5.5 Mapping Invasive *Phragmites* with Satellite Imaging Radar in the Coastal Great Lakes

**Introduction**

Throughout the past two centuries, the Great Lakes region has witnessed a variety of non-native (exotic) species permeate its boundaries. These species often remain unnoticed and are not detrimental to the habitat in which they reside. However, when these exotic species become established in a given ecosystem and begin to cause economic, human health, or environmental damage in that ecosystem, they are termed invasive (U.S. Environmental Protection Agency, 2009).

One species in particular, a fast-growing invasive reed, has begun to plague the Great Lakes region. The common reed, *Phragmites australis* (Figure 1), has recently been labeled an **extreme threat** to native ecosystems due to its aggressive ability to dominate a variety of ecosystems once introduced. There is a native species of *Phragmites* throughout the Great Lakes region; however, the invasive form is quickly displacing the native variety, as well as many other native types of vegetation. Invasive *Phragmites* is most prevalent in emergent wetlands throughout the Great Lakes region. This is due to rapid water level changes and the vast areas of exposed habitat. *Phragmites* can become well-established quickly because it propagates through underground rhizomes.

Within 10 km of the Great Lakes coastline, over 121,406 hectares (300,000 acres) of freshwater emergent wetlands exist. These areas, which are home to many endangered and threatened fish and wildlife species, are at risk of being invaded by dense stands of *Phragmites*. Once established, *Phragmites* is difficult to control and requires repeated applications of herbicide, cutting and/or burning. This regimen, however effective, also kills any native vegetation that remains after the initial invasion of *Phragmites*.

Currently there is no comprehensive map or documentation of the status/extent of *Phragmites* infestation in the Great Lakes region. There are, however, numerous environmental organizations attempting to locate and record the location of *Phragmites*, but their surveys usually cover small areas of land. A comprehensive map is needed to aid in effective management and control efforts across the Great Lakes basin.

Using a combination of dual polarization, L-band (23 cm wavelength), ALOS PALSAR data, as well as field documentation, known and potential *Phragmites* monoculture locations are being identified for the entire United States Great Lakes coastal basin within 10 km of shore (Figure 2). This is the first U.S. basin-wide map to be produced on this invasive plant. Advanced Land Observing Satellite (ALOS) is a Japanese satellite platform, which has an L-band (23 cm wavelength) imaging radar sensor, PALSAR, on board. Imaging radar (Synthetic Aperture Radar or SAR) is an active system that interacts differently...
with vegetative ecosystems based upon biomass, structure and moisture characteristics. It can also detect phenological changes in vegetation biomass and flood conditions which aid in wetland classification. Since L-band imaging radars are sensitive to differences in plant biomass and inundation patterns, it allows for the extraction of these tall (up to 5 m or 16.6 ft), high-density, high-biomass *Phragmites* stands.

**Methods**

**Field Data Collection**

In the spring of 2010, a large field campaign was initiated to collect information on wetland type at randomly selected locations within coastal emergent wetlands of the entire US coastal Great Lakes basin. To match the minimum mapping unit (mmu) of the satellite data (0.2 hectare or 0.5 acre) all sites were sampled to this extent. Both training data and validation data, which were reserved for accuracy assessments of the map products, were collected from May to October of 2010 and 2011. For each basin, a spatial query was performed in order to generate random points for validation data collection. The National Wetlands Inventory (NWI) emergent class was merged with the Great Lakes Coastal Wetlands geomorphology map (http://www.glc.org/wetlands/inventory.html) to include all wetlands from the coast to 10 km inland in the selection. Using a NOAA Sampling Design Tool in ArcGIS, points were randomly generated within these emergent wetlands for field collection. Field collection occurred throughout the summer of 2010 and will continue through the fall of 2011. To date, 1047 sites (693 validation and 354 training sites) have been visited and extensively documented. This field work, conducted by graduate and undergraduate students, helps to provide accurate identification of ecosystem types when classifying the PALSAR imagery and accurate validation information upon the completion of the mapping process. Information gathered at the 0.2 hectare (0.5 acre) sites such as, ecotype, percent cover, dominant species, and water level are used to help train the mapping algorithm.

