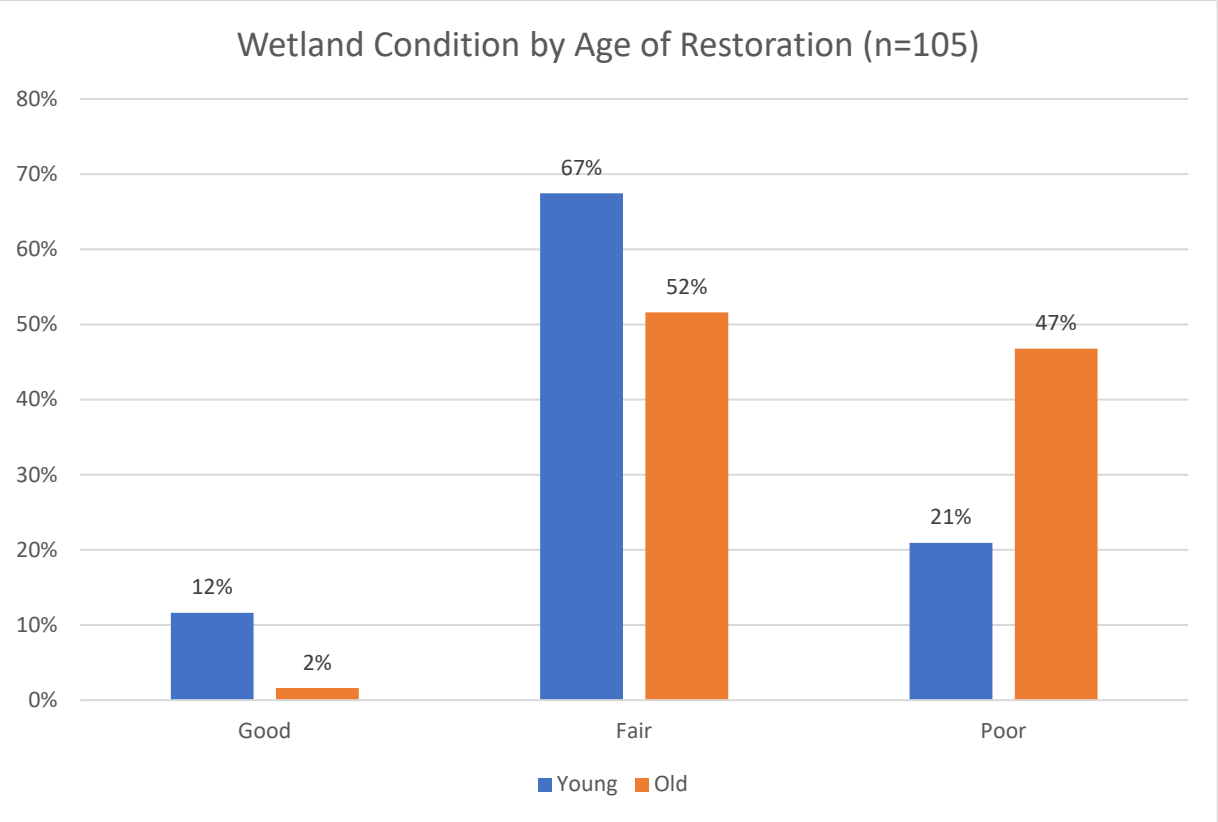


Figure 14. Wetland condition of young vs old AAs for depression HGM class.

