



# Building the Coastal Spatial Data Infrastructure to Promote Hazard Resilience on the Great Lakes

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*University of Wisconsin Sea Grant Institute*

University Consortium for Geographic Information Science  
*Washington, DC*

*Thursday, February 4, 2010*

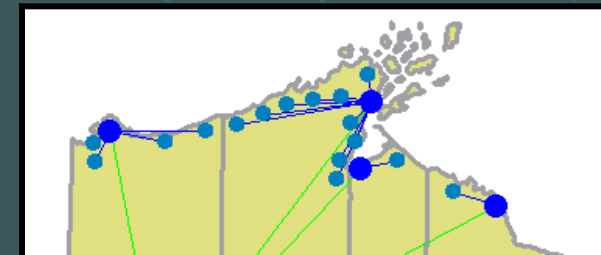
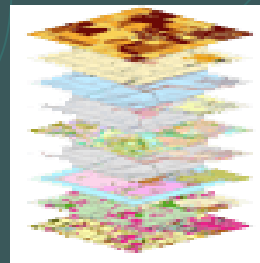
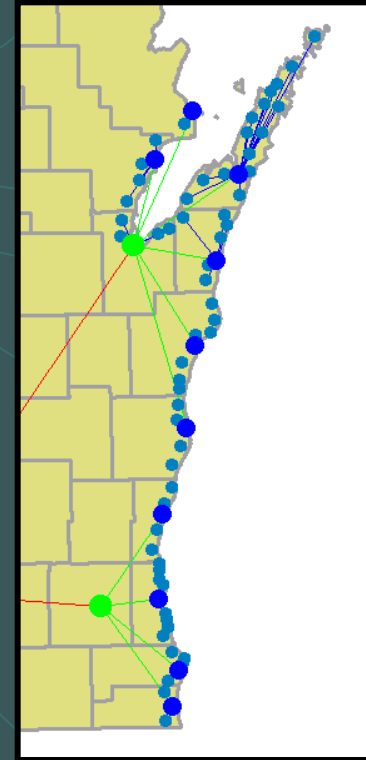


# Presentation Outline

- Wisconsin Coastal GIS Applications Project (1994-2009)
  - Lessons Learned from Four Coastal Hazards Projects
- Wisconsin Coastal Atlas (2010-?)
  - Transition
  - A Research Agenda for the WCA
  - The Role of the WCA in Addressing Coastal Hazards
- Promoting a Great Lakes Coastal Atlas Network

# WI Coastal GIS Applications Project

- The mission of the Wisconsin Coastal GIS Applications Project was to teach the application of GIS and related geospatial technologies to support sustainable use of Great Lakes coastal resources.
- The primary audience was local, regional, and state government professionals.
- A Sea Grant/LICGF partnership started in 1994.



