Designing Measurable Targets for Restoring Fish and Wildlife Habitats and Populations in the Lower Green Bay and Fox River Area of Concern




Robert Howe, Amy Wolf, and Erin Giese
University of Wisconsin-Green Bay

6 March 2018

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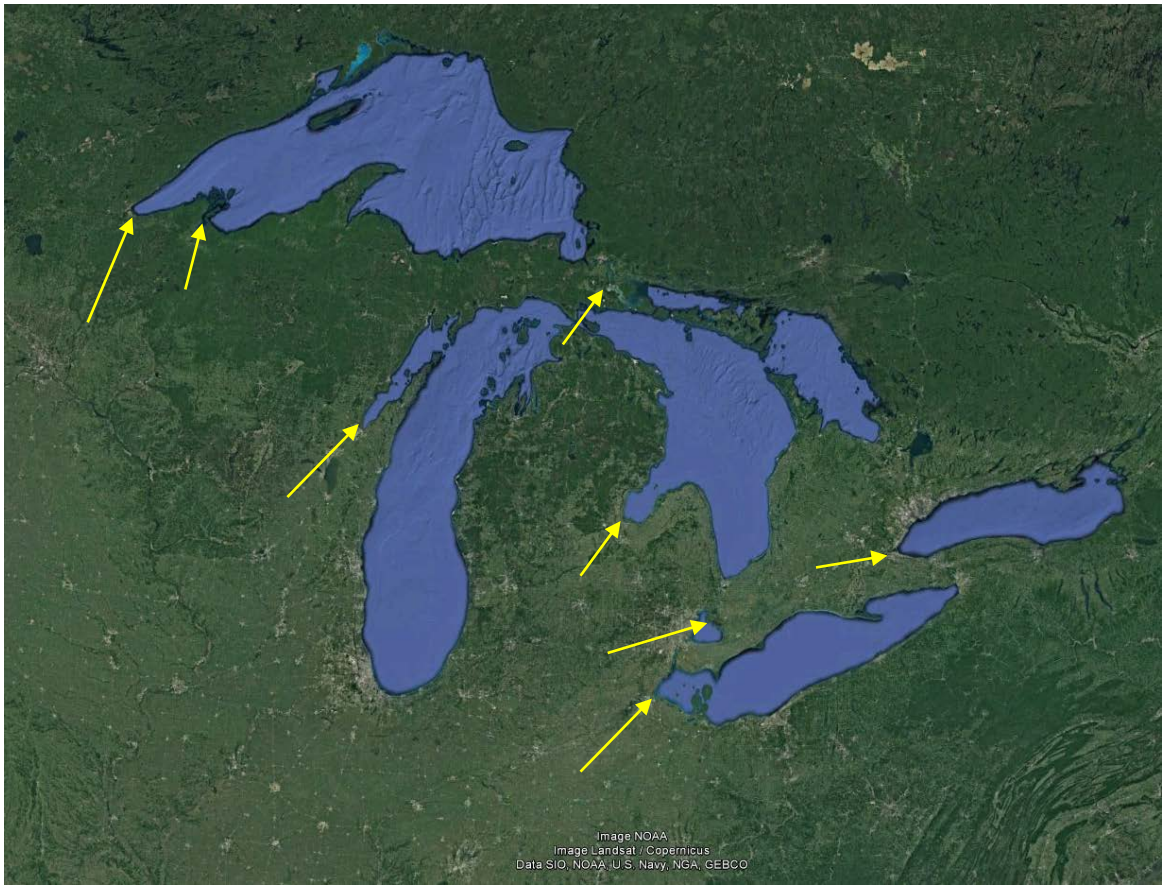
The Nature Conservancy

Great Lakes Restoration

Wisconsin Dept. of Natural Resources

Estuarine Ecosystems



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Lower Green Bay

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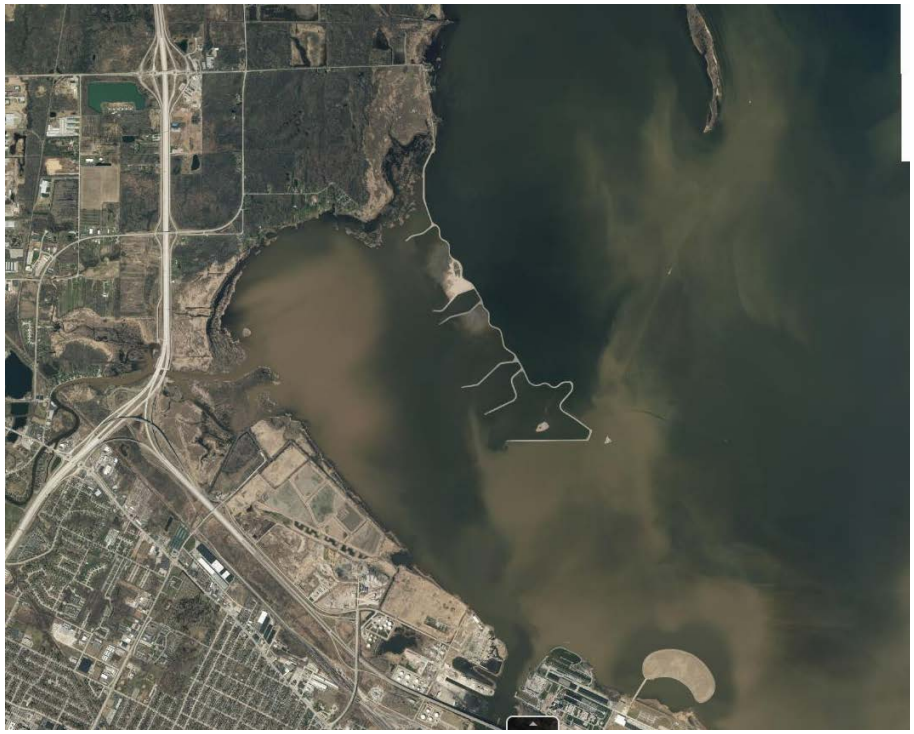

2017

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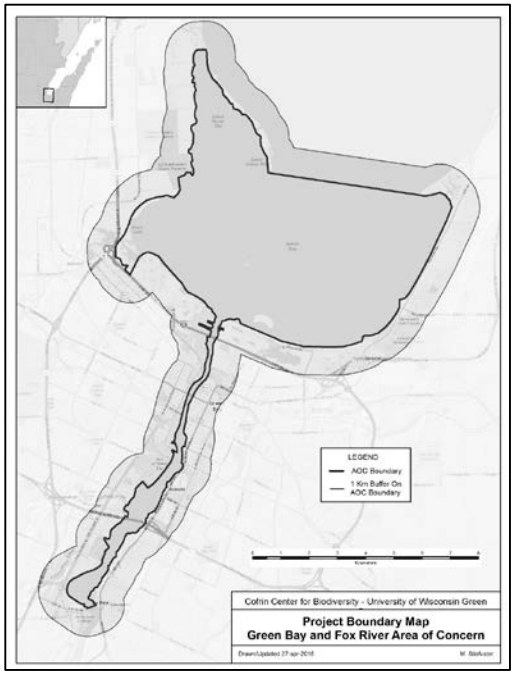
Lower Green Bay and Fox River Area of Concern (AOC)

Beneficial Use Impairments of the AOC

1. Restrictions on fish & wildlife consumption
2. Tainting of fish & wildlife flavor
3. **Degradation of fish & wildlife populations**
4. Fish tumors or other deformities
5. Bird or animal deformities or reproductive problems
6. Degradation of benthos
7. Restrictions on dredging activities
8. Eutrophication or undesirable algae
9. Restrictions on drinking water consumption
10. Beach closings
11. Degradation of aesthetics
12. Degradation of phytoplankton & zooplankton populations
13. **Loss of fish & wildlife habitat**



Goal: Evaluate AOC's current condition and recommend de-listing targets.

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Lower Green Bay and Fox River Area of Concern (AOC)

1. Identify characteristic habitats and important species/species groups.

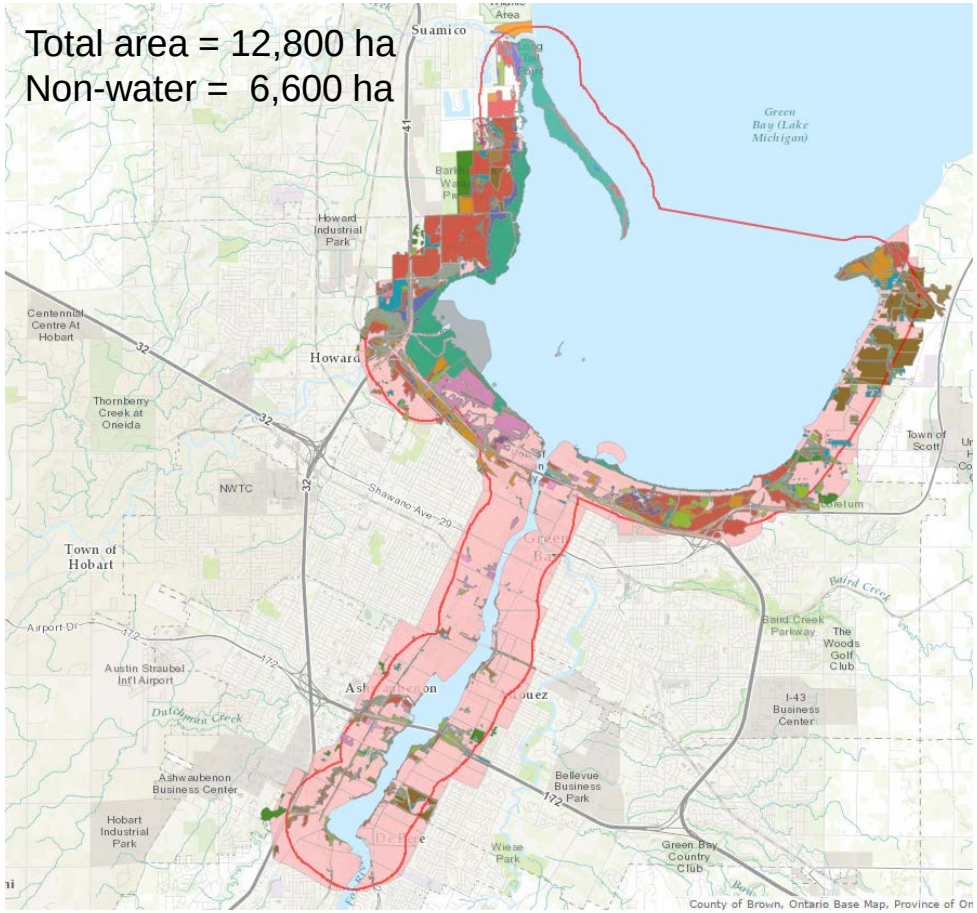
2. Assess relative importance to each habitat and species/species groups.

3. Devise systematic method for measuring current and future condition.

4. Set a meaningful system-wide restoration target.

5. Identify restoration projects needed to achieve the quantitative target.

Lower Green Bay/Fox River Area of Concern



GIS map developed in 2015-16 (M. Stiefvater and J. Weinzinger)

Field surveys (2015) and 2014 near infrared and true color aerial imagery (Brown County)

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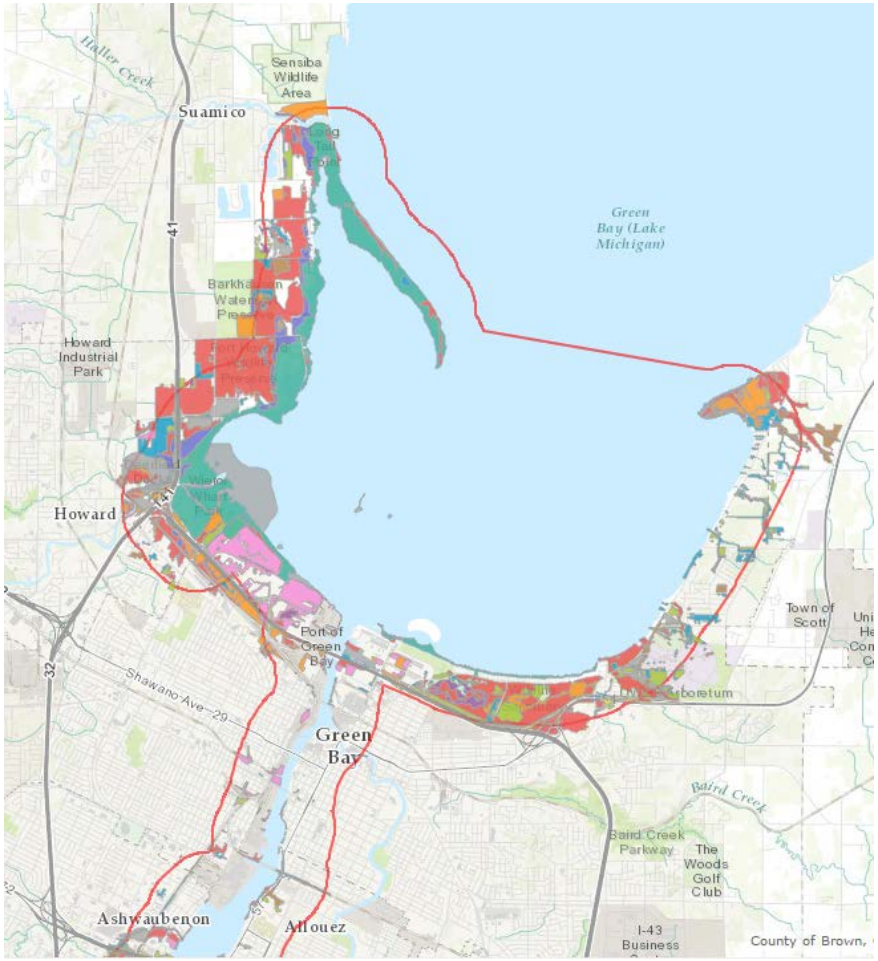
Lower Green Bay / Fox River AOC

About 45% of AOC can be classified as some type of wildlife habitat.

