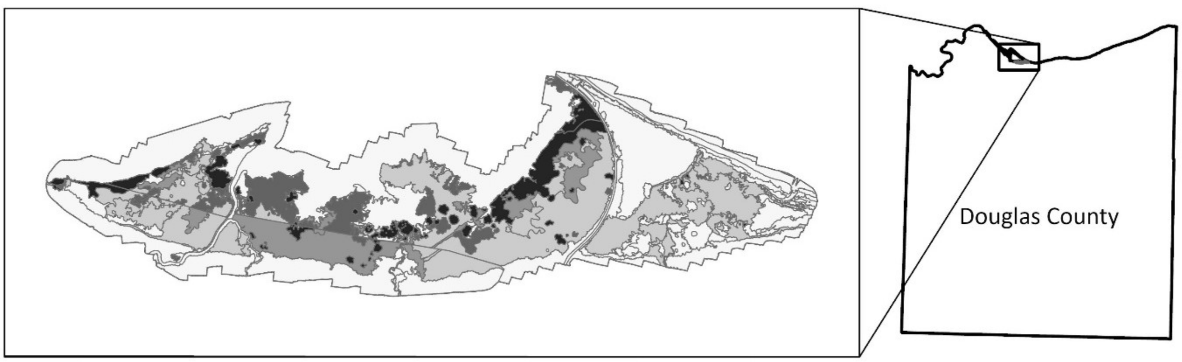
# Implementing Invasive Species Management in Coastal Wetlands Along Lake Superior

## EDRR II Drone Analysis Addendum: Task #1

# Summary Report

March 26th, 2021




*Drone analysis of cattail (Typha sp.) population density in the Allouez Bay southern wetland complex.*

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**Executive Summary/Introduction:**

Freshwater coastal wetlands provide water storage and filtration, nesting and hunting habitat for fish, birds, mammals, amphibians, and macroinvertebrates, and maintain an efficient storage of carbon. With approximately 55,035 acres on Lake Superior, this project is focusing on sampling 250 acres of a coastal wetland along Wisconsin's south shore of Lake Superior, known as Allouez Bay. Allouez Bay is located within the Lower St. Louis River Estuary in a large bay near the original outlet of the St. Louis River separated from Lake Superior by a natural sand spit, Wisconsin Point. The coastal wetland complex consists of a wet meadow with wire sedges, lake sedge, leatherleaf, and sweet gale; an emergent marsh with bur-reeds, arrowhead, bulrushes, and wild rice; and floating aquatic mats with pond weeds, lily pads, and bladderworts. Allouez Bay is still representative of somewhat intact coastal wetland plant communities and has suffered some invasions from non-native species, though it remains in overall good health. Determining the impact of invasive plant species on coastal wetland health is a priority for the Wisconsin Department of Natural Resources (WDNR). Due to the vast acreages and difficult terrain within Great Lakes coastal wetlands, vegetation sampling is both time consuming and costly. Allouez Bay was selected as a pilot location for testing new drone technology to determine if the technology was suitable for detecting invasive species, specifically invasive cattail. This pilot investigation was conducted in an area of Allouez Bay where on-going studies observed invasive cattail to be spreading rapidly within the habitat.

Drone technology has become more capable and affordable with the advent of increased manufacturing, high energy dense batteries, and highly advanced light weight computers. It has the potential to map buckthorn in the fall after leaf-off, purple loosestrife in August while flowering, as well as other rapidly colonizing species such as cattail and phragmites. Concurrent with an early detection and rapid response program - designed to search for invasive species through rapid ground surveying of a small percentage of each complex - drone imagery is being tested as a possible new tool for invasive species detection and baseline mapping. Allouez Bay was selected as a pilot area to understand if it was possible to identify existing patches of cattail from other vegetation within the floating mat and emergent marsh. At this time, Allouez Bay is also the focus of a collaborative effort among multiple organizations to restore certain habitats and create a standard for future restorations within the St. Louis River Estuary. If the use of drones is proven effective, it could increase efficiencies in surveying and documenting ubiquitous populations of invasive species and help understand trends of a population's extent.