# Wisconsin Coastal GIS Phases



**PHASE 1**  
GIS TEACHING  
MODELS

Shoreland  
Management

Coastal  
Erosion

Water  
Quality

Other  
Coastal Issues

**PHASE 2**  
COMPREHENSIVE  
COASTAL GIS

Data  
Discovery

Data  
Acquisition

Data  
Integration

Spatial  
Analysis

**PHASE 3**  
DYNAMIC AND  
DISTRIBUTED GIS

Web  
Mapping

Geospatial  
Interoperability

Catalog Services  
for the Web

Open  
Archives

**PHASE 4**  
VISUALIZATION


3D  
Visualization

Animation

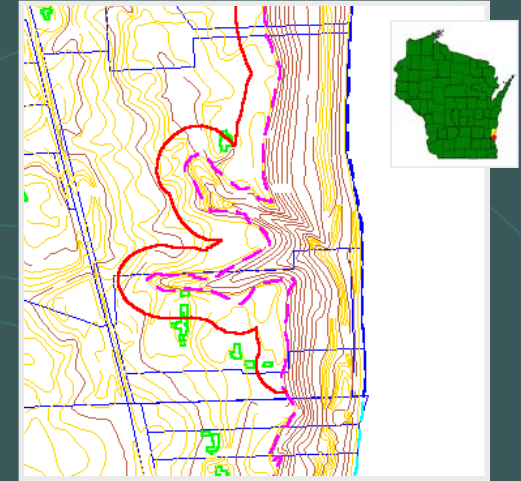
Data  
Visualization

Dashboard

# Wisconsin Coastal Hazards GIS Projects

- 
- Coastal GIS Training Exercises (95-98)
    - Funded by UW Sea Grant
  - Lake Michigan Potential Damages Study (98-00)
    - Funded by U.S. Army Corps of Engineers
  - Lake Superior Coastal Mapping Portal (03-05)
    - Funded by NOAA Coastal Services Center
  - Visualizing Coastal Erosion (03-06)
    - Funded by NASA IAGT and UW Sea Grant

# Coastal GIS "Teaching Models"



- Shoreland Management: Blue Lake, Oneida Co.
- Coastal Erosion: Town of Mosel, Sheboygan Co.
- Floodplain Management: Ozaukee Co.
- Urban Nonpoint Source Runoff: Marquette, MI

# Coastal GIS Training Lessons

- Over two dozen customized coastal GIS training courses were conducted, reaching over 250 people.
- GIS training using local data to study local issues was effective.
- Placing the coastal GIS exercises on the web spread benefits far beyond Wisconsin.
- As the Wisconsin Land Information Program matured, we saw the potential of building a “bottom-up GIS” using local spatial data to analyze coastal issues at a regional scale.

# Lake Michigan Potential Damages Study



As part of a Corps of Engineers' project to assess potential damage along Lake Michigan arising from varying lake levels, digital spatial data including parcels, base maps, orthophotos, land use/land cover, and soils were acquired and integrated for coastal counties and cities in Wisconsin.

# Assessed Value of the Coast


## Assessed Value of Parcels that Intersect the 1000' Jurisdiction Stipulated in State Shoreland Zoning Regulations (NR115)

Study Unit	Land Value	Improvement Value	Total Value
Marinette County <sup>1</sup>	33,230,950	73,506,600	\$ 106,737,550
Oconto County	\$ 17,715,600	\$ 20,575,100	\$ 38,290,700
Brown County	parcels as lines	parcels as lines	parcels as lines
Door County	\$ 993,054,820	\$ 908,584,360	\$ 1,901,639,180
Kewaunee County	\$ 32,691,220	\$ 70,433,430	\$ 103,124,650
Manitowoc County	no local hydro	no local hydro	no local hydro
City of Two Rivers	parcels as lines	parcels as lines	parcels as lines
City of Manitowoc	\$ 16,440,400	\$ 70,568,600	\$ 87,009,000
Sheboygan County	\$ 62,669,016	\$ 53,410,850	\$ 116,079,866
City of Sheboygan	parcels as lines	parcels as lines	parcels as lines
Ozaukee County	parcels as lines	parcels as lines	parcels as lines
Milwaukee County	no tax roll received	no tax roll received	no tax roll received
City of Milwaukee	parcels as lines	parcels as lines	parcels as lines
Racine County <sup>2</sup>	\$ 7,535,700	\$ 17,694,400	\$ 25,230,100
Kenosha County	\$ 75,868,100	\$ 176,258,500	\$ 252,126,600
<b>Totals</b>	<b>\$ 1,239,205,806</b>	<b>\$ 1,391,031,840</b>	<b>\$ 2,630,237,646</b>


<sup>1</sup>Figures for Marinette County include only the Town of Peshtigo.

<sup>2</sup>Gaps exist in the local hydro representation of the Lake Michigan shore.

# LMPDS Lessons

- 
- Data acquisition issues (mostly institutional)
  - Data integration issues (mostly technical)
  - Many of the same data sets are used repeatedly in different coastal analyses
  - When the project was finished, we had a valuable integrated data base
  - But... some coastal data quickly goes out of date and maintaining currency takes much effort and cost

# Lake Superior Coastal Mapping Portal




- The University of Wisconsin Sea Grant Institute and Land Information and Computer Graphics Facility worked to develop a “dynamic and distributed GIS” to support integrated coastal management along the Lake Superior coast of Wisconsin.

