Methodology Report for Prioritizing Saginaw Bay Wetlands

This methodology report is intended to accompany the geographic information system models and final dataset used to prioritize wetlands in the counties surrounding Saginaw Bay. The intent of the report is to allow the user to understand how wetlands were scored, re-create the model for the Saginaw bay region, or to use the same methodology in a different region of Michigan.

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Purpose

The purpose of this model is to assist the Michigan Department of Environmental Quality (MDEQ) and other Saginaw Bay Coastal Initiative (SBCI) partners to prioritize wetlands for acquisition or for protection through other means. While the model is designed for the Saginaw Bay region, the model methodology can be used as a template to guide prioritization of wetlands in other parts of Michigan.

Approach

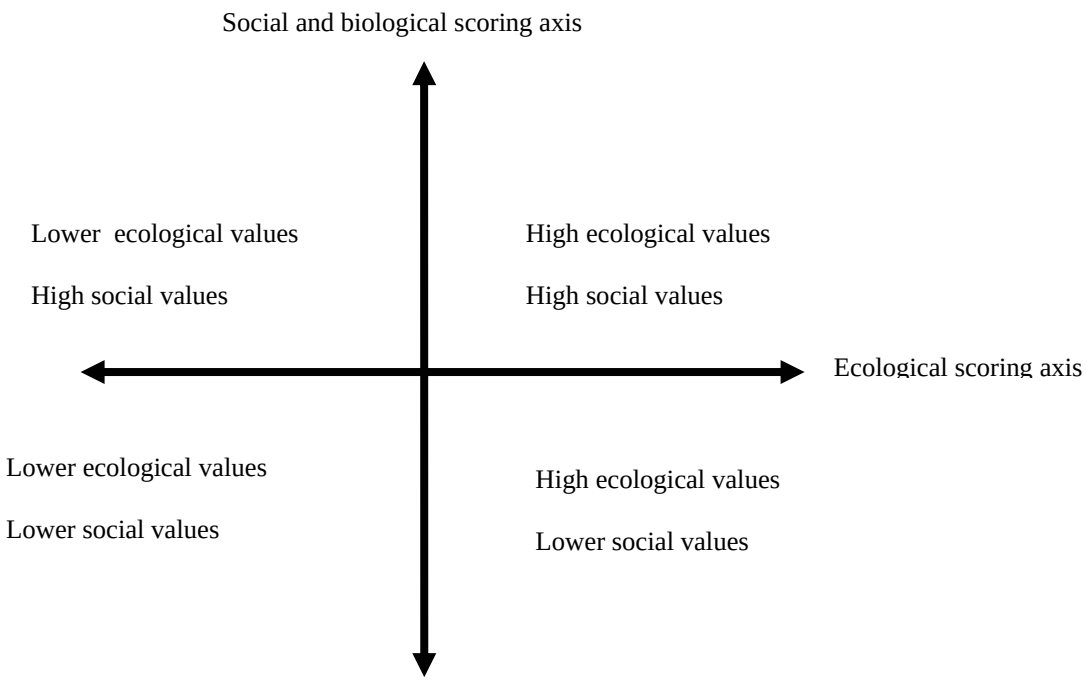
We use two types of criteria to prioritize the wetlands for protection. One set of criteria are designed to measure the ecological integrity of the wetlands. These ecological integrity criteria, such as size, lend themselves to a range of scores. Criteria in this group include area, proximity to streams, landscape context, and proximity to important bird areas.

The other set of criteria are a mix of biological and social criteria used to measure the desirability of a particular wetland. This group of criteria is a mix of vulnerability, biological significance, and cultural values. These biological and social criteria can be used to prioritize one wetland over another when both have the same ecological integrity. For example, given two wetlands with equal ecological integrity values, what would make one more important than another for acquisition? One reason may be threatened and endangered species. Of two wetlands with equal ecological integrity, one known to harbor endangered species may be a higher acquisition priority.

