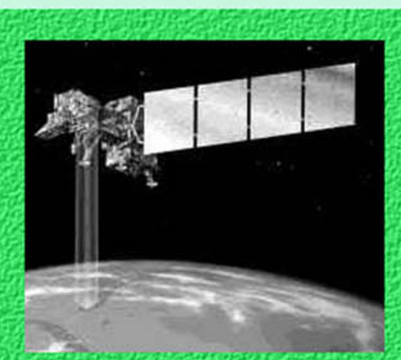
An Ecological Assessment of Invasive and Aggressive Plant Species in Coastal Wetlands of the Laurentian Great Lakes:

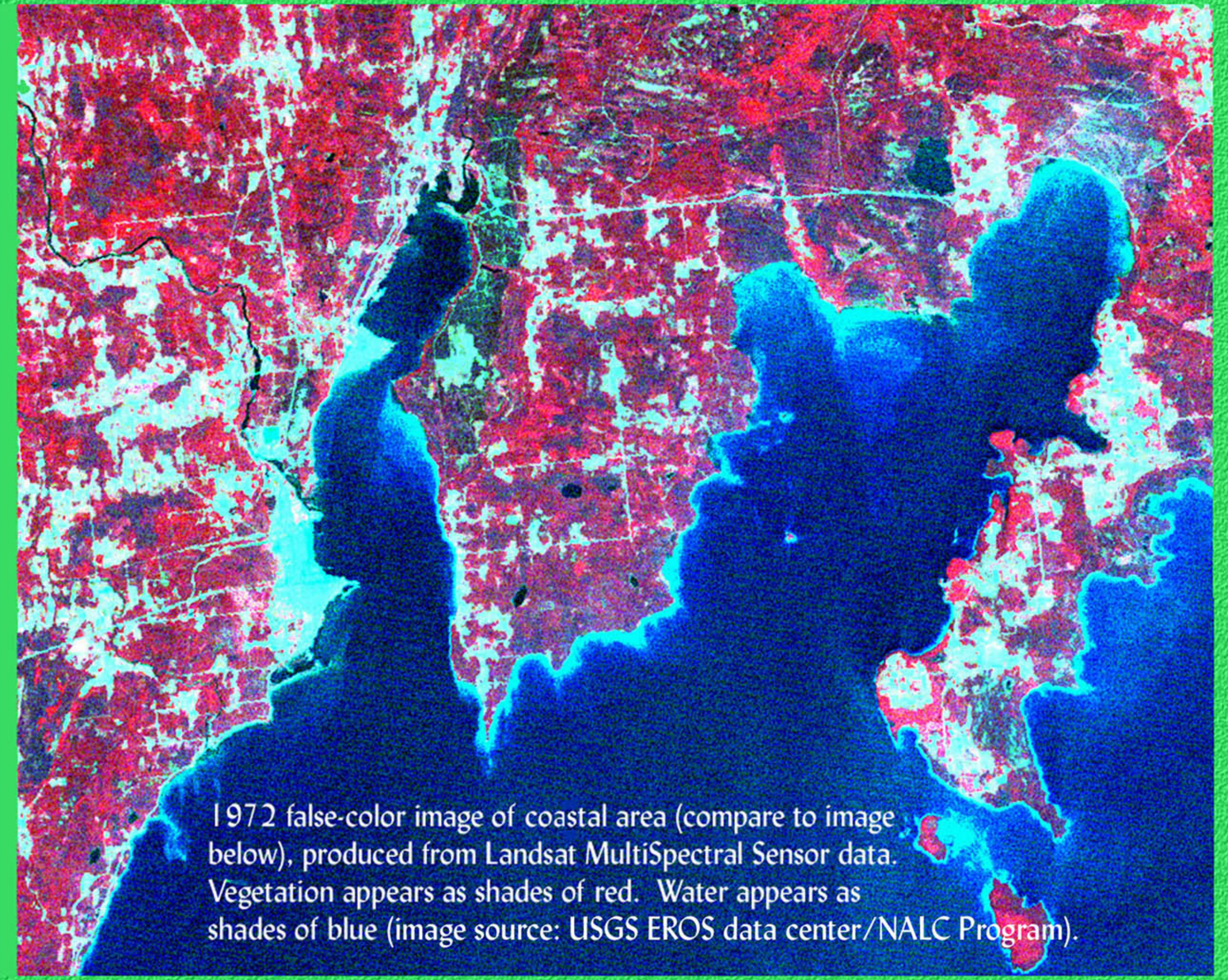
A Combined Field-Based and Remote-Sensing Approach