- The two-year project (June 2003 to June 2005) was funded by the NOAA Coastal Services Center.



# Project Tasks

- 
- The first task involves the development of web mapping sites for coastal data custodians, with a primary focus on county government land information.
  - The second task concerns the implementation of interoperable web mapping services that allow integration of disparate GIS data across political boundaries.
  - The third task was originally conceived to build upon a successful coastal GIS training program developed as part of the Coastal GIS Applications project to teach local government professional staff, citizens, and other coastal constituents how to use these integrated web mapping services to address coastal issues.

# Lake Superior Coastal Mapping Portal

**Wisconsin's Lake Superior Coastal Mapping Portal**

WLSCMP **Viewer** Web Mapping Resources Forum

Choose a Map Context

**TOOLS**

- WMS Layers
- Open Context
- Save Context
- OpenSLD
- Save SLD
- Map Size
- Print

**LEGEND**

- US States
- US Counties
- Canadian Provinces
- Great Lakes

Redraw Map

Ground Scale: 6965608

Choose a Quick Zoom Location

0 64 128 192 256 320 mi

Geographic Coordinate System: WGS84; EPSG Code 4326

Left: -94.66 Map Units: Degree

Right: -83.60 Dist:

Bottom: 41.49 Mouse X:

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WLSCMP **Viewer** Web Mapping Resources Forum

**TOOLS**

- WMS Layers
- Open Context
- Save Context
- OpenSLD
- Save SLD
- Map Size
- Print

**Choose a Map Context**

- Choose a Map Context
- Great Lakes: Weather
- Great Lakes: Sea Surface Temperature
- Great Lakes: Fire Detection
- Great Lakes: Misc. Layers
- Great Lakes: Base Map
- Lake Superior: Sea Surface Temperature
- Lake Superior: Recreation
- Lake Superior: Base Map
- Wisconsin: Parcels
- Wisconsin: Land Use-Land Cover
- Wisconsin: Imagery
- Wisconsin: Base Map
- WI Lake Superior Coast: Parcels
- WI Lake Superior Coast: Orthophotography
- WI Lake Superior Coast: Circle Tour
- WI Lake Superior Coast: Misc. Layers

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Left: -94.66 Map Units: Degree  
Right: -83.60 Dist:  
Bottom: 41.49 Mouse X: -87.71

Redraw Map

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WLSCMP Viewer Web Mapping Resources Forum

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- Map Size
- Print

**LEGEND**

- lightning
- GOES I/M Winds
- Current Tornado Warning
- Current Thunderstorm Warr
- Current Flash Flood Warni
- Current Special Marine W.
- Current Severe Weather W
- US RADAR
- Weather Warnings
- Texas Mesonet Radar Leger  
courtesy Texas A and M Uni  
(<http://mesonet.tamu.edu/>)
- US States
- US Counties
- Canadian Provinces

Ground Scale: 12081821

Choose a Quick Zoom Location

0 110 220 330 440 550 mi

Geographic Coordinate System: WGS84; EPSG Code 4326

Left: -93.68 Map Units: Degree  
Right: -74.50 Dist:  
Bottom: 38.37 Mouse X:

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites

http://maps.aqua.wisc.edu - Map Browser - Microsoft Internet Explorer provided by A...