Some of the criteria in this group do not lend themselves to scoring for a range of values such as the area criterion. For example, either the wetland contains threatened or endangered species or it doesn't. Either a wetland is a coastal wetland or it isn't. When mixing a number of criteria that have a range of one to four with criteria that have only a zero or one value, the single value criteria can rapidly become meaningless. Instead of mixing the two groups of criteria together, we plot them on separate axes on a two axis system (Figure 1). This approach places wetlands into four categories;

- high ecological integrity score with high biological and social scores
- high ecological integrity score with low biological and social scores
- low ecological integrity score with high biological and social scores
- low ecological integrity score with low biological and social scores

Figure 1



Wetlands having higher ecological integrity scores along with higher biological and social scores become the first priorities for acquisition. Conversely, wetlands with lower ecological integrity scores and with lower biological and social scores will be the lowest priority for acquisition. The user determines the four categories by setting the threshold values for the two sets of criteria independent of each other.

The user will need to determine how to prioritize the wetlands falling into the remaining two categories. There are three potential options. One option is to make the wetlands with higher ecological measures and lower biological and social scores the second highest priority. The second option is to make wetlands with higher biological and social scores and lower ecological integrity scores the second highest priority. The third option is to lump the two categories into one category and make that category the second highest priority. This option would leave the user with three categories, high, moderate, and low priority for protection.

The analysis was performed using Environmental Systems Research Institute (ESRI) ArcGIS 9.2, ESRI ArcView 3.X, and Hawths tools. Datasets used in the analysis and included in the delivered project are in parenthesis throughout the text. The name of the GIS database field used for each criterion appears in brackets in each criterion description.

Wetland site selection

This analysis utilizes the National Wetland Inventory (NWI) wetland dataset to define the wetland sites. The NWI is a photo interpreted dataset using the Cowardin classification system (U.S. Fish and Wildlife Service. *circa* 1980). The dataset used in this analysis (NWI_SagBay_04072008) is an update of the original US Fish and Wildlife service dataset. The update was created and made available by Ducks Unlimited (DU) (http://www.ducks.org/glaro).

The projection of the DU dataset is Albers Equal Area projection while the other datasets used in the analysis are in Michigan Georef projection. Because different GIS software packages are used in the analysis, the DU dataset was re-projected to Michigan Georef.

The NWI dataset used in this analysis contains wetlands that extend past the borders of the counties in this analysis. The entire extent of those wetlands is included in the analysis. The dataset also contains open water sources such as lakes and rivers as well as excavated ponds. Open water polygons and excavated wetlands are removed by selecting them with the following SQL statement, then reversing the selection. "ATTRIBUTE" LIKE 'L1%' OR "ATTRIBUTE" LIKE 'L2%' OR "ATTRIBUTE" LIKE 'R1%' OR "ATTRIBUTE" LIKE 'R2%' OR "ATTRIBUTE" LIKE 'PUB%x'.

The NWI dataset used in this analysis also contains the boundaries of wetlands that no longer exist. In cases where wetland boundaries have changed over time, the dataset contains both the historic wetland boundary and the current boundary. For this analysis we used only the current boundaries of existing active wetlands by selecting only those wetland shapes where "STATUS" = 0. A total of 24,322 individual wetlands are not open water or excavated wetlands and are considered active wetlands.

Often different wetland types will be adjacent to each other, forming a complex of different wetland types. SBCI group members decided to use the wetland complex, not the individual wetlands, as the basis for the analysis. In cases where wetlands of different types are adjacent to each other, the adjoining NWI polygons are dissolved together into a single wetland site polygon. All further analysis and scoring are performed on these single polygons (wetland_sites.shp).

After selecting appropriate wetland types and dissolving adjoining boundaries, the study area contains 20,046 wetland sites. These wetland sites could be a single distinct wetland type or could be a complex made up of several wetland types. The 20,046 wetland sites are made up of 24,322 individual wetland polygons. The sites range in area from 0.014 acre to 6821 acres.

Ecological Integrity Criteria

Area [area_scor]

As a general rule, the larger the wetland, the more likely it is that natural processes can take place. Larger areas can also provide greater buffer from anthropogenic stresses to both ecological process and to wetland dependent species.

Wetland sites are given a one to four score based on the area of the entire site [area_ac]. The area scoring thresholds were determined as practical based on local experience of the SBCI working group members. The scoring thresholds and the number of wetland sites within each group are found in Table 1.