Total agriculture = 200 ha
Total high impact = 3,200 ha
Total habitat = 2,761 ha

Total habitat

6,823 acres



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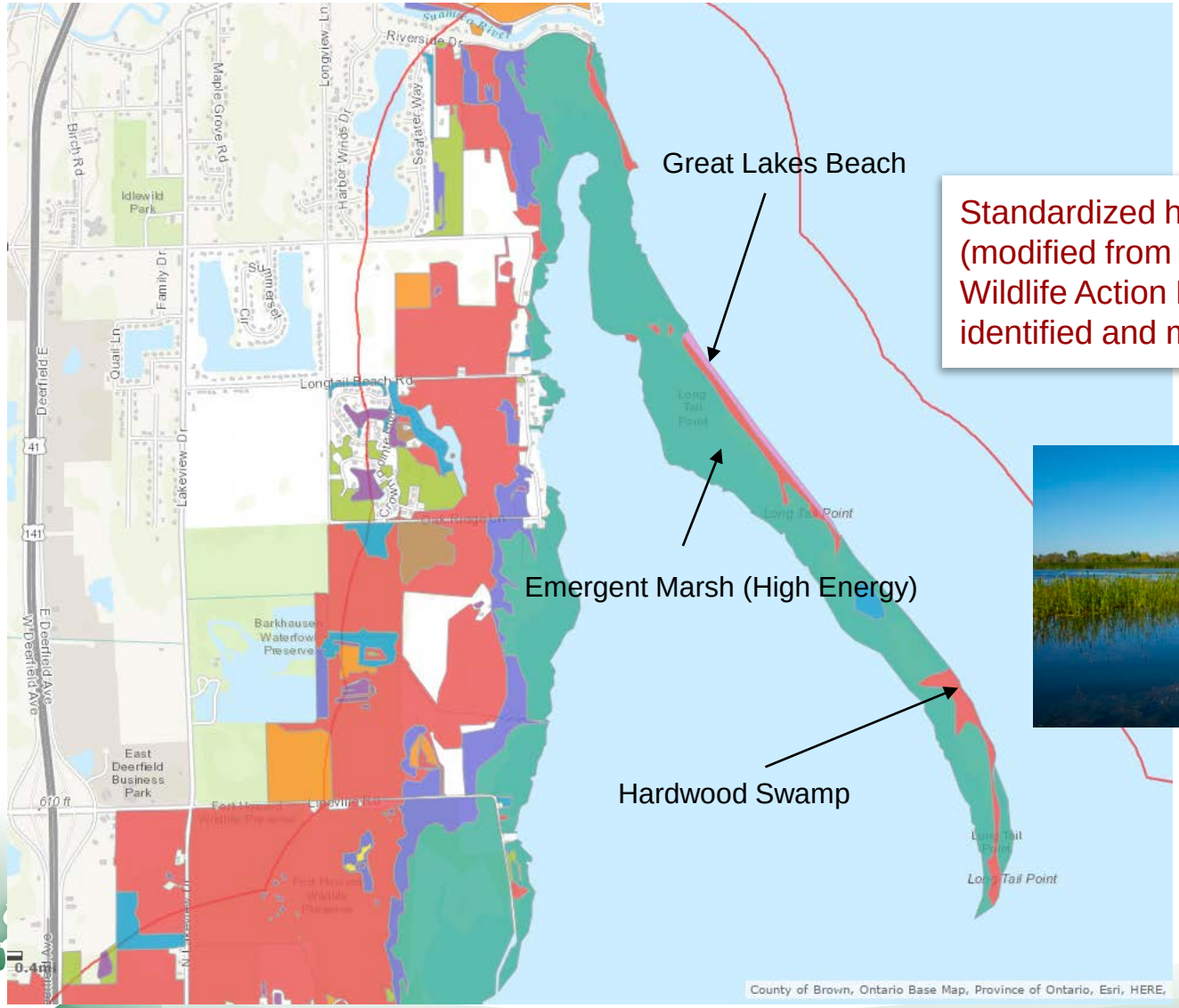
Long Tail Point



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Lower Green Bay / Fox River AOC

Most widespread habitat types are **emergent wetland** and **hardwood swamp**.

Code	Habitat	Polygons	Area(ha)	Area(ac)	MaxArea(ha)
EMHE	Emergent Marsh (high energy coastal)	42	513	1268	163
EMIN	Emergent Marsh (inland)	83	229	566	29
EMRI	Emergent Marsh (riparian)	12	51	126	35
EMRS	Emergent Marsh Roadside	22	25	63	5
GLBE	Great Lakes Beach	38	36	90	15
HASW	Hardwood Swamp	181	892	2205	136
NMFO	Northern Mesic Forest	34	65	162	13
NWMF	Northern Wet Mesic Forest	3	26	65	15
OPWA	Open Water	84	52	128	11
OTFO	Other Forest	179	191	471	32
SDMF	Southern Dry Mesic Forest	11	30	73	7
SGOF	Surrogate Grassland	146	174	430	16
SGRE	Surrogate Grasslands restored (native grasses)	7	12	29	3
SGRS	Surrogate Grassland (Roadside)	68	58	143	4
SHCA	Shrub Carr	24	102	253	18
SSME	Southern Sedge Meadow	2	1	2	1
SUMA	Submergent Marsh	25	138	341	126
WAST	Wasteland	54	166	410	77

Open water in Green Bay (6,200 ha) excluded.

Habitat types derived from Wisconsin Wildlife Action Plan (2015) with modifications.

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Lower Green Bay / Fox River AOC

Formerly common habitats like **sedge meadow** and **undeveloped beach** are now rare.

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AOC Beneficial Use Impairments

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5. Bird or animal deformities or reproductive problems
6. Degradation of benthos
7. Restrictions on dredging activities
8. Eutrophication or undesirable algae
9. Restrictions on drinking water consumption, or taste and odor problems
10. Beach closings
11. Degradation of aesthetics
12. Degradation of phytoplankton and zooplankton populations
13. **Loss of fish and wildlife habitat**

AOC Priority Wildlife Species

ID1	ComName	SciName	ID	Taxon	Subtaxon	Priorit	Conservation	FedStatus	StateStatus	IUCNStatus	State Rank	GlobalStatus	NativeSt
594	Great Egret	Ardea alba	48	Birds	Other Waterbirds	E1	SGCN		Threatened	LC	S2	G5	N
611	Red Knot	Calidris canutus	156	Birds	Shorebirds	E1		Threatened		LC			N
335	Piping Plover	Charadrius melodu	74	Birds	Shorebirds	E1	SBIRD, SGCN	Endangered	Endangered	VU	S1	G3	N
610	Black Tern	Chlidonias niger	18	Birds	Other Waterbirds	E1	SGCN, WBIRD	Species of Conc	Endangered	LC	S2	G4	N
334	Yellow Rail	Coturnicops noveb	908	Birds	Other Waterbirds	E1	SGCN, WBIRD		Threatened	LC	S1	G4	N
573	Peregrine Falcon	Falco peregrinus	71	Birds	Raptors	E1	SGCN		Endangered	LC		G4	N
574	Caspian Tern	Hydroprogne caspi	32	Birds	Other Waterbirds	E1	SGCN		Endangered	LC		G5	N
576	Forster's Tern	Sterna forsteri	45	Birds	Other Waterbirds	E1	SGCN		Endangered	LC	S1	G5	N
609	Common Tern	Sterna hirundo	37	Birds	Other Waterbirds	E1	SGCN, WBIRD	Species of Conc	Endangered	LC	S1	G5	N
607	Golden-winged Warbler	Vermivora chrysop	46	Birds	Passerines	E1	PIF, SGCN	Species of Conc	Special Concern	NT		G4	N
832	Northern Long-Eared Ba	Myotis septentrior	331	Mammals	Bats	E1	SGCN		Threatened	LC			N
13	American Bullfrog	Lithobates catesbe	1	Amphibians	Frogs	E2			Special Concern	LC		G5	N
15	Northern Leopard Frog	Lithobates pipiens	8	Amphibians	Frogs	E2		Species of Conc	Special Concern	LC		G5	N
5	Common Mudpuppy	Necturus maculosu	905	Amphibians	Salamanders	E2	SGCN		Special Concern	LC		G5	N
606	Northern Pintail	Anas acuta	67	Birds	Waterfowl	E2	WFOWL		Special Concern	LC	SNA	G5	N
579	Blue-winged Teal	Anas discors	23	Birds	Waterfowl	E2	SGCN		Special Concern	LC		G5	N
597	American Black Duck	Anas rubripes	11	Birds	Waterfowl	E2	SGCN, WFOWL		Special Concern	LC		G5	N
598	Lesser Scaup	Aythya affinis	59	Birds	Waterfowl	E2	SGCN, WFOWL		Special Concern	LC	S3	G5	N
583	Redhead	Aythya americana	78	Birds	Waterfowl	E2	SGCN		Special Concern	LC	S2	G5	N
582	Canvasback	Aythya valisineria	31	Birds	Waterfowl	E2	SGCN		Special Concern	LC	S2	G5	N
596	American Bittern	Botaurus lentigino	10	Birds	Other Waterbirds	E2	SGCN, WBIRD		Special Concern	LC	S3	G4	N
499	Common Goldeneye	Bucephala clangul	123	Birds	Waterfowl	E2			Special Concern	LC		G5	N
569	Dunlin	Calidris alpina	41	Birds	Shorebirds	E2	SBIRD, SGCN		Special Concern	LC	S4	G5	N
545	Canada Warbler	Cardellina canade	30	Birds	Passerines	E2	PIF, SGCN		Special Concern	LC		G5	N
546	Veery	Catharus fuscesce	95	Birds	Passerines	E2	PIF, SGCN		Special Concern	LC		G5	N
547	Northern Harrier	Circus cyaneus	66	Birds	Raptors	E2	PIF, SGCN		Special Concern	LC		G5	N
586	Yellow-billed Cuckoo	Coccyzus americar	105	Birds	Other Landbirds	E2	SGCN		Special Concern	LC	S3	G5	N
543	Black-billed Cuckoo	Coccyzus erythrop	19	Birds	Other Landbirds	E2	PIF, SGCN		Special Concern	LC		G5	N

Current list = 1200+ taxa

Priority Species = 194

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Lower Green Bay / Fox River AOC

Criteria for Selection of Priority Species (194)

1. Officially designated as endangered, threatened, or vulnerable
2. Demonstrably sensitive to environmental degradation
3. Economically or ecologically highly important

Ranking Criteria:

- official status (endangered/threatened species are highest priority)
- Identified in original Remedial Action Plan
- economic/ecological importance (vertebrates generally highest priority)
- degree of sensitivity (highly sensitive species rank higher)
- strength of evidence for status/sensitivity (well-documented rank higher)

AOC Populations

Priority Fish & Wildlife Populations	Toxic Sensitivity	Economic Importance	Aquatic Dependence	Keystone Species	Conservation Status	Impact Potential	Weight	Current Condition	Subscore	Current F&W Populations Score
Colonial waterbirds (breeding season)	3	2	3	2	3	3	16	5	80	4.65
Coastal wetland Mustelids	3	3	3	2	1	3	15	4	60	
Tributary fish	2	3	3	2	2	3	15	5	75	
Coastal birds (breeding season)	3	2	3	1	3	2	14	6	84	
Fox River fish	3	3	3	2	1	2	14	5	70	
Freshwater Unionid mussels	3	1	3	1	3	3	14	1	14	
Shoreline fish	2	3	3	2	1	3	14	4	56	
Wetland terns	3	2	3	1	3	2	14	3	42	
Muskrat	1	2	3	3	1	3	13	6	78	
Piping Plover	2	3	2	1	3	2	13	2	26	
Anurans	2	1	3	1	2	3	12	7	84	
Bald Eagle (winter)	3	2	2	1	2	2	12	7	84	
Marsh breeding birds	2	2	3	1	2	2	12	6	72	
Nearshore invertebrates	1	1	3	2	2	3	12	3	36	
Shorebirds (migratory)	2	2	3	1	2	2	12	5	60	
Turtles	3	1	3	1	2	2	12	5	60	
Waterfowl (migratory)	2	3	3	1	1	2	12	6	72	
Bats	2	1	1	1	3	3	11	4	44	
Coastal wetland aquatic macroinvertebrates	1	1	3	2	1	3	11	3	33	
Stream macroinvertebrates	1	1	3	2	1	2	10	4	40	
Wooded wetland birds (breeding season)	1	2	2	1	1	2	9	6	54	
Landbirds (migratory)	1	2	1	1	1	2	8	7	56	

