Appendix 3: Habitat Mapping (2015) Methodology

Habitat Classification

In order to assess the current habitat conditions of the LGB&FR AOC, we launched a habitat mapping effort in July 2015 that combined field ground-truthing with the use of satellite imagery and other reference maps in order to identify and map the primary plant communities.

An initial habitat classification used air photos and infrared imagery to distinguish residential and other highly urbanized or industrialized lands ("Developed") and cultivated land ("Agricultural") from all other categories. Mapped non-habitat polygons (Developed and Agricultural lands) were excluded from the subsequent habitat analysis.

Plant communities described in the Wisconsin Wildlife Action Plan (WWAP; 2015) formed the basis of habitat classification (Table 1, Appendix 3). Nineteen habitat types occur within the LGB&FR AOC. Howe, Wolf, and Giese, in consultation with TNC staff and GIS specialist Michael Stiefvater, modified and expanded these categories to account for highly degraded habitat types, which are relatively common in the LGB&FR AOC (Table 1, Appendix 3). Specifically, we:

- Added a plant community type "other forest" in order to distinguish pine plantations and early successional forest (e.g., young forest including dominants like aspen [*Populus* spp.], box elder [*Acer negundo* L.], etc.) from more mature, high quality forest (e.g., northern mesic forest).
- Added plant community type "wasteland" to distinguish highly disturbed industrial lands that are dominated by exotic grasses and forbs (including invasive *Phragmites australis* [Cav.] Steud) from other types like "surrogate grassland."
- Subdivided two original WWAP plant community types into finer categories to better distinguish important habitat types in the LGB&FR AOC. Specifically, we subdivided "emergent marsh" into emergent marsh "high energy coastal" (emergent marsh located along a Great Lakes shoreline that is subject to wave energy and fluctuating water levels), "inland" (emergent marsh located inland that is disconnected from a Great Lake), "riparian" (emergent marsh found alongside a stream), and "roadside" (emergent marsh that occurs in places like roadside ditches).
- Partitioned "surrogate grassland" into three finer divisions: "old field" (open, dry, non-forested area dominated by grasses and/or small shrubs), "restored" (open, dry, non-forested area that was restored to native grasses), and "roadside" (open, dry, non-forested area that occurs along highways and other roads).
- Added category "open water inland" (e.g., lake or pond) and "open water" (bay of Green Bay).

All plant communities listed in Table 1 (Appendix 2) were used during the fieldwork effort, except "emergent marsh roadside," "inland open water," "open water," "Fox River open water," "tributary open water," and "surrogate grassland roadside," which were later added during the digitization process (see "GIS Mapping") to further refine the main categories. All of these modifications improved the co-PIs and Giese's abilities to assess current habitat conditions, identify potentially restorable habitat, and distinguish between areas of lower habitat quality (e.g., "emergent marsh roadside") from potentially higher habitat quality (e.g., "emergent marsh high energy"). If needed, these finer subdivisions and additions can always be combined into the original WWAP categories (e.g., number of hectares of habitat types "surrogate grassland old field," "surrogate grassland restored," and "surrogate grassland roadside" could be combined and reclassified as the original category "surrogate grassland"). Note that "floodplain forest" (FLFO)

was listed as a possible habitat that occurs in the LGB&FR AOC but was later determined after the 2015 field work that it does not occur in this area; therefore, this habitat is not included in Table 1 (Appendix 2).

Table 1. Plant communities found within the Lower Green Bay and Fox River Area of Concern that were used for the 2015 habitat mapping effort. Community types and descriptions originated from the Wisconsin Wildlife Action Plan (WWAP; 2015); however, two communities (emergent marsh and surrogate grassland) were subdivided into more detailed categories[1], several communities or subdivisions were added for the field work that were not included in the original WWAP[2], others were added after the field work[3], and some descriptions were modified to better describe each type within this AOC. Scientific names of each common name provided below as a table footnote ‡.

Plant Community Type	Habitat Code	Description
Emergent Marsh[1,2] (High Energy Coastal)	EMHE	Open wetland with standing water in some part of area, dominated by emergent macrophytes. Dominants include cattails, bulrushes, bur-reeds, arrowheads, spikerush, etc.; often invaded by *Phragmites* or reed canary grass. Common in AOC.
Emergent Marsh[1,2] (Inland)	EMIN	
Emergent Marsh[1,2] (Riparian)	EMRI	
Emergent Marsh[1,2,3] (Roadside)	EMRS	
Fox River Open Water[2,3]	FOXR	Open water of the Fox River.
Great Lakes Beach	GLBE	Shoreline habitat at interface of land and water along the margins of Lakes Michigan. Common in AOC. Includes sand, shells, mud, cobble, rip-rap, vegetation.
Hardwood Swamp	HASW	Wet forest dominated by green or black ash, sometimes with red maple, yellow birch, cottonwood, swamp white oak, and elm. Very common in AOC.
Northern Mesic Forest	NMFO	Widespread forest type dominated or co-dominated by sugar maple, eastern hemlock, white pine, and American beech can be a co-dominant. Other important tree species include yellow birch, American basswood, and white/green ash. Fairly common in AOC.
Open Water Inland[2,3]	OWIN	Inland open water bodies (e.g., retention pond, small lake). Common in AOC.
Green Bay Open Water[2,3]	GBAY	Open water of the bay of Green Bay (i.e., pelagic zone).
Other Forest[2]	OTFO	Broad category meant to capture forest types that don't fit into other communities. Early successional forests dominated by aspen, box elder, cottonwood, sumac, and young trees of mixed