Table 1

Score	Acres	# Wetlands
0	< 5.0	15,217
1	5.0 - 80	4,496
2	80 - 300	257
3	300 – 3000	72
4	> 3000	4

Proximity to streams and tributaries [h2o_prox]

The closer wetlands are to water bodies, the more likely they are part of a larger aquatic system. To score wetland sites for their hydrologic connectivity to water bodies the wetland polygons are scored for proximity to a stream, up to a 500 foot maximum distance. This analysis used a variant of the National Hydrologic Dataset (NHD) (mi_nhd_gap.shp) obtained from the Institute for Fisheries Research (http://ifrgis.snre.umich.edu/). Because of file size limitations the NHD dataset was clipped to the extent of the counties in the area of interest (mi_nhd_gap_clip). The distance thresholds and the number of wetland sites in each group are found in Table 2.

Table 2

Score	Distance from stream (feet)	# Wetlands
0	X > 500 feet	12,556
1	400 < X < 500	882
2	300 < X < 400	978
3	200 < X < 300	944
4	X < 200	4,686

Landscape context [context]

Wetlands in less disturbed areas are more likely to have greater ecological integrity because they are better buffered from anthropogenic stresses than wetlands in urban or agricultural settings. To score the wetland site polygons for landscape context we examine the percentage of natural land cover within a 100 meter buffer of each wetland site polygon.

A 100 meter doughnut of each wetland site (wetland_sites_doughnuts.shp) was created using an ArcView 3.X script (make doughnuts.ave) included with the project. To determine the landscape context of the wetland sites we utilized the IFMAP land cover dataset (lu2000_f) provided by the Michigan Department of Natural Resources (MDNR, 2003). The IFMAP land cover dataset is a circa 2000 remote sensed raster with a 30 meter cell size. The IFMAP dataset is reclassified to two values representing either natural or non-natural land cover types as found in Table 3.

The amount of natural and non-natural land covers within each wetland site doughnut were tabulated using Hawth's tools Thematic Raster Summary tool (Beyer, H. L. 2004). This tool was chosen over the ESRI spatial analyst tools in ArcGIS 9.2 because it will correctly tabulate areas in overlapping polygons. ArcGIS 9.2 will produce an incorrect tabulation when the doughnut polygons overlap each other.

The output of the Thematic Raster Summary tool is a summary table with fields containing the number of cells for each raster value. To calculate the percentage of natural land cover within each doughnut, a floating point field was added to the table and the field was calculated by dividing the number of natural cells by the sum of the number of natural and non-natural cells, e.g. ([percnt] = [TRS_2] / ([TRS_1] + [TRS_2])). The summary table is then joined to the wetland site shapefile table. The thresholds for scoring and the number of wetland sites in each category are found in Table 4.

Table 3

Raster value	Cover type	Classification
1	Low Intensity Urban	Non-natural
2	High Intensity Urban	Non-natural
3	Airports	Non-natural
4	Roads / Paved	Non-natural
5	Non-vegetated Farmland	Non-natural
6	Row Crops	Non-natural
7	Forage Crops / Non-tilled herbaceous	Non-natural
9	Orchards / Vineyards / Nursery	Non-natural
10	Herbaceous Openland	Natural
12	Upland Shrub / Low-density trees	Natural
13	Parks / Golf Courses	Non-natural
14	Northern Hardwood Association	Natural
15	Oak Association	Natural
16	Aspen Association	Natural
17	Other Upland Deciduous	Natural
18	Mixed Upland Deciduous	Natural
19	Pines	Natural
20	Other Upland Conifers	Natural
21	Mixed Upland Conifers	Natural
22	Upland Mixed Forest	Natural
23	Water	Natural
24	Lowland Deciduous Forest	Natural
25	Lowland Coniferous Forest	Natural
26	Lowland Mixed Forest	Natural
27	Floating Aquatic	Natural
28	Lowland Shrub	Natural
29	Emergent Wetland	Natural
30	Mixed Non-Forest Wetland	Natural
31	Sand / Soil	Natural
32	Exposed Rock	Natural
33	Mud Flats	Natural
35	Other Bare / Sparsely Vegetated	Natural

Table 4

Score	**Thresholds**	**# Wetlands**
0	natural < 25%	3,483
1	25% < natural < 50%	2,987
2	50% < natural < 75%	4,073
3	75% < natural < 90%	2,958
4	> 90% natural	6,545

Important migratory bird areas [DU_birds]

Ducks Unlimited (DU) has scored areas within the Saginaw Bay for their importance to migratory birds (Ducks Unlimited. 2006). The DU model used various criteria to score polygons indicative of the polygon's importance to migratory birds. Wetland sites are scored based on the highest scoring DU polygon that intersects the wetland site. The thresholds for scoring and the number of wetland sites in each category are found in Table 5.