Spaceborne Sensors

PROJECT MAJOR DELIVERABLES

1) Project Report: "An Ecological Assessment of Invasive and Aggressive Plant Species in Coastal Wetlands of the Laurentian Great Lakes: A Combined Field-Based and Remote-Sensing Approach"
2) Refereed journal articles:
   - A - "Coastal wetlands detection in the Laurentian Great Lakes: a cross-sensor test"
   - B - "Identification of invasive and aggressive plant species in coastal wetlands of the Laurentian Great lakes: a cross-sensor test"
   - C - "The landscape-ecological relationships between land cover change and invasive and aggressive plant species in Great Lakes coastal wetlands (USA)"
3) Images/data from all wetland study sites
4) Historical land cover maps from 1970's - 2000's



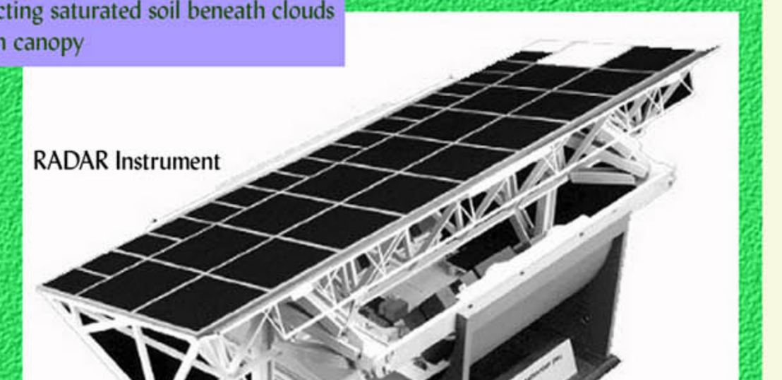
1972 false-color image of coastal area (compare to image below), produced from Landsat MultiSpectral Sensor data. Vegetation appears as shades of red. Water appears as shades of blue (image source: USGS EROS data center/NALC Program).

1992 false-color image of coastal area (compare to image above), produced from Landsat MultiSpectral Sensor data. Vegetation appears as shades of red. Water appears as shades of blue. Image contrast is a function of atmospheric conditions during data acquisition (image source: USGS EROS data center/NALC Program).

SELECTED SENSOR CHARACTERISTICS

Passive Sensor Type	Spectral Resolution	Spatial Resolution
MSS	Coarse	Coarse
TM	Coarse	Moderate
AVIRIS	Fine	Moderate
CV	Coarse	Fine to Coarse