Lower Green Bay West Shore Habitats

Priority Fish & Wildlife Habitat	Historical Importance	State Rank	Global Rank	AOC Conservation Status	Geographic Significance	Significance to AOC Biodiversity	Functional Significance	Weight	Notes	CCondition	Subscore2	Current F&W Habitat Score
Great Lakes Beach	3	S2	G3	3	3	3	2	14	includes nearshore littoral zone	2	28	3.60
Southern Sedge Meadow	3	S3	G4	2	3	3	3	14	northern sedge meadow might have been present historically	2	28	
Emergent Marsh (high energy coasta	3	S4	G4	1	3	3	3	13	present along exposed shorelines	4	52	
Submergent Marsh	3	S4	G5	1	3	3	3	13	dominated by submereged aquatic vegetation (SAV); includes nearshore littoral zone	5	65	
Emergent Marsh (riparian)	3	S4	G4	1	2	3	3	12	very limited extent today	3	36	
Fox River Open Water	3	N/A	N/A	2	3	2	2	12	includes bottom features	3	36	
Green Bay Open Water	3	N/A	N/A	2	3	2	2	12	includes bottom features	3	36	
Shrub Carr	3	S4	G5	1	2	3	3	12	shrubby wetland; intergrades with sedge meadow and emergent marsh	4	48	
Tributary Open Water	3	N/A	N/A	2	3	2	2	12	stream channel and substrate	3	36	
Hardwood Swamp	3	S3	G4	2	1.5	2	3	11.5	one of two most widespread habitat types in AOC	5	57.5	
Emergent Marsh (inland)	2	S4	G4	1	1	2	3	9	separated from bay by dike or land	4	36	
Open Water (inland)	2	N/A	N/A	1	1	1	2	7	pond	3	21	
Southern Dry Mesic Forest	1	S3	G4	2	1	1	2	7	oak,hickory, basswood, maple	5	35	
Emergent Marsh (roadside)	0	N/A	N/A	1	2	2	1	6	can be important for fish spawning if connected to bay or river	3	18	
Northern Mesic Forest	1	S4	G4	1	1	1	2	6	most extensive pre-settlement habitat type in WI	4	24	
Other Forest	1	N/A	N/A	1	1	1	1	5	early successional	5	25	
Surrogate Grassland (old field)	1	N/A	N/A	1	1	1	1	5	can be important as buffer habitat	5	25	
Surrogate Grassland Restored	1	N/A	N/A	1	1	1	1	5	greater importance of native species than old fields	5	25	

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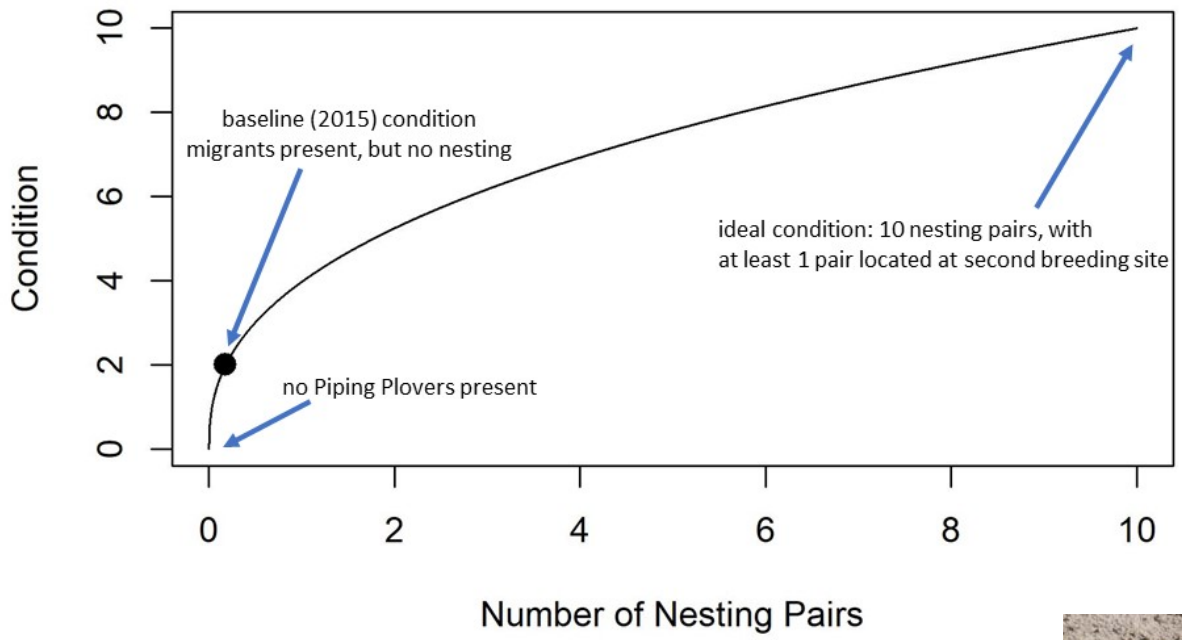
Piping Plover



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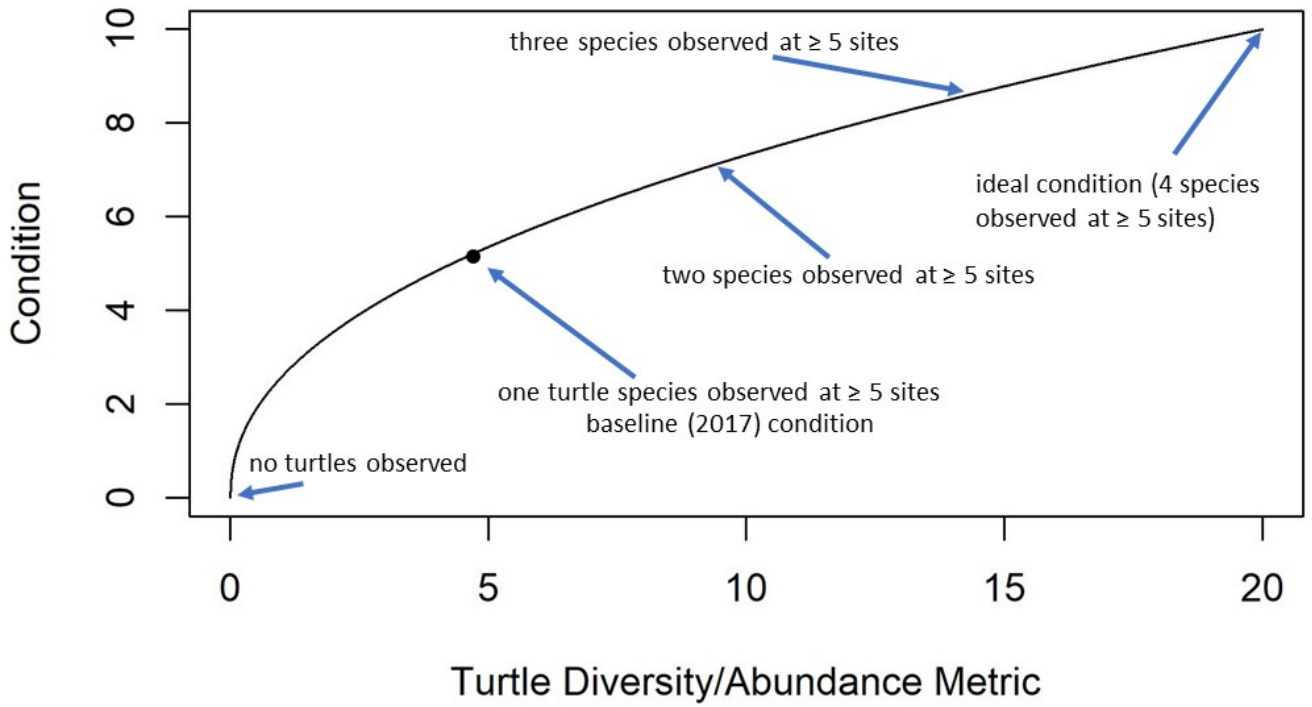
Turtles



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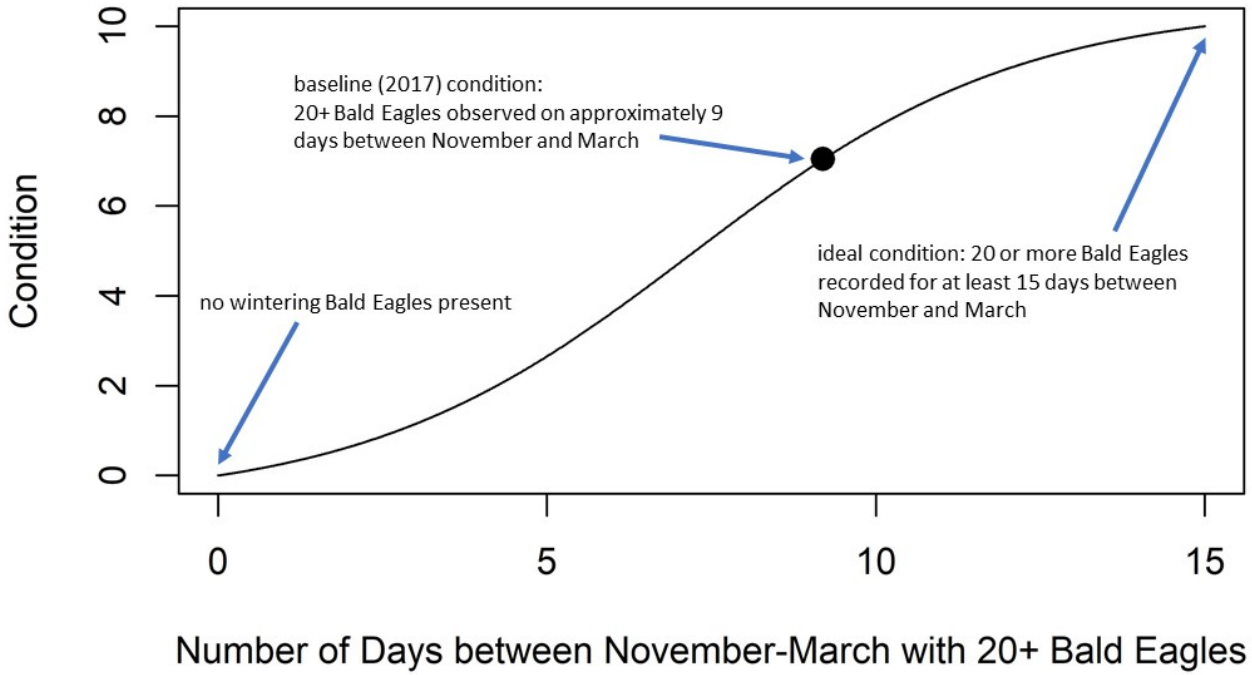
Wintering Bald Eagles



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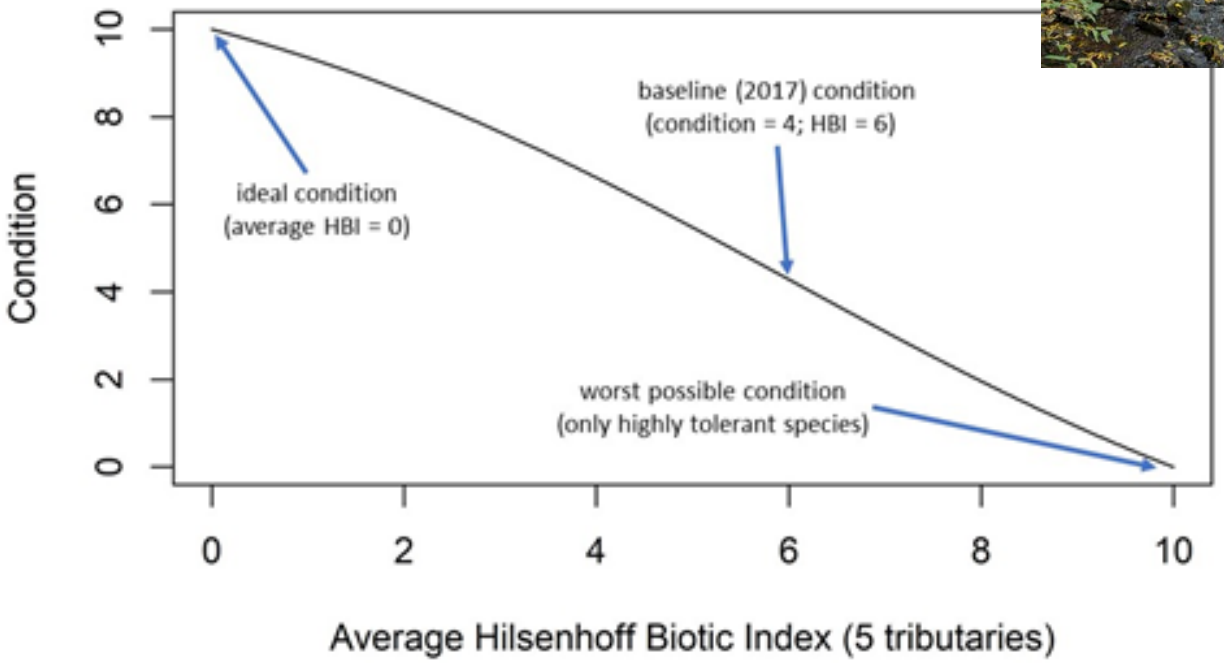
Stream Macroinvertebrates