Table 5

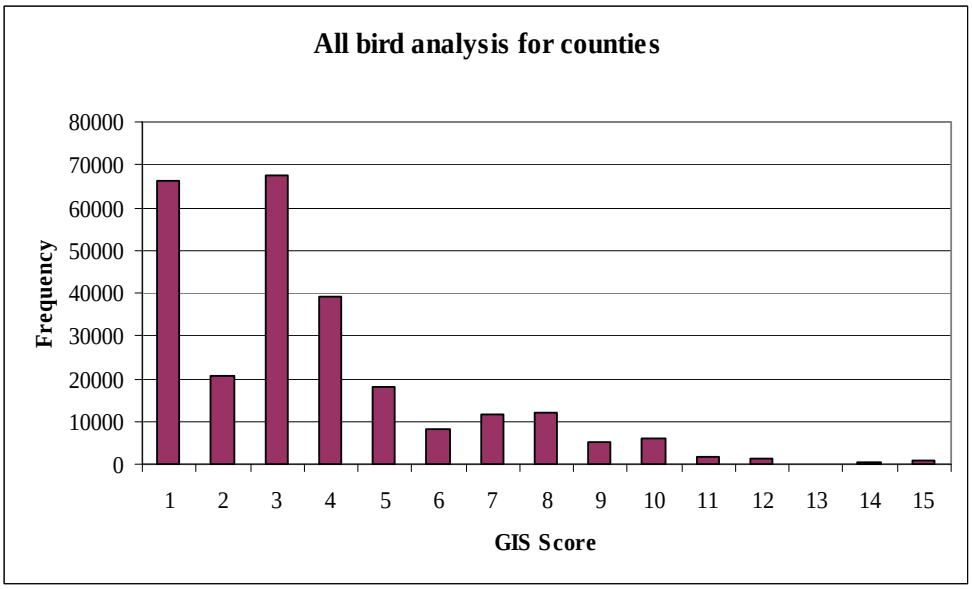
Score	Threshold (DU score)	# Wetlands
0	X < 20% (DU score < 5)	12,603
1	20% < X < 15% (DU score of 5)	2,435
2	15% < X < 10% (DU score of 6)	1,731
3	10% < X 5% (DU score of 7 & 8)	2,011
4	Top 5% polygons (DU score of 9 – 15)	1,266

These scoring thresholds are based on a frequency distribution (number of polygons with a given score) of the scores in the DU dataset. The frequency distribution of scores is found in Table 6 and Figure 2 is a graph of the distributions for the DU polygons;

Table 6

Score	Frequency	Percent	Cumulative Percent
1	66121	25.6	25.6
2	20839	8.1	33.6
3	67497	26.1	59.7
4	39181	15.1	74.9
5	18264	7.1	81.9
6	8207	3.2	85.1
7	11664	4.5	89.6
8	11902	4.6	94.2
9	5057	2	96.2
10	6015	2.3	98.5
11	1566	0.6	99.1
12	1265	0.5	99.6
13	176	0.1	99.6
14	233	0.1	99.7
15	676	0.3	100
Total	258663	100	

Figure 2



Biological and Social Criteria

Proximity to protected areas [protect]

One wetland may be more desirous than another wetland because it builds on an already protected area. Wetland sites completely contained within a protected area are considered protected and subsequently are not prioritized for acquisition. Wetland sites that straddle the boundary of a protected area are given a score of two. Wetland sites within 0.25 mile of a protected area are given a score of one. Six hundred eighty-one wetland sites straddle the boundary of a protected area. One thousand five hundred thirty-four wetland sites are within 0.25 mile of a protected area.

Table 7
Management description
Forest Management
Forest Reserve
Game Area
National Wildlife Refuge (NWR)
Nature Preserve
Wildlife Area
Recreation Area
Education Center
Sportsman's/Gun/Hunting/Fishing Club
Conservation easement

The DU Conservation and Recreation Lands (CARL) (MI_CARL_20070620.shp) dataset is used to define the protected areas (DU and The Nature Conservancy, 2007). The CARL dataset contains a wide variety of lands covering a range of ownership and protection status. For this analysis the areas in Table 7 are selected as protected areas from the management description field (mgmt_desc) in the CARL dataset.