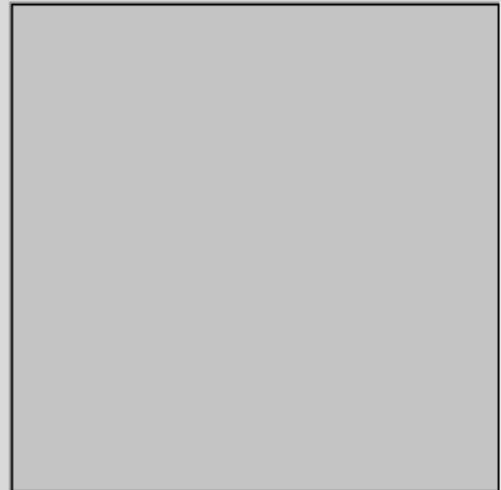
### Explore WMS Layers

**BROWSE:** Select a server in the list below to browse its WMS layers.  
**SEARCH:** Supply search terms in the field below and click the search button.  
 Select 'Search Results' from the list at any time to browse the found WMS layers.  
**ADD TO MAP:** Click the 'add to map' button at the bottom of this dialog to add the selected layer.

- Bayfield County: WMS Test \*\*
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- Bay Lake RPC: Sheboygan Land Use
- Iron County: WMS
- UW LIGF: Sheboygan Land Use Tes
- SCO: DNR Services
- SCO: DOA Services
- SCO: DOT Services
- UW ERSC: Latest GOES (28May06 21
- UW ERSC: Weather Warnings (29Ma
- UW ERSC: Current Fires
- UW ERSC: Wisconsin Lake Clarity
- UW Sea Grant: LS Circle Tour WMS
- US Census Bureau: TIGER Test \*\*\*
- FEMA: Flood Hazards**
- Iowa Mesonet: RADAR
- NASA JPL: POET Test \*\*\*
- NASA JPL: WMS
- Microsoft TerraServer: WMS
- NOAA: ENC Test \*\*\*
- NOAA: NOSA
- SEACCOOS: In Situ
- SEACCOOS: Remote Sensing
- SEACCOOS: WMS
- USFS: Fire Maps Test \*\*
- USFWS: Wetlands Test \*
- USGS EROS: Reference
- USGS: National Map Test \*\*\*
- USGS: NHD-Hydro Test \*\*\*
- USGS: NLCD-Land Cover
- USGS: Weather Warnings

Servers

Search



**Abstract:** Select a layer.

+ Add Layer    X Close


### LEGEND

- Parcels - Bayfield County, Wisconsin
- Parcels -- Iron County WI
- US States
- US Counties
- Canadian Provinces
- Great Lakes

Redraw Map

0 mi

# LSCMP Lessons

- 
- While the LSCMP served as an early testbed showing the potential of integrating web mapping services in Wisconsin, it suffered from slow performance and maintenance issues.
  - The Chameleon interface proved to be poorly suited to maintain a functional catalog of interoperable web mapping services.
  - We needed to put more thought into how we presented interoperable web mapping services to support decision-making.

Lake Superior Coastal Mapping Portal  
<http://maps.aqua.wisc.edu/lscmp/>

# Visualizing Coastal Erosion on the Great Lakes

- Information collected about coastal processes is often very technical in nature and difficult for coastal landowners to understand.
- This project integrates animation, aerial photography, pictures, charts, and text to help the public better understand coastal processes and the need for development setbacks.



## Bluff Erosion Visualization

introduction

erosion cycle

erosion factors

3d animation

stable slope angle

building setbacks

Photo by: Mike Swenson

next ▶

# Bluff Erosion Visualization

## Bluff Erosion Cycle

[introduction](#)[erosion cycle](#)[erosion factors](#)[3d animation](#)[stable slope angle](#)[building setbacks](#)[read more](#)[about](#)

While not always visible, the bluffs are continuously changing due to erosion. Years and even decades can pass without any major loss, and then in one large event (see picture below), a section of bluff-top 50-feet deep and 100-feet wide can fall into the lake.



High (>100 ft), complex bluff that failed in the early 1990s by a large deep-seated slump north of Milwaukee, Wisconsin, on the western shore of Lake Michigan.

Bluff erosion and failure, in the form of slumps, can potentially occur anytime the bluff is unstable. As the bluff becomes steeper the bluff will become more unstable. This cycle of bluff failure and

### Cycle of Bluff Failure and Erosion

◀ back next ▶



High bluffs (over 100 ft high) are typical in this region and are composed of clayey till and lake sediment.