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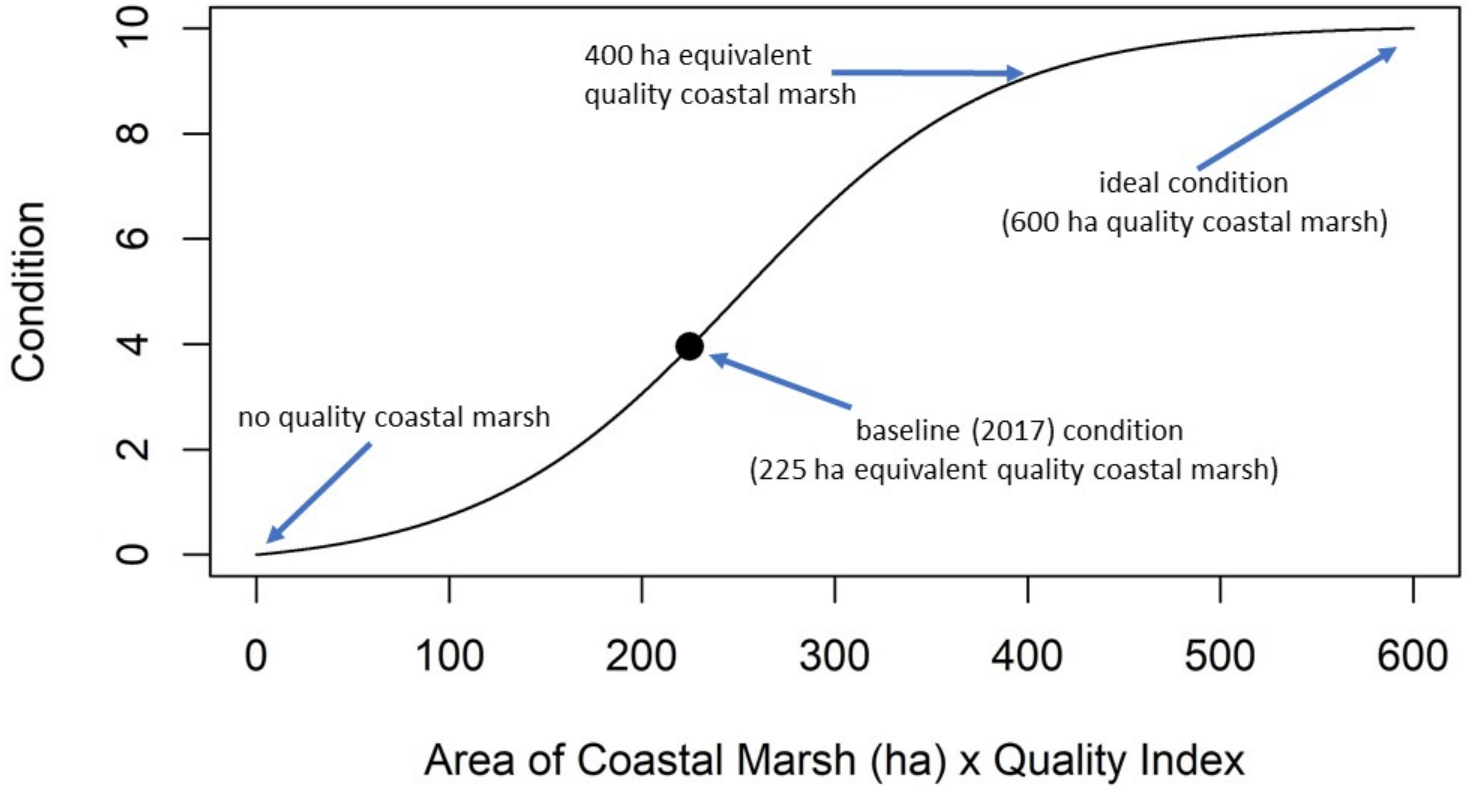
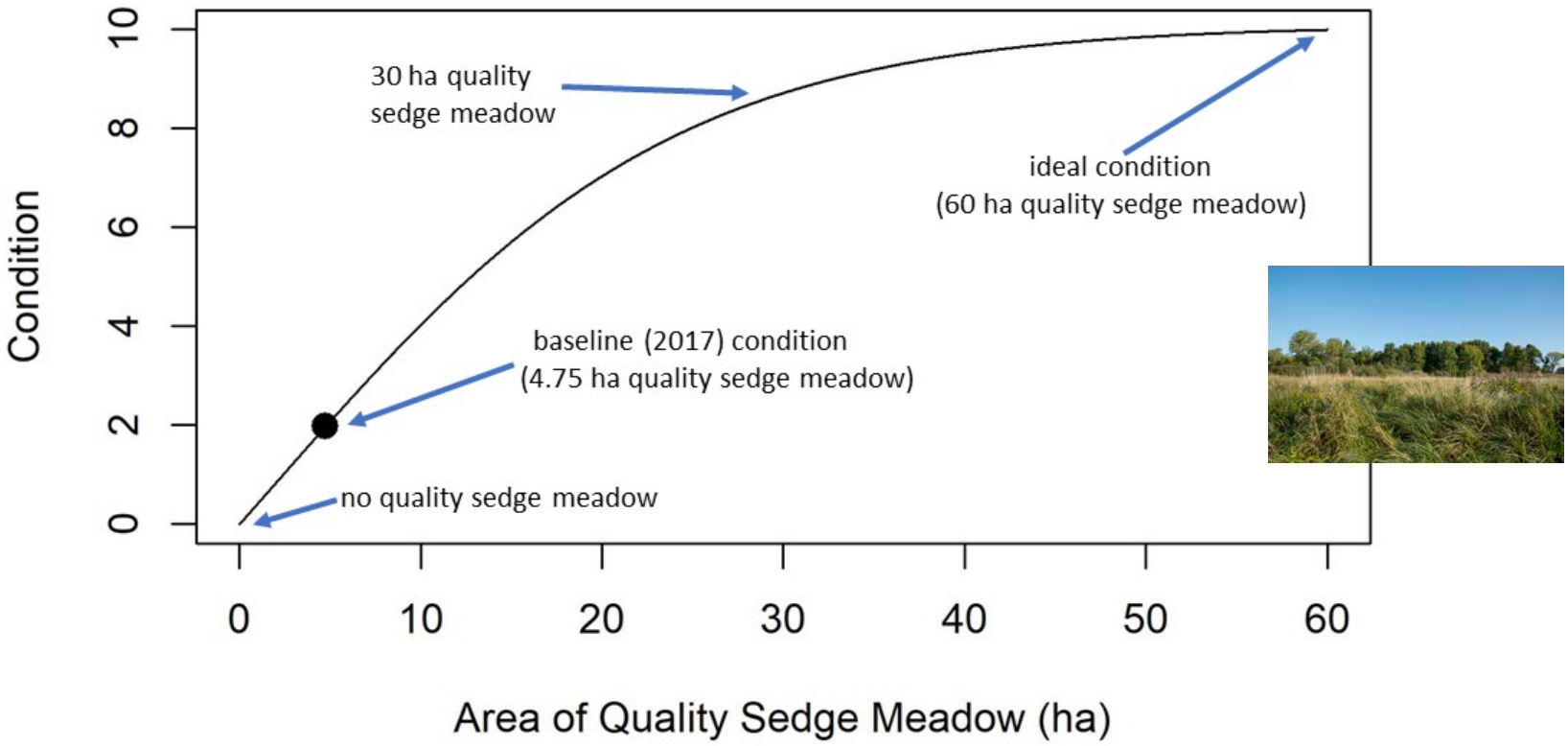
Coastal Emergent Marsh



Sedge Meadow



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Shoreline fish	2	3	3	2	1	3	14	4	56	
Wetland terns	3	2	3	1	3	2	14	3	42	
Muskrat	1	2	3	3	1	3	13	6	78	
Piping Plover	2	3	2	1	3	2	13	2	26	
Anurans	2	1	3	1	2	3	12	7	84	
Bald Eagle (winter)	3	2	2	1	2	2	12	7	84	
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Nearshore invertebrates	1	1	3	2	2	3	12	3	36	
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Emergent Marsh (high energy coasta	3	S4	G4	1	3	3	3	13	present along exposed shorelines	4	52	
Submergent Marsh	3	S4	G5	1	3	3	3	13	dominated by submereged aquatic vegetation (SAV); includes nearshore littoral zone	5	65	
Emergent Marsh (riparian)	3	S4	G4	1	2	3	3	12	very limited extent today	3	36	
Fox River Open Water	3	N/A	N/A	2	3	2	2	12	includes bottom features	3	36	
Green Bay Open Water	3	N/A	N/A	2	3	2	2	12	includes bottom features	3	36	
Shrub Carr	3	S4	G5	1	2	3	3	12	shrubby wetland; intergrades with sedge meadow and emergent marsh	4	48	
Tributary Open Water	3	N/A	N/A	2	3	2	2	12	stream channel and substrate	3	36	
Hardwood Swamp	3	S3	G4	2	1.5	2	3	11.5	one of two most widespread habitat types in AOC	5	57.5	
Emergent Marsh (inland)	2	S4	G4	1	1	2	3	9	separated from bay by dike or land	4	36	
Open Water (inland)	2	N/A	N/A	1	1	1	2	7	pond	3	21	
Southern Dry Mesic Forest	1	S3	G4	2	1	1	2	7	oak,hickory, basswood, maple	5	35	
Emergent Marsh (roadside)	0	N/A	N/A	1	2	2	1	6	can be important for fish spawning if connected to bay or river	3	18	
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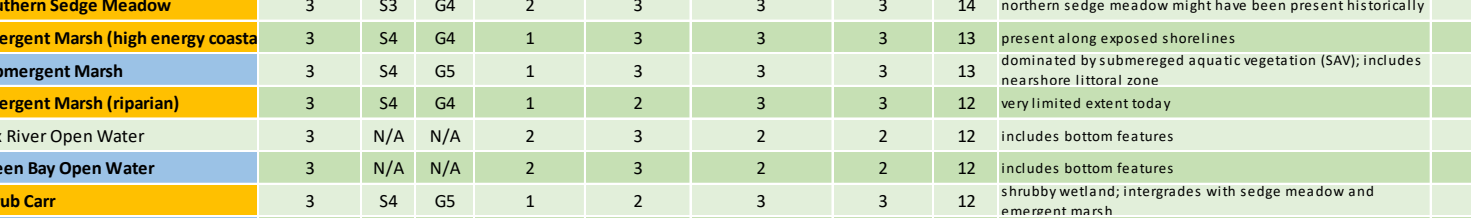
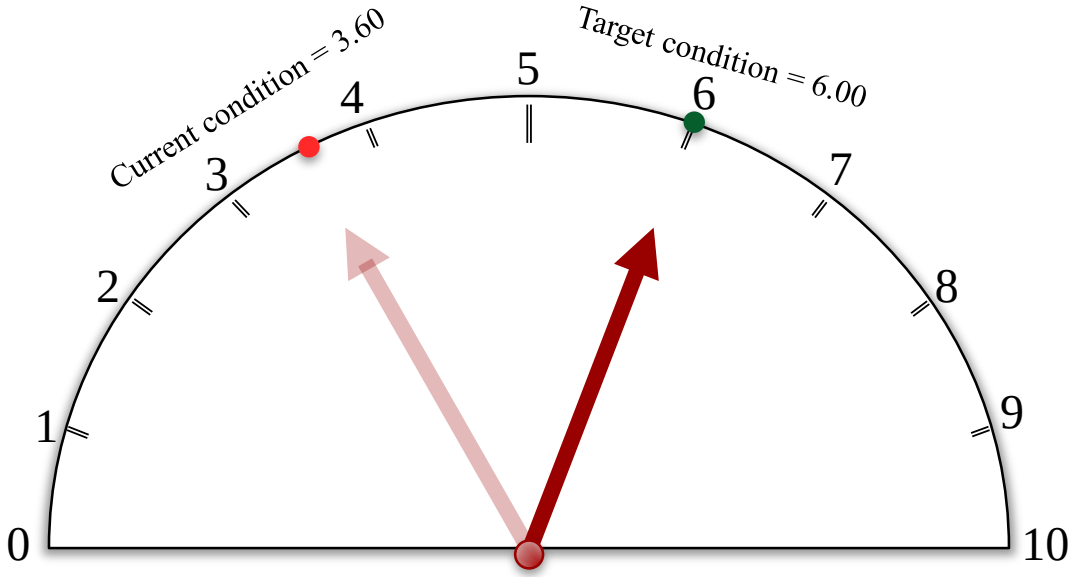
Other Forest	1	N/A	N/A	1	1	1	1	5	early successional	5	25	
Surrogate Grassland (old field)	1	N/A	N/A	1	1	1	1	5	can be important as buffer habitat	5	25	
Surrogate Grassland Restored	1	N/A	N/A	1	1	1	1	5	greater importance of native species than old fields	5	25	



Lower Green Bay / Fox River AOC

- Progress is measured by quantitative measures
- Overall AOC index can be improved by conservation actions
- Actions on highest priority areas or species will be most effective



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Great Lakes Beach

	A	C	D	E	F	G	H	I	J	O	P	Q	R
1	Priority Fish & Wildlife Habitat	Historical Importance	State Rank	Global Rank	AOC Conservation Status	Geographic Significance	Significance to AOC Biodiversity	Functional Significance	Weight	Notes	CCondition	Subscore2	Current F&W Habitat Score
2	Great Lakes Beach	3	S2	G3	3	3	3	2	14	includes	2	28	3.60
3	Southern Sedge Meadow	3	S3	G4	2	3	3	3	14	northern	2	28	
4	Emergent Marsh (high energy coastal	3	S4	G4	1	3	3	3	13	present	4	52	
5	Submergent Marsh	3	S4	G5	1	3	3	3	13	dominat	5	65	
6	Emergent Marsh (riparian)	3	S4	G4	1	2	3	3	12	very lim	3	36	
7	Fox River Open Water	3	N/A	N/A	2	3	2	2	12	includes	3	36	
8	Green Bay Open Water	3	N/A	N/A	2	3	2	2	12	includes	3	36	
9	Shrub Carr	3	S4	G5	1	2	3	3	12	shrubby	4	48	
10	Tributary Open Water	3	N/A	N/A	2	3	2	2	12	stream c	3	36	
11	Hardwood Swamp	3	S3	G4	2	1.5	2	3	11.5	one of tv	5	57.5	
12	Emergent Marsh (inland)	2	S4	G4	1	1	2	3	9	separate	4	36	
13	Open Water (inland)	2	N/A	N/A	1	1	1	2	7	pond	3	21	
14	Southern Dry Mesic Forest	1	S3	G4	2	1	1	2	7	oak,hick	5	35	
15	Emergent Marsh (roadside)	0	N/A	N/A	1	2	2	1	6	can be ir	3	18	
16	Northern Mesic Forest	1	S4	G4	1	1	1	2	6	most ext	4	24	
17	Other Forest	1	N/A	N/A	1	1	1	1	5	early suc	5	25	
18	Surrogate Grassland (old field)	1	N/A	N/A	1	1	1	1	5	can be ir	5	25	
19	Surrogate Grassland Restored	1	N/A	N/A	1	1	1	1	5	greater i	5	25	
20													