Significant biological features [rare_spec]

Michigan Natural Features Inventory (MNFI) maintains the Michigan natural heritage database of rare species and high quality natural communities. MNFI creates a model based on the natural heritage database that scores areas for their biological importance (MNFI, 2006). The MNFI model is an open ended scoring system but less than 5% of statewide units have a score of 25 or higher. For this analysis we used only MNFI model sites having a score of 25 or higher. Wetland sites intersecting a model area with a bio-rarity value of 25 or higher are given a score of one. Fifty-one wetland sites intersect areas of the biodiversity value model that score 25 or higher.

Coastal wetlands [contour]

To prioritize coastal wetlands for protection, wetland sites intersecting the 585 foot elevation contour line (contour584_mg.shp) are given a score of one. Six hundred ninety wetland sites are within the 585 foot contour line. Twenty-eight wetland sites were within the Saginaw Bay, but outside of the 585 foot contour polygon. These wetland sites were manually selected and scored for being within the 585 contour line. The 585 foot contour line (contour584_dd.shp) was supplied by the DU Great Lakes Regional Office (http://glaro.ducks.org). The original dataset was spatially defined in decimal degrees and was converted to Michigan Georef projection.

Isolated wetlands [isolated]

Isolated wetlands are those wetlands greater than 500 feet from a water body and less than five acres in size. These wetlands currently have no legislative protection. To prioritize isolated wetlands for protection, those wetland sites greater than 500 feet from a stream or tributary and less than five acres are given a score of one. Two thousand one hundred fifty-four wetland sites fall into this category.

Results and Discussion

Scoring [ecol] [social]

Wetlands are scored for each set of criteria by simply adding the fields associated with each set of criteria; [ecol] = [area_scor] + [h2o_prox] + [context] + [DU_birds] and [social] = [protect] + [rare_spec] + [contour] + [isolated]. Each wetland site receives a zero to 16 score for ecological integrity attributes; area (0 - 4), landscape context (0 - 4), stream proximity (0 – 4), and migratory bird score (0 – 4). Each wetland receives a zero to five score for biological and social factors; protected area proximity (1 or 2), significant biological features (1), coastal wetlands (1), and isolated wetlands (1).

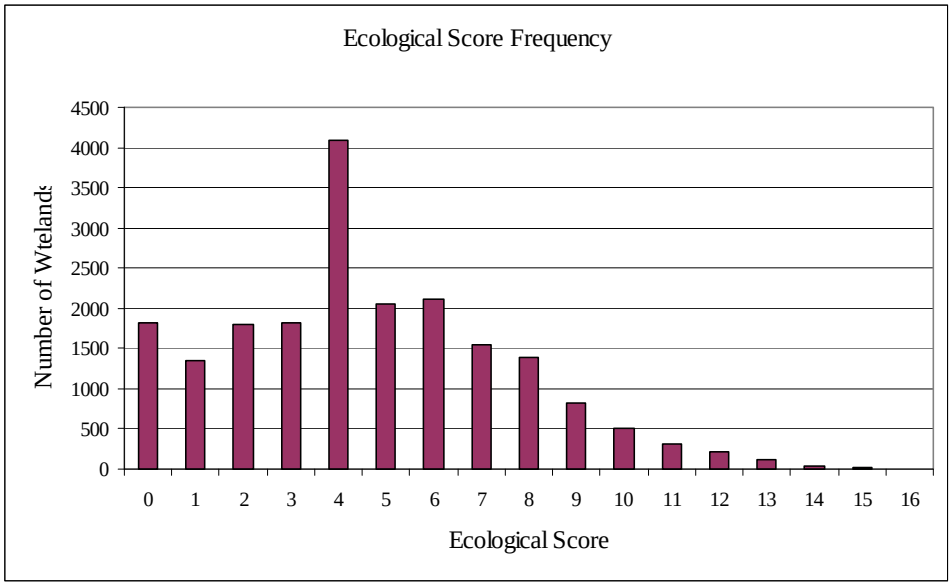
Ecological integrity score distribution

Table 8 shows the number of wetland sites for each score, percentage of total, and the cumulative percentage for ecological integrity scores. Figure 3 is a graph of the ecological score distribution. Of note, only two wetland sites scored the maximum score of sixteen points.