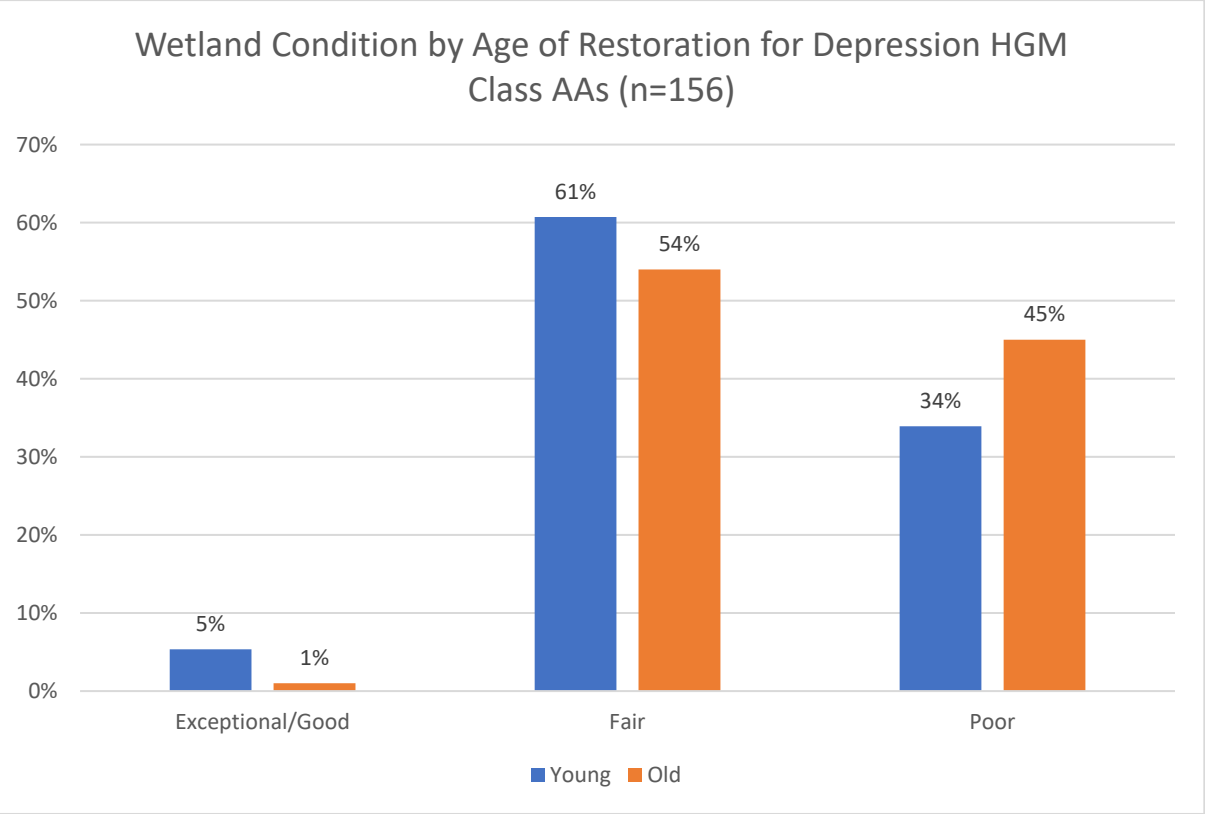
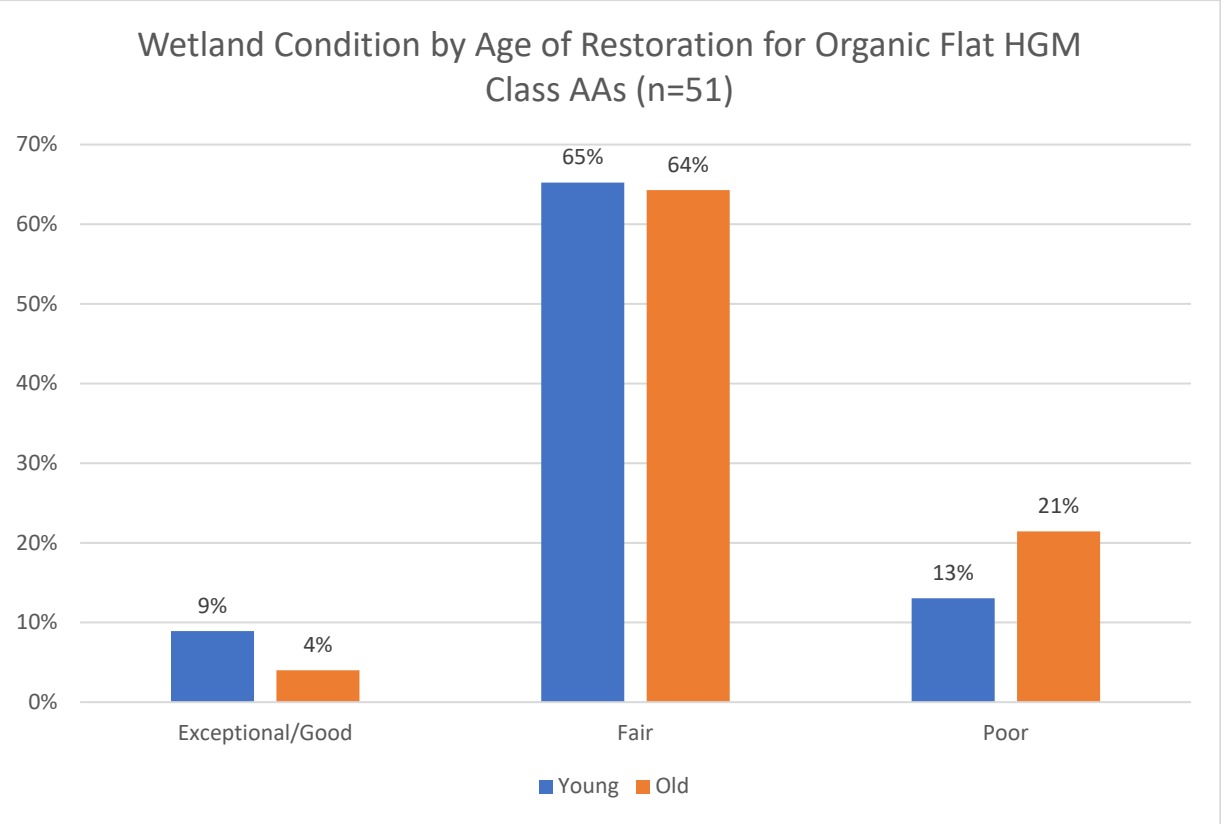


Figure 15. Wetland condition of young vs old AAs for organic flat HGM class.



Wetland Condition by Restoration Establishment and Management Variables

Assessed plant communities within AAs were restored via regeneration from the natural seedbank or through active seeding with seed mixes that included anywhere from 3 to 40 different species. The percentage of plant communities in fair and good condition was slightly higher for unseeded than for seeded communities (**Figure 16**). There were minor to no differences in the condition of plant communities when grouped by the frequency of management actions (frequent vs infrequent) (**Figure 17**). The percentage of plant communities in good condition was much higher when invasive hybrid cattails were actively controlled (78% vs 22%) (***Figure 18***). This pattern held regardless of the plant community type.