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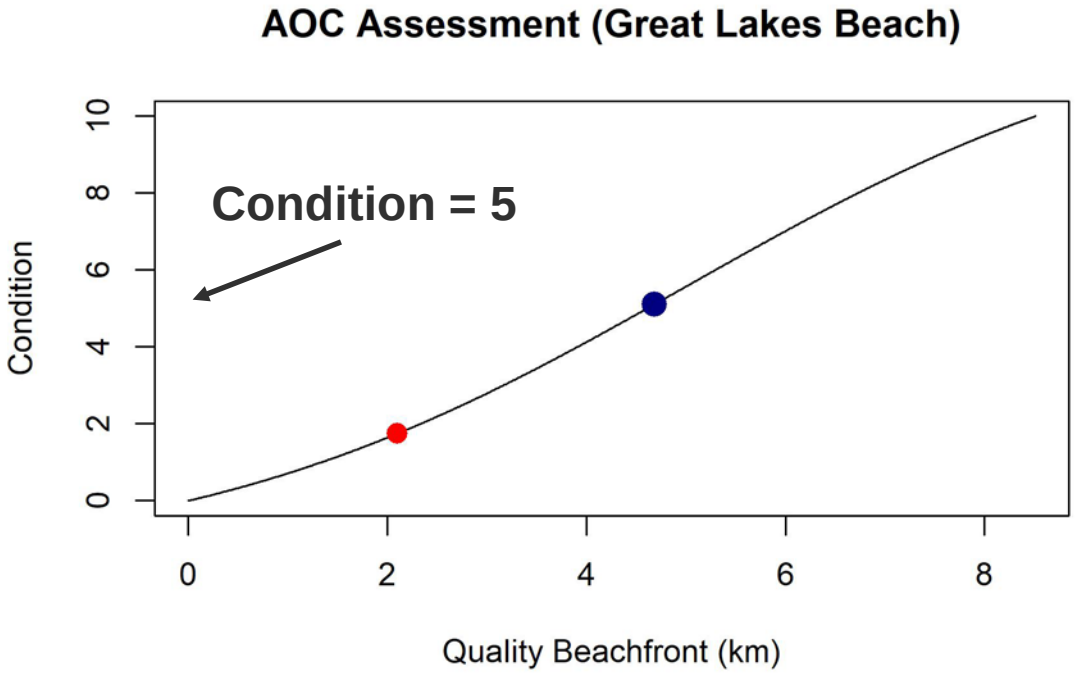
Great Lakes Beach



Current beach metric = 8.51 km x 0.25 (mean quality) = 2.13

Future beach metric = 8.51 km x 0.55 (mean quality) = 4.68

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Lower Green Bay and Fox River Area of Concern (AOC)

1. Identify characteristic habitats and important species/species groups.

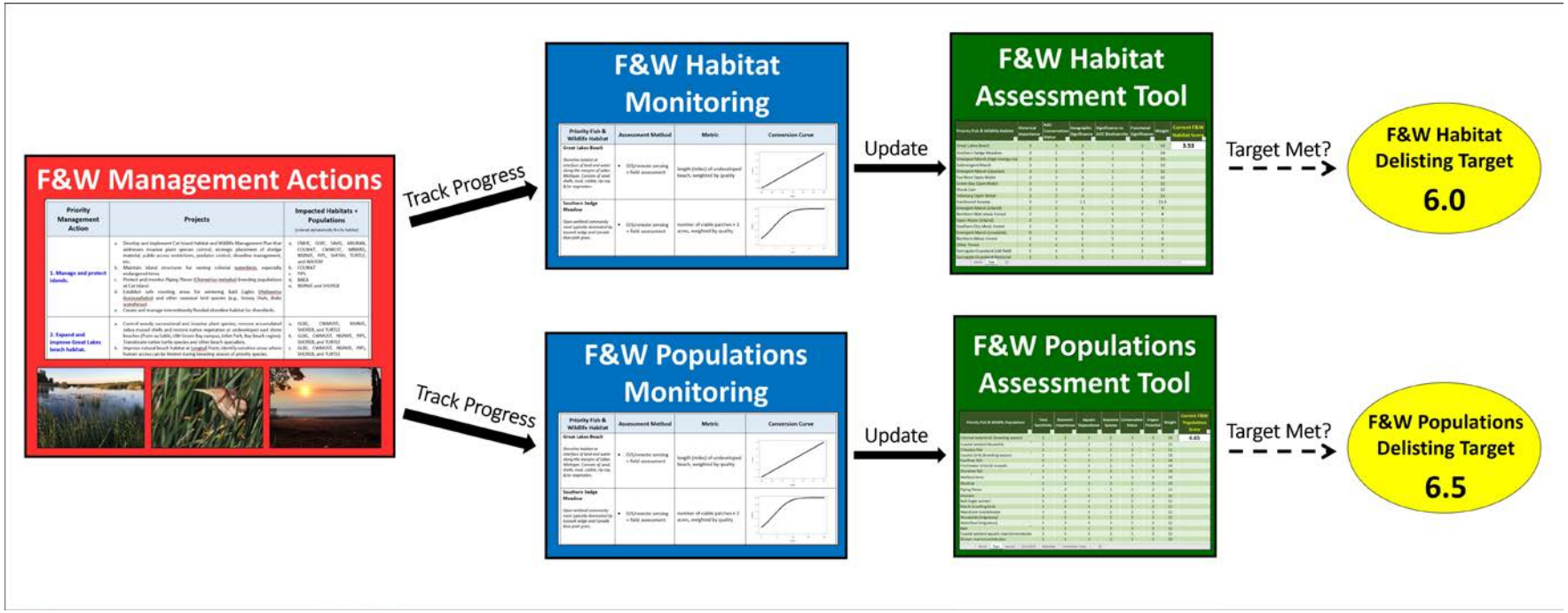
2. Assess relative importance to each habitat and species/species groups.

3. Devise systematic method for measuring current and future condition.

4. Set a meaningful system-wide restoration target.

5. Identify restoration projects needed to achieve the quantitative target.

Lower Green Bay / Fox River AOC



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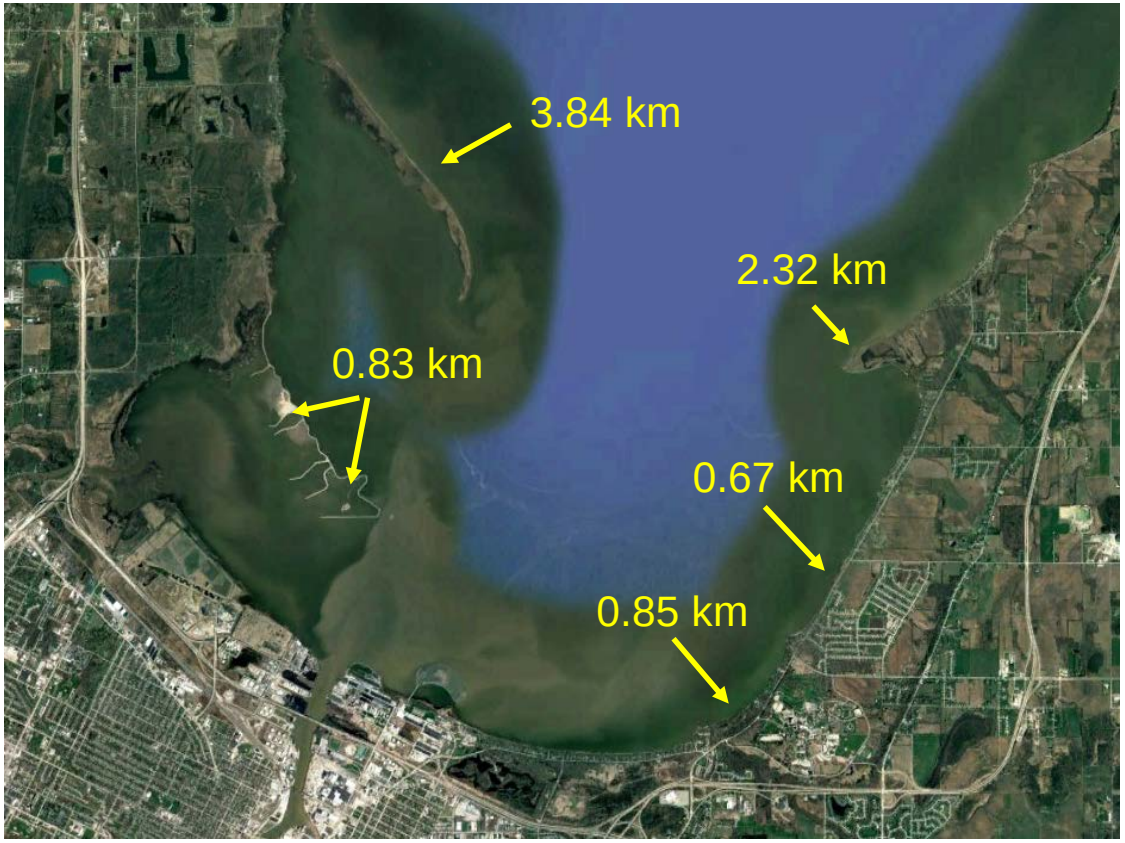
Great Lakes Beach

Great Lakes Beach



Total undeveloped beach = 8.51 km

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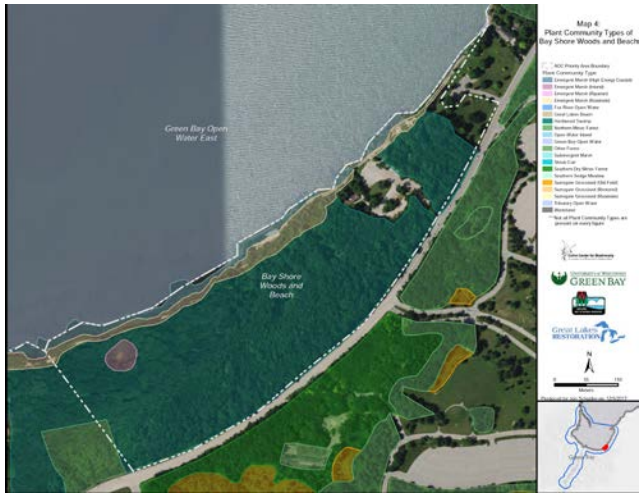
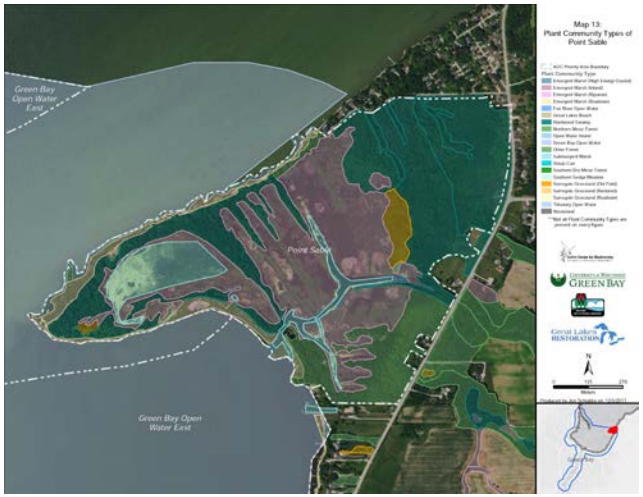
Great Lakes Beach





2. Expand and improve Great Lakes beach habitat.	7. Control woody successional and invasive plant species, remove accumulated zebra/quagga mussel shells, and restore native vegetation at undeveloped east shore beaches (Point au Sable, UW-Green Bay campus, Joliet Park, Bay Beach region). 8. Conduct biotic inventories along AOC shoreline and if necessary re-establish populations of native turtle species and other beach specialists. 9. Identify critical buffer habitats and shorelines with potential den sites for mink, otter, and other shoreline wildlife species. 10. Improve natural beach habitat at Longtail Point; identify sensitive areas where human access can be restricted during breeding season of priority species.	7. GLBE, CWMUST, NSINVE, SHOREB, and TURTLE 8. GLBE, CWMUST, NSINVE, PIPL, SHOREB, and TURTLE 9. GLBE, CWMUST, NSINVE, PIPL, SHOREB, and TURTLE 10. SHOREB, TURTLE, NSINVE, CWMUST

Great Lakes Beach

https://www.earthrangers.com/wildwire/blandings-turtle/

2. Expand and improve Great Lakes beach habitat.	7. Control woody successional and invasive plant species, remove accumulated zebra/quagga mussel shells, and restore native vegetation at undeveloped east shore beaches (Point au Sable, UW-Green Bay campus, Joliet Park, Bay Beach region). 8. Conduct biotic inventories along AOC shoreline and if necessary re-establish populations of native turtle species and other beach specialists. 9. Identify critical buffer habitats and shorelines with potential den sites for mink, otter, and other shoreline wildlife species. 10. Improve natural beach habitat at Longtail Point; identify sensitive areas where human access can be restricted during breeding season of priority species.	7. GLBE, CWMUST, NSINVE, SHOREB, and TURTLE 8. GLBE, CWMUST, NSINVE, PIPL, SHOREB, and TURTLE 9. GLBE, CWMUST, NSINVE, PIPL, SHOREB, and TURTLE 10. SHOREB, TURTLE, NSINVE, CWMUST

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Lower Green Bay / Fox River AOC

Restoration Projects for Lower Green Bay & Fox River AOC Fish and Wildlife

Amy T. Wolf, Robert W. Howe, Erin E. Gnass Giese, Cofrin Center for Biodiversity, University of Wisconsin-Green Bay

