Establishment of the wetland condition and function monitoring program in the rapidly changing, ecologically significant watersheds of Gallatin County, Montana

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MONTANA STATE UNIVERSITY EXTENSION

THE SEAL OF GALLATIN COUNTY STATE OF MONTANA

Abstract

Wetlands are an important component of our watersheds. They provide important functions and ecosystems services including plant and animal habitat, flood attenuation, groundwater recharge, and improvements to water quality. Wetlands can be affected by natural and anthropogenic disturbance both indirectly and directly. Natural events such as drought, storms, and floods can all impact wetlands; as well as, anthropogenic alteration including changes to vegetation, water inputs/outputs, sediment input, and fragmentation.

The land use of Gallatin County, Montana has seen recent large scale changes including changes to both the level and the extent of urban, exurban, and agriculture development. This project has been developed to monitor the effect of these changes on wetlands by annually assessing wetland condition and function across a broad sample of wetlands across the project area. Our annual monitoring of the wetlands within Gallatin County will provide us an understanding of the local trends in wetland health. Additionally, this project's assessment tool, and eventual online application, seek to improve the accessibility of these assessments to volunteers and citizen groups.

The project's assessments are at two levels, a landscape level and a local level. Our landscape level assessment of wetlands within Gallatin County indicates that the privately owned wetlands are an important component of the local wetland ownership. These areas represent a critical opportunity to preserve wetland condition and function. Additionally, the land cover in and around wetlands within the landscape, regardless of ownership, has seen a slight increase in disturbance and/or human use since 2010.

Our local level assessments occurred at the wetland level. During the summer of 2015 we established 42 permanent wetland assessment areas. Through these on-the-ground assessments we found that the condition of a majority of wetlands was at a slight or less departure from reference state. Additionally, the function of these wetlands was at a high level. Subsequent annual visits of these 42 permanent assessment areas will allow us to explore an interannual trend of wetland health.

Over the course of the winter of 2015/2016, the assessment tool will be migrated to an online website application. The tool will allow the field entry of assessment metric and integrate behind the scenes calculations of function, condition, and an aggregate score.

Acknowledgments

This project was funded by the U.S. Environmental Protection Agency Region 8 Wetland Program Development Grant. We would like to thank Cynthia Gonzales for her support. We thank Adam Rice and Hayley Richards for their careful data collection and insights into the assessment tool. We thank all the folks who listened to our random questions, provided great insights, and provided on the ground training. These include Tammy Swinney, Ray Heagney, Craig Campbell, Dale White, Larry Urban, Peter Brown, Rich McEldowney, Bill Kleindl, Tony Hartshorn, Steve Carpenedo, Lynda Saul, and Karen Newlon. Thanks to Paula Cudney, Mary Vanberby, Emily Lockard, JaNaie Veca, Tisha Stahly, Jason Killam, and Barbara Bunge for editorial review and assistance with grant administration.

Table of Contents

Abstract 2

Acknowledgments 3

Overview 5

- Background 5
- Study Area 5

Methods 6

- Level 1-Wetland Landscape Profiling 6
- Level 2 - On the ground Wetland Assessments 8
  - Initial Site Establishment 10
  - Dynamic Data 11

Results 13

- Level 1-Wetland Landscape Profiling 14
- Level 2 - On the ground Wetland Assessments 16
  - Wetland Classification 16
  - Location 21
  - Dynamic Data – Condition and Function 21
  - Dynamic Data - Stressors 26

Discussion 27

Additional Products 29

Literature Cited 30

Overview

Background

Over the last several decades Gallatin County has seen extensive land use changes, one of the highest population growth rates of any county in Montana - predicted to grow 36% by 2040, and an explosion in residential development and economic opportunity. These rapid changes are expected to continue and are likely to contribute to dynamic pressures on the water resources of Gallatin County and downstream users. While several volunteer and government groups are working in the watersheds to monitor the water quality and quantity of riverine systems, a need exists to know more about the extent, condition, and function of wetlands within the watershed and to share this information to inform decision-making.

Through monitoring wetland health, this project will establish reference points to track annual and interannual alteration of condition and function. The locations of monitoring sites were limited to sites with public access and were selected to promote ease of access and efficiency of monitoring. As support for the project and the number of trained technicians/volunteers increases the opportunity to expand monitoring to additional wetlands will be explored. Both the monitoring tool and the collected data is available through the MSU Extension – Gallatin County website.

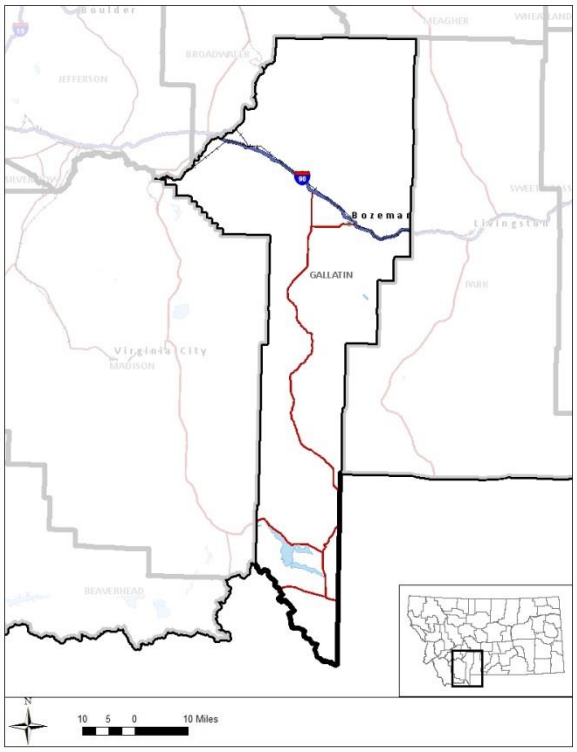

Figure 1: Gallatin County, Montana

Study Area

Our study area is Gallatin County, Montana (Figure 1). The project area includes four basins: Jefferson River – 10020005, Upper Missouri River - 10030102, Madison River – 10020007, Gallatin River – 10020008 and covers 2,632 square miles (1,684,480 acres). Major towns in the project area include Bozeman, Belgrade, Manhattan, and West Yellowstone. Land use within the project area is primarily agriculture and recreation. Residential and commercial development occurs in and around the major towns (Figure 2). Montane portions of the project area are largely publicly owned, with the U.S. Forest Service being the primary landowner (Figure 3). Private

ownership is focused principally in the valleys and lower foothills.