Figure 16. Comparison of wetland condition between plant communities that were restored with and without installation of a seed mix.

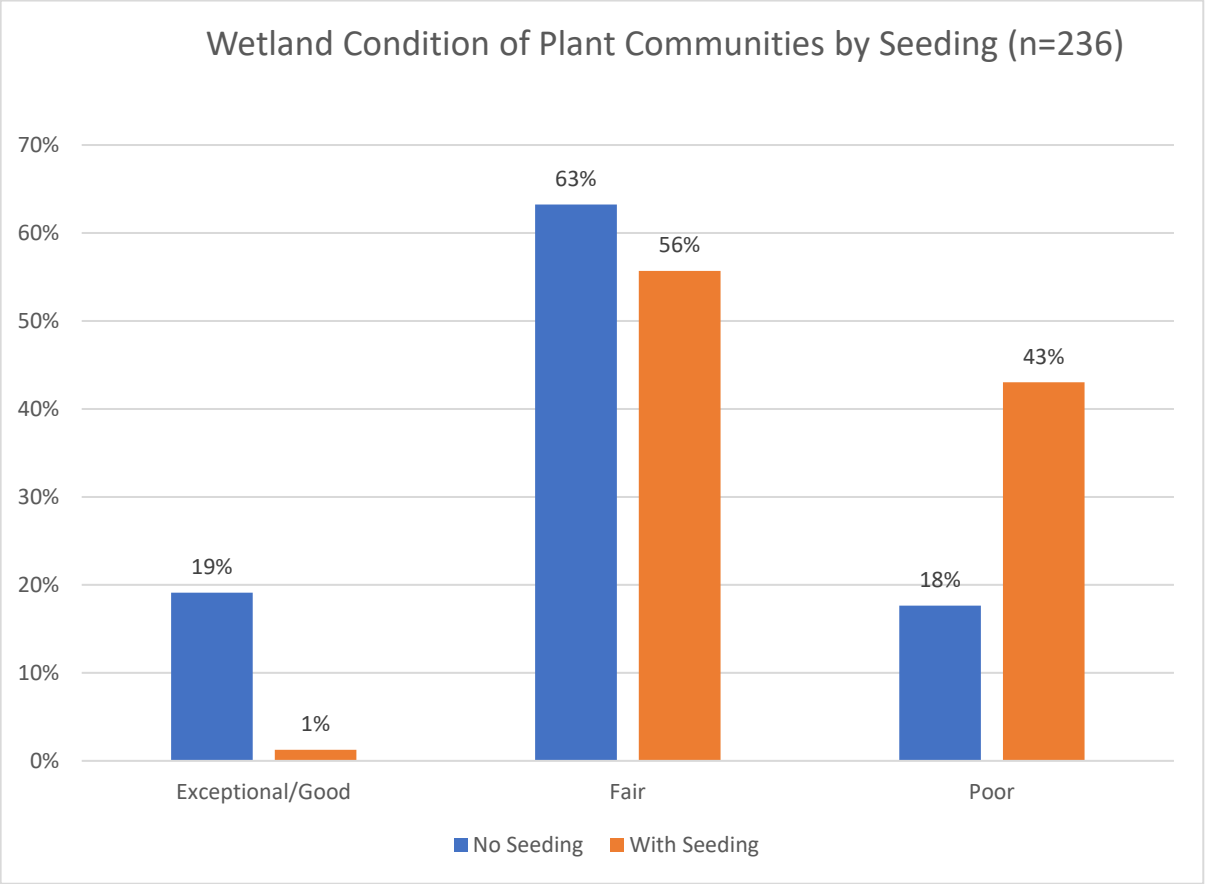


Figure 17. Comparison of wetland condition among plant communities with frequent vs infrequent levels of active management during restoration.