**Problem Definition/Background:**

Early detection efforts require experienced and skilled botanists who can identify all species present and use intuition in locating species of interest along search paths. Pre-determined search paths are often informed by complex algorithms that enable more data to assist in the planning stage of the surveys; however, deviating from those paths is sometimes necessary when field conditions are different than expected. Since large areas of wetland cannot feasibly be surveyed on foot within short periods of time, capturing the larger populations of invasive species with drone technology would allow for a more economical method of documenting those existing populations and monitoring them over time. This is true of cattail in Allouez Bay and if successful could be used to survey buckthorn in Lost Creek and native phragmites (*Phragmites australis ssp. americanus)* populations which are exhibiting invasive characteristics within Bark Bay, Sioux River, and Port Wing of Bayfield County. Drone assistance would provide a more comprehensive picture of a complex and have the potential to inform land managers of the direction to take when assessing the threat posed by established populations of “common” invasive species in Wisconsin’s sensitive coastal wetland ecosystems.

**Objectives:**

Aerial imagery acquired from the Wisconsin DNR was utilized from composite drone photography of the wetland complex located in the southern part of Allouez Bay (Superior, WI). Imagery was visually interpreted for population of cattail (*Typha* sp.) and categorized into cover classes. For quality assurance, a review of 10% total area for both the polygons and associated cover classes was analyzed for accuracy. Project deliverables listed below:

- Map cattail populations with cover class specified (% cattail within each polygon)
- Conduct quality control analysis (minimum of 10% by second research specialist)
- Submit ArcMap geo referenced shapefile electronically to WDNR
- Submit a report (2-page) describing the objectives, methods, results and brief discussion
- Attend coordination meetings (2) and communicate with project lead from WDNR as needed

**Methods:**

Aerial images of the Allouez Bay wetland complex were sourced from the Wisconsin Department of Natural Resources. Two georeferenced TIFF files named AllouezBay312feet20200830 and AllouezBay312feetSouth20200904 were used in the analysis. The first file AllouezBay312feet20200830, made up 77% of the area and contained the northern and eastern extent of the imaged area. The second file AllouezBay312feetSouth20200904 made up the remaining 33% of the imaged area’s southwest corner. The provided images had a misalignment in their georeferenced location. To compensate the produced analysis was split and an additional field was added to reference the analysis’ source image. The mapped cattail analysis was split into two field categories based on associated imagery, North and South (*Appendix A. Table 2*).

A polygon was created to encompass the entire photographed area. The boundary of the raster files was used, which was clipped based on the empty cells found on the edges of the georeferenced images. Due to the misalignment, a single boundary cut was used to separate the two images. A new field “img_source” was added to cite the north or south image used to analyze each future polygon (*Appendix A. Table 2*).

The polygon was initially clipped based on noticeable, large scale features within the base imagery. A field was added to the polygon’s table to document rudimentary land cover classes, “type”. For example, the roadway separating the East and West wetland complex was easily distinguished from the surrounding habitat and given the land cover class of “Developed”. Additionally, habitats that fell outside any wetland designation were separated out by the perceived difference in vegetation composition. Finally, tree canopy was designated into its own polygon because it prevented analysis of the understory, including the target species, cattail.

Aquatic macrophytes and open water were labeled “aquatic” and had a predictable boundary along the wetland shoreline. The remaining polygons were divided, and priority was given to large, often monoculture patches of cattail. Three different designations were used to classify plant community type: marsh, meadow, and shrub scrub.

Polygons containing at least some cattail were further divided to accommodate variation in cattail density. Population cover was broken down into five classes in 25% increments, ranging from 0% to 100% (Appendix A, Table 2). The field “cattail_cov” assigned cover classes to individual polygons. These cover classes were used to denote the estimated foliage cover of cattail in a given polygon. Polygons with the type “canopy” were estimated at a cover class of 0% cattail since analysis of canopy could not distinguish cattail under full tree cover.

**Results:**

A total of 474.18 acres were analyzed from the WDNR provided drone imagery. Of that, 222.73 acres (47%) were estimated to contain cattail. Individual polygons were highly variable in size and ranged from 2 $ft^2$ to 88.02 acres. Based on preliminary results of the drone imagery mapping, the highest density ≤ 100 (76-100% cover) populations existed along the shorelines of the floating mat and emergent marsh, represented by 116 polygons and totaling 29.86 acres. The lowest density populations ≤ 25 (1-25% cover) were mapped within the sedge meadow from the upland tree line and transitioned into higher density cattail cover as they progressed closer to the open water. There were 68 polygons with a total of 126.95 acres in the 1-25% class. Several small patches of cattail were mapped with high density cattail in the sedge mat, not adjacent to water. The wetland on the east side of the road has remained relatively unimpacted from cattail, with very few populations of high-density cattail present. See Table 1 below for further breakdown of other cover classes.