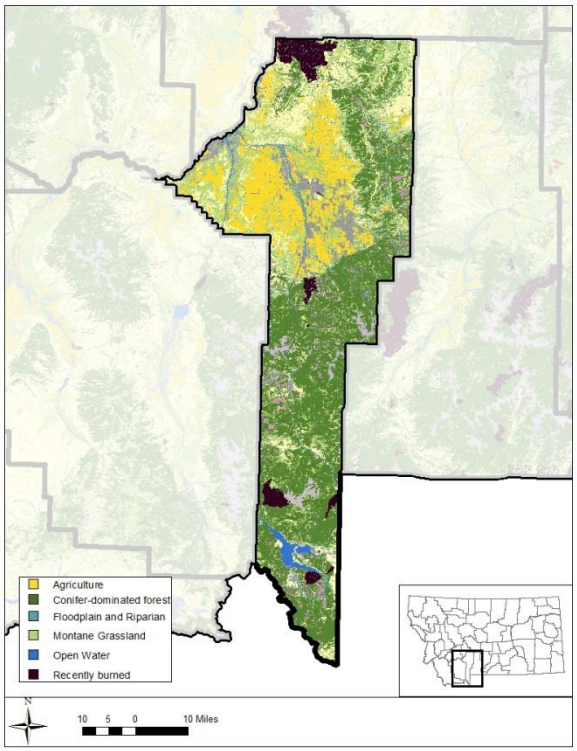

Figure 2: Land cover

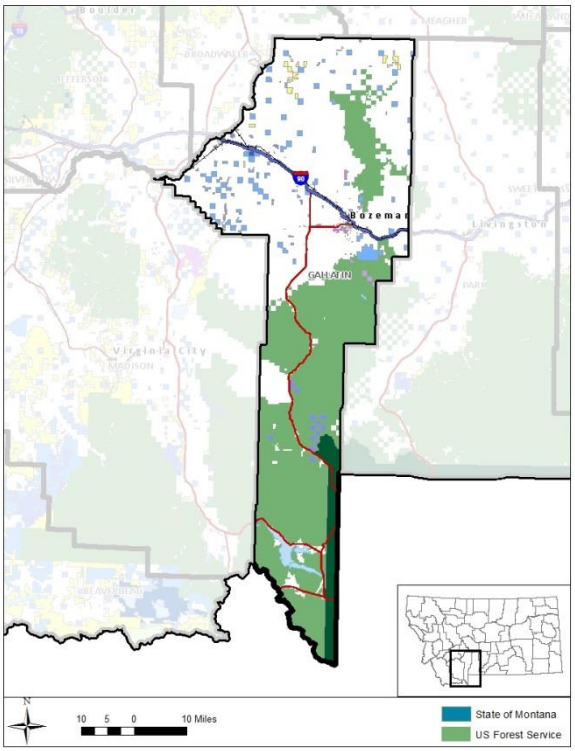

Figure 3: Ownership

Methods

Level 1-Wetland Landscape Profiling

We assessed wetland health at two levels. Our level 1 analysis was a GIS landscape analyses consisting of: 1) wetland landscape profiles, which used digital wetland mapping to summarize information on wetland abundance, type, extent, and ownership across the watershed; and 2) a landscape characterization of the change of land cover within and surrounding wetlands.

Using digital wetland mapping provided by the Montana Natural Heritage Program (MTNHP) we prepared a landscape level profile of the wetlands within the project area (MTNHP 2014). This GIS driven analysis was developed to provide a broad characterization of ownership and the degree of recent change in land cover in and around wetlands within the project area.

Within the project area we randomly selected 1000 remotely sensed, palustrine wetlands. The ownership of each wetland was derived from Montana Cadastral Database (Montana State Library 2015). Each of the selected wetlands were buffered at 0 m, 100 m, 300 m, and 1000 m. The land cover for each wetland and at each buffer was characterized for 2010 and 2013 using Montana Land Cover to inform local changes to the landscape condition (MTNHP 2010, MTNHP 2013). Land cover data was categorized into three primary bins: Human Use, Recent Disturbance, and Other (Table 1).

Table 1: Land cover categories (bin for analysis) captured for each of the 1000 randomly selected wetlands.

Attribute Value (Bin)	Definition of Attribute Value
Human Land Use (Human Use)	Developed areas in rural or urban settings (including roads), strip mines and gravel pits, and agricultural lands.
Recently Disturbed or Modified (Recent Disturbance)	Recently burned or harvested vegetation and introduced upland and riparian vegetation.
Sparse and Barren Systems (Other)	Badlands, dunes, and cliffs and canyons, that are characterized by sparse vegetation or are unvegetated. Abiotic substrate features dominant. Vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources (total vegetation cover is typically less than 25% and greater than 0%).
Alpine Systems (Other)	Barren substrate or herbaceous and low shrubby vegetation above mountain timberline.
Forest and Woodland Systems (Other)	All natural forest and woodland systems, with the exclusion of riparian systems.
Shrubland, Steppe and Savanna Systems (Other)	All natural shrub/scrub systems, with the exclusion of alpine and riparian systems. Shrubland: Shrubs generally greater than 0.5m tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 25% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover, respectively. Vegetation dominated by woody vines is generally treated in this class. Dwarf shrubland: Low-

	growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and tall shrubs generally less than 25% cover).
Grassland Systems (Other)	All natural herbaceous systems, with the exclusion of alpine and riparian systems. Herbaceous: Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 25% cover; trees, shrubs, and dwarf-shrubs generally with less than 25% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover, respectively.
Open Water/Wetland and Riparian Systems (Other)	Natural systems located in areas where the soil or substrate is periodically saturated with or covered with water.

Level 2 - On the ground Wetland Assessments

Our second level of analysis (level 2) was a field-based assessment. We captured elements of two standard Montana wetland assessment tools to simultaneously assess both wetland condition and wetland function. To capture wetland condition we followed methods outlined in the Montana Ecological Integrity Assessment (EIA) Field Manual (MTNHP 2015). To capture wetland function we followed Functional Assessment (FA) methods outlined in the 2008 Montana Wetland Assessment Methods (MDT 2008).

The EIA metric ratings were integrated to produce an overall scores for four attributes: 1) Landscape Context; 2) Biotic Structure and Composition; 3) Physicochemical; and 4) Hydrology. The ratings for these four attributes were combined to produce an overall EIA score (Table 2).

Table 2: Ecological Integrity Assessment metric and ecological attributes measured.

Attribute	Metric
Landscape Context Score	Landscape Connectivity
	Width of Vegetated, Natural Buffer
	Condition of Plants within a 200m Buffer
	Condition of Soil within a 200m Buffer
Vegetation Attribute Score	Relative Cover of Native Plant Species
	Relative Cover of Noxious Weeds
	Relative Cover of Aggressive Graminoids
	Herbaceous Litter/ Woody Debris Accumulation
	Interspersion of Plant Zones
	Woody Species Establishment and Regeneration
	Utilization of Trees and Shrubs
Physiochemical	Soil Surface Integrity
	Water Quality - Algae
	Water Quality - Turbidity
	Water Quality - Sheen
Hydrology	Water Inputs
	Water Outlets
	Hydroperiod
	Surface Water Connectivity

The FA methods were scored across 12 functions (Table 3). The ratings for these 12 functions were combined to produce an overall FA score. Additionally, using the rubric in the 2008 Montana Wetland Assessment Methods guide we were able to convert the FA scores to wetland category 1 through 4 (MDT 2008).

Table 3: Functional Assessment attributes measured.

Functions
Listed/Proposed T&E species Habitat
MT Natural Heritage Program Species Habitat
General Wildlife Habitat
General Fish Habitat
Flood Attenuation
Short and Long Term Surface Water Storage
Sediment/Nutrient/Toxicant Removal
Sediment/Shoreline Stabilization
Production Export/Food Change Support
Groundwater Discharge/Recharge
Uniqueness
Recreation/Education Potential

Additionally, the EIA and FA scores results were combined for each site to capture a simple aggregate assessment score (aggregate score) that was a mean of the EIA and the FA scores.

Initial Site Establishment

Forty-two sites were randomly selected across public ownership. Sites were limited to public ownership to help ensure that sites will be available for future monitoring. These sites will be revisited annually to develop a trend in condition and function.

In 2015 each assessment required approximately two hours to complete. At each sample wetland, we established a 0.5 ha assessment area (AA). Prior to field visits, we created a set of field maps for each targeted sample point. The field maps outline the potential AA boundary and multiple radial buffers around the AA. These buffers are used to assess several of the attribute from both the EIA and the FA component of the assessment.

Once at the target sample point field team members determined the extent of the AA by pacing and flagging the perimeter. Indicator species (wetland obligate and facilitative wetland) were used to define whether at least 90% of the AA lay within a wetland. The initial establishment of AA in 2015

allowed the AA to be moved to ensure it met this minimum criterion. Subsequent years of sampling efforts will return to the exact site established in 2015 regardless of changes in the site including changes in classification and/or disturbance.

Initial sampling in 2015 captured wetland classification. To capture the natural variability within wetland classes we classified wetlands using Ecological Systems classification (Comer et al. 2003), the USFWS System (aka Corwardin classification system) (Corwardin et al. 1979), and the hydrogeomorphic (HGM) classification system (Hauer et al. 2002).

In addition to the wetland classification, the initial sampling in 2015 also collected standard site variables at each sample location. These included:

- UTM coordinates
- Elevation, slope, and aspect
- Description of onsite and adjacent ecological processes and land use
- Description of general site characteristics and a site drawing
- Water table depth
- Locating directions

Dynamic Data

At least four photos were taken from the AA center at each site. Photos were taken at 90° from each other at the cardinal directions. Additional photos were taken as needed to document the wetland and surrounding landscape.

The remainder of the monitoring was designed to capture an assessment of disturbances within the AA and a 200 m buffer (Table 4) and the wetland condition and function (Tables 2 and 3).