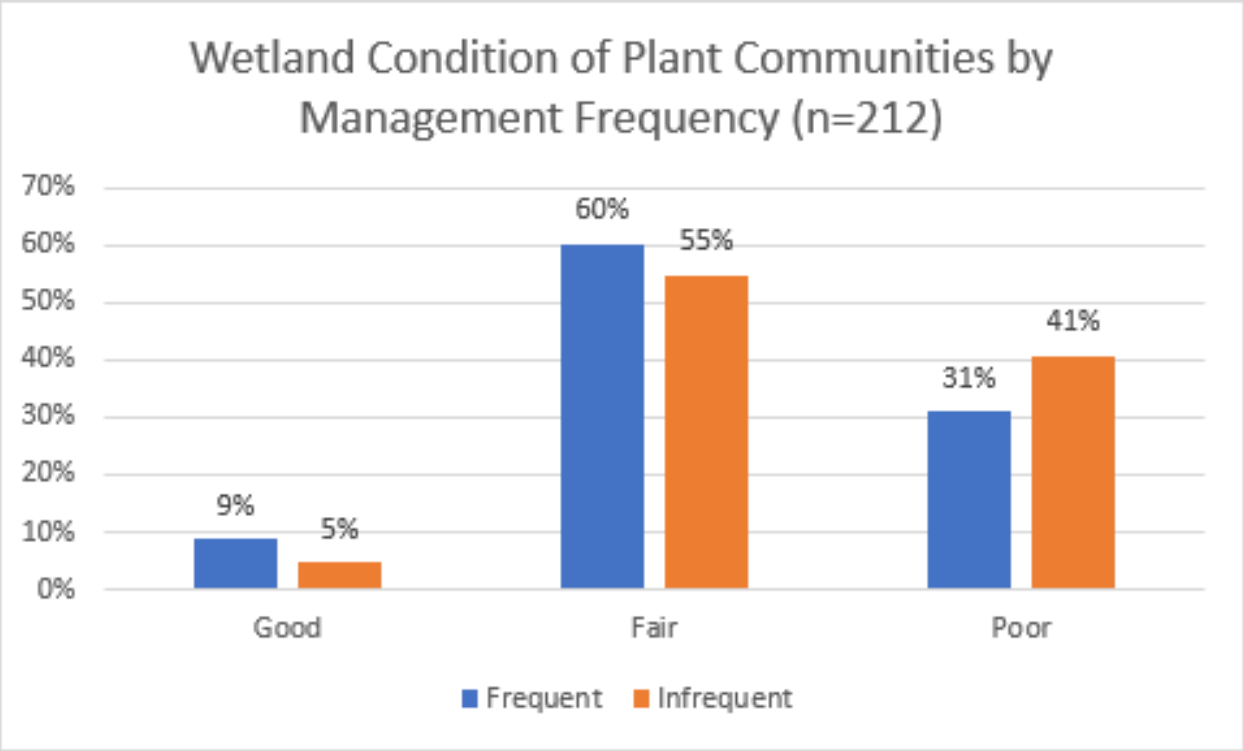
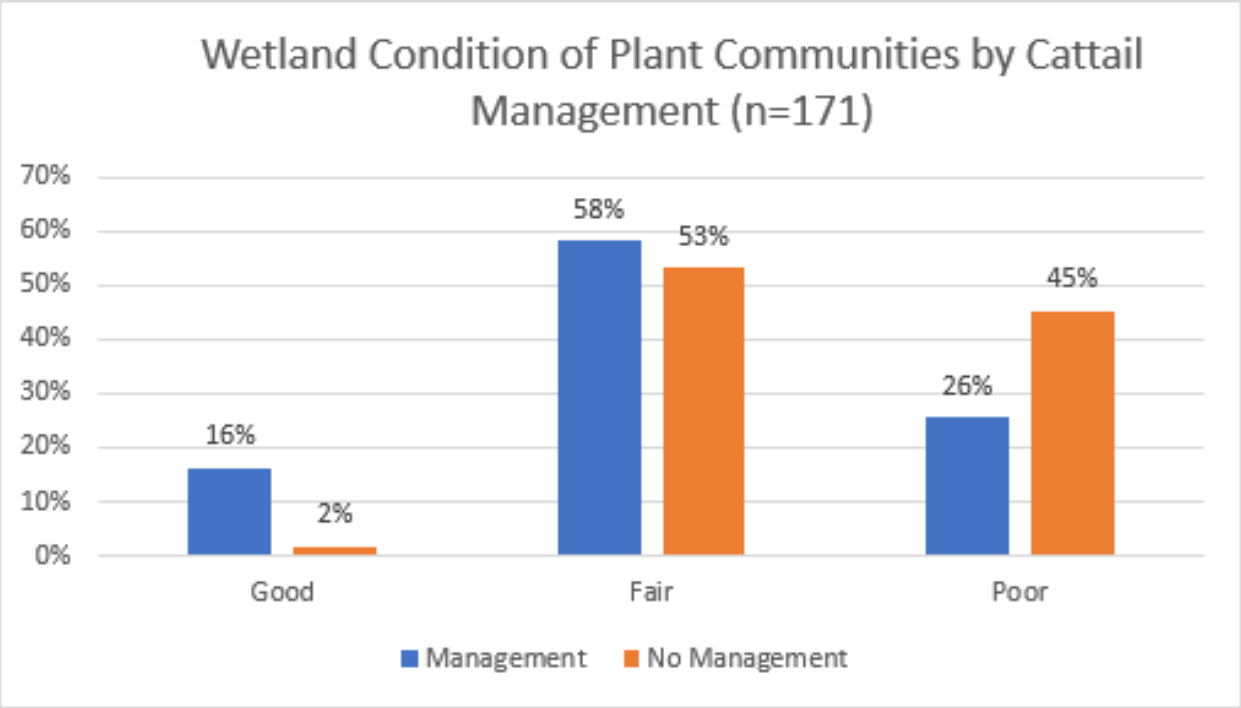