Bluffs of this type, called "cohesive bluffs" are prone to infrequent, large scale (150-200 ft wide), deep-seated slumps.

# Bluff Erosion Visualization

3d Animation

- introduction
- erosion cycle
- erosion factors
- 3d animation
- stable slope angle
- building setbacks
- read more
- about

## Bluff Erosion Animation



### Bluff Features

- Bluff Top
- Bluff Toe
- Profile Line

### Building Setback - 75'

- Setback Top
- Setback Toe

### Compare 1956 to 2000

- Bluff Top
- Setback Top
- Bluff Toe
- Setback Toe

### Bluff Slope

- Slope Angle 1956
- Slope Angle 2000

1956 1960 1965 1970 1975 1980 1985 1990 1995 2000

◀ 1956 ■ stop ▶ play 2000 ▶

You Are Here

Plan View

Profile View



"you are here"

This animation was created to simulate how the natural erosion

Watch as small and large "slumps" occur in the animation. In the

The animation is viewed from a perspective just south of the Concordia University campus, looking north - see the

### Setback Components

At least four factors should be considered when estimating a safe setback distance:

1. useful life of structure
2. recession rate
3. stable slope angle
4. relocation room

A well-constructed building might have a useful life of 70 to 100 years. A new home too close may have to be moved to save the structure. The setback distance based on this factor varies depending on local regulations.

The bluff toe determines the starting point for measuring a stable slope. As the toe recedes the stable slope angle distance will push the bluff top landward as well. The toe recession rate for our area is 106-ft over 44-years or almost 2.5-ft per year. This would equal about 121-ft over a 50-year period.

The stable slope angle was discussed previously, so the last factor to consider is making sure enough room remains for equipment to relocate the building.



The bluff material for the area in the image above consists generally of glacial till (cohesive soils) and averages about 113-ft high (greater than 30-m). The current slope in this area measures 24-degrees.

### Calculate a setback

Setbacks are calculated using:

1. useful life of structure
2. toe recession rate
3. stable slope angle distance

Use the calculation tool below to enter these factors and determine different building setback distances.

#### Simple Bluff

##### 1.) Structure Life

Local Regulation (ft)

##### 2.) Stable Slope Angle

Bluff Height (ft)

Current Bluff Angle (deg.)

Stable Bluff Angle (deg.)

Stable Angle Setback (ft)

##### 3.) Recession

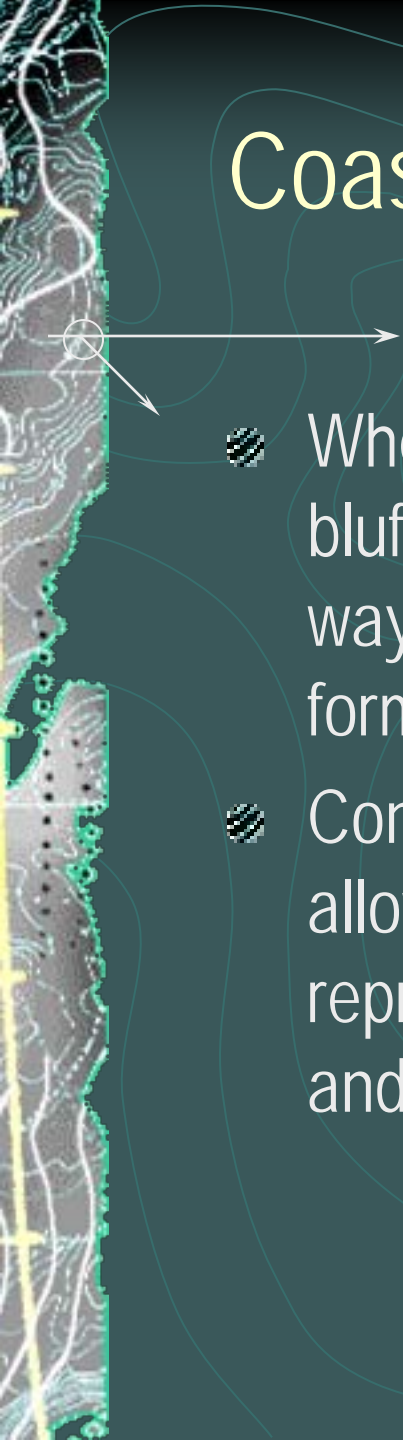
Recession Rate (ft/yr)

Recession Setback: 50yrs (ft)

Total Setback Distance (ft)

Experiment with different values and determine stable slope angles for various types of bluffs with different heights.