Table 4: Disturbances assessed within the AA and within a 200 m buffer of the AA.

Transportation Disturbances
Paved surfaces (e.g., roads, parking lots)
Unpaved roads
Railroads

Land Use Disturbances-Agriculture
Dryland farming (e.g., wheat, barley, etc.)
Open range livestock grazing
Horse paddock
Feedlot
Irrigated cropland
Irrigated hay pasture
Irrigation ditches affecting wetland
Cropland treated with pesticides
Disturbed fallow lands dominated by exotic species
Haying of native grassland
Fallow fields (no human use in past 10 years)
Fields with recent plowing or discing
Shelterbelts
Fences that impede wildlife
Permanent tree plantation

Land Use Disturbances-Vegetation Removal/Conversion

Land Use Disturbances-Development or Recreation
Domestic or commercial development
Intensively managed sports fields, golf courses
Recreation or human visitation
Filling or dumping of sediment or fill
Trash or refuse dumping

Land Use Disturbances-Resource Extraction
Gravel pits, open pit mining
Small scale mining activity or abandoned mines
Abandoned oil/gas wells
Oil/gas pump jacks (active)
Injection wells, tank batteries,
collection facilities, or other oil/gas- associated infrastructure
Intensive logging (50-75% trees of >50cm diameter removed
Selective logging (<50% of trees >50 cm diameter removed)

Hydrologic Disturbances
Upstream spring box
Impoundment of flowing water
Potential for agricultural runoff
Potential for urban runoff
Culvert

Chemical vegetation control
Evidence of intentional burning
Mechanical vegetation removal
Vegetation conversion (e.g., from shrubland to grassland)

Natural or Environmental Disturbances
Beetle-killed *Pinus* species
Other diseased conifers
Evidence of recent fire (<5 years)
Beaver activity
Evidence of prolonged drought
Browsing of woody vegetation by native ungulates

Upstream dam
Reservoir/stock pond Weir or drop structure
Dredged inlet/outlet channel
Engineered channel (e.g., riprap)
Pumps, diversions, or ditches that move water into wetland
Pumps, diversions, or ditches that move water out of wetland
Berms/Dikes/Levees

Results

The data from the 2015, the project's first year, were entered into a series of Excel worksheets and related to a GIS attribute table. This GIS table was linked to an online map (http://www.msuextension.org/gallatin/NaturalResourcesWetlandsMap.htm). Through the course of winter 2015/2016 the assessment form will be migrated to a website application that will be used to collect the field based data. Additionally, behind the scenes, this application will calculate the condition, function, and the aggregate score from the values entered during the field assessment. This website application and the resulting calculation will be housed at MSU Extension and will allow the data to be stored in a relational database.

Level 1-Wetland Landscape Profiling

The 1000 randomly selected wetlands were widely distributed across the project area (Figure 4).

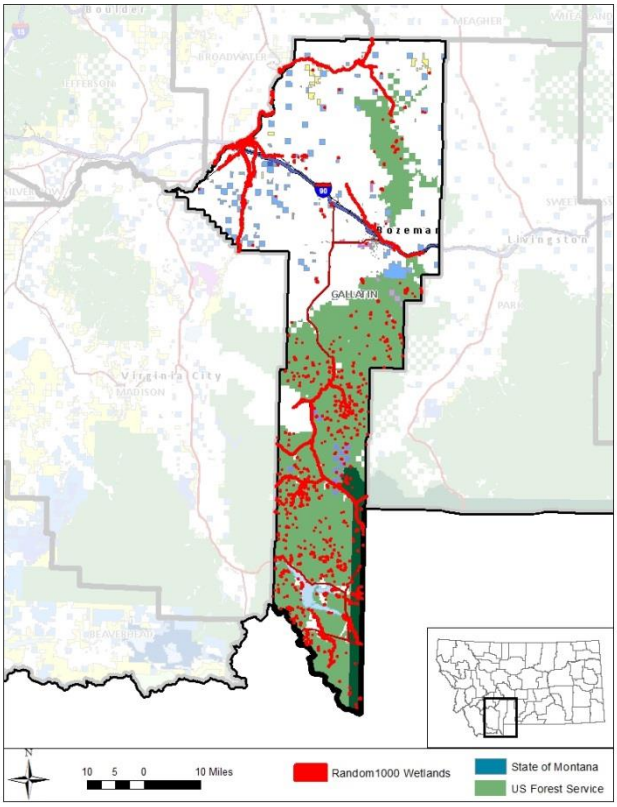

Figure 4: 1000 Random Wetlands for Landscape Profiling

For the 1000 randomly selected wetlands we calculated descriptive statistics across of the selected wetlands and across ownership. Additionally, we calculated acres and descriptive statistics for the selected wetlands based on land cover. Wetlands and other waterbodies totaled 78,514 acres within the project area. By class the majority of the mapped wetlands were palustrine (Table 5).

Table 5: Wetlands by Class in the Project Area

Wetland Class	Percentage of Total Acres
Palustrine	64%
Lacustrine	0%
Riverine	6%
Riparian	30%

The 1000 randomly selected wetlands captured 4170 acres or approximately 5% of the total wetland acres in the project area. The majority of the wetland acres were in public ownership; however, private ownership contained the greatest amount of wetland acres of any one ownership category (Table 5).

Table 6: Wetland acres in 1000 randomly selected wetlands.

	Across All Ownership	Federal Government	State Government	Local Government	Private
Minimum Acres	0.01	0.01	0.01	0.01	0.01
Maximum Acres	1450.53	281.24	154.29	7.34	1295.84
Mean Acres	4.17	2.06	3.4	1.37	18.8
Total Acres	4170.14	1814.79	394.34	24.62	1936.39
# of Wetlands	1000	879	116	18	103

Land cover was captured for the 1000 randomly selected wetlands across all buffers (0 m, 100 m, 300 m, and 1000 m) the largest land cover was the aggregate category of "Other" (Table7).

Table 7: Land cover at and proximate to the 1000 randomly selected wetlands

No Buffer	**2010 (acres)**	**2013 (acres)**	**Percent Change**
Other	3701	3661	-1%
Human Use	49	87	1%
Recent Disturbance	8	26	0%
100 m buffer	**2010 (acres)**	**2013 (acres)**	**Percent Change**
Other	35577	33259	-3%
Human Use	1423	3228	2%
Recent Disturbance	352	873	1%
300 m buffer	**2010 (acres)**	**2013 (acres)**	**Percent Change**
Other	110421	103607	-3%
Human Use	5144	9610	2%
Recent Disturbance	1901	4251	1%
1000 m buffer	**2010 (acres)**	**2013 (acres)**	**Percent Change**

Other	435900	413048	-2%
Human Use	52859	34521	-2%
Recent Disturbance	10477	20673	1%

Across nearly all buffers the level of Human Use and Recent Disturbance has increased slightly from 2010 to 2013.

Level 2 - On the ground Wetland Assessments

The forty two assessment sites were located randomly across the county (Figure 5). Scores were calculated for each site using scoring formulas modeled after those used in NHP (2012) and MDT (2008). Additionally, the aggregate score was calculated for each site.

Wetland Classification

The majority of our monitoring sites are Rocky Mountain Riparian Shrubland (Figure 6), Riverine HGM Class (Figure 7), and Palustrine Corwardin Class (Figure 8).