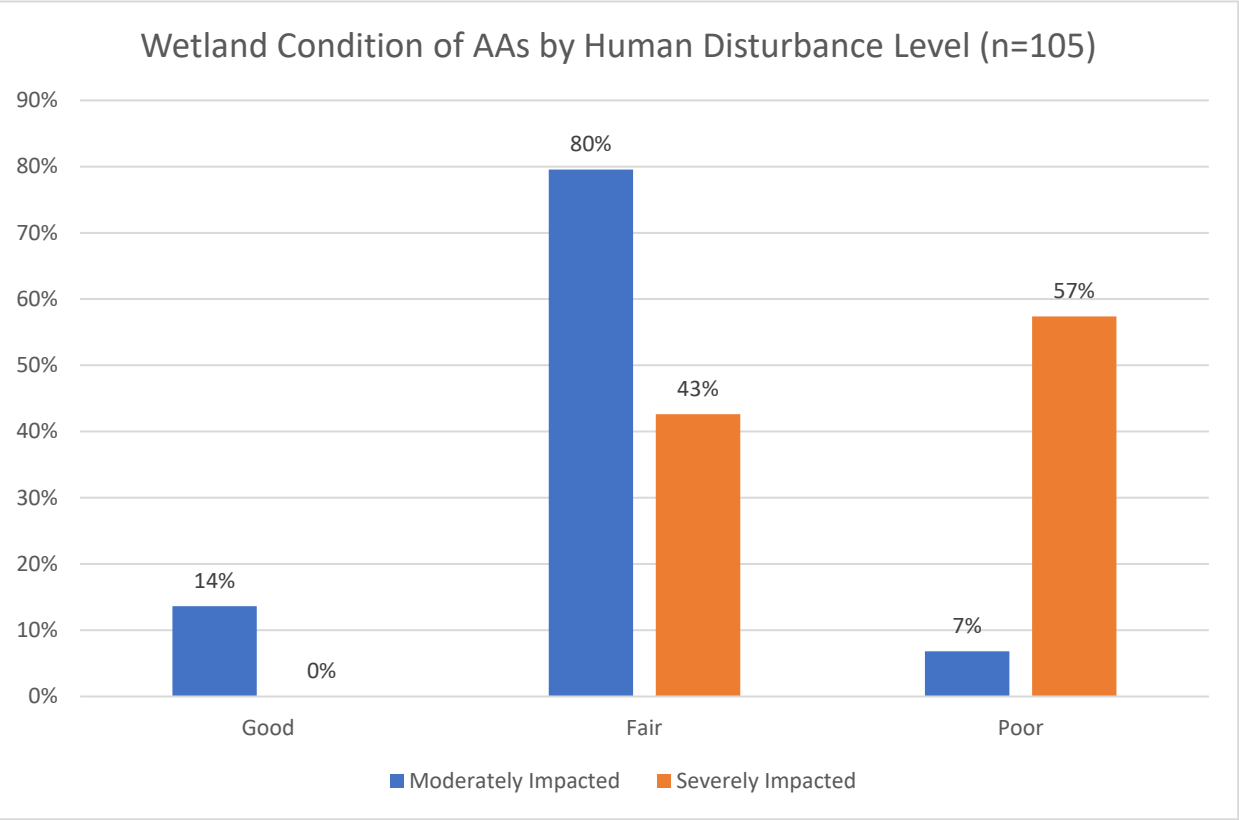
Figure 18. Comparison of wetland condition among plant communities with active hybrid cattail management versus no cattail management during restoration.



Wetland Condition by Human Disturbance

AAs that were classified as a moderately impacted human disturbance level were generally in better condition than those classified as severely impacted with a higher percentage of good (14% vs 0%) and fair (80% vs 42%) condition AAs and a lower percentage of poor condition AAs (7% vs 58%) (***Figure 19***).

Figure 19. Comparison of wetland condition of AAs with moderate vs severe human disturbance levels.



Wetland Condition by Multiple Variables

Plant community condition ratings were grouped for several different combinations of human disturbance levels and management frequency. Communities with a moderate human disturbance level and frequent/periodic management during restoration had the highest percentage of good condition ratings at 19% (***Figure 20***). When plant communities were grouped by different combinations of age since restoration and management frequency, the highest percentage of good condition communities (14%) were young restorations with frequent/periodic management during establishment (***Figure 21***). When plant communities were grouped by different combinations of age since restoration and human disturbance level, the highest percentage of good condition communities (21%) were young restorations with a moderate human disturbance level (***Figure 22***).

Figure 20. Comparison of wetland condition of AAs with different combinations of human disturbance levels and management frequency.