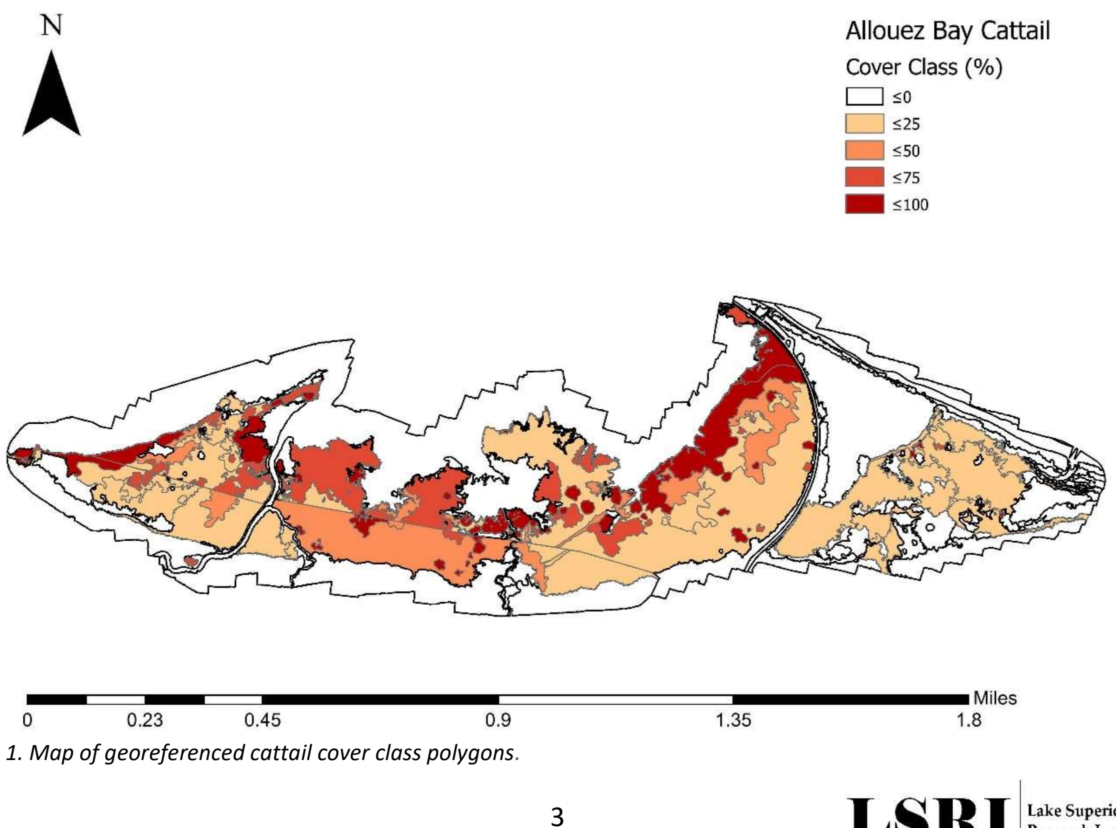


*Figure 1. Map of georeferenced cattail cover class polygons.*

*Table 1. Summary of cattail (Typha sp.) cover classes by total number of acres and polygon count per cover class.*

| Typha Cover Class (%) | Number of Polygons | Acres |
|---|---|---|
| ≤ 0 | 381 | 251.45 |
| ≤ 25 | 68 | 126.95 |
| ≤ 50 | 29 | 37.61 |
| ≤ 75 | 39 | 28.31 |
| ≤ 100 | 116 | 29.86 |

**Discussion:**

Allouez Bay is actively used by duck hunters, boaters and fisherman while remaining a part of the Duluth/Superior shipping harbor. The bay's importance extended to migratory birds as well as resident waterfowl and geese, the latter of which are reported to have increased in recent decades. Considered to be in relatively healthy condition when compared to other industrialized fresh water shores, Allouez Bay has experienced pollution and is included in Wisconsin's St. Louis River Area of Concern. Past and recent surveys have shown that invasive plant species are reducing habitat quality in the bay. This drone project is LSRI's first to attempt to determine if cattail can be detected using high resolution aerial imagery obtained from drone composite photography.