Table 8

Score	# Wetlands	% Total	Cumulative %
0	1815	9.05%	9.05%
1	1352	6.74%	15.80%
2	1800	8.98%	24.78%
3	1818	9.07%	33.85%
4	4084	20.37%	54.22%
5	2064	10.30%	64.52%
6	2118	10.57%	75.08%
7	1555	7.76%	82.84%
8	1385	6.91%	89.75%
9	826	4.12%	93.87%
10	516	2.57%	96.44%
11	312	1.56%	98.00%
12	219	1.09%	99.09%
13	121	0.60%	99.70%
14	42	0.21%	99.91%
15	17	0.08%	99.99%
16	2	0.01%	100.00%

Figure 3



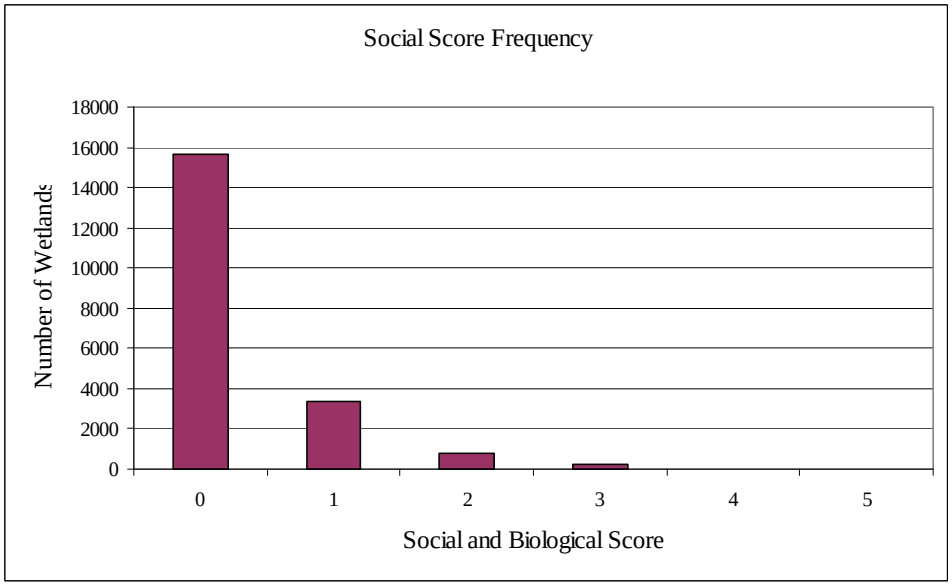
Social and biological score distribution

Table 9 shows the number of wetland sites for each score, percentage of total, and the cumulative percentage for social and biological scores. Of note, only two wetland sites scored the maximum of five points. Figure 4 is a graph of the social and biological score distribution.

Table 9

Score	# Wetlands	% Total	Cumulative %
0	15621	77.93%	77.93%
1	3335	16.64%	94.56%
2	817	4.08%	98.64%
3	244	1.22%	99.86%
4	27	0.13%	99.99%
5	2	0.01%	100.00%

Figure 4



Final classification [status] [reason]

The model is designed such that the user selects a threshold value for both sets of criteria to determine the highest priority wetlands for protection. Those wetland sites scoring at or above the threshold for both sets of criteria are the most desirable to protect. These wetland sites have higher ecological values and higher social and biological values than the others in the dataset. Based on the score distributions in this analysis, a threshold of nine to eleven on the ecological axis and a threshold of two or three on the social and biological axis appear appropriate. Table 10 shows the number of highest priority wetlands selected when using different combinations of threshold values.

Table 10

Ecological Axis	Social Axis	# Highest Priority Wetlands
9	2	330
9	3	81
10	2	211
10	3	49
11	2	149
11	3	36

For this effort we selected thresholds of eleven on the ecological axis and two on the social and biological axis to determine the highest priority wetland sites. Using these thresholds, 149 wetland sites (~1%) become the highest priority for protection. The 149 wetland sites are made up of 1,031 different NWI polygons.

Because this effort was to prioritize wetlands for acquisition, those wetlands entirely on protected areas received no score for proximity to protected areas. Four of the highest priority sites scored high enough on other criteria to be included in the highest priority category.

For the purposes of this effort, we placed the 564 wetland sites with higher ecological integrity values but lower social values (~3%), and the 941 wetland sites with lower ecological integrity values but higher social values (~5%), into the high priority category. These wetland sites are considered a high acquisition priority because they have either high ecological values or high social and biological values. The 18,392 wetland sites (~92%) that score below the threshold for ecological integrity values and below the threshold for social and biological values are rated as a moderate acquisition priority.