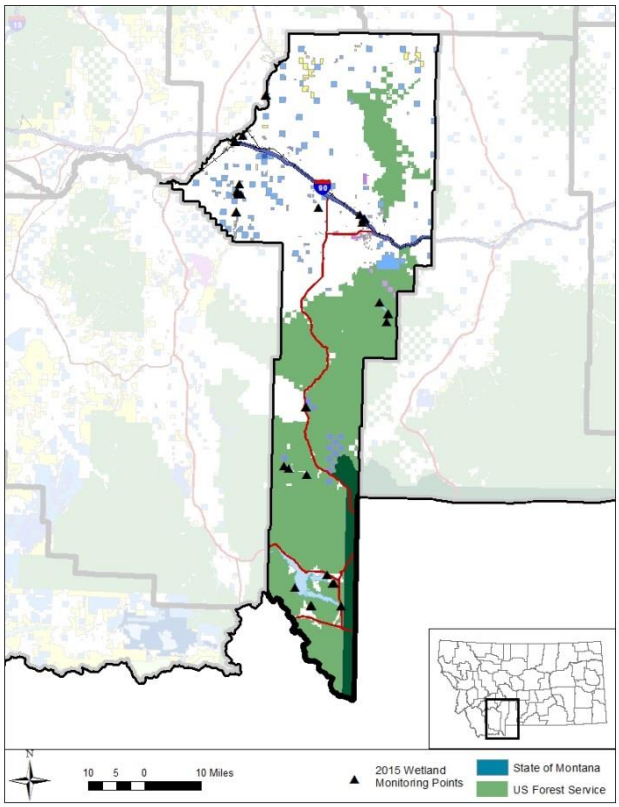

Figure 5: Monitoring Locations

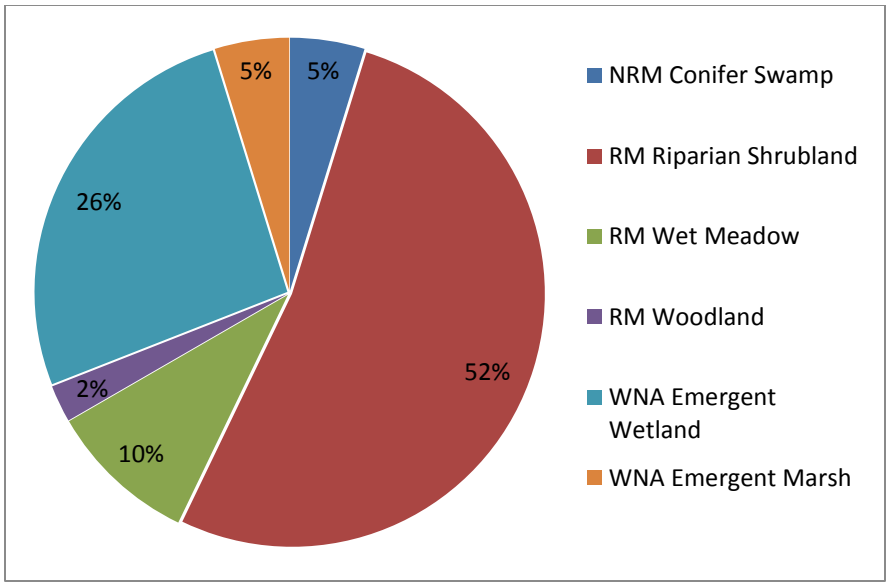

Figure 3: Ecological Systems of sampled wetlands, n = 42

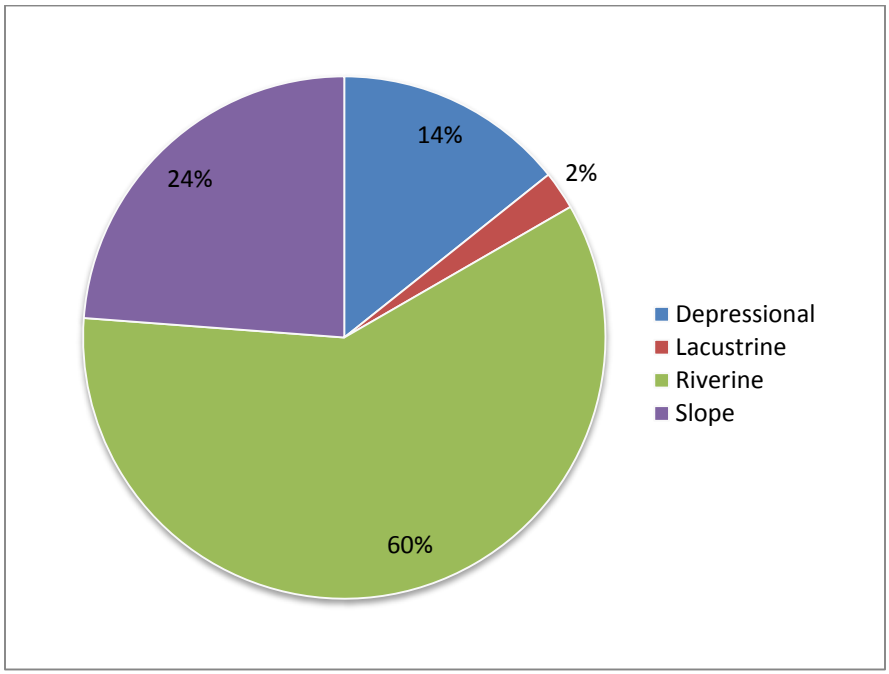

Figure 4: Hydrogeomorphic Class of sampled wetlands, n = 42

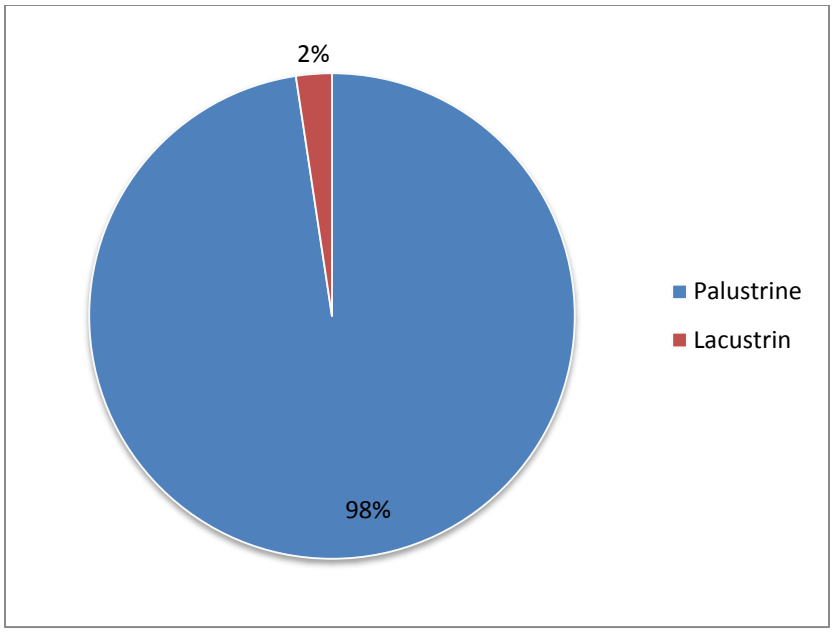

Figure 5: Corwardin Class of sampled wetlands, n = 42

An ANOVA was run for the affect of the Ecological System on the aggregate assessment score. A significant p value of < 0.05 was calculated for variance between groups (p = 0.002, Figure 9).

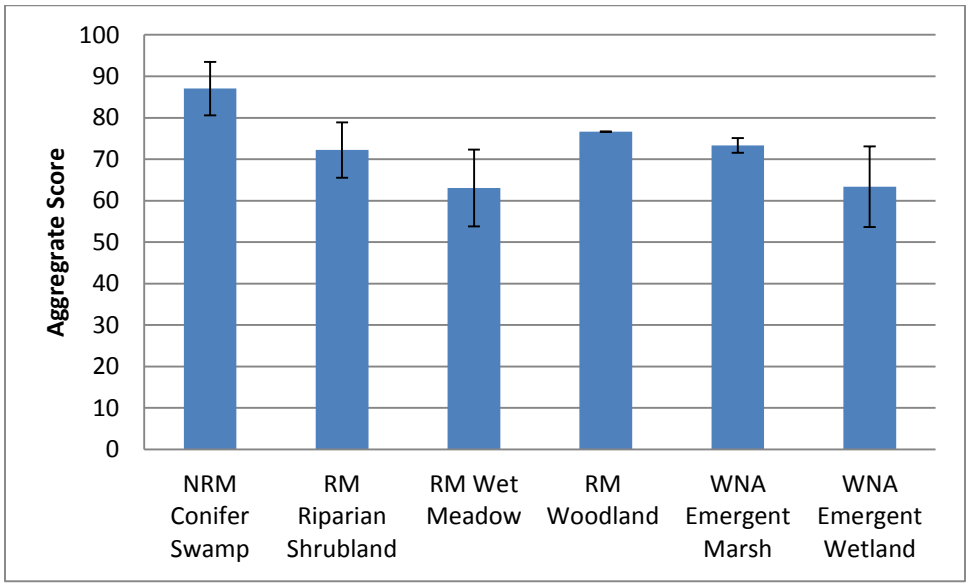

Figure 6: Aggregate assessment score by Ecological System

An ANOVA was run for the affect of the Topographic Position on the aggregate assessment score. The p value did not indicate a signficant difference in the variance between groups (p = 0.36, Figure 10).