# Coastal Visualization Lessons

- 
- When coastal landowners see the 3D animations of bluff erosion, they understand coastal processes in a way that scientists can't describe solely through formulas and charts.
  - Conversely, the 3D animations also help scientists by allowing them to revise their theories. This "knowledge representation process" can help scientists build better and more useful representations of coastal change.

Visualizing Coastal Erosion on the Great Lakes  
<http://www.geography.wisc.edu/coastal/>



# The Transition from Coastal GIS Applications to a Coastal Web Atlas

- In recent years, it became clear that it was time to move beyond a successful campus research and outreach project and build a broader platform for collaboration with numerous stakeholders to discover, access, integrate, and utilize coastal geospatial data in Wisconsin.
- International Coastal Atlas Network panel at Coastal Zone '07 in Portland, OR.
  - A coastal web atlas integrated many of the projects we worked on since 1994.
  - The ICAN coastal erosion use case was relevant to issues faced by the Wisconsin Coastal Hazards Work Group.



# Coastal Web Atlas Defined

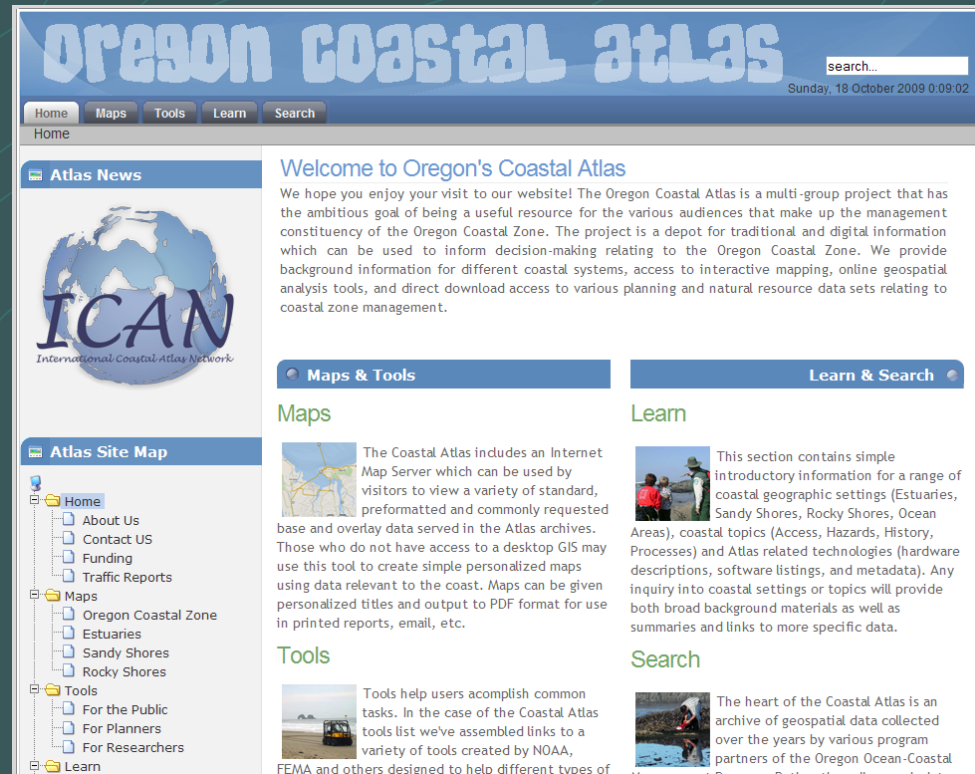
- A Coastal Web Atlas is a collection of digital maps and datasets with supplementary tables, illustrations, and information that systematically illustrate the coast, oftentimes with cartographic and decision-support tools, and all of which are accessible via the Internet.