Objectives	Projects	Impacted Habitats + Populations (ordered alphabetically first by habitat)
1. Manage and protect AOC islands.	1. Develop and implement Cat Island Habitat and Wildlife Management Plan that addresses invasive plant species control, strategic placement of dredge material, public access restrictions, predator control, shoreline management, etc. 2. Construct and maintain island structures for nesting colonial waterbirds, especially endangered terns. 3. Protect and monitor Piping Plover (*Charadrius melodus*) breeding populations at Cat Island and at least one other location. 4. Identify and protect safe roosting areas for wintering Bald Eagles (*Haliaeetus leucocephalus*) and other seasonal bird populations (e.g., Snowy Owls, *Bubo scandiacus*). 5. Create and manage intermittently flooded shoreline habitat for shorebirds on Green Bay islands and shoals. 6. Locate and protect heron rookeries; inform land managers and provide guidance for protection measures.	1. EMHE, GLBE, SAVG, ANURAN, COLWAT, CWMUST, MBBIRD, NSINVE, PIPL, SHFISH, TURTLE, and WATERF 2. COLWAT 3. PIPL 4. BAEA 5. NSINVE and SHOREB 6. COLWAT
2. Expand and improve Great Lakes beach habitat.	7. Control woody successional and invasive plant species, remove accumulated zebra/quagga mussel shells, and restore native vegetation at undeveloped east shore beaches (Point au Sable, UW-Green Bay campus, Joliet Park, Bay Beach region). 8. Conduct biotic inventories along AOC shoreline and if necessary re-establish populations of native turtle species and other beach specialists. 9. Identify critical buffer habitats and shorelines with potential den sites for mink, otter, and other shoreline wildlife species. 10. Improve natural beach habitat at Longtail Point; identify sensitive areas where human access can be restricted during breeding season of priority species.	7. GLBE, CWMUST, NSINVE, SHOREB, and TURTLE 8. GLBE, CWMUST, NSINVE, PIPL, SHOREB, and TURTLE 9. GLBE, CWMUST, NSINVE, PIPL, SHOREB, and TURTLE 10. SHOREB, TURTLE, NSINVE, CWMUST

This list provides candidate projects for inclusion in the *management actions* for delisting two BUIs in the Lower Green Bay and Fox River AOC: 1) degradation of fish & wildlife populations and 2) loss of fish and wildlife habitat.

version 5 December 2017

Restoration Projects for Lower Green Bay & Fox River AOC Fish and Wildlife

Amy T. Wolf, Robert W. Howe, Erin E. Giese, Cofrin Center for Biodiversity, University of Wisconsin-Green Bay

3. Restore and enhance southern sedge meadow habitat.	11. Expand existing southern sedge meadow remnants at the Malchow-Olson Tract, Point au Sable, Fort Howard Wildlife Area, Duck Creek, and small areas upstream along the East River. Control invasive plant species, restore hydrology, and promote the spread of native plant species (especially tussock forming sedge, *Carex stricta*). 12. Restore extensive southern sedge meadow/wet meadow habitat in northern Duck Creek delta (Wisconsin DNR lands east of E. Greenfield Ave).	11. SSME, ANURAN, BATS, CWAQMA, CWMUST, LANDBI, MBBIRD, and WETTER 12. SSME, ANURAN, CWAQMA, CWMUST, LANDBI, MBBIRD, and WETTER
4. Improve habitat quality of small AOC tributaries (enhance fish passage, restore natural stream substrates, and protect riparian vegetation)	13. Use The Nature Conservancy's fish passage GIS tool to identify and remove barriers that provide access to potential spawning areas. 14. Improve substrate (including gravel and riffles) and reduce sediment pollution. 15. Protect and enhance riparian habitats at Mahon Creek, Wequiock Creek, Duck Creek, and parts of the East River. 16. Reduce magnitude of storm surges (flashiness) by creating or maintaining upstream vegetation buffers and mitigating inputs from stormwater drainages.	13. EMRI, EMRS, FOXR, TRIB, CWMUST, FRFISH, FUMUSS, MUSKRA, STRMAC, TRFISH, and TURTLE 14. FOXR, TRIB, FRFISH, FUMUSS, and TRFISH 15. EMRI, FOXR, TRIB, CWMUST, FUMUSS, MUSKRA, STRMAC, TRFISH, and TURTLE 16. TRIB, STRMAC, and TRFISH
5. Improve open water and nearshore fish habitat in lower Green Bay.	17. Enforce TMDL regulations in Fox River Watershed. 18. Develop or restore important fish spawning and nursery habitats, such as rocky reefs, gravel, cobble, woody debris, and sandy areas for shoreline fish. 19. Improve fish spawning substrate at existing shoreline reef structures, such as Renard Island.	17. Nearly all fish and wildlife habitats and populations, especially OWGB, FOXR, SAVG, ANURAN, FRFISH, FWMUSS, NSINVE, SHFISH, STMAC, and TRFISH 18. COABIR, FRFISH, NSINVE, SHFISH, and TRFISH 19. COABIR and SHFISH

Restoration Projects for Lower Green Bay & Fox River AOC Fish and Wildlife

Amy T. Wolf, Robert W. Howe, Erin E. Giese, Cofrin Center for Biodiversity, University of Wisconsin-Green Bay

6. Expand and improve quality of emergent marsh (high energy) complexes.	20. Control invasive plant species (e.g., *Phragmites australis*, common reed; *Typha* × *glauca*, hybrid cattail) and maintain an appropriate mix of open water native emergent vegetation in west shore marshes. 21. Protect nest sites (e.g., tree cavities, snags, artificial nest boxes) for coastal birds (breeding) and establish nesting platforms for Osprey (*Pandion haliaetus*) and Bald Eagle (*Haliaeetus leucocephalus*). 22. Designate and protect sensitive areas at Dead Horse Bay, Longtail Point, Peters Marsh, Malchow-Olson tract, Point au Sable, Duck Creek Delta, and Duck Creek. 23. Create nest structures for wetland terns at Peters Marsh, Duck Creek, and Point au Sable and ensure there are at least 20 breeding pairs of Black Tern (*Chlidonias niger*) and Forster's Tern (*Sterna forsteri*). 24. Establish safe road crossings at strategic areas for anurans and turtles. 25. Develop long-term management plan for sustaining emergent wetland habitat at sensitive wetlands during both high and low water periods.	20. EMHE, ANURAN, BATS, COABIR, CWAQMA, CWMUST, COLWAT, LANDBI, MBBIRD, MUSKRA, NSINVE, SHFISH, TRFISH, TURTLE, WATERF, and WETTER 21. COABIR 22. EMHE, ANURAN, BATS, COABIR, CWAQMA, CWMUST, COLWAT, LANDBI, MBBIRD, MUSKRA, NSINVE, SHFISH, TRFISH, TURTLE, WATERF, and WETTER 23. WETTER 24. ANURAN and TURTLE 25. EMHE, ANURAN, COABIR, CWAQMA, CWMUST, COLWAT, MBBIRD, MUSKRA, NSINVE, SHFISH, TRFISH, TURTLE, WATERF, and WETTER
7. Expand and improve quality of submerged aquatic vegetation.	26. Control introduced plant species (e.g., *Myriophyllum spicatum*, *Najas minor*, and *Potamogeton crispus*) and maintain extensive and high quality submerged aquatic vegetation (SAV) with native plants at Dead Horse Bay, Duck Creek, Peters Marsh, and Point au Sable. 27. Determine substrate needs for target plant species and then enhance and restore substrate condition. 28. Protect, maintain, and expand SAV biodiversity hotspots.	26. SAVG, ANURAN, CWAQMA, CWMUST, MBBIRD, MUSKRA, NSINVE, SHFISH, TURTLE, WATERF, and WETTER 27. SAVG 28. SAVG
8. Protect strategic coastal landscapes through land acquisition or conservation easement.	29. Establish conservation easement for Malchow-Olson Tract, unprotected wetlands in Duck Creek delta, and sections of the East River.	29-30. Impacted habitats and populations will depend on the habitats and areas of interest that are protected or purchased.

Restoration Projects for Lower Green Bay & Fox River AOC Fish and Wildlife

Amy T. Wolf, Robert W. Howe, Erin E. Giese, Cofrin Center for Biodiversity, University of Wisconsin-Green Bay

	30. Designate sensitive coastal landscapes at UW-Green Bay's Bay Shore Woods and Beach, Barkhausen Waterfowl Preserve, Cat Island, Point au Sable, and Longtail Point.	
9. Protect large areas of quality wooded wetlands along AOC coast.	31. Control invasive woody plants in quality hardwood swamps at Barkhausen, Malchow-Olson Tract, Bay Beach Wildlife Sanctuary, UW-Green Bay's Bay Shore Woods and Beach, and Point au Sable. 32. Restore and expand habitats with native fruiting shrubs to improve stopover habitat for migratory land birds.	31. HASW, LANDBI, and WWBIRD 32. LANDBI
10. Re-establish freshwater mussel populations.	33. Conduct inventory for remnant freshwater mussel beds and translocate/reintroduce populations at favorable locations. Use published studies (e.g., Morales et al. 2006) to identify optimal sites for re-introduction.	33. CWMUST, FWMUSS, and WATERF
11. Improve water quality in Green Bay, Fox River, and smaller tributaries.	34. Promote best management practices and innovative nutrient management measures in Fox River watershed. 35. Reduce unimpeded flow of toxins, nutrients, and sediments from urban/suburban storm water discharge pipes. 36. Implement effective non-point source pollution management plans in smaller watersheds and drainages.	34-36. Nearly all fish and wildlife habitats and populations would benefit from improved water quality, especially SAVG, ANURAN, FRFISH, FWMUSS, NSINVE, SHFISH, STMAC, and TRFISH
12. Designate and protect contiguous wetland habitat gradients at select AOC coastal sites.	37. Restore hydrologic gradient ranging from emergent marsh to shrub carr and to hardwood swamp at Peters Marsh, Malchow-Olson Tract, Duck Creek North, Point au Sable, and possibly Ken Euers Wildlife Area.	37. EMHE, HASW, SHCA, SSME, ANURAN, BATS, COABIR, CWAQMA, CWMUST, COLWAT, FUMUSS, LANDBI, MBBIRD, MUSKRA, NSINVE, SHOREBI, SHFISH, TURTLE, WATERF, WETTER, and WWBIRD

Lower Green Bay and Fox River Area of Concern (AOC)

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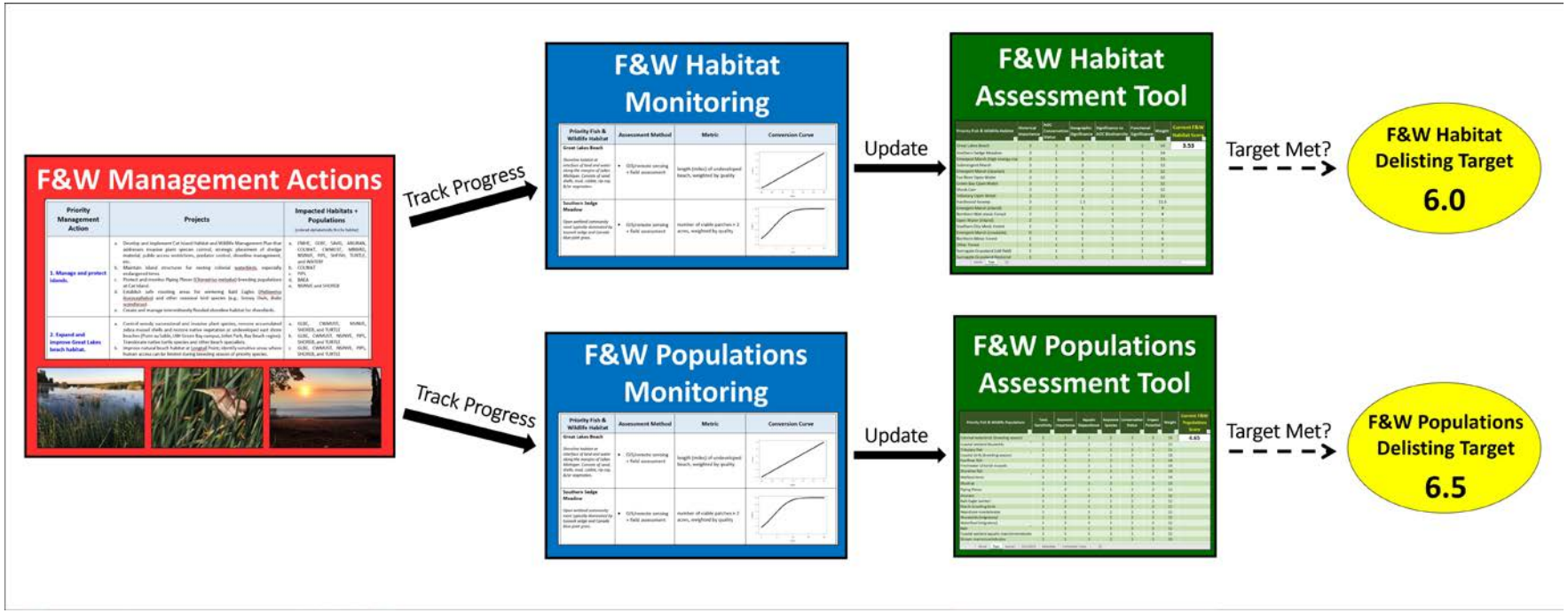
Lower Green Bay / Fox River AOC



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Lower Green Bay / Fox River AOC BUI Removal

Part 1 of the Final Report for the

Lower Green Bay & Fox River Area of Concern
Habitat Restoration Plan and
Path Toward Delisting Project

Submitted to the Wisconsin Department of Natural Resources and the U.S. Environmental Protection Agency

January 2018

Robert Howe, Amy Wolf, Erin E. Gnass Giese, and James Horn

University of Wisconsin-Green Bay's Cofrin Center for Biodiversity

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Habitat/Species Accounts

Turtles

The original de-listing targets for the LGB&FR AOC (WDNR 2016) proposed that reptiles (including snapping and painted turtles) should be sustained in "abundances sufficient to provide ecological function." Assuming that turtles have been an integral part of the historically recent (~500 yr ago to present) Green Bay ecosystem, maintenance of viable turtle populations in the AOC implies that their ecological function is at least partially fulfilled. Presence of viable populations themselves, unfortunately, are not clearly established today. We observed few turtles of any kind during our field surveys, although of course the methods were not targeted toward this group. Nevertheless, this is a group that we suggest deserves increased attention.