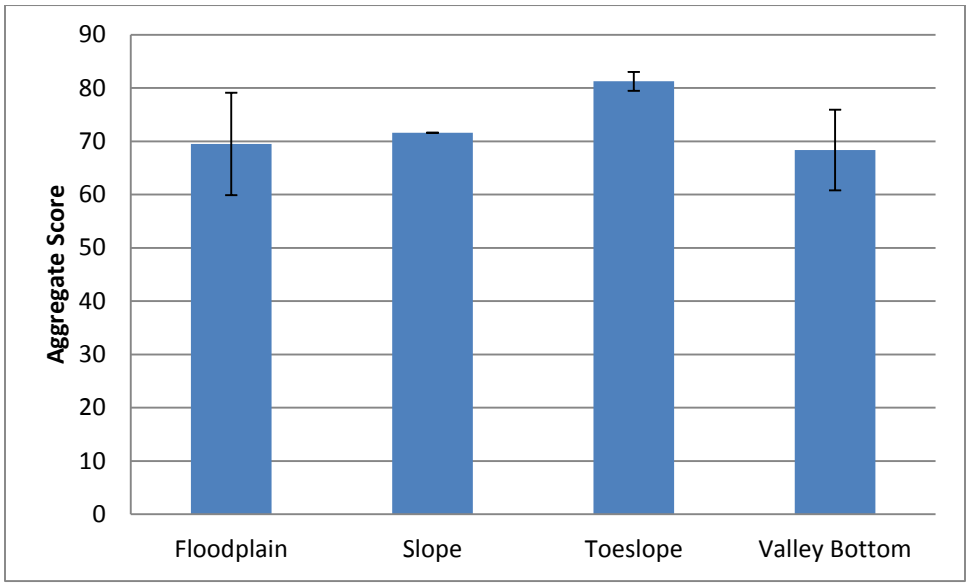

Figure 7: Aggregate assessment score by Topographic Position

An ANOVA was run for the affect of the Hydrogeomopphic class on the aggregate assessment score. The p value did not indicate a signficant difference in the variance between groups (p = 0.06, Figure 11).

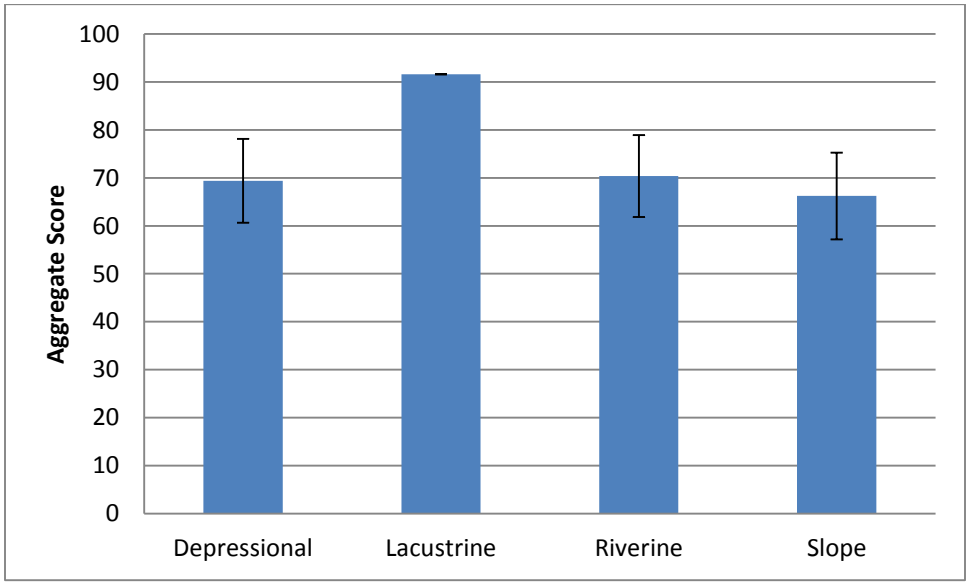

Figure 8: Aggregate assessment score by Hydrogeomorphic Class

The dominant sampled water regime is “Permanent Perennial” (Figure 12).

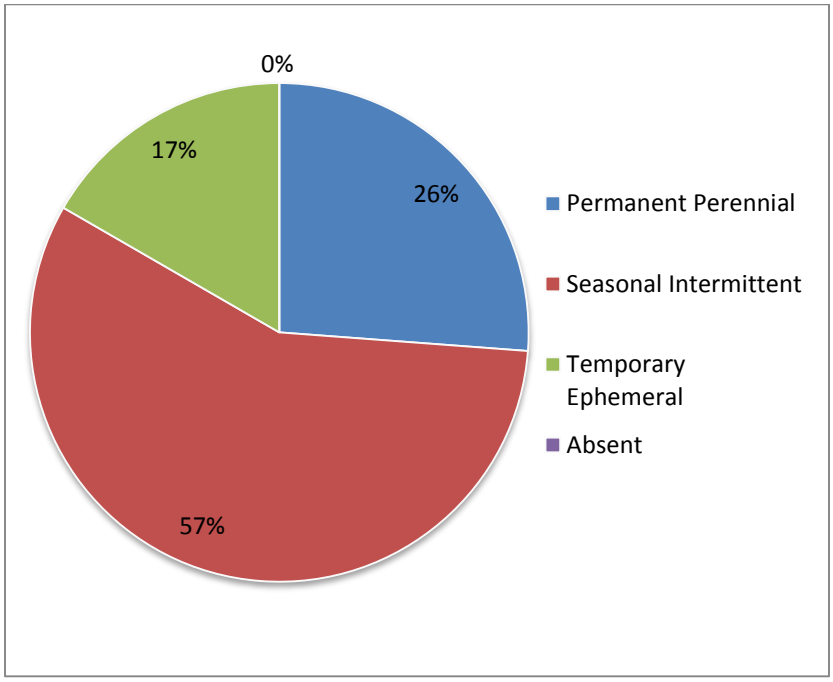

Figure 9: Water regime of sampled wetlands, n = 42

An ANOVA was run for the affect of the Ecological System on the aggregate assessment score. A significant p value of < 0.05 was calculated for variance between groups (p = 0.000, Figure 13).

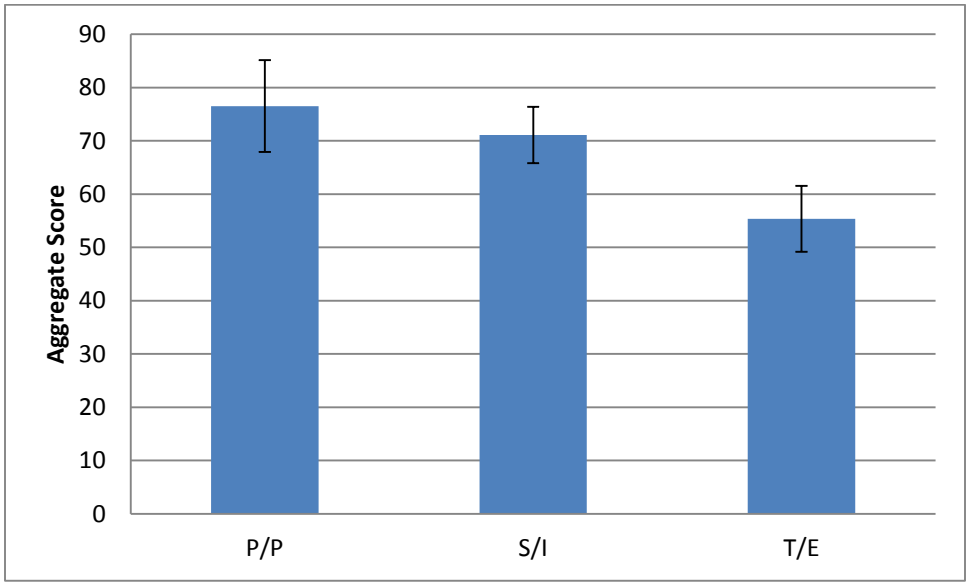

Figure 10: Aggregate assessment score by Water Regime.