		composition. Pine plantations. Very common in AOC.
Submergent Marsh	SUMA	Herbaceous community of aquatic macrophytes in lakes, ponds, and rivers. Dominants include pondweeds along with waterweed, eel-grass, and species of water-milfoil and bladderworts. Somewhat common in AOC.
Shrub Carr	SHCA	Transitional habitat between open wetlands and forested wetlands. Dominated by tall shrubs such as red-osier dogwood, silky dogwood, meadowsweet, and various willows. Canada blue-joint grass is often very common. Common in AOC.
Southern Dry Mesic Forest	SDMF	Forest dominated by red oak, white oak, basswood, sugar and red maple; white ash and shagbark hickory often also present. Relatively uncommon in AOC.
Southern Sedge Meadow	SSME	Open wetland community most typically dominated by tussock sedge and Canada blue-joint grass. Not common in AOC.
Surrogate Grassland[1] (Old Field)	SGOF	Variety of open, non-forested habitats dominated by grasses or upland shrubs. Very common in AOC.
Surrogate Grassland (Restored)[1,2]	SGRE	Variety of open non-forested habitats dominated by native grasses or shrubs. Uncommon in AOC.
Surrogate Grassland (Roadside)[1,2,3]	SGRS	Variety of open non-forested habitats dominated by grasses or shrubs found along roadsides. Very common in AOC.
Tributary Open Water[2,3]	TRIB	Open water of a tributary (e.g., Duck Creek, Mahon Creek).
Wasteland[2]	WAST	Highly disturbed industrial lands dominated by non-native grasses and forbs (e.g., *Phragmites australis*), including the occasional tree/shrub. Common in AOC.

‡ Scientific names of common names listed in Table 1 above are provided alphabetically as follows: American basswood (*Tilia americana* L), American beech (*Fagus grandifolia* Ehrh.), balsam fir (*Abies balsamea* [L.] Mill.), black ash (*Fraxinus nigra* Marshall), bladderworts (*Utricularia* spp.), bur oak (*Quercus macrocarpa* Michx.), Canada blue-joint grass (*Calamagrostis canadensis* [Michx.] P. Beauv.), eastern hemlock (*Tsuga canadensis* [L.] Carrière), eel-grass (*Vallisneria americana* Michx.), elm (*Ulmus* spp.), meadowsweet (*Spiraea alba* Du Roi), northern white cedar (*Thuja occidentalis* L.), pondweeds (*Potamogeton* spp.), red maple (*Acer rubrum* L.), red oak (*Quercus rubra* L.), red-osier dogwood (*Cornus sericea* L.), shagbark hickory (*Carya ovata* [Mill.] K. Koch), silky dogwood (*Cornus amomum* Mill.), spruces (*Picea* spp.), sugar maple (*Acer saccharum* Marshall), sumac (*Rhus* spp.), tussock sedge (*Carex aquatilis* Wahlenb.), water-milfoil (*Myriophyllum spicatum* L.), waterweed (*Elodea canadensis* Michx.), white ash (*Fraxinus americana* L.), white oak (*Quercus alba* L.), white pine (*Pinus strobus* L.), willows (*Salix* spp.), and yellow birch (*Betula alleghaniensis* Britton)

Field Work Planning

To organize and distribute the habitat mapping field work, Howe, Wolf, and Giese divided the study area (LGB&FR AOC boundary plus 1 km of shoreline at Lake Michigan/Green Bay high water level of 177.2 m AMSL) into three general areas (east shore [E], Fox River [F], and west shore [W]) and then divided each area into 44 regions: eight regions on the east shore (E1, …, E8), 17 regions on the Fox River (F1, …, F17), and 19 regions on the west region (W1, …, W19; Figure 1, Appendix 3). To identify and map plant communities directly onto paper maps in the field, they created sub-region maps (n = 197), which presented a closer, more detailed view of each of these regions. Each sub-region map was assigned a name starting with the region name (e.g., F9) followed by a lowercase letter (a, b, c, …, z). For example, map "W1" (which features the western shoreline of the mouth of the Fox River in lower Green Bay) was subdivided into two sub-region maps, W1a and W1b (Figure 2, Appendix 3). All region maps were scaled the same at 500 m, and each sub-region map was scaled at 250 m. Both map types were set to dimensions 1,280 x 720 pixels and printed on 8.5" x 11" paper. In addition to these region and sub-region maps, Stiefvater and two UW-Green Bay students also created two reference maps (printed on 24" x 16" paper) per region (excluding a few Fox River regions) in the field: a) region map that displayed basic property information and Wisconsin Wetland Inventory polygons and associated wetland types (Figure 3A, Appendix 3) and b) region map showing false color infrared imagery, which helps to distinguish different vegetation types (Figure 3B, Appendix 3). These reference maps, particularly region maps displaying Wisconsin Wetland Inventory polygons, were used as starting points for field crews to use when identifying plant communities in the field.