Two widespread species, eastern snapping turtle (*Chelydra serpentina*) and painted turtle (*Chrysemys picta*), are by far the most common turtles in the LGB&FR AOC. Additionally, Blanding's turtle (*Emydoidea blandingii*), recently de-listed as a Wisconsin threatened species, has been reported from Brown County (Casper 2007). Suitable habitat (Ross and Anderson 1990) occurs in coastal landscapes such as Point au Sable, Bay Beach Wildlife Sanctuary, Duck Creek Delta, Barkhausen Waterfowl Preserve, and the Malchow-Olson Tract, where mosaics of ponds, forested swamps, and wet meadows are located near the Green Bay shoreline (Joyal et al. 2001). Spiny softshell turtle (*Apalone spinifera*) has been verified from Brown County (Casper 2007) and is likely present in Green Bay or the Fox River. Wood Turtle (*Glyptemys insculpta*), officially listed as Threatened in Wisconsin, favors forested streams with nearby wet meadows (Compton et al. 2002). This species is not likely to be present in the coastal zone of Green Bay, but it might occur in upper reaches of Duck Creek and could potentially occur at other sites along the East River or Baird Creek.

Turtles are weighted in the lower middle quartile of population groups based on the assumption that both Blanding's turtle and wood turtle are extirpated from the LGB&FR AOC. Reintroduction of either species could elevate the ranking due to their state and global status. Despite the fact that Blanding's turtle was de-listed in 2014, it is still a species of special concern and has a global NatureServe ranking of G4 (http://explorer.natureserve.org/granks.htm). Several recent studies, including Smith et al. (2018) have demonstrated that turtles, especially long-lived species like snapping turtle and Blanding's turtle, concentrate toxic heavy metals in their tissues and may be valuable species for monitoring environmental contaminants.

Although aquatic traps are often used for inventorying and monitoring turtles, we recommend a metric based on time-limited (4 hr maximum) visual surveys during late spring and early summer, when vegetation growth is minimal and visibility is maximized. Surveys can be conducted from kayaks/boats or at strategic observation points located 500 m or more apart (Marchand and Litvaitis 2004, Quesnelle et al. 2013). By-catch from fish surveys (e.g., Wieten et al. 2012) and periodic trap surveys can be used to validate results from the visual surveys, which are relatively inexpensive and can be repeated frequently and at many locations. All four likely-occurring species (painted turtle, eastern snapping turtle, Blanding's turtle, and eastern spiny softshell turtle) are known to bask regularly during late spring or early summer (e.g., Obbard and Brooks 1979, Millar and Blouin-Demers 2011), although basking sites appear to be least important for spiny softshell turtles (DonnerWright et al. 1999).

We present a simple metric (T; Figure x3) that incorporates both species richness and turtle abundance, where $T = \sum_{k=1}^{k} a_k$, where a = number of sites (separated by at least 500 m) where species k was observed during standard surveys in optimal basking conditions; the maximum value for any single species is limited to 5. An ideal condition (10) occurs when at least 4 species of turtles are observed at 5 or more sites (T = 20). This somewhat unlikely condition is mitigated by the non-linear curve, which yields a condition of > 8.0 when only 3 species are regularly observed (T = 15) and approximately 7 when two species are observed at the maximum 5 sites.

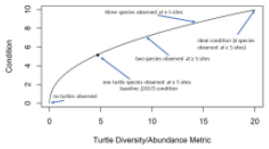
We have little information about the current status of turtles in the LGB&FR AOC. Based on this fact, we assigned a conservative baseline condition score of 5.0, assuming that at least one turtle species is regularly observed in the AOC or two species are present at just a few localities each.

Wieten et al. (2012) demonstrated that submersed/submerged aquatic vegetation (SAV), water-lillies, cattails, and hydrologic features of drowned river mouths were associated with abundance of turtles at 56 coastal wetlands in Lakes Huron, Michigan, and Superior. Conservation of areas with extensive SAV and water-lillies (e.g., at Duck Creek and Dead Horse Bay) will be important for improving the condition of turtles in the AOC. Threats from highway mortality and nest predation also need to be addressed. Surveys for locating nesting habitat may be combined with caging or fencing egg burial sites during the turtle incubation period.

Basking sites such as shoreline deadwood, sandbars, or vegetation islands have been shown to be critical for thermoregulation in turtles (Boyer 1965). These habitats are generally missing from developed shorelines in the AOC and should be an important element of proposed beach and shoreline restoration projects.

Translocation of Blanding's turtles at appropriate sites like Point au Sable, Bay Beach, the Duck Creek Estuary, Barkhausen Waterfowl Preserve, and the Malchow-Olson Tract should be considered as a measure for increasing the condition of turtles in the LGB&FR AOC. All of these sites contain protected ponds for overwintering, wet meadow habitats, and sandy openings for nesting. Point au Sable and the Malchow-Olson Tract are also isolated from major roads, minimizing one of the major mortality threats. Translocation of Blanding's turtles has been successful in Massachusetts, particularly when individuals were "headstarted" by raising hatchling turtles in captivity for 9 months before release (Buhlmann et al. 2015). Because Blanding's turtles are long-lived and require 14–20 yr to reach sexual maturity (Congdon and van Loben Sels 1993), large numbers will need to be released to account for even modest juvenile and sub-adult mortality.

Turtles



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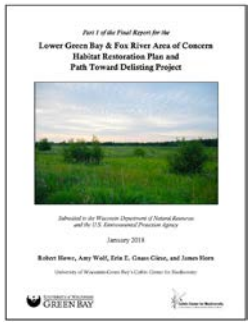
Priority Area Descriptions



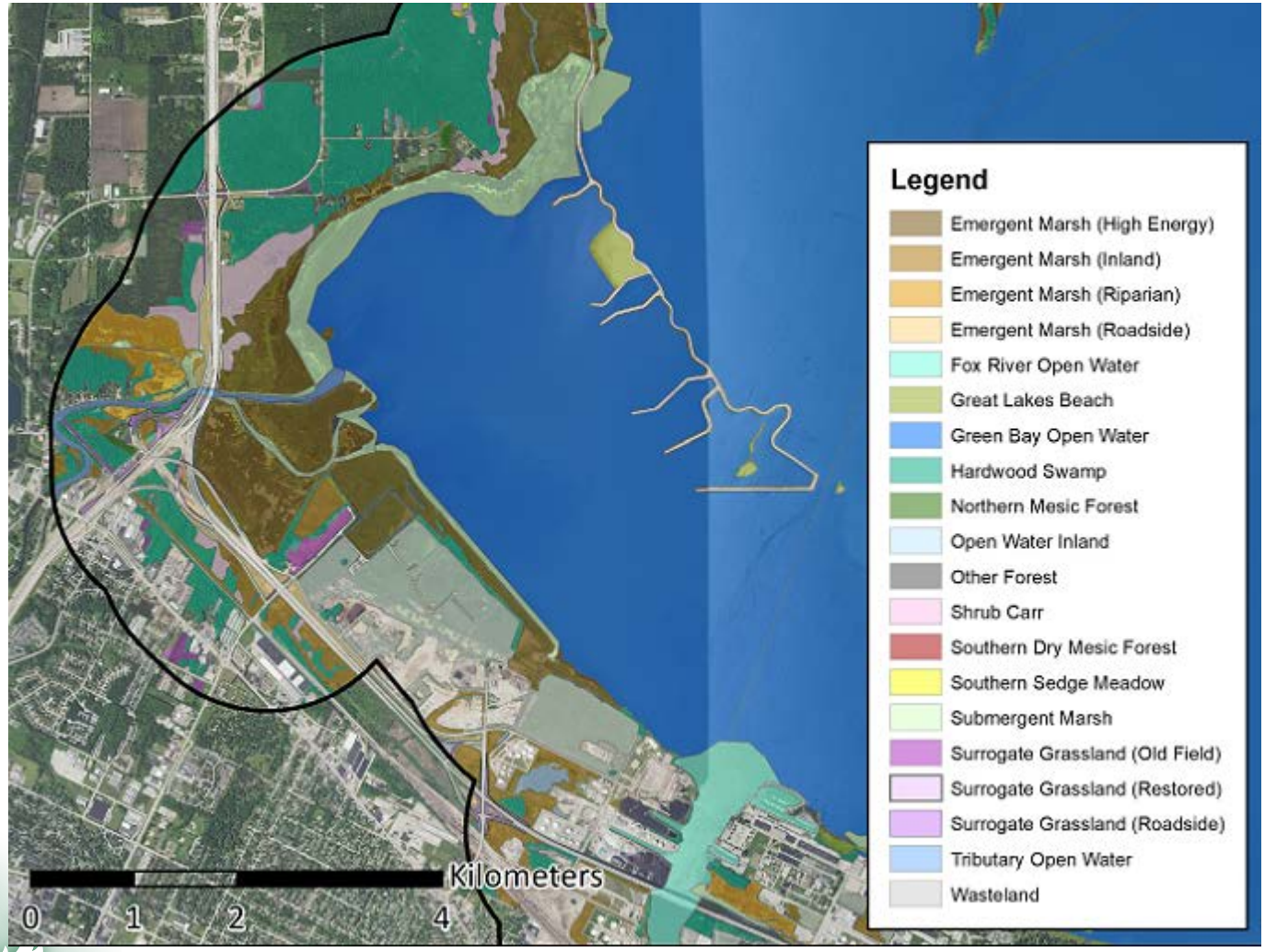
Appendix 7.5: Cat Island

Written by Erin Giese and Dr. James Horn

Location (centroid)	Lat. 44.566961°, Lon. -88.008842°[1] (NAD 1983, UTM Zone 16N)
Total Area (ha)	152.50 ha
Area Public Land (ha)	0 ha The Cat Island Wave Barrier is currently owned by the Brown County Port and Recovery office in Green Bay, and the U.S. Army Corps of Engineers (USACE) is actively filling the reconstructed island "cells" with shipping channel dredge material. The USACE will continue to fill these "cells" over the next 20-30 years. Because it is an active construction site and because the recently placed dredge material can behave like quick sand, it is considered to be dangerous and poses a serious safety hazard. The causeway/wave barrier is gated and locked at two locations. Therefore, there is no public access available at this time.
Area of Habitat Types Present (ha) and Percent of Each Habitat Type	**Dominant Habitat Types:** These habitat types were documented during a July 2015 habitat mapping effort led by the University of Wisconsin-Green Bay Cofrin Center for Biodiversity (CCB) across the Lower Green Bay and Fox River Area of Concern (LGB&FR AOC)[2]. Habitat types within Cat Island are displayed as a static map at the bottom of this document. There is a total of 132.30 ha of natural habitat within Cat Island.

Habitat Type	Area (ha)	Percent
Emergent Marsh (High Energy Coastal)	0.01	0.01
Great Lakes Beach	10.83	8.18

Lower Green Bay West Shore Habitats



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Field Data and Maps

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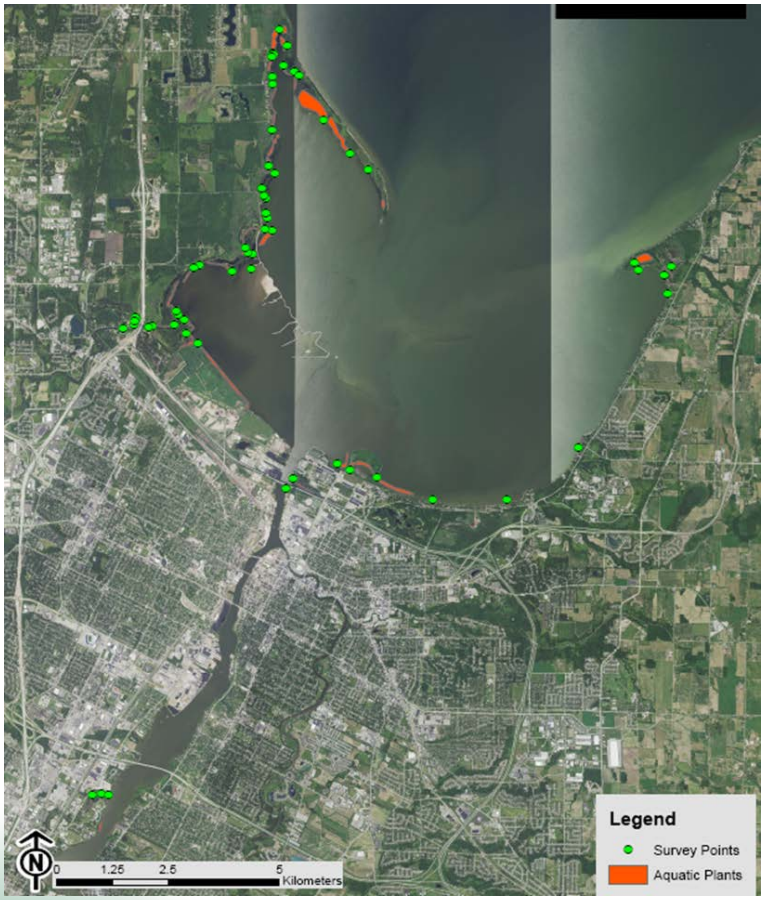
SAV Distribution Lower Green Bay

(Wolf and Horn 2017)