Location

All of the sample sites are on public land (Figure 14, Figure 3).

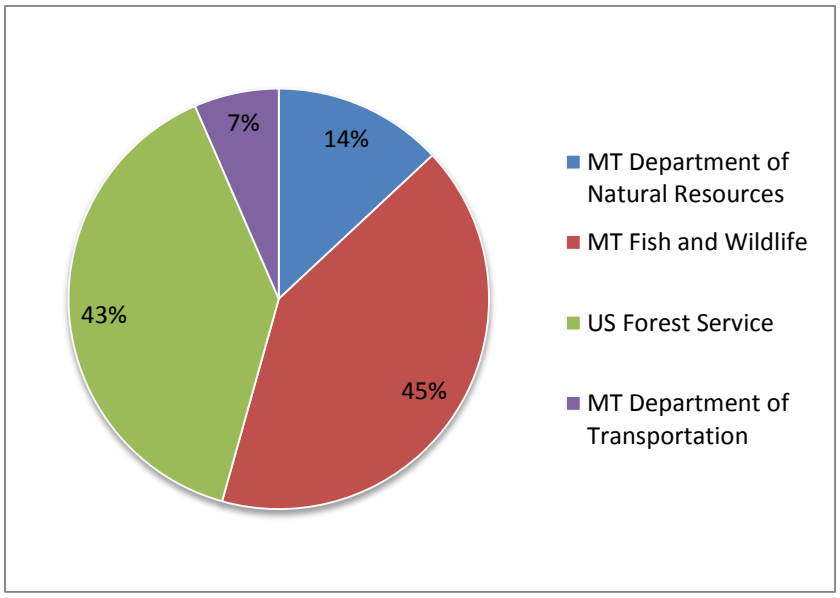

Figure 11: Ownership of sampled wetlands

Dynamic Data – Condition and Function

Condition scores ranged from 62.7 to 85.5 with a mean score of 76.9. The majority of monitored sites had a score indicating a moderate departure from reference state (Table 8, Figure 15).

Table 8: Departure from reference state

Wetland Condition Category	Count
Severe Departure (<70)	4
Moderate Departure (70-79)	25
Slight Departure (80-89)	13
At or Near (90-99)	0

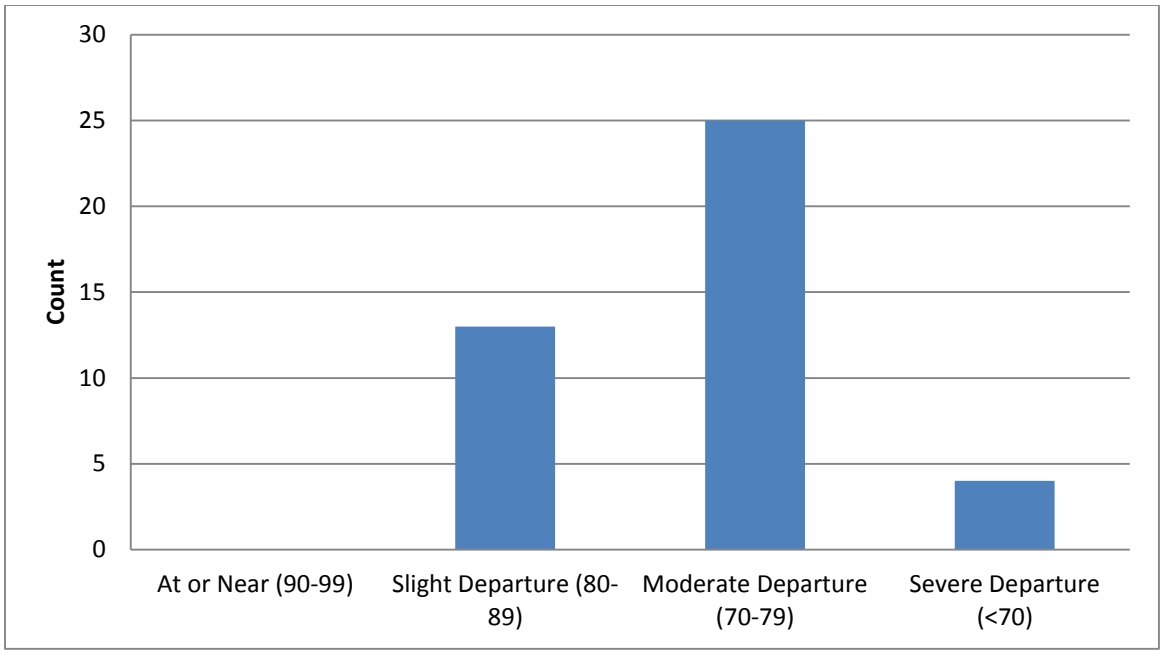

Figure 12: Condition of monitored wetlands, n = 42

Function scores ranged from 30.0 to 100.8 with a mean score of 62.9 (Table 9, Figure 16).

Table 9: Wetland Function Score

Wetland Function Score	Count
< 65%	20
65 - 80%	17
> 80%	4

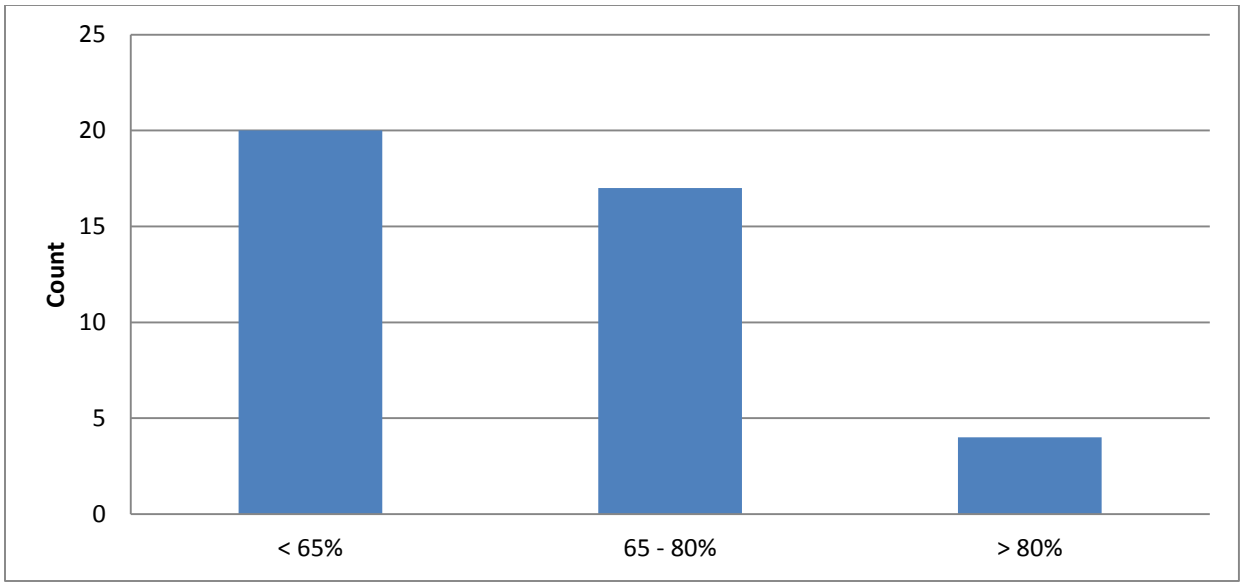

Figure 13: Function of monitored wetlands, n = 42

The majority of monitored sites had a score indicating a category 1 or 2 wetland (Table 10, Figure 17).