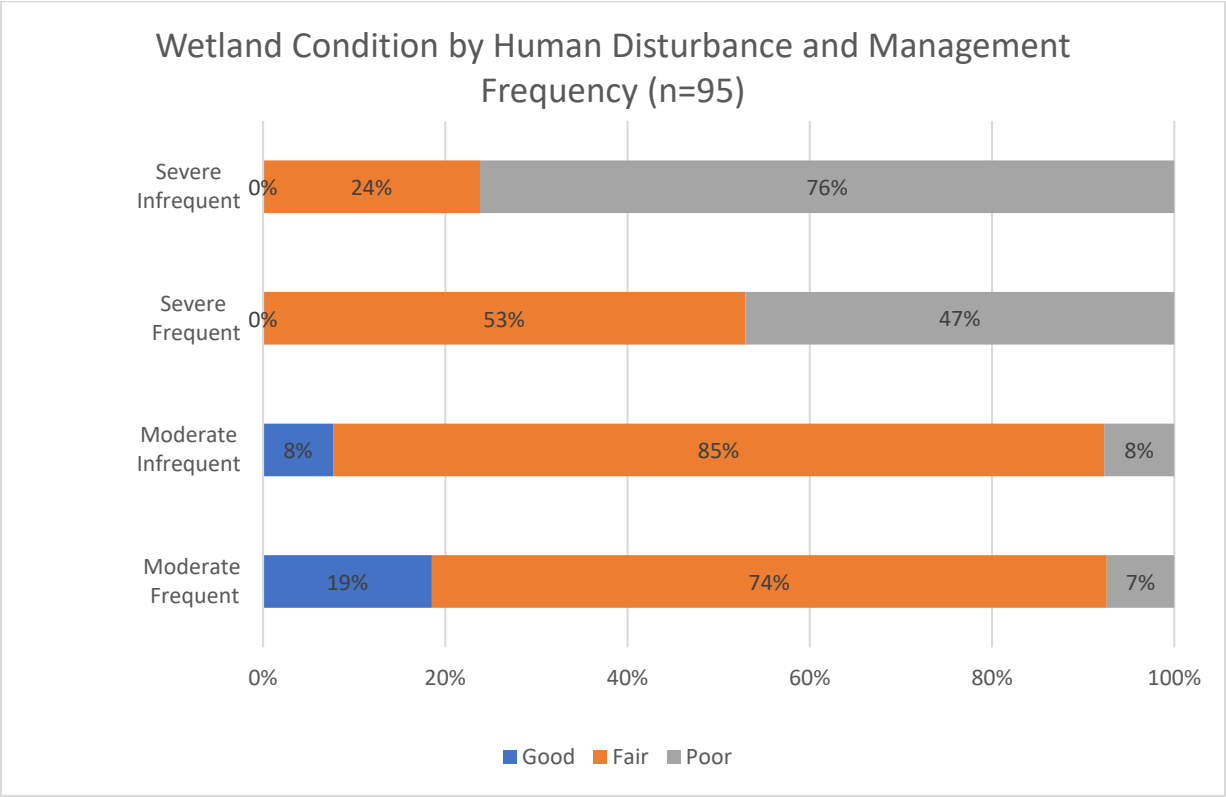


Figure 21. Comparison of wetland condition of AAs with different combinations of management frequency and age of restoration.

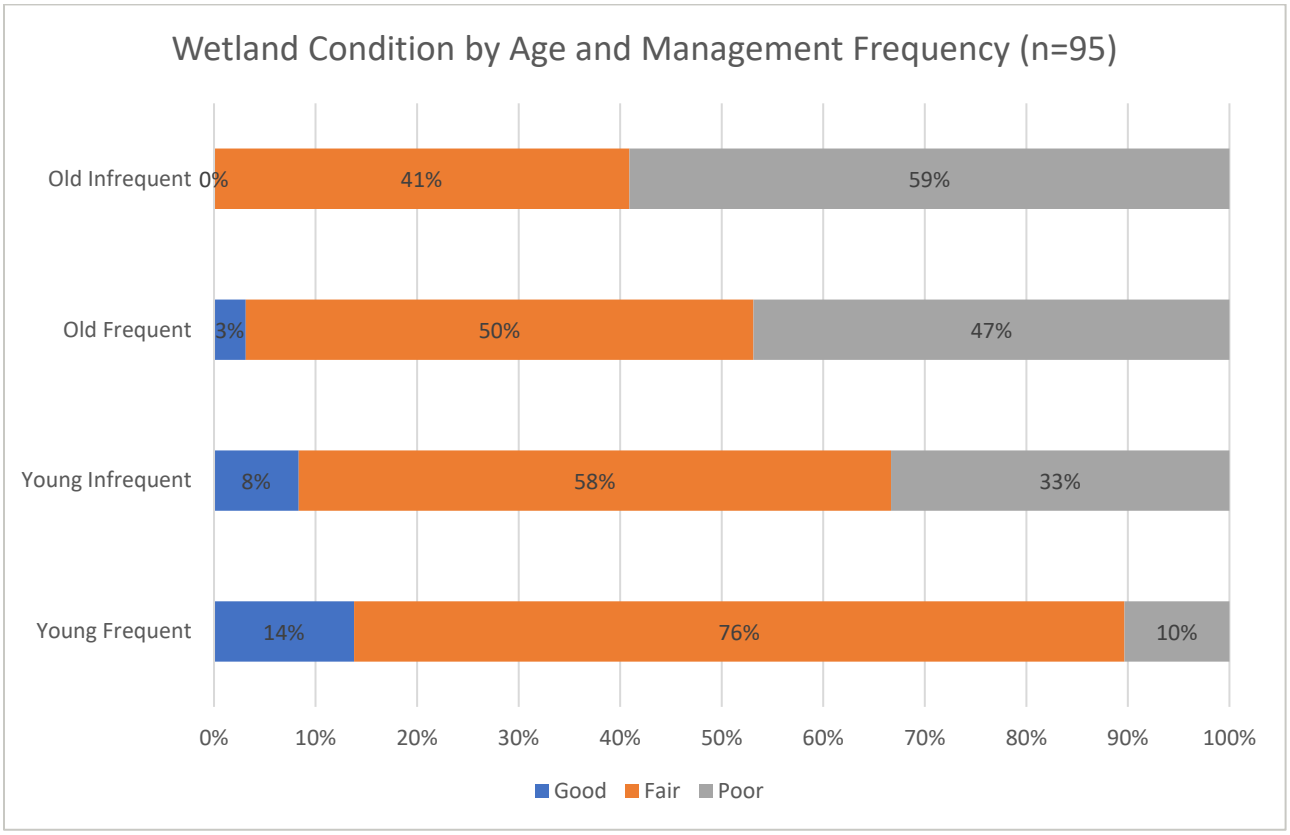
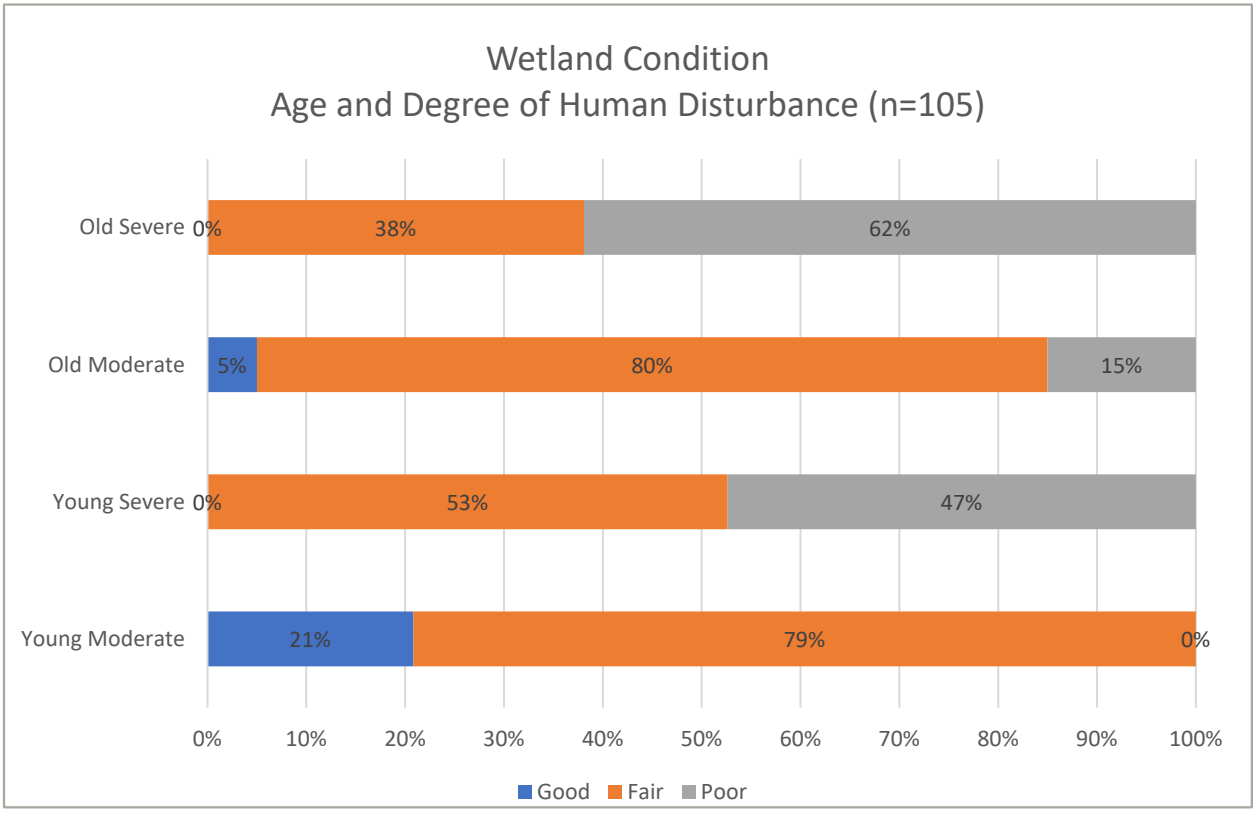