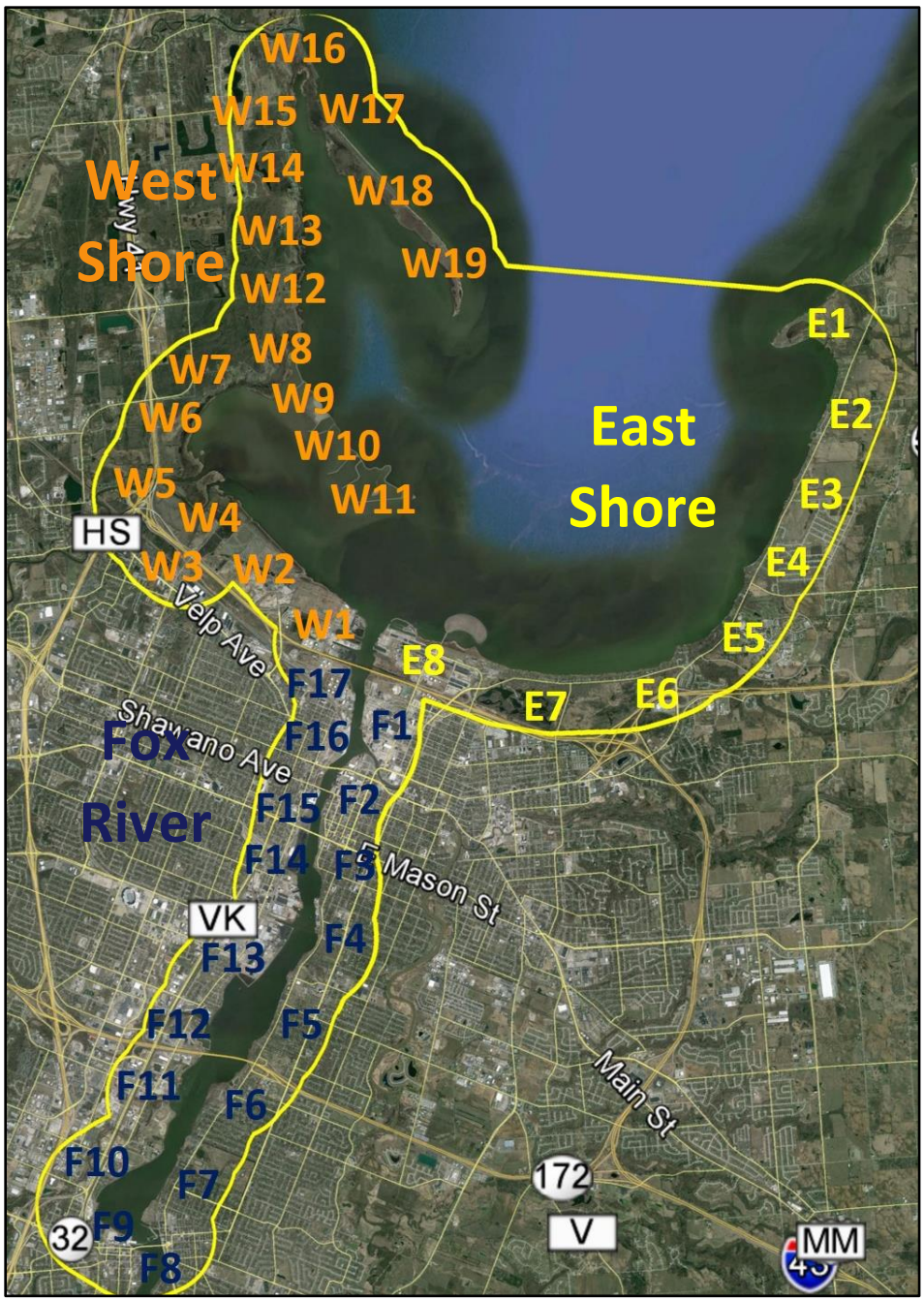

Figure 1. Map of the study area (Lower Green Bay and Fox River Area of Concern boundary plus 1 km of shoreline at Lake Michigan/Green Bay high water level of 177.2 m AMSL; denoted as thick yellow line) that was divided into three areas, the east shore (yellow text), Fox River (blue text), and west shore (orange text), and 44 regions (e.g., E1, …, E8; F1, …, F17; and W1, …, W19) for the July 2015 habitat mapping effort. Satellite imagery shown is from Google Earth (map data: Google, NOAA; imagery date: 13 April 2015; access date: 3 July 2015). Map created using Google Earth Pro.