Table 10: Wetland category based on function score

Wetland Category	Count
1	5
2	27
3	10
4	0

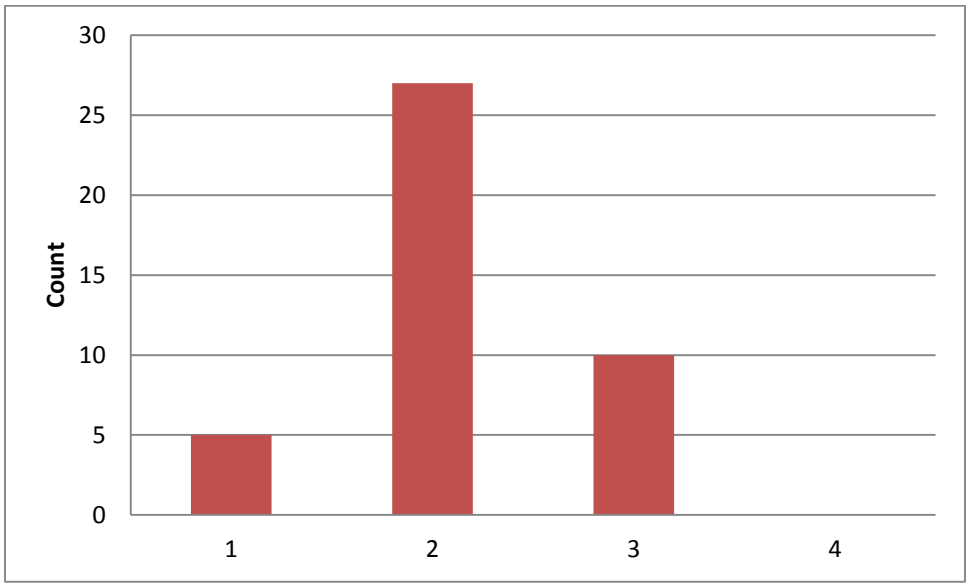

Figure 14: Wetland category based on function, n = 42

The difference in condition and function for each monitored wetland varied widely (Figure 18 and Figure 19)

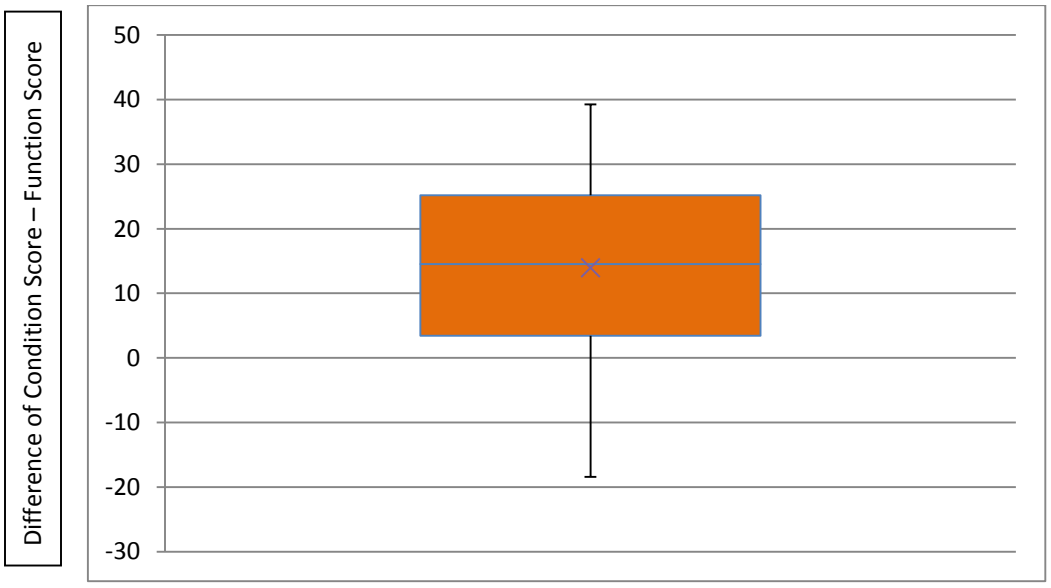

Figure 15: Box plot of difference of condition and function scores. The mean difference (X in the chart) was approximately 14.

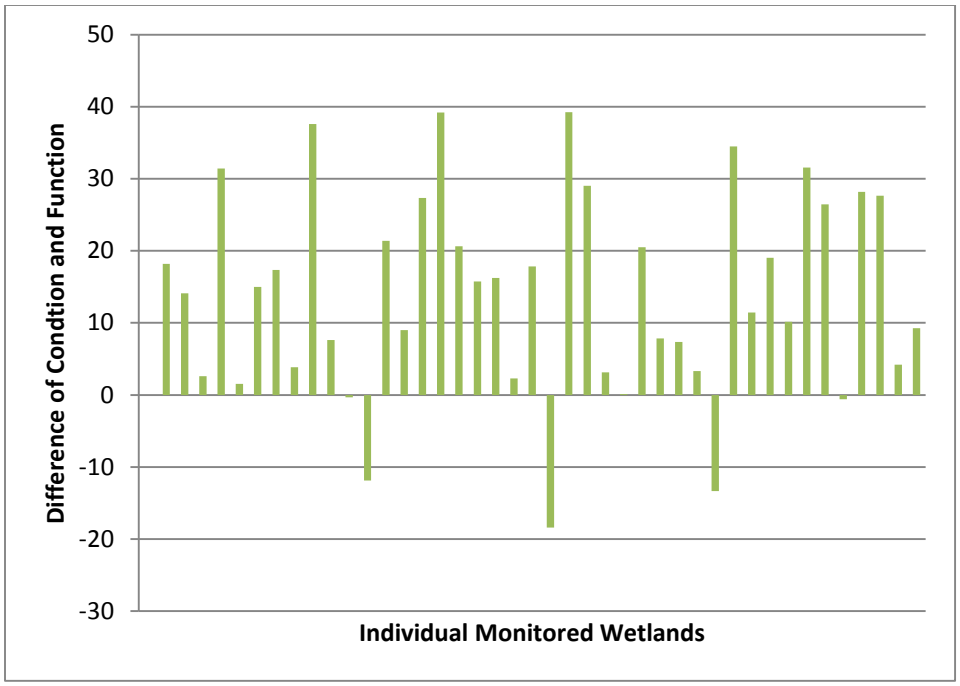

Figure 16: Difference of condition score and function score for each monitored wetland, n = 42

The aggregate score of condition and function indicated that most of the monitored wetlands scored in the top 30 percent of the possible score (Table 11, Figure 20).

Table 11: Aggregate condition and function scores

Aggregate Score	Count
90-100	1
80-89	4
70-79	21
<70	16

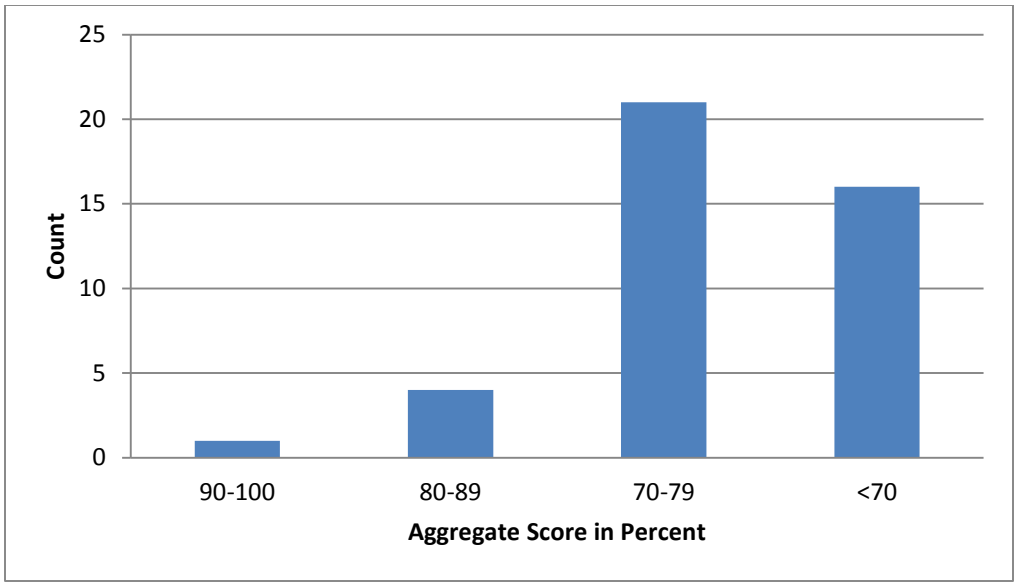

Figure 17: Aggregate condition and function score, n = 42

Several of the sites were within the same wetland complex allowing an exploration of intra-wetland variability in assessment scores. Variation by the random location assessment sites was large, with a median difference in intra-wetland variability being 14%. Minimum variation was 0.2% and the maximum was 21%.