-- *O'Dea et al., 2007*

- Or, more simply, a coastal geoportal built to share.

# Oregon Coastal Atlas

- The atlas has been a resounding success.
- It now serves more than 3,500 data sets and received about 2.5 million hits in 2008.
- The map interface has become a common framework for discussing coastal management issues.



The screenshot shows the Oregon Coastal Atlas website. The header features the title "OREGON COASTAL ATLAS" in large, stylized blue letters, with a search bar and the date "Sunday, 18 October 2009 0:09:02". Below the header is a navigation menu with buttons for "Home", "Maps", "Tools", "Learn", and "Search". The main content area is divided into several sections:

- Atlas News:** Features a globe icon and the text "ICAN International Coastal Atlas Network".
- Atlas Site Map:** A tree view showing the website's structure, including "Home", "About Us", "Contact US", "Funding", "Traffic Reports", "Maps", "Tools", and "Learn".
- Welcome to Oregon's Coastal Atlas:** A paragraph explaining the project's goal and the types of information available.
- Maps & Tools:** A section titled "Maps" with a small map icon and text describing the Internet Map Server and its capabilities.
- Learn & Search:** Two sub-sections: "Learn" with a photo of people on a beach and text about introductory information, and "Search" with a photo of a person in a boat and text about the geospatial data archive.

Oregon Coastal Atlas  
<http://www.coastalatlus.net/>



# Wisconsin Coastal Atlas

● The Wisconsin Coastal Atlas (WCA) is a two-year research project funded by the UW Sea Grant starting in February 2010


- Goal 1: The WCA will serve as the portal to geospatial data for the Great Lakes coasts of Wisconsin
- Goal 2: The WCA will promote the development of a spatial data infrastructure for the Great Lakes coasts of Wisconsin through methods for cataloging, archiving, and semantic integration



# Wisconsin Coastal Atlas – Portal Objectives

- Design and evaluate the WCA using a formalized development process
  - Develop a LOGIC model template for coastal web atlases
- Develop the web portal interface drawing on experience from Oregon
  - Initial focus on implementing the maps and search components for coastal hazards
- Develop the web mapping interfaces for the WCA
  - Explore and evaluate the range of web mapping technologies
  - Promote strong cartographic design for web mapping