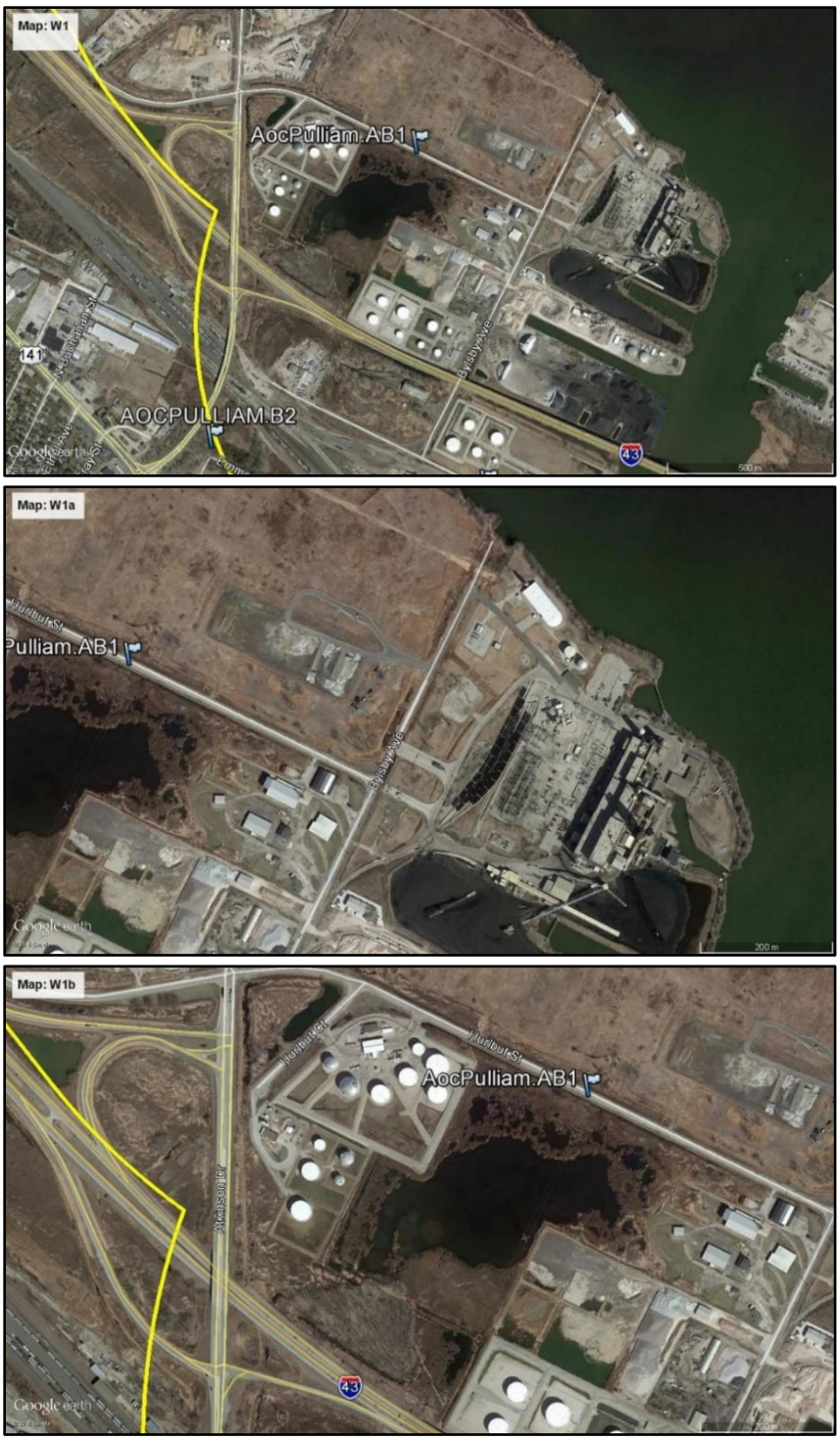

Figure 2. Sample field maps used to identify and map habitat types during the July 2015 field work effort, including a sample region map (W1) and two sub-region maps (W1a and W1b). Field teams drew habitat types by hand directly onto each sub-region map. Anuran and bird point count locations (e.g., AocPulliam.AB1) were added to these maps and uploaded into field teams' GPS units for reference to easily identify accessible locations. Note there is some overlap across sub-region maps as shown in the example above. Habitat types were only identified and mapped on just one of the sub-region maps if maps overlapped. The thick yellow arc indicates the 1 km buffer around the official LGB&FR AOC boundary. Region and sub-region maps were created in Google Earth Pro using Google Earth satellite imagery (map data: Google; imagery date: 13 April 2015; access date: 2 July 2015).

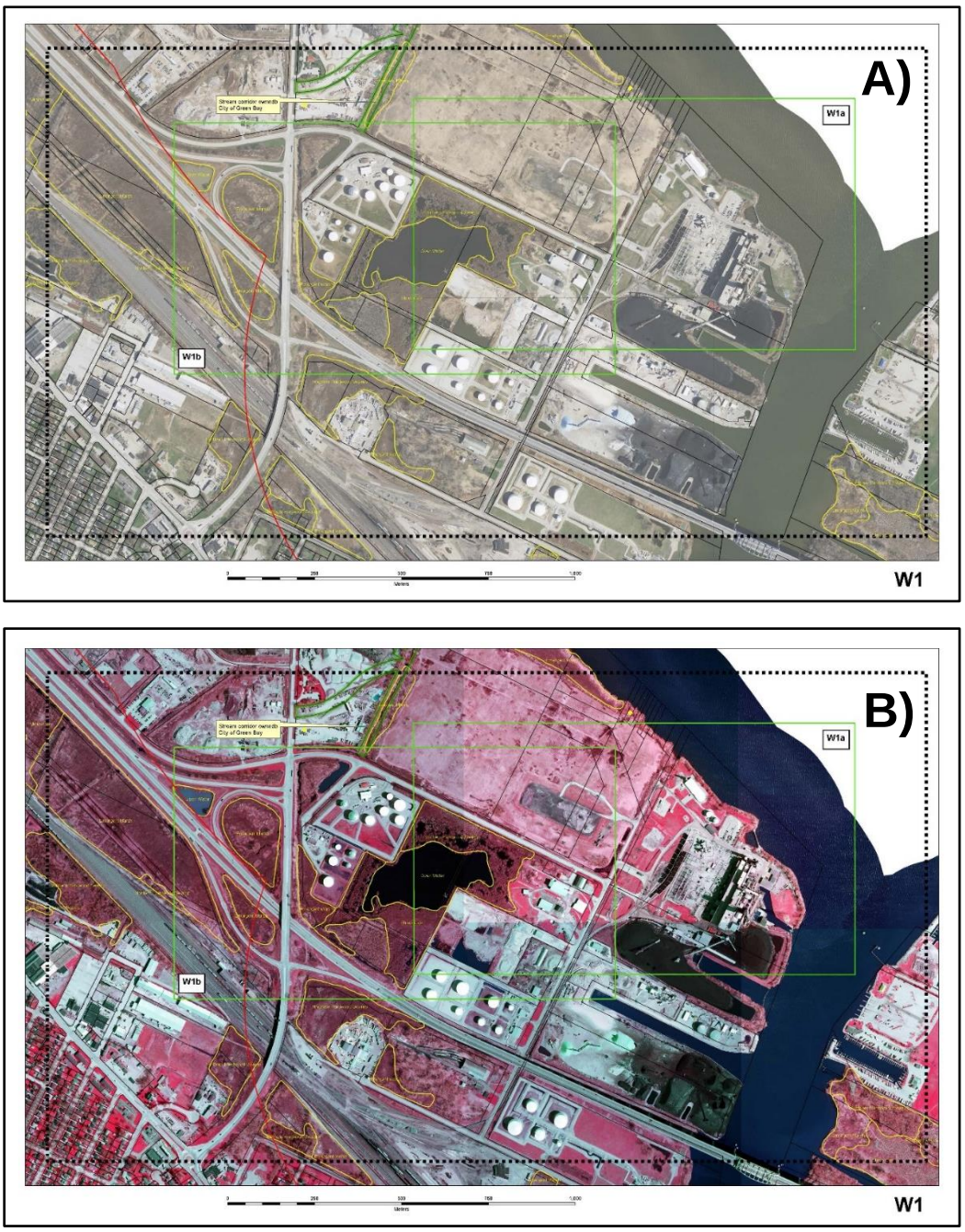

Figure 3. Sample reference maps used in the field during the July 2015 habitat mapping effort: A) aerial photography (dated May 2014) that shows basic property boundaries and Wisconsin Wetland Inventory polygons and wetland types and B) false color infrared imagery (dated May 2014) that distinguishes changes in vegetation; dark red signifies conifers and broad-leaf trees/vegetation (e.g., deciduous tree), light red signifies sparsely vegetated areas (e.g., grass), and dark blue signifies water. Region map boundaries (e.g., W1) shown as a black dotted line. Sub-region map boundaries (e.g., W1a, W1b) denoted as solid green lines. Reference maps were produced by Michael Stiefvater and two UW-Green Bay students using ArcGIS 10.3 software (Environmental Systems Research Institute 2015).

Before the field work, Wolf and Giese next identified locations that they wanted field teams to visit to identify and map plant communities in easily accessible locations (e.g., along a road or trail, public land). Specifically, they examined the satellite imagery displayed on the region and sub-region maps and drew small red dots on areas where the vegetation changed, whether the

vegetation was in an isolated patch (e.g., small woodlot) or in a continuous tract of land (e.g., open marsh with a patch of a different habitat type in the middle of the marsh; Figure 4, Appendix 3). They also outlined suggested travel routes via roads or trails using red markers. Field teams were then instructed to visit all locations marked with a red dot on the region/sub-region satellite imagery maps.