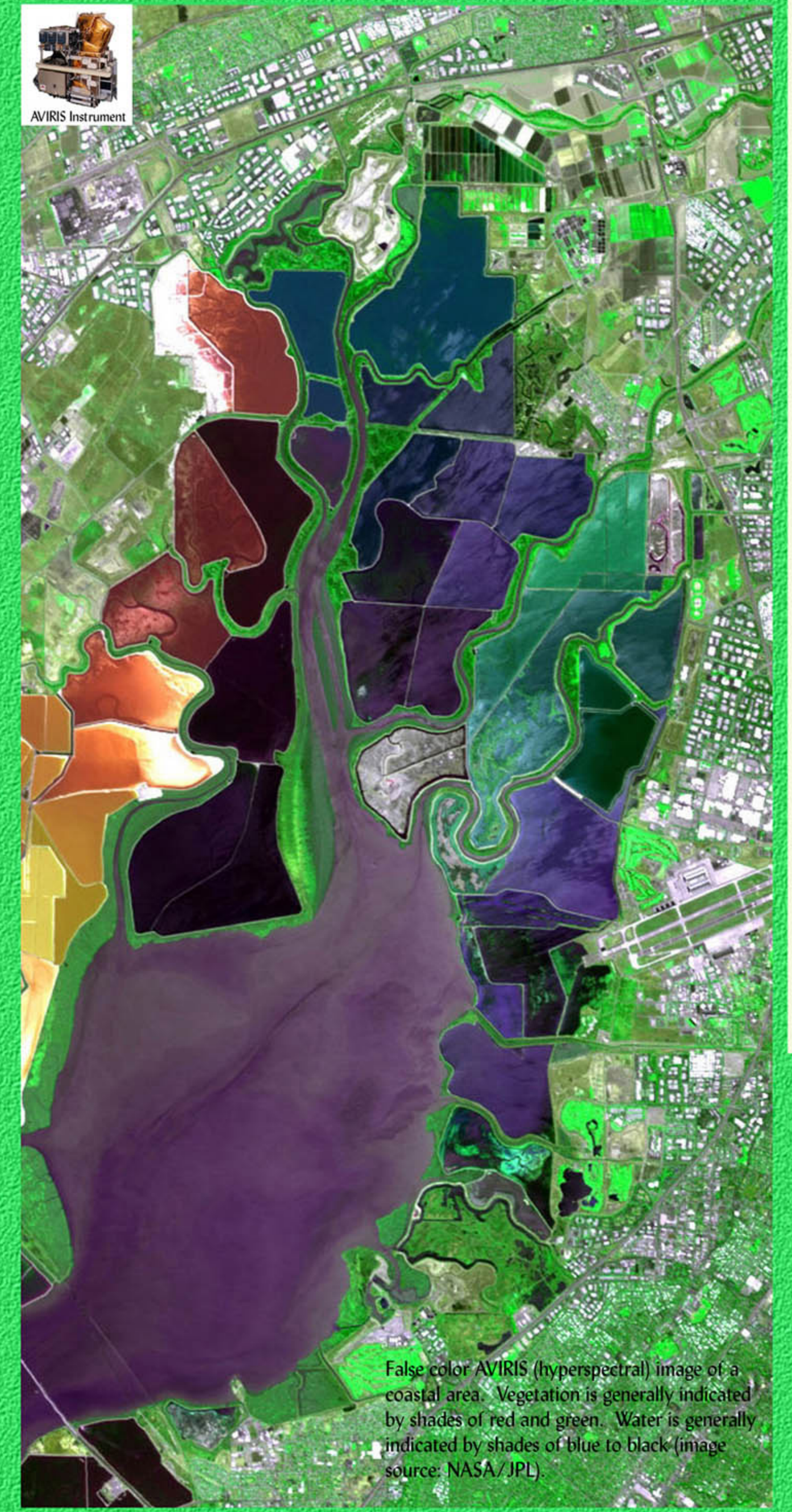
- RADAR is an active sensor that offers the unique capability of detecting saturated soil beneath clouds and the vegetation canopy



RADAR Instrument

False color RADAR image of a coastal area. Vegetation is indicated by shades of green, water and other lesser-vegetated areas are indicated by shades of blue (image source: RADARSAT).

Airborne Sensors



AVIRIS Instrument

False color AVIRIS (hyperspectral) image of a coastal area. Vegetation is generally indicated by shades of red and green. Water is generally indicated by shades of blue to black (image source: NASA/JPL).