In order to rapidly integrate and analyze the imagery, a basic yet effective method of visually interpreting a targeted population was used. Using themethods described above, cattails could be differentiated from other vegetation in the provided imagery, particularly in populations of higher density (51-100% cover) and where those were adjacent to open water. Densities cover classes less than 50% tended to represent scattered populations. This type of scattered growth habit is more indicative of native cattail (*Typha latifolia*) than invasive cattail (*Typha angustifolia & T. X glauca*), which often forms large colonial mats.

Most often denser population of cattails could be differentiated using pixel color. Individual pixel color is definitely affected by species density, but it may also help in identifying species of cattail (native v. invasive). Although this type of analysis is outside the scope of this project, the ground-truthing survey may help us better understand if there is a relationship at all between pixel color and species.

Smaller pockets of difficult-to-detect interspersed populations are still troubling since cattail appears to have the ability to outcompete other vegetation in what seems to be an otherwise intact complex. However, with lower densities of cattail (below 25%) our confidence in the detection level fell, and it became very difficult to discern a pioneering population of just a few stems.

In wetland communities with only a few stems of cattail scattered throughout, difficulties arose in defining those within a given polygon. Therefore, these small populations were lumped with a larger polygon and may give the impression that cattail density is uniform within the polygon's total expanse. This results in very few polygons being completely devoid of cattail. A ground-truthing phase will also help determine how to handle small, scattered populations in the drone analysis.

Ground truthing schedule for the summer of 2021 will allow LSRI researchers to compare field survey densities with drone analysis densities to better understand if cattail density can accurately be classed and if the classes used in this study should be adjusted. It may also reveal the least number of stems (or percent cover) that can be accurately detected within each unique community type.

Ground surveys may also allow us to understand if certain growing conditions (i.e., level of inundation or community composition) affect detection accuracy. And if, for example, a modifier could be used for analyzing imagery in different areas of the wetland (i.e., adjacent to the water's edge or within a diverse vegetative mat).

This pilot study shows that mapping cattail populations from drone imagery will be beneficial for detecting large populations of invasive species in addition to tracking changes to the extent of the population. We believe that future flights of the same area will be able to show – at least overall – if cattail is spreading and at what rate. Comparing drone imagery with historical imagery could potentially reveal where invasion started and therefore, help understand which areas are most important to protect from further invasion and which areas may be more susceptible to future invasion.

Aerial image analysis, while not entirely new, will see exponential growth into many fields as technologies allow for more frequent flights and high-resolution imaging. This baseline visual interpretation may help inform more rapid methods of vegetation population analysis. As the total number of imaged habitats increases, new methods of analysis will be required to meet with this higher demand. Having high quality data and analysis to compare to a more rapid analysis technique will in turn create better methods overall.

**Appendix A:**

*Table 2. Metadata table for Cattail Cover Shape File (AllouezBayCattail_LSRI2021).*

| Field Name | Description | Unique Identifiers | Unique Identifier Descriptions |
|---|---|---|---|
| FID | Standard unique value | None | - |
| ID | Unused identifier | None | - |
| type | Estimated land cover | Aquatic | Open water and aquatic macrophyte communities. |
| | | Back Dune | Upland community progressing way from the lake behind the dune |
| | | Canopy | Tree canopy |
| | | Developed | Permanent man-made structures |
| | | Dune | Sand dune and beach |
| | | Field | None forested upland. |
| | | Meadow | Wet meadow dominated by grasses or sedges |
| | | Marsh | Wetland community not dominated by woody vegetation |
| | | Shrub Scrub | Wetland community composed mainly of short woody vegetation |
| catail_cover | Cover classes of estimated cattail (*Typha* sp.) foliage coverage based on source imagery | 0 | Percent cover of cattail (*Typha* sp.) foliage. 0% |
| | | 25 | Percent cover of cattail (*Typha* sp.) foliage. 1 to 25% |
| | | 50 | Percent cover of cattail (*Typha* sp.) foliage. 26 to 50% |
| | | 75 | Percent cover of cattail (*Typha* sp.) foliage. 51 to 75% |
| | | 100 | Percent cover of cattail (*Typha* sp.) foliage. 76 to 100% |
| area_acre | Area of polygon, unit US acres | None | - |
| img_source | Reference source imagery | North | Source image file AllouezBay312feet20200830South |
| | | South | Source image file AllouezBay312feetSouth20200904 |