Figure 4. Sample map (sub-region F7a; i.e., east side of Fox River in De Pere, Wisconsin by the St. Norbert Abbey) displaying suggested travel routes (red lines) and field locations (red dots) that field teams were instructed to scout and map habitat types during the July 2015 field work effort. The suggested field locations (red dots) were identified prior to the field work and indicate where vegetation changed. Anuran and bird point count locations (e.g., AocAbbey.AB1) were added to these maps and uploaded into field teams' GPS units for reference to easily identify accessible locations. The thick yellow arc indicates the 1 km buffer around the official LGB&FR AOC boundary. Sub-region maps were created in Google Earth Pro using Google Earth satellite imagery (map data: Google; imagery date: 13 April 2015; access date: 2 July 2015).

Field Work Logistics

Field teams consisted of at least three people each filling one of three roles: 1) field crew leader, 2) mapper/navigator, and 3) photographer. Each field team visited every previously identified site location (previously identified as described above) for each sub-region map. The field crew leader's job was to identify and map the major plant communities at each of the site locations. All field crew leaders have extensive knowledge and previous experience at identifying dominant trees, shrubs, and invasive species (e.g., *Phragmites australis*) and a good understanding of the major plant communities in northeastern Wisconsin. Field crew leaders also filled out the accompanying habitat data form (Figure 5, Appendix 3) recording the dominant tree and shrub species and invasive species. The mapper/navigator's responsibilities were to navigate to each location as well as mark reference waypoints with a GPS unit. The photographer was in charge of documenting the major habitat types at each reference waypoint with photographs and filled out the accompanying photograph data form (Figure 6, Appendix 3).

Lower Green Bay & Fox River AOC Habitat Field Survey Form

Date:_______________2015 **Observer(s):**______________________________________ **GPS ID:**_________

Month Day (Use 4-letter name code: "ROHO" = "Robert Howe"; circle botanist's code) (ID on top of unit)

	Time (24-hr)	**Route Description** (describe starting and ending location for data sheet)
Start	_____:_____ h	
End	_____:_____ h	

Waypoint # **(ref. pt.)** (e.g., RE1a01)	**Coordinates** (reference point)	**Map Label**	**Habitat Code**	**Invasives***	**Description / Notes** (record dominants)
R_______	44.________________ -8___.______________			□ <33% □ 33-66% □ >66%	
R_______	44.________________ -8___.______________			□ <33% □ 33-66% □ >66%	
R_______	44.________________ -8___.______________			□ <33% □ 33-66% □ >66%	
R_______	44.________________ -8___.______________			□ <33% □ 33-66% □ >66%	
R_______	44.________________ -8___.______________			□ <33% □ 33-66% □ >66%	
R_______	44.________________ -8___.______________			□ <33% □ 33-66% □ >66%	
R_______	44.________________ -8___.______________			□ <33% □ 33-66% □ >66%	
R_______	44.________________ -8___.______________			□ <33% □ 33-66% □ >66%	
R_______	44.________________ -8___.______________			□ <33% □ 33-66% □ >66%	

Code	**AOC Community Type**	**Code**	**AOC Community Type**
EMHE	Emergent Marsh (high energy coastal)	OTFO	Other Forest (early successional forest, plantation)
EMIN	Emergent Marsh (inland)	SDMF	Southern Dry Mesic Forest (oak dominated)
EMRI	Emergent Marsh (riparian)	SHCA	Shrub Carr
FLFO	Floodplain Forest	SSME	Southern Sedge Meadow
GLBE	Great Lakes Beach (sand, shells, mud, cobble, rip-rap, veg.)	SUMA	Submergent Marsh
HASW	Hardwood Swamp	SGOF	Surrogate Grassland (old field, upland shrubland)
NWMF	Northern Wet Mesic Forest	SGRE	Surrogate Grassland (restored native grasses)
NMFO	Northern Mesic Forest	WAST	Wasteland (upland *Phragmites*, grasses, industrial barrens)

*Document the invasive intensity of *Phragmites*, reed canary grass (RCG), cattail, Japanese knotweed, buckthorn, and honeysuckle.

Figure 5. Sample habitat data sheet designed by Robert Howe, Amy Wolf, and Erin Giese that was used for the July 2015 habitat mapping effort. Note that several community types (e.g., emergent marsh-roadside, tributary open water) were added after the field work was completed during the digitization process, which is why these categories are not listed at the bottom of the data form.

Lower Green Bay & Fox River AOC Photo Documentation

Date:_______________2015 **Photographer:**___________________ **Camera:**________________ **GPS ID:**_____
Month Day (4-letter name code: "ROHO" = "Robert Howe") (ID on top of unit)

	Time (24-hr)	**Route Description** (describe starting and ending location)
Start	_____:_____ h	
End	_____:_____ h	

Waypoint ID (Map ID + ##) (e.g., PE1a01)	**Prefix:______ Photo #**	**Latitude / Longitude**	**Direction(°)**	**Habitat Type / Map Label**
P________		44.____________ -8___.____________		
P _______		44.____________ -8___.____________		
P _______		44.____________ -8___.____________		
P _______		44.____________ -8___.____________		
P _______		44.____________ -8___.____________		
P _______		44.____________ -8___.____________		
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P _______		44.____________ -8___.____________		

Figure 6. Sample photograph data sheet designed by Robert Howe, Amy Wolf, and Erin Giese that was used for the July 2015 habitat mapping effort.