PROJECT APPROACH & DESIGN

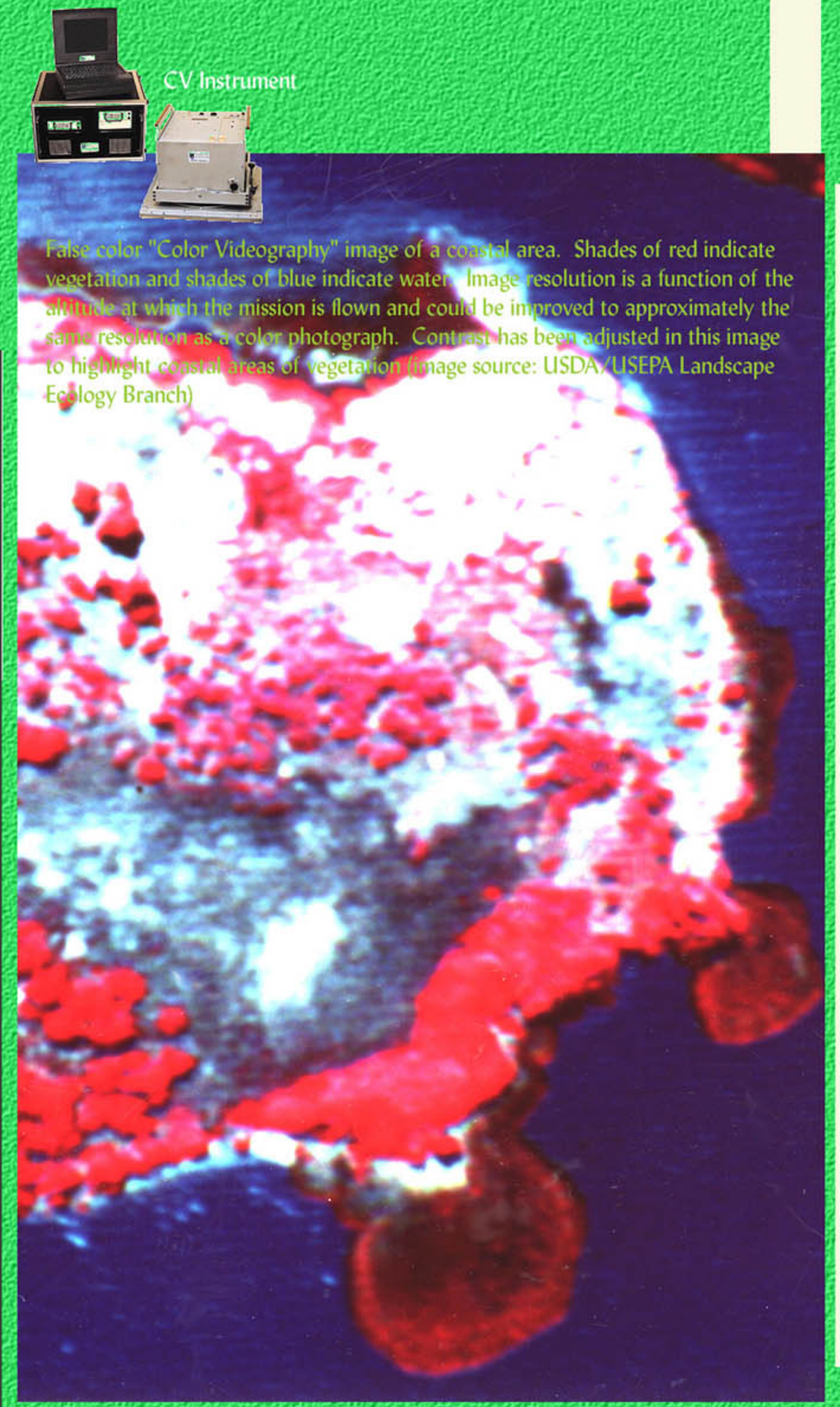
The approach of this study is to 1) determine which species are identifiable using remote sensing data, and by which sensor(s); 2) identify Great Lakes coastal wetlands that are dominated by each of the invasive or aggressive plant species; 3) establish a group of 'gradient test sites' that range from high to low dominance of each invasive or aggressive species, using the EMAP sampling strategy; 4) determine how historical land cover change among the 'gradient test sites' is related to the presence and the spatial extent of invasive or aggressive species. Note that, depending upon the outcome of the preliminary sensor/species studies, all of the species and sensors may not be required to complete step 4. Calibration of the remote sensing data will be accomplished by mapping the vegetation in coastal wetland plant communities that are known a priori to contain patches of either purple loosestrife, giant reed grass, or cattails. During vegetation sampling the field team will use a Global Positioning System (GPS) to delimit the boundary of invasive/aggressive species patches and use a hand-held spectrometer to calibrate the AVIRIS data from that summer. Within the patches dominated by the above species, standard cover estimates, stem density, and above-ground biomass measurements will be performed per traditional field methods. During the study, field data will also be used to test the efficacy of using CV, AVIRIS, TM, and/or RADAR sensor data for identifying the patches of invasive and aggressive plant species in coastal wetlands. Sensor accuracy assessments from the study will provide information about which sensor(s) are suitable to detect the invasive/aggressive species, and will be used to determine which type(s) of remote sensing data will be most useful to complete the site analyses. Each wetland will be assessed for the presence of invasive/aggressive species during summer sampling using information from the sensor comparison portion of the study. Ground-based sampling will be used to accuracy assess the wetland characteristics determined by remote sensing using the EMAP sampling strategy. North American Landscape Characterization (NALC) data from the 1970's to the 1990's (i.e., Landsat MultiSpectral Scanner data), along with the TM data collected during 2000's will be used to develop land cover maps. The land cover maps will be used to quantify 30 years of land cover change in the vicinity of the coastal wetlands studied. Multivariate statistics will be used to test for substantive relationships between land-cover change and the invasive/aggressive plant characteristics at wetland study sites (i.e., all appropriately sampled wetland study sites).