**Mapping**

PALSAR data spanning three seasons (spring, summer, and fall) were utilized to aid in discriminating various other wetland cover types from *Phragmites*. More than 200, 70 x 70 km, 20 meter resolution PALSAR images were acquired over the U.S. side of the Great Lakes basin for mapping. The fine beam dual polarization (FBD) PALSAR data provide two polarizations: horizontal send and receive (HH polarization) and horizontal send and vertical receive (HV polarization). The HV polarization is more sensitive to variations in biomass across cover types while the HH polarization is most sensitive to inundation changes and interactions with the vegetation.

Each 70 x 70 km PALSAR area was mapped separately using field data and air photo comparison for training. The three season triplicats were used to improve discrimination of *Phragmites australis* by taking advantage of the phenological changes that occur in vegetation and inundation patterns over the seasons. Unlike many other
herbaceous species, the dead stalks of *Phragmites* remain standing in spring and exhibit different patterns of radar scattering than most other herbaceous wetland cover types over the seasons.

Mapping was conducted through maximum likelihood, unsupervised classification of the triplicats, followed by a series of clusterbusting masks in ERDAS IMAGINE to identify the *Phragmites*. Once the classification was complete, agricultural confusion pixels were filtered using NOAA C-CAP and Cropland Data Layer products in ArcGIS. These confusion classes often occur due to the effect of row structure on SAR backscatter. The classification maps were then run through the clump and eliminate model in ERDAS IMAGINE to group like-pixels and eliminate small groupings. Both of these steps helped to rid the final maps of small areas of confusion throughout the upland areas.

**Results**

Initial first run results were delivered to the U.S. Geological Survey (USGS) in the spring of 2011. Additional analyses and more field training data were collected in May and June of 2011 to improve the mapping. Final products have since been delivered for Lakes Ontario, Michigan and Erie with Huron expected to be completed by the end of October.

Large monotypic *Phragmites* stands were identified throughout the Great Lakes basin with the most dense and tallest stands found on the southwest shore of Lake Erie and the northern portion of Lake St. Clair, as seen in Figures 3 and 4, respectively. 9,500 hectares (23,475 acres) of *Phragmites* were identified within 10 km of the coast from Sandusky, Ohio to the north side of Lake St. Clair. Of the 1,047 field sites visited, over 31% of them had *Phragmites* presence at some level. Only Lake Erie has a completed accuracy assessment (Table 1) due to ongoing field collections for the other lake basins. For Lake Erie, the overall accuracy was 86%.

The completion of the mapping phase of the *Phragmites* distribution study is set for December 2011, at which point focus will shift completely to the ecological niche models and analysis of coastal wetlands and stream corridors that the USGS Great Lakes Science Center is conducting. The corridor network that provides the framework for vulnerability assessment is composed of NWI wetlands, NHD flow lines and water bodies, and coastal corridors based on simulated reduced lake level scenarios. An online map-based decision support tool hosted by the USGS Center for Integrated Data Analytics will allow depictions of current *Phragmites* distribution at user-defined scales, and a variety of approaches for assessing vulnerability to future invasions. The vulnerability assessment approaches available to users will be based on proximity to existing *Phragmites* populations, a habitat suitability index, or a cost-distance analysis that integrates these two concepts.
Invasive *Phragmites* treatment and control operations are underway across the Great Lakes region, most often through small operations limited in geographic extent. The Michigan departments of Environmental Quality and Natural Resources, in cooperation with the Great Lakes Commission, have been holding stakeholder meetings to develop a Strategic Framework for the Management and Control of Invasive *Phragmites* in Michigan (http://glc.org/ans/initiatives.html#phrag). It is through these regional and basin-wide scale mapping, monitoring, modeling and management efforts that such a widely distributed and problematic species as *Phragmites australis* can be controlled.

### Table 1. Lake Erie Invasive Phragmites Classification vs. 2010 Field Data: Phragmites > 90% cover, mmu ½ acre

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**Producer’s Accuracy** 88.00% 85.00% **Overall Accuracy: 86.15%**

### References


### Contact Information

Laura L. Bourgeau-Chavez, Michigan Tech Research Institute, Michigan Technological University
lchavez@mtu.edu

Martha L. Carlson Mazur, U.S. Geological Survey Great Lakes Science Center
mcarlsonmazur@usgs.gov