Several of the monitored wetlands were previously monitored by the Montana Natural Heritage Program in 2010 (MTNHP 2012). Comparing the results of past monitoring will provide some context for how wetland condition might have changed since 2010 (Figure 21). As this project continues, yearly monitoring of all 42 sites will provide a greater understanding of change in wetland condition and function.

Dynamic Data - Stressors

The scope and severity of each observed stressor was recorded within a 200 m envelope around the assessment area to help identify potential impacts to wetland condition and function. The scope and severity were combined to develop an impact score which characterizes the buffer's deviation from "no impact". A combined stressor score of 12 indicated no impact of stressors within buffer to the AA. The majority of the buffers had very little impact on overall aggregate assessment score (Figure 20).

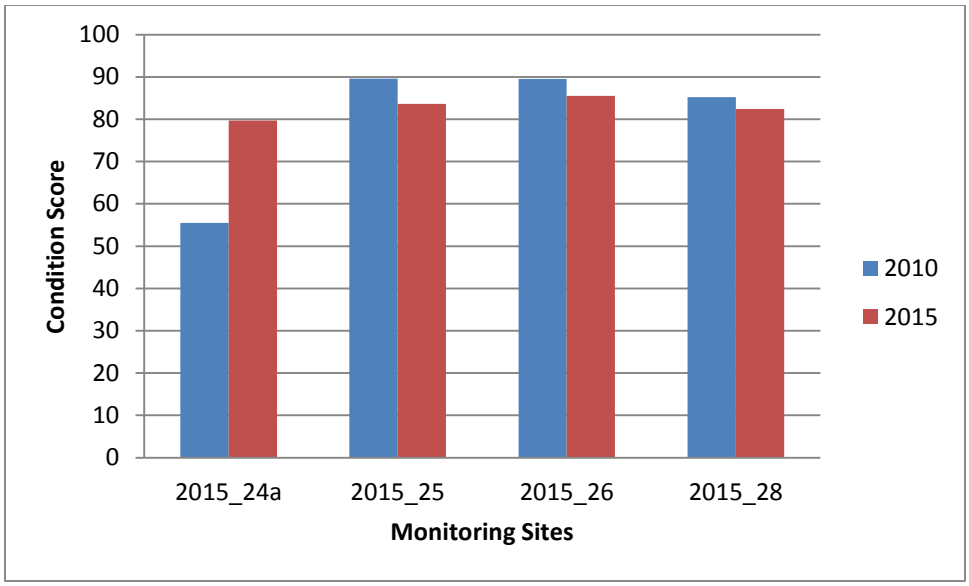

Figure 18: Sites monitoring by Montana Natural Heritage Program in 2010 and revisited by this project in 2015.

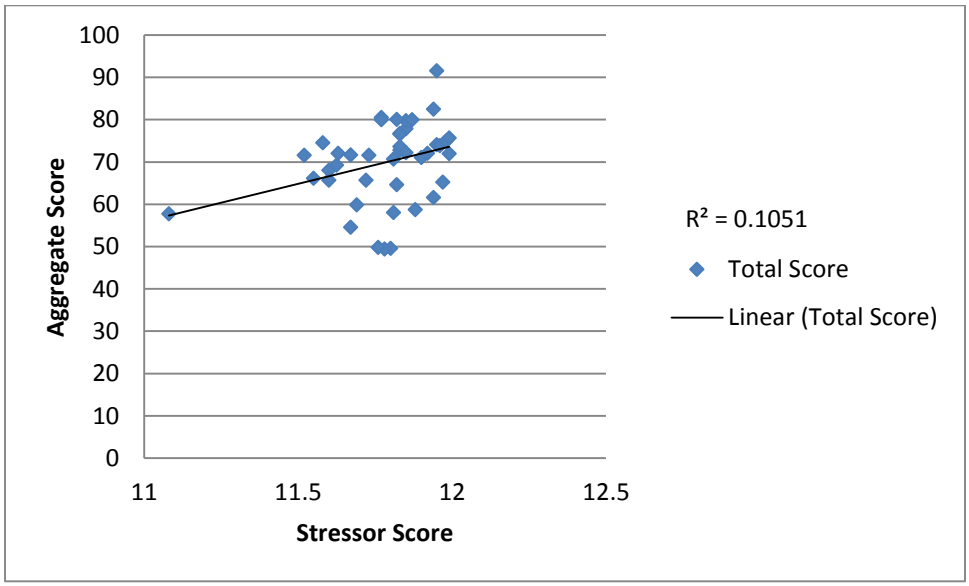

Figure 19: The combined scope and severity of stressors within 200 m of the AA and the related aggregate assessment score.

Discussion

Results from our wetland landscape profile indicate that wetlands make up about 5% of Gallatin County. Our level 1 analysis indicated that wetlands were predominantly found at locations with a land cover other than that of human use or recent disturbance. However, a slight increase was seen from 2010 to

2013 in the amount of acres of wetlands found in places with a land cover of human use or recent disturbance. The importance of private ownership to wetland health is underlined in that we found private ownership contained the greatest amount of wetland acres of any one ownership category within our project area. Land cover change continues to be a challenge for wetlands and will continue to be assessed through this project.

Overall, 69% of the wetlands sampled in our level 2 assessments were at moderate or less departure from reference condition. 76% of the assessment wetlands were functioning at a category 2 or better. The assessed score for condition and function for a given wetland were on average widely different suggesting the value of measuring both condition and function at each assessed wetland. The aggregate assessment scores indicate 62% of the wetlands were in the top 30% of possible score and that the intra-wetland variation in assessment scores varied widely.

Condition was monitored for four sites that had been monitored by the Montana Natural Heritage Program in 2010. The condition appears to be relatively similar from 2010 to 2015 for each of the four sites. However, as this project continues a trend will be developed for all monitored wetlands for both condition and function.

Finally, the stressors observed within and around the assessment areas appear to have a low impact on the aggregate assessment score. However, as this project continues this variable will be further monitored.

Additional Products

Wetland Indicator Species Guide	http://www.msuextension.org/gallatin/documents/naturalresourcesdocuments/Wetland%20Indicators.pdf
Web based Map of Results	http://www.msuextension.org/gallatin/NaturalResourcesWetlandsMap.htm
Monitoring Form	http://www.msuextension.org/gallatin/documents/naturalresourcesdocuments/2015DataForm_ForEpaReport.pdf
Web based Monitoring Application	Coming Winter 2015/2016

Literature Cited

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terres- trial Systems. NatureServe, Arlington, VA.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Washington, D.C. FWS/OBS-79/31.

Hauer, F. R., B. J. Cook, M. C. Gilbert, E. J. Clairain, Jr., and R. D. Smith. 2002. A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of intermontane prairie pothole wetlands in the northern Rocky Mountains. ERDC/EL TR-02-7.

Montana Department of Transportation (MDT). 2008. 2008 Montana Wetland Assessment Method.

Montana Natural Heritage Program (MTNHP). 2010. Montana Land Cover/Land Use Theme. Based on classifications originally developed by the University of Idaho, Sanborn and the MTNHP for the Pacific Northwest ReGAP project. Helena, Montana.

Montana Natural Heritage Program (MTNHP). 2012. Southwest Montana Wetland Assessment: Developing a statewide assessment and monitoring strategy for Montana. Helena, Montana.

Montana Natural Heritage Program (MTNHP). 2013. Montana Land Cover/Land Use Theme. Helena, Montana.

Montana Natural Heritage Program (MTNHP). 2014. Montana Wetland and Riparian Framework. http://gisservice.mt.gov/ArcGIS/rest/services/MSDI_Framework/WetlandsRiparian/MapServer.

Montana Natural Heritage Program (MTNHP). 2015. Ecological Integrity Assessment Field Manual.

Montana State Library. 2015. Montana Cadastral Mapping Project. http://ftp.geoinfo.msl.mt.gov/Data/Spatial/MSDI/Cadastral/Parcels/.