Figure 22. Comparison of wetland condition of AAs with different combinations of human disturbance level and age of restoration.



Discussion

The predominance of fair condition wetlands and plant communities within wetland bank sites is not unexpected given that restoration goals were not focused on plant species assemblages that lead to high coefficients of conservatism, higher FQA scores, and hence higher condition ratings. Rather, restoration goals were focused on achieving more diversity and a high percentage of native species coverage in a relatively short amount of time (5-7 years). Secondly, sites selected for wetland banking typically have been highly impacted and degraded as restoration of these type of sites will generally result in more functional lift and higher credit allocations per land area. Restoring these types of sites to an exceptional or even good condition is challenging in a such a short time, particularly when goals are not focused on the same plant community characteristics that drive FQA condition scores.

Statewide, AAs and plant communities within wetland bank sites are in poorer condition as compared to other wetlands in the state. This is primarily driven by the high number of exceptional condition natural wetlands in northeastern Minnesota (Bourdaghs 2019). When AAs and plant communities are compared to other wetlands by ecoregion, the differences are much less for the Mixed Wood Shield and Mixed Wood Plains ecoregions. While exceptional condition wetlands in the Mixed Wood Shield ecoregion drive the overall state condition assessment, it is noteworthy that wet meadow communities within wetland banks have a higher percentage of

fair and a lower percentage of poor condition ratings as compared to other wetlands on a statewide basis. This observation could reflect the disproportionate amount of effort and resources that wetland bank sponsors tend to put into restoring degraded wet meadows as opposed to other community types. It is possible that plant community condition in wetland banks sites would be like other wetlands if not for the influence of the abundant exceptional condition communities in northeastern Minnesota.

The limited distribution of AAs among different HGM classes make it difficult to discern any differences in condition by HGM class. The data indicate wetlands in organic flats are in slightly better condition than those classified as depressional, but this may be more of a reflection of the greater number of wet meadow communities in organic flats that appear to drive higher condition scores on wetland banks.

Of the variables measured, the data indicate differences in the condition of wetland bank AAs and/or plant communities by age, management frequency, hybrid cattail management, seeding, and human disturbance ratings (***Table 4***).

Table 4. Wetland condition trends by specific variables determined for AAs or plant communities within wetland bank sites.