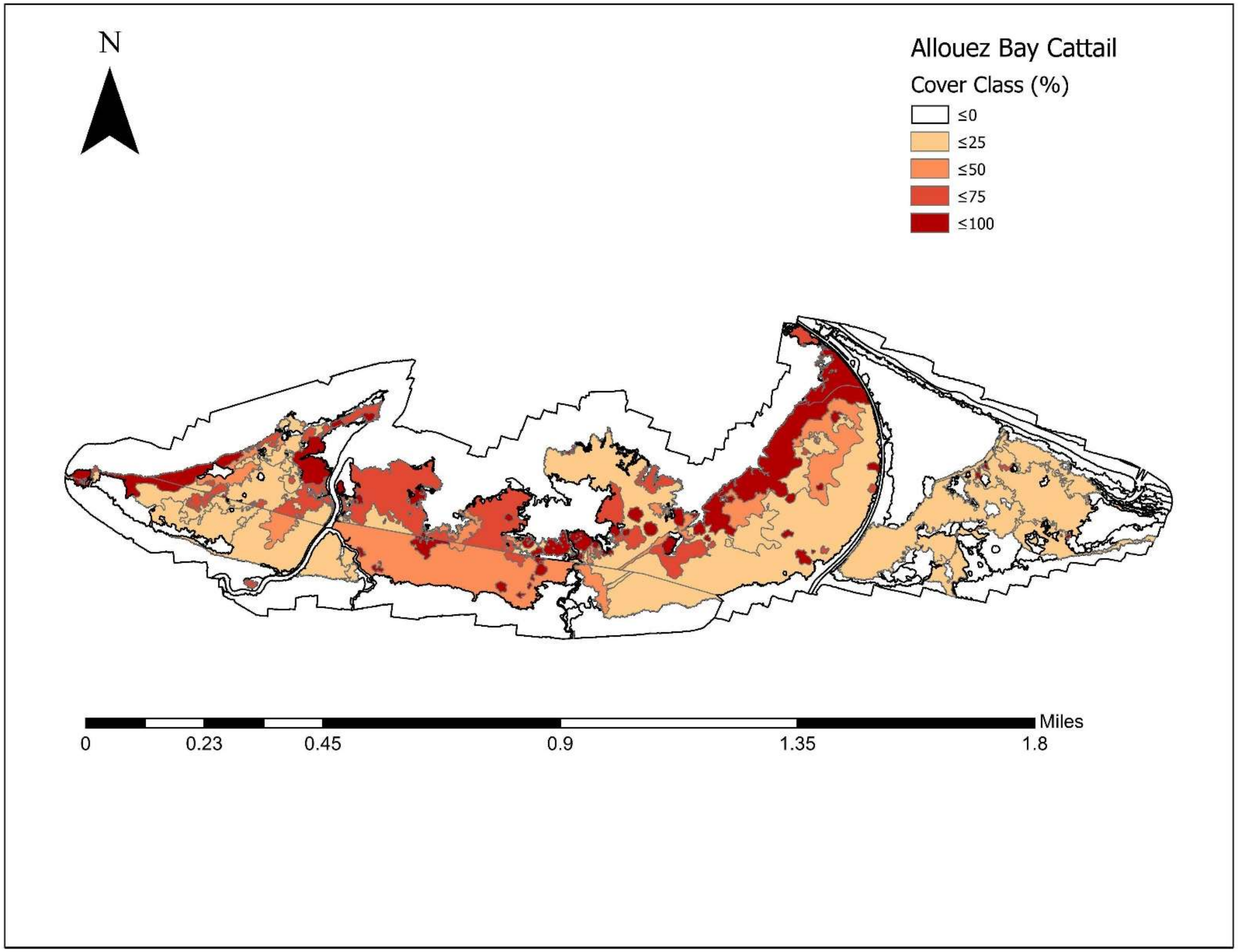


*Figure 2. Higher resolution of Figure 1, map of georeferenced cattail cover class polygons.*