PROJECT DESCRIPTION - PURPOSE

The aquatic plant communities within coastal wetlands of the Laurentian Great Lakes are among the most biologically diverse and productive systems of the world. Coastal wetlands have also undergone a decline in biological diversity, in concert with an increase in the dominance of invasive (non-native) or aggressive plant species. Research suggests that invasive and aggressive plant species are affecting the ecological integrity of coastal wetlands, and that these changes may be related to changes in the frequency of landscape disturbance within a wetland or on the edges of wetlands. However, little is known about such ecological relationships in the Great Lakes, especially at the lake basin scale. The purpose of this study is to determine these landscape-scale ecological relationships by quantifying the extent and pattern of invasive/aggressive plant species and testing for substantive relationships with local landscape disturbance over the past 30 years. Remote sensing technologies offer a unique opportunity to measure the extent of these invasive and aggressive species over a large area. Our approach is to use ground-based vegetation sampling to calibrate remote sensing data, to develop spectral signatures of invasive/aggressive species that may then be used to address the ecological vulnerability of coastal wetlands. The outcome of this study will help managers target vulnerable coastal wetlands in need of restoration or protection, an important component of improving the water quality and ecological integrity of the Great Lakes Ecosystem.

PROJECT DESCRIPTION - RATIONALE & NEED

This project is the first step needed to identify the extent of wetlands being stressed by invasive and aggressive plant species. Depending on the resolution of the sensor of choice, the rate of invasion might be detectable with future data collection. If this project is successful in creating a remote sensing protocol capable of identifying the extent of these species occurrence, this protocol could be used for inland wetlands, as well as coastal wetlands. This project is supported by the management of the Great Lakes National Program Office, the Region 5 Wetlands group, and the Region 5 Critical Ecosystems Team. These offices have indicated that staff wetland scientists and ecologists are available to support the field component of this project. Both Great Lakes coastal wetlands and invasive species have been identified by managers and scientists within the international Great Lakes basin as important indicators of the ecological health of the Great Lakes basin. These discussions and proposed indicator identifications have occurred in the international forum of the State of the Lakes Ecosystem Conferences and are available at http://www.epa.gov/glnpo/solec/98 or http://www.cciw/ca/solec/intro.html



CV Instrument

PROJECT TIME-LINE

2001 Jan. - April	Initial team member meetings to develop sampling protocols, site selection, order site maps and aerial photographs, order available imagery, schedule overflights, preliminary site reviews with team members, ensure site access
2001 May - June	Testing of ground sampling and remote-sensing protocols
2001 July - Aug.	Field/remote-sensing data collection
2001 Sept. - Dec.	Processing of summer 2001 remote sensing data (CV, AVIRIS, RADAR), analysis of vegetation data and study site GPS data
2002 Jan. - April	2002 study site selection with team members, ensure site access, evaluate sampling protocols, begin processing NALC data (1970's - 1990's) for land-cover change analysis
2002 May - June	Refinement of sampling protocols
2002 July - August	Field/remote sensing data collection
2002 Sept. - Dec.	Processing of summer 2002 remote sensing data, analysis of field data
2003 Jan. - April	Sensor accuracy assessment using ground-based data, finish processing NALC data (1970's - 1990's) and 2000's TM data for land-cover change analysis
2003 May - June	Wetland site selection utilizing land-cover gradient strata criteria, prepare manuscripts for journal articles #1, #2
2003 July - Aug.	Field/remote-sensing data collection
2003 Sept. - Dec.	Final processing of remote sensing data, analysis of invasive/aggressive patch characteristics in context of land cover change, complete project report, develop manuscript for refereed journal article #3