Wolf, Howe, and Giese distributed field effort by dividing up field teams across the study area by region (east shore, west shore, and Fox River; Figure 1, Appendix 3). At each previously identified site location (marked as red dots on paper maps), field crew leaders first identified the dominant woody vegetation (in field "Description / Notes"), then determined the plant community type (in field "Habitat Code"; e.g., "hardwood swamp" = "HASW"), and finally assessed the intensity of the following invasive plant species: *Phragmites australis* (common reed), reed canary grass, cattail (*Typha x glauca* Godr.), Japanese knotweed (*Fallopia japonica* [Houtt.] Ronse Decr.), buckthorn (*Frangula alnus* Mill. and *Rhamnus cathartica* L.), and honeysuckle (*Lonicera* spp.) using one of three percentage estimates: < 33%, 33-66%, and > 66% (see sample habitat data sheet in see Figure 5, Appendix 3). To keep field documentation simple, other slightly less widespread and less well-known invasive plant species (e.g., spotted knapweed; *Centaurea stoebe* L.) were not included in this invasive intensity estimate but were sometimes noted in the "Description/Notes" field. The navigator/mapper marked a habitat reference waypoint (in field "Waypoint # [ref. pt.]") using his or her GPS unit to geotag where the field crew leader determined the plant community type. Habitat reference points were named using this schematic: starting with the letter "R" ("R" = reference), followed by the sub-region map name (e.g., F7a, E1a), and ending with an incremental two-digit number (including padded zeros). For example, the first habitat reference waypoint taken in sub-region map W3a was called "RW3a01." Each habitat reference waypoint was marked on the habitat data form (Figure 5, Appendix 3), written directly on the associated sub-region map (Figure 7, Appendix 3), and saved to the mapper/navigator's GPS unit. The field crew leader also recorded this habitat reference waypoint and associated geospatial coordinates directly on the habitat data form as a "back-up" in case the information was not saved on the GPS unit. To better distinguish habitat codes drawn on the sub-region maps, the field crew leader also assigned a one- or two-digit number called "map label" and recorded it on the habitat data form. Lastly, for each new habitat data form, field effort and general information were recorded at the top, including date, observers, field crew leader (or "botanist"; using a 4-letter name code consisting of the first two letters of the first name and the first two letters of the last name; e.g., "AMWO" = "Amy Wolf"), GPS unit identifier (ID corresponds to the Cofrin Center for Biodiversity's inventory), and start/end times/routes.

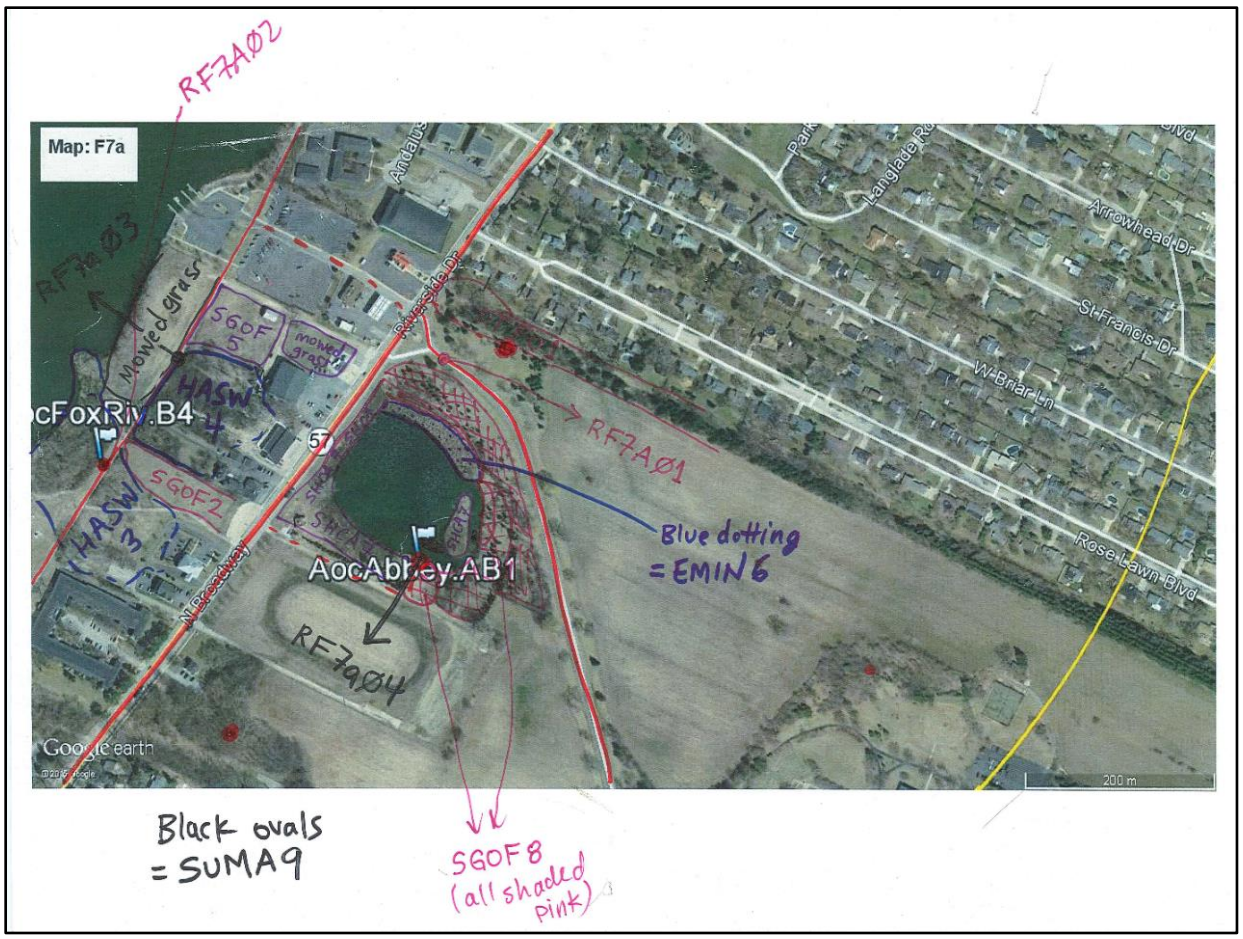

Figure 7. Sample of a completed habitat sub-region map (sub-region F7a; i.e., east side of Fox River in De Pere, Wisconsin by the St. Norbert Abbey) after a field team visited the suggested field locations (red dots) displaying habitat reference waypoints (e.g., RF7a04) and outlined habitat types (if able to do so) and associated map labels (e.g., SGOF8). The suggested field locations (red dots) and travel routes (red lines) were identified prior to the field work and indicate where vegetation appears to change. Anuran and bird point count locations (e.g., AocAbbey.AB1) were added to these maps and uploaded into field teams' GPS units for reference to easily identify accessible locations. The thick yellow arc indicates the 1 km buffer around the official LGB&FR AOC boundary. Sub-region maps were created in Google Earth Pro using Google Earth satellite imagery (map data: Google; imagery date: 13 April 2015; access date: 2 July 2015).