Variable Combinations	Categories	Results
Age of Restoration	Young (6-9 yrs), Old (10-16 yrs)	Generally higher condition ratings for young AAs.
Seeding	No seed mix used, seed mix used (3-40 species)	Slightly higher condition ratings for plant communities where no seed mix was used.
Vegetation Management Frequency	Frequent, Infrequent	Generally higher condition ratings for plant communities with frequent management during establishment period.
Hybrid Cattail Management	Managed to Control Hybrid Cattail, Not Managed	Generally higher condition ratings for plant communities that were specifically managed to control hybrid cattail.
Human Disturbance Level	Moderate, Severe	Higher condition ratings for AAs with moderate levels of human disturbance.

As expected, higher management frequency, hybrid cattail management, and a lower level of human disturbance were associated with higher condition ratings for AAs and plant communities within AAs for wetland banks. However, wetland condition was poorer for older sites. This could be due to the lack of long-term maintenance and expansion of invasive species, or because of the ever-increasing restoration standards which were applied more consistently to younger wetland bank sites.

Paradoxically, plant communities within bank sites had higher condition ratings if they were not planted with a seed mix during restoration. There may be some underlying factor driving this result for which we were not able assess due to our relatively small sample size and lack of specific management information on all AAs. One potential reason for this result is that some wetland bank projects are not seeded if it is likely that a diverse native seedbank is present and will result in successful establishment.

Where possible based on sample size distributions, wetland condition results of wetland bank AAs were sorted by certain combinations of variables (***Table 5***).

Table 5. Wetland condition trends by specific variables determined for AAs or plant communities within wetland bank sites.

Variable	Categories	Results
Human Disturbance Level & Management Frequency	Severe Disturbance/Frequent Mgmt, Severe Disturbance/Infrequent Mgmt, Moderate Disturbance/Frequent Mgmt, Moderate Disturbance, Infrequent Mgmt	Highest condition ratings were for AAs with a moderate level of disturbance and frequent management during establishment. Moderate disturbance levels appear to be more of an influence on condition as compared to management frequency.
Restoration Age & Management Frequency	Young/Frequent Mgmt, Young/Infrequent Mgmt, Old/Frequent Mgmt, Old/Infrequent Mgmt	Highest condition ratings were for young AAs with frequent management during establishment. Age appears to be more of an influence on condition as compared to management frequency.
Restoration Age & Human Disturbance Level	Young/Severe Disturbance, Young/Moderate Disturbance, Old/Severe Disturbance, Old/Moderate Disturbance	Highest condition ratings were for young AAs with moderate disturbance levels. Disturbance level appears to be more of an influence on condition as compared to restoration age.

The results suggest a strong influence of human disturbance level on the condition of wetlands within wetland banks. While the older restorations tended to have lower condition ratings, the data suggest the overriding influence of human disturbance levels.

Sample size distribution among the variables measured was too low to make statistically significant conclusions. However, the data does suggest the potential level of influence that certain variables/factors have on condition outcomes as well as identifying potential future investigations.

Some preliminary indications from this study are as follows:

- The long-term condition of wetland banks is like other wetlands except in northeastern Minnesota where most of the exceptional condition wetlands in the state are located. An increased focus on vegetation performance standards that equate to increased FQA scores would likely be needed in the northeast to improve the long-term condition of wetland banks.

- Human disturbance factors from surrounding land uses and other stressors may be a significant influence on the condition of wetland banks, particularly as the banks age. Increased scrutiny of wetland bank siting and more buffering of restored wetlands may be a means to improve wetland condition.

- Specific control and management of hybrid cattail during wetland bank establishment may contribute to better long-term condition scores. The frequency of management actions during establishment and the use of seed mixes appears to have little influence on the long-term condition of wetlands within wetland banks. Management that targets hybrid cattail during plant community restoration may be important in long-term condition outcomes. The use of seed mixes and the number of species they include may be of limited importance in long-term condition.

To make more definitive conclusions about the long-term condition of wetland banks, continued condition assessments of these same wetland banks over time is needed along with sampling of other wetland banks in a way that increases sample sizes among different variables. More samples and analysis by ecoregion is necessary to determine if the variables/factors potentially affecting long-term wetland bank condition vary regionally. Data on the condition of wetland banks at the time active management and credit releases cease could be compared to the condition at various ages of restoration to determine the effect of age.

Literature Cited

Bourdaghs, M. 2012. Development of a Rapid Floristic Quality Assessment. wq-bwm2-02a. Minnesota Pollution Control Agency, St. Paul, MN.

Bourdaghs, M. 2019. Wetland Monitoring Standard Operating Procedures. wq-bwm3-01. Minnesota Pollution Control Agency, St. Paul, MN.

Bourdaghs, M., J. Genet, and M. Gernes. 2019. Status and Trends of Wetlands in Minnesota: Minnesota Wetland Condition Assessment. wq-bwm1-11. Minnesota Pollution Control Agency, St. Paul, MN.

Milburn, S.A., M. Bourdaghs, and J.J. Husveth. 2007. Floristic Quality Assessment for Minnesota Wetlands. wq-bwm2-01. Minnesota Pollution Control Agency, St. Paul, MN.

Minnesota Pollution Control Agency (MPCA). 2014. Rapid Floristic Quality Assessment Manual. wq-bwm2-02b. Minnesota Pollution Control Agency, St. Paul, MN.