Field Based Data Collection

PROJECT OBJECTIVES

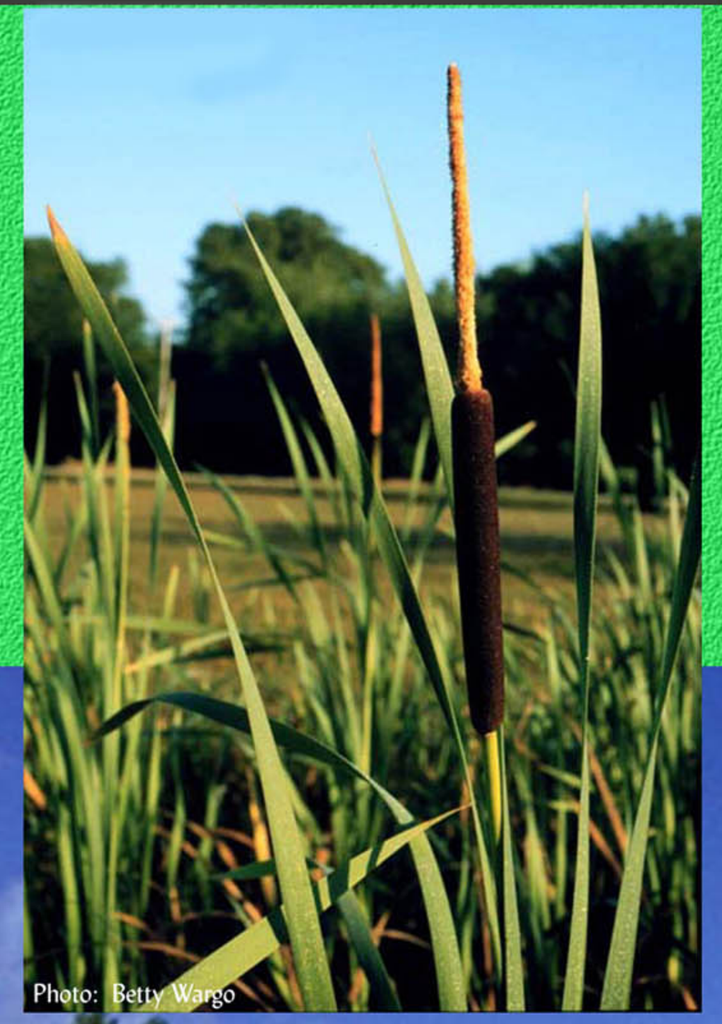
3 fundamental wetland detection questions will be addressed by the study:

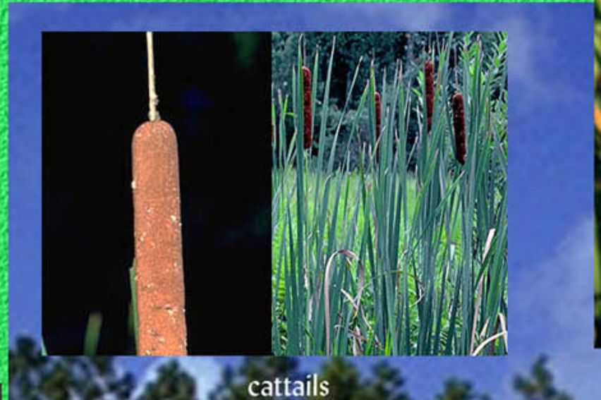
1. Can airborne color videography (CV) data, airborne visible infrared imaging spectrometer (AVIRIS) data, satellite thematic mapper (TM) data, and/or satellite RADAR data be used to accurately identify patches of purple loosestrife [*Lythrum salicaria* (L.)], giant reed grass [(*Phragmites australis* (Cav.) Steudel], and cattails *(Typha* spp.) in coastal wetlands?
2. Which sensor(s) is(are) most effective for identification of vegetation patches of the above species?
3. What is the detection accuracy of each sensor (or sensor combination), using ground-based plant community data as truth?