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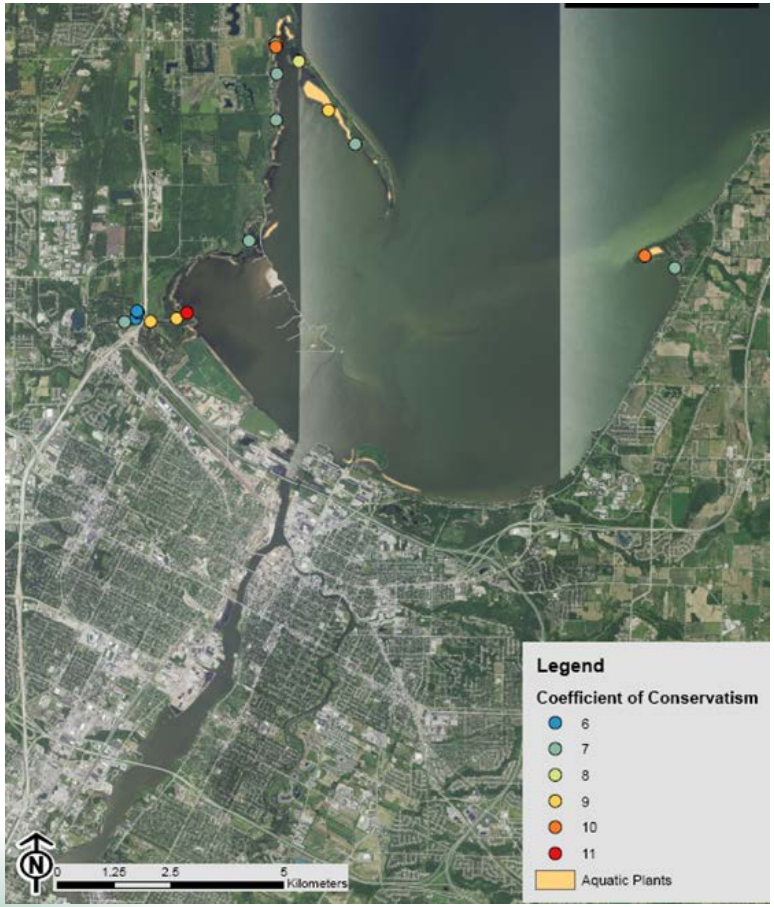
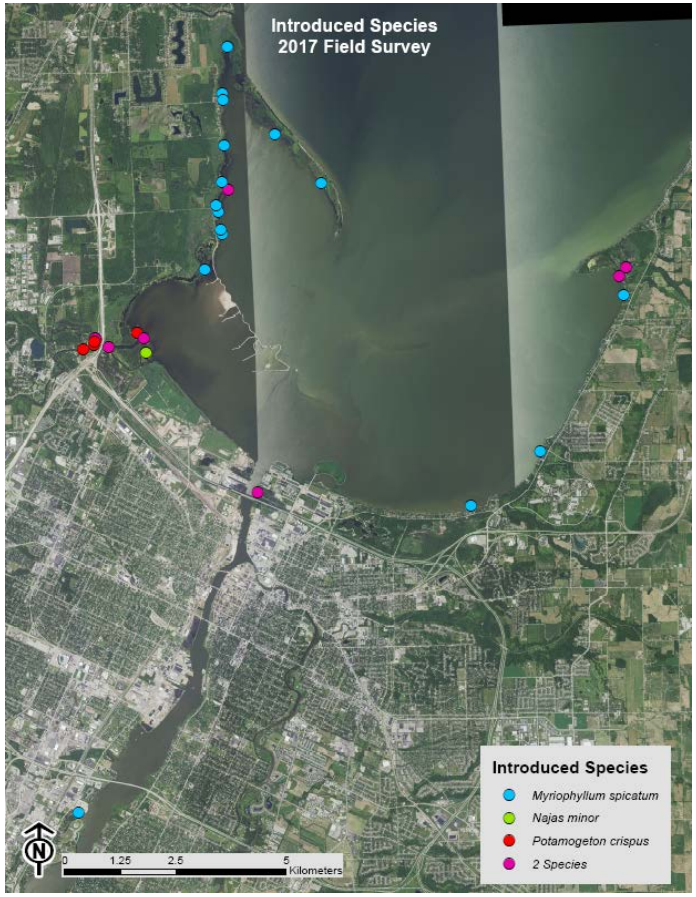
SAV “Hot Spots” and Locations of Introduced species





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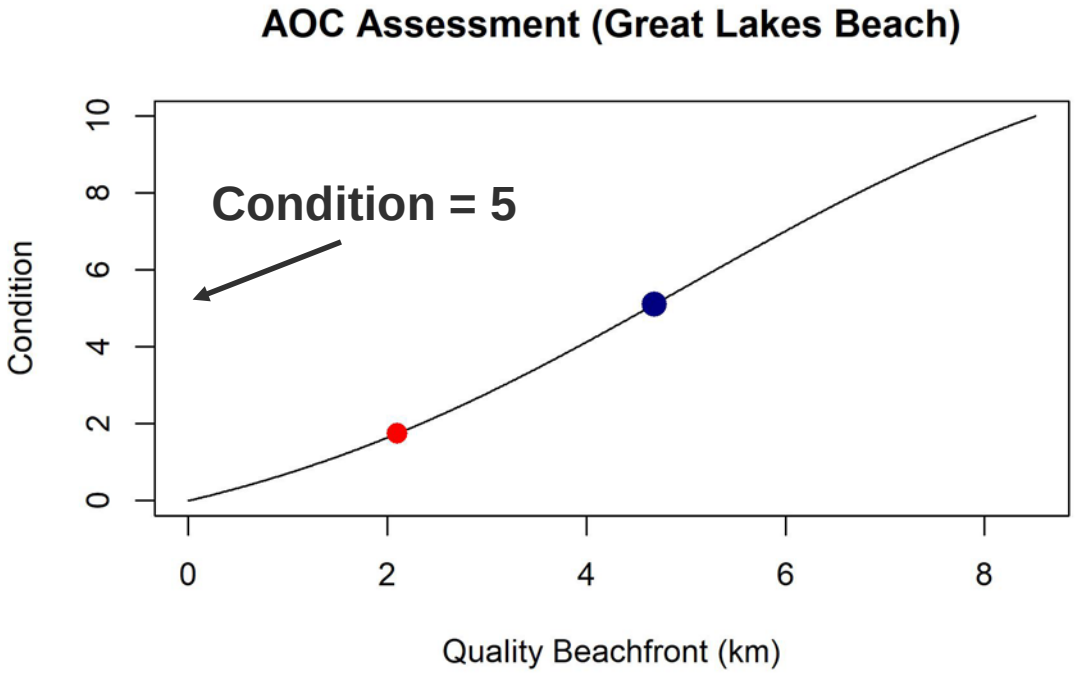
AOC Habitats

Priority Fish & Wildlife Habitat	Historical Importance	State Rank	Global Rank	AOC Conservation Status	Geographic Significance	Significance to AOC Biodiversity	Functional Significance	Weight	Notes	CCondition	Subscore2	Current F&W Habitat Score
Great Lakes Beach	3	S2	G3	3	3	3	2	14	includes nearshore littoral zone	2	28	3.60
Southern Sedge Meadow	3	S3	G4	2	3	3	3	14	northern sedge meadow might have been present historically	2	28	
Emergent Marsh (high energy coasta	3	S4	G4	1	3	3	3	13	present along exposed shorelines	4	52	
Submergent Marsh	3	S4	G5	1	3	3	3	13	dominated by submereged aquatic vegetation (SAV)	5	65	
Emergent Marsh (riparian)	3	S4	G4	1	2	3	3	12	very limited extent today	3	36	
Fox River Open Water	3	N/A	N/A	2	3	2	2	12	includes bottom features	3	36	
Green Bay Open Water	3	N/A	N/A	2	3	2	2	12	includes bottom features	3	36	
Shrub Carr	3	S4	G5	1	2	3	3	12	shrubby wetland; intergrades with sedge meadow and emergent marsh	4	48	
Tributary Open Water	3	N/A	N/A	2	3	2	2	12	stream channel and substrate	3	36	
Hardwood Swamp	3	S3	G4	2	1.5	2	3	11.5	one of two most widespread habitat types in AOC	5	57.5	
Emergent Marsh (inland)	2	S4	G4	1	1	2	3	9	separated from bay by dike or land	4	36	
Open Water (inland)	2	N/A	N/A	1	1	1	2	7	pond	3	21	
Southern Dry Mesic Forest	1	S3	G4	2	1	1	2	7	oak,hickory, basswood, maple	5	35	
Emergent Marsh (roadside)	0	N/A	N/A	1	2	2	1	6	can be important for fish spawning if connected to bay or river	3	18	
Northern Mesic Forest	1	S4	G4	1	1	1	2	6	most extensive pre-settlement habitat type in WI	4	24	
Other Forest	1	N/A	N/A	1	1	1	1	5	early successional	5	25	
Surrogate Grassland (old field)	1	N/A	N/A	1	1	1	1	5	can be important as buffer habitat	5	25	
Surrogate Grassland Restored	1	N/A	N/A	1	1	1	1	5	greater importance of native species than old fields	5	25	

Great Lakes Beach



Current beach metric = 8.51 km x 0.25 (mean quality) = 2.13

Future beach metric = 8.51 km x 0.55 (mean quality) = 4.68

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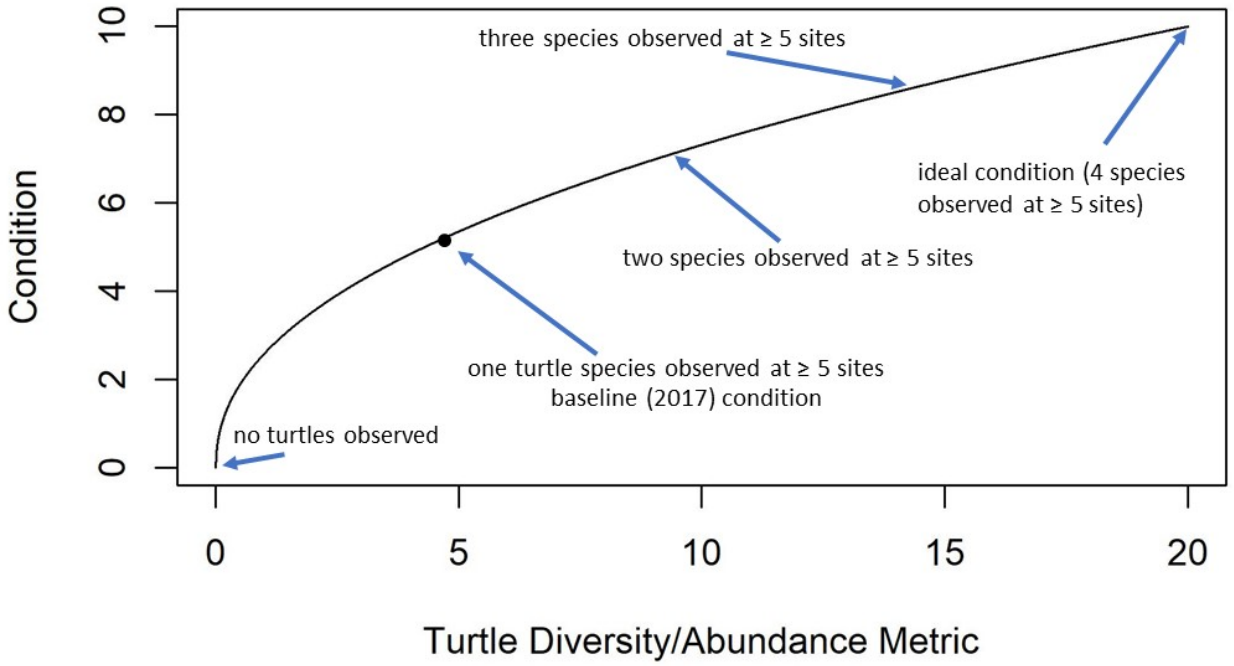
Turtles



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Restoration Projects for Lower Green Bay & Fox River AOC Fish and Wildlife

Amy T. Wolf, Robert W. Howe, Erin E. Giese, Cofrin Center for Biodiversity, University of Wisconsin-Green Bay

13. Enhance backwater habitats along Fox River for larval fish and invertebrates	38. Remove unwanted debris and reduce invasive species in backwater channel located under Leo Frigo Bridge on east side of Fox River. 39. Explore opportunities for creating backwater habitats in vicinity of De Pere Dam and possibly Ashwaubomay Park, National Railroad Museum, and St. Francis Park.	38. FOXR, EMRI, FRFISH, NSINVE, SHFISH, TURTLE 39. FOXR, EMRI, FRFISH, NSINVE, SHFISH, TURTLE
14. Restore rocky and gravel substrates in open Fox River channel at suitable locations.	40. Map and subsequently improve benthic substrate in vicinity of the De Pere Dam. 41. Establish multiple rock/gravel reefs at other sites in Fox River.	40. FOXR, FRFISH, NSINVE, FUMUSS, TRFISH 41. (same as a)
15. Control invasive species and improve shoreline habitat at inland wetlands near Green Bay and Fox River shoreline.	42. Establish native plants and construct or restore (if necessary) shallow topographic gradient at edges of small wetlands in AOC project area (within 1 km of shoreline) or along Duck Creek, East River, and other tributaries. 43. Work with local public works departments to improve habitat value of retention ponds and other artificial habitats in urban environment. 44. Identify and formally protect existing inland wetlands at Barkhausen Waterfowl Preserve, Duck Creek corridor, Bay Beach Wildlife Sanctuary, City of Green Bay landfill site, Point au Sable, and other areas.	42. EMIN, SHCA, OWIN, ANURAN, COABIR, CWAQMA, MBBIRD, WATERF, LANDB, COLWAT, SHFISH 43. (same as a) 44. (same as a)
16. Improve or restore floodplain deltas near river mouths at AOC tributaries	45. Expand protected zones surrounding lower reaches of Mahon Creek, Wequiock Creek, and other watercourses flowing into east shore of lower Green Bay. 46. Protect or restore backwater habitats near mouth of Fox River. 47. Aggressively remove invasive species and restore low shorelines at river mouths of west shore tributaries.	45. TRIB, CWMUST, FUMUSS, STRMAC, TRFISH 46. TRIB, ANURAN, CWMUST, TRFISH 47. TRIB, FUMUSS, CWMUST, TRFISH