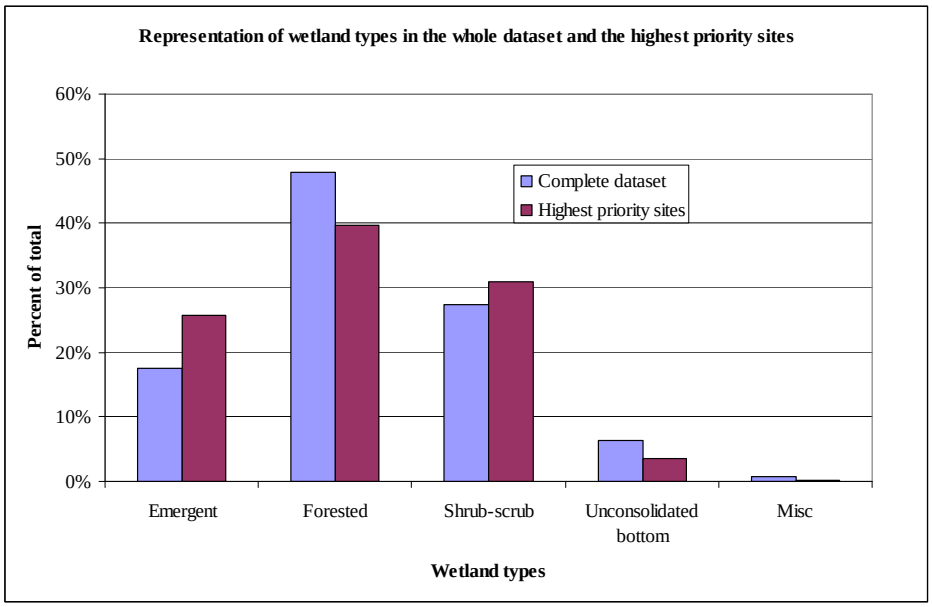
When comparing the distribution of individual wetland types within the highest priority wetland sites to the distribution of individual wetland types within the entire set of wetland sites, the model does not appear to

Table 11

	Complete data set		Highest priority	
Wetland type	**# wetlands**	**% total**	**# wetlands**	**% total**
Emergent	4239	17.43%	264	25.73%
Forested	11667	47.97%	407	39.67%
Shrub-scrub	6679	27.46%	317	30.90%
Unconsolidated bottom	1538	6.32%	36	3.51%
Misc	199	0.82%	2	0.19%
Total	24322		1026	

strongly bias towards one type of wetland. Table 11 shows the percentage of wetland types within both the full set of wetland sites and within the highest priority wetland sites. Figure 5 is a graph of the same information.

Figure 5



Considering that the model did not consider wetland type as a factor, the percentages of wetland types captured in the highest priority group track reasonably well with their representation in the larger dataset. The largest differences are in the distributions of emergent and forested wetland types. A higher percentage of emergent wetlands and a lower percentage of forested wetlands are represented in the highest priority selection. It should be noted that many of the wetland types are combinations. For instance, 36 of the wetland types in the final selection are shrub scrub-emergent combinations. Eighty-seven of the wetland types are forested-shrub scrub combinations. The percentages in Table 11 are calculated using the first wetland type for a given wetland polygon. For example, a wetland coded as PSS/EMB (shrub-scrub-emergent combination) is considered shrub scrub.

When looking at the spatial distribution of highest priority wetland site, they appear to be distributed throughout the study area. Each county within the study area contains highest priority sites. Table 12 shows the number of high priority sites within each county and the number of all wetland sites within each county. While Saginaw County had the highest number of wetland sites it ranked third in the number of highest priority sites. Note that a wetland may be in more than one county.

Table 12

	Highest priority wetland sites		All wetland sites	
County	**# sites**	**% total**	**# sites**	**% total**
Arenac	36	24.16%	2993	14.93%
Bay	16	10.74%	3921	19.56%
Huron	21	14.09%	2294	11.44%
Saginaw	24	16.11%	6028	30.07%
Tuscola	56	37.58%	4812	24.00%

SBCI team members desired to bias the model towards selecting coastal wetlands, using the 585 foot elevation contour line to determine coastal wetlands. In this respect the model seems to be successful. Sixty-two of the highest priority sites, (~42%) are within the 585 contour line although the 585 contour only makes up approximately 7% of the total study area.

Citations

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