5 fundamental landscape ecology questions will be addressed by the study:

1. What is the range of landscape stress among coastal wetland study sites, as evidenced by historical land-cover change (early 1970's - 2000's)?
2. What are the ecological relationships between landscape stressor(s) and the extent of the invasive/aggressive plant species in Great Lakes coastal wetlands?
3. What coastal areas in the Great Lakes are the most threatened by invasive/aggressive plant species?
4. What is the areal extent of Great Lakes coastal wetlands being stressed by invasive plants?
5. Can this project serve as the baseline for measuring the rate of expansion of invasive plant species?

Spectroradiometer





cattails *Typha* spp.

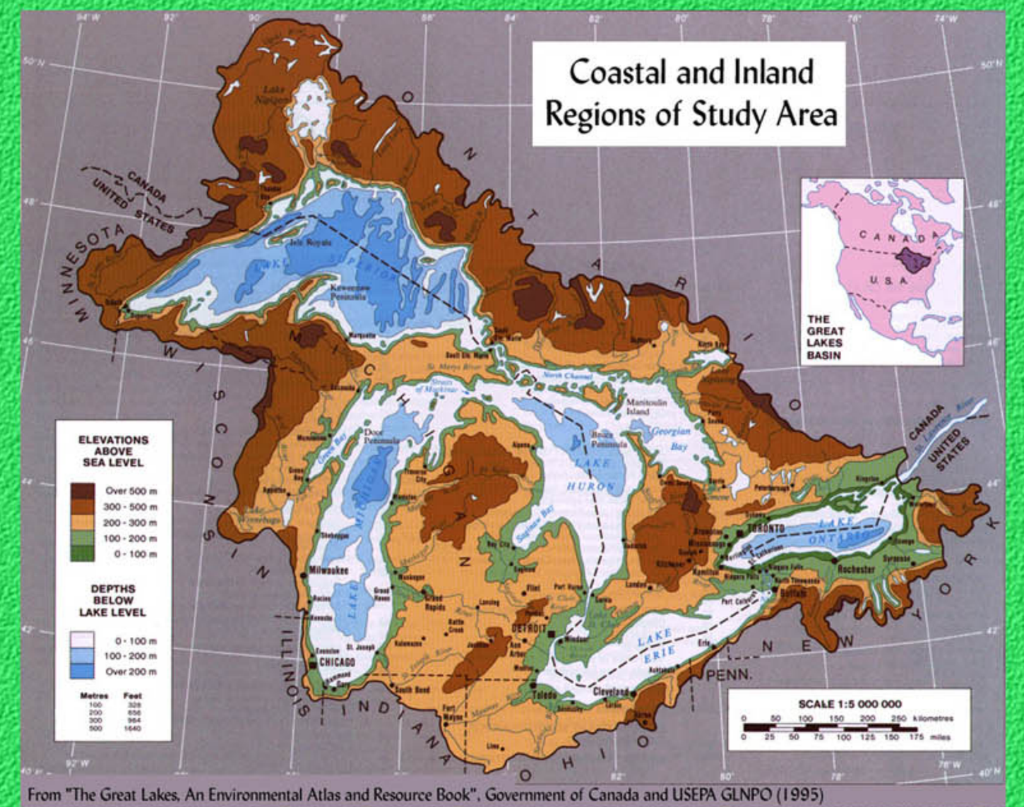
Photos: University of Florida Aquatic, Wetland and Invasive Plant Information Retrieval System. Inset from USDA Plants Database

giant reed grass *Phragmites australis* (Cav.) Steudel

Photos: Mary Moffett USEPA NHEERL. Inset from USDA Plants Database

CURRENT USEPA TEAM MEMBERS AND AFFILIATION

- NERL/ESD/Landscape Ecology Branch: Chad Cross, Donald Ebert, Curtis Edmonds, Daniel Heggem, K. Bruce Jones, Ricardo D. Lopez, John G. Lyon, Anne C. Neale
- EPIC: Terrence Slonecker, David Williams
- Great Lakes National Program Office: John Schneider
- NHEERL; David W. Bolgrien, Mary F. Moffett



purple loosestrife *Lythrum salicaria* (L.)

Photos: The Nature Conservancy. Inset from USDA Plants Database