Photo Documentation

At each location field crews visited and mapped habitat types, the photographer crew member took still, digital photographs of the plant communities near the habitat reference waypoints using high end digital cameras; however, new and different waypoints were established called photograph reference waypoints, which geotagged where each photograph was taken. Photograph reference points were named using a similar schematic starting with the letter "P" ("P" = photograph), followed by the sub-region map name (e.g., F7a, E1a), and ending with an incremental two-digit number (including padded zeros). For example, the first photograph reference waypoint taken somewhere in sub-region map W3a was called "PW3a01." Each photograph reference waypoint was marked on the photograph data form (Figure 6, Appendix 3) as well as the photograph file name (in field "Photo #" with associated file name prefix [e.g., "DSC_"]) and saved to the mapper/navigator's GPS unit. Note that photograph reference waypoints are <u>not</u> the same as the habitat reference waypoints despite being named similarly. Photograph waypoints geotagged locations photographs were taken, not necessarily where the

field crew leader identified the plant community (i.e., habitat reference waypoint). A compass bearing was taken at each marked photograph reference waypoint to clearly identify the habitat the photograph was documenting. In some cases, for example, the field crew may have been assessing habitat on a road or trail with different habitats on both sides of them; therefore, the compass bearing distinguishes those photographs to avoid confusion. On each photograph data form, field effort and general information were recorded at the top, including date, photographer (using a 4-letter code consisting of the first two letters of the first name and the first two letters of the last name; e.g., “ROHO” = “Robert Howe”), camera (model and identifier [e.g., model, inventory number]), GPS unit ID (ID corresponds to the Cofrin Center for Biodiversity’s inventory), and start/end times/routes.

Field Crew and Training

Including Howe, Wolf, and Giese, 18 field crew members (Table 2, Appendix 3) participated in this habitat mapping field effort. Wolf, Howe, and Giese first led a training for only the field crew leaders on 7 July 2015. Wolf and Howe gave an oral presentation to the crew leaders summarizing the names and descriptions of the main plant communities everyone is likely to encounter during habitat mapping in the LGB&FR AOC. They also highlighted the dominant plants that occur within each plant community as well as presented examples using photographs. After the office training, they took the crew leaders into the field (Point au Sable Nature Preserve) to practice correctly identifying plant communities as a group, estimating the intensity of invasive plants, and filling out the data forms to ensure that all crew leaders were calibrated together. On 8 July 2015, Howe, Wolf, and Giese next led a second training to the remaining students who participated in the habitat mapping effort, including the field crew leaders. In the office they first reviewed the project and field methods of the habitat mapping, including a shortened review of the plant communities. Afterwards, they took the group out in the field (UW-Green Bay Cofrin Memorial Arboretum) to teach the students how to conduct the field work, including marking waypoints, taking photographs, and filling out data forms. Howe, Wolf, and Giese used and saved the data they collected near the lakeshore on the Arboretum as a group as a part of the habitat mapping effort.

Table 2. List of field crew members and their associated roles who participated in the July 2015 habitat field mapping effort. Field crew leaders identified and mapped major plant community types and filled out habitat data forms (Figure 5, Appendix 3) at each site location. Mappers/navigators navigated to each location as well as took habitat and photograph reference waypoints using GPS units. Photographers took still photographs of plant communities identified near habitat reference waypoints and filled out the accompanying photograph data form (Figure 6, Appendix 3). Eight field crew members participated as both the mapper/navigator and photographer.

Name	Role
Erin Giese	field crew leader
Jay Horn	field crew leader
Samantha Nellis	field crew leader
Nick Walton	field crew leader
Bobbie Webster	field crew leader
Amy Wolf	field crew leader
Cody Becker	mapper/navigator
Stephanie Beilke	mapper/navigator
Michael Stiefvater	mapper/navigator
Katie Crews	photographer
Robert Howe	photographer; mapper/navigator
Jason Brabant	photographer; mapper/navigator
Becky DeValk	photographer; mapper/navigator
Abigail Englebert	photographer; mapper/navigator
Chelsea Gunther	photographer; mapper/navigator
Matt Peter	photographer; mapper/navigator
Tom Prestby	photographer; mapper/navigator
Jesse Weinzinger	photographer; mapper/navigator

Six field crew members were field crew leaders, eight participated as both a photographer and mapper/navigator, three crew members participated as the mapper/navigator only, and one crew member played the role of photographer only. Most of the habitat mapping was completed on 13-15 July 2015, though two crews finished mapping remaining areas on 16-17 July 2015. On 30 July 2015, one team operated a small motorized boat to map plant communities along the shorelines of the west and east shorelines. The boat operator was certified by the state of Wisconsin to operate motorized boats, while the others passed the Paddle Sports Safety Course (http://www.boaterexam.com/paddling/), which teaches safety in using canoes, kayaks, and paddleboards. To ensure that all field teams were calibrated and recording data similarly (in terms of habitat assignments and invasive species estimates), Howe, Wolf, and Giese mixed up the field crew members between the first (13 July 2015) and second (14 July 2015) full work days. Meaning, they reassigned one or two field crew members from one team on the first day with a different team on the second day. After the first and second days, field crews also reconvened in

the office after field work to discuss and resolve any issues or questions that arose while collecting data. This further ensured that teams were collecting information in the same manner across teams.

Field Data Management and Archiving

Giese designed a system to have crew members back up his or her team's data that were collected in the field that day, including geospatial data (GPS unit) and digital photographs, immediately at the end of each field work day. She trained and provided instructions on how to organize the information properly to individual students and staff. Photographs and geospatial coordinates (saved as .gpx) were saved in individual folders and file names labeled with the team's field crew leader's 4-letter name code (e.g., "AMWO" = "Amy Wolf") and 8-digit calendar date of download ("14 JUL 2015" = "20150714"). Wolf and Giese scanned all data sheets and maps either at the end of a field work day or the next day as back-up copies. Implementing these strict data back-up procedures ensured no data were lost. All habitat and photograph reference waypoints (n = 612) are shown in Figure 8 (Appendix 3).

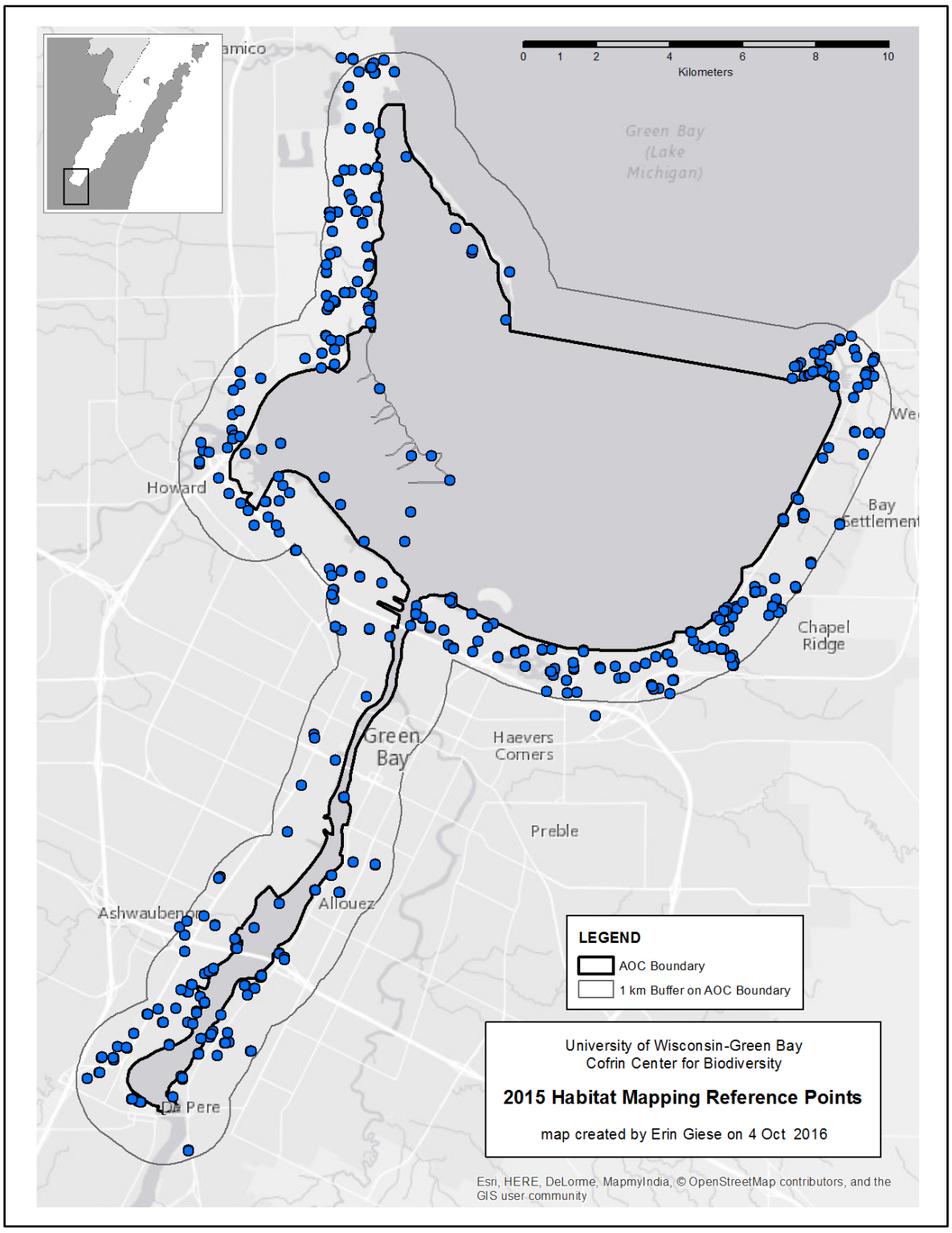

Figure 8. Reference habitat and photograph waypoints (n = 612; 278 habitat waypoints and 334 photograph waypoints) that were visited by field crews to map the main plant communities and document these habitats with digital photographs in July 2015. Habitat and photograph waypoints were displayed using the same symbol because they overlap. They are located close to or within 1 km of shoreline at Lake Michigan/Green Bay high water level of 177.2 m AMSL in the Lower Green Bay and Fox River Area of Concern (AOC) in Wisconsin. Points collected outside the 1 km buffer were used to identify plant communities located within the buffer. Basemap sources include Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community. Map created in ArcGIS 10.3.1 (Environmental Systems Research Institute 2015).

Photograph Processing

After the field season, UW-Green Bay undergraduate student, Sahara Tanner, used MS Photo Gallery to conduct minor edits to the photographs taken of plant community types as needed. For example, some photographs were either underexposed (too dark) or overexposed (too bright); therefore, the student performed minor adjustments using the “Adjust exposure” option in MS Photo Gallery including adjusting brightness or contrast. In most cases, photographs were edited using minor brightness adjustments; however, sometimes the image’s contrast was adjusted to bring out the original image. In all cases, the integrity and reality of the photograph were maintained so that the original or realistic colors of the plant community were not lost or greatly modified. Reference habitat photographs that were geotagged and documented on the field data forms were separated from general field work photographs (e.g., documenting an unidentified plant, picture of a bird, picture of field crew), which were filed into separate folders. The reference habitat photographs and the data that correspond to them (e.g., habitat type, dominant plants) were organized by UW-Green Bay undergraduate student, Jordan Marty, under the guidance of Michael Stiefvater and Giese.

Data Entry

After the field season, the habitat and photograph data were double entered into MS Excel spreadsheets created by Giese that employed data validation techniques to minimize data entry error (see “Data Management” for more details on data entry). Two undergraduate students, Sahara Tanner and Jeremiah Shrovnal, comprised the first entry; graduate student, Chelsea Gunther, constituted the second entry. Gunther compared the two entries of each data set and gave Giese these two first draft data sets. Giese spent significant time editing, auditing, and correcting additional errors and issues with the data sets, including comparing the collected waypoints saved as .gpx files against the list of waypoints entered from the habitat and photograph data sheets. Corrections were made as needed. Giese wrote accompanying metadata and produced two final, high quality data sets.