# Wisconsin Coastal Atlas – SDI Objectives

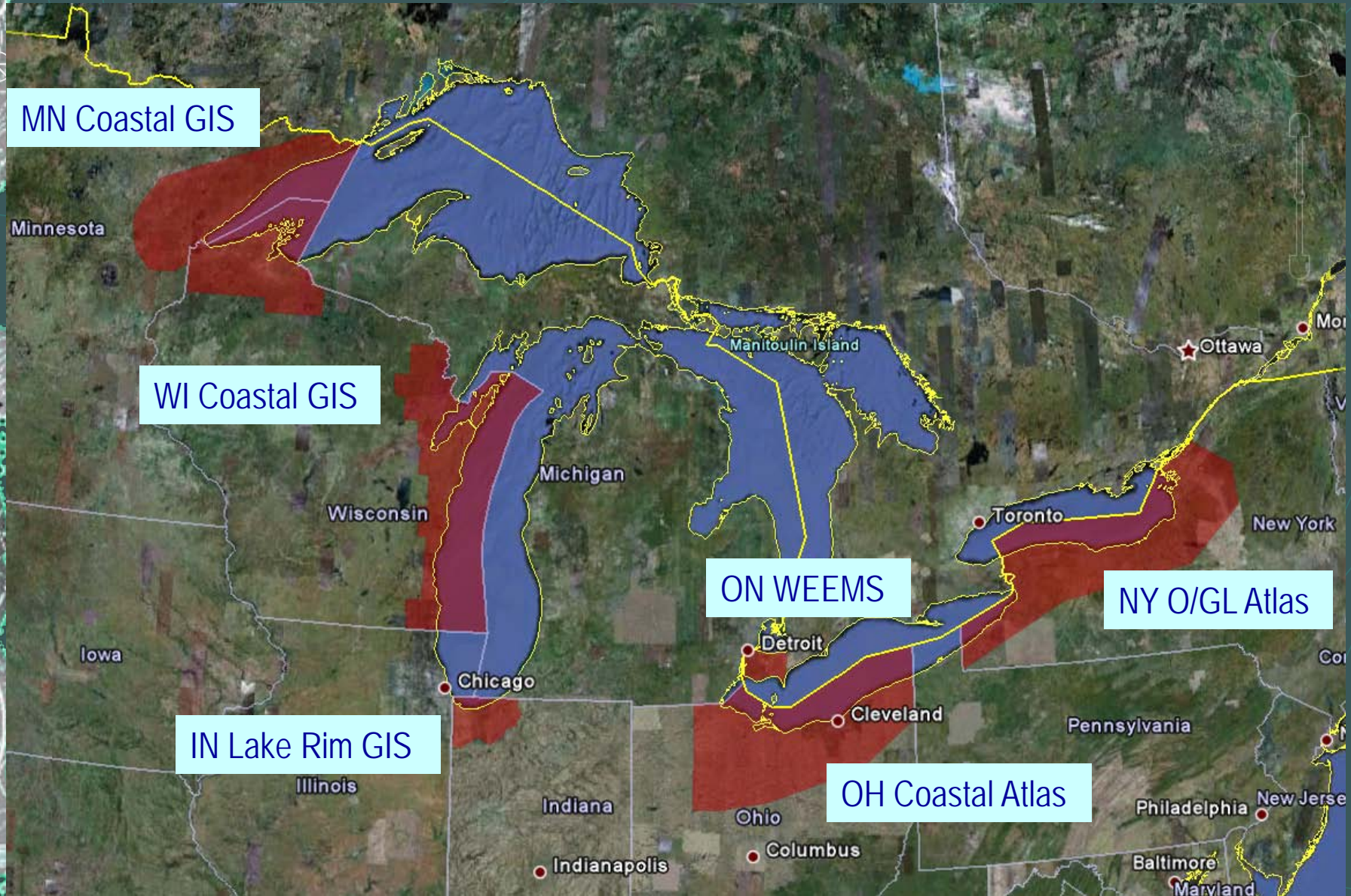
- 
- Implement a geospatial data catalog with concurrent archiving capabilities.
    - Explore the issues facing creation of a domain spatial data infrastructure
    - Development of effective methods for archive of digital geospatial data will help resolve a critical problem facing local data custodians
  - Apply ontology tools to promote semantic mediation of local government spatial data sets to conduct spatial analyses of coastal issues at a regional scale
  - Develop a local coastal erosion ontology in Wisconsin that will be mapped to the ICAN global coastal erosion ontology



# Coastal Hazards/Planning Tools

- The WCA project will be synchronized with a NOAA Coastal Management Fellow starting in August 2010 who will build a Great Lakes Spatial Decision Support Toolbox.
- Develop a framework to evaluate coastal spatial decision support tools. Evaluate and promote existing d-s tools.
- Build spatial decision support tools that leverage the WCA
  - Coastal Hazards (shoreline recession and oblique photo viewer)
  - Coastal Resilience (based on concepts in Timothy Beatley's new book on Planning for Coastal Resilience)
  - Comprehensive Plan Implementation (influenced by Philip Berke's research on improving the effectiveness of plan implementation)

# Great Lakes Coastal GIS/Coastal Atlases





# Great Lakes Coastal Atlas Network

- Enhance existing Great Lakes web mapping sites based on principles embraced by ICAN
- Promote a “bottom-up” approach to Great Lakes GIS that strengthens existing efforts
  - Great Lakes Information Network GIS, GLIN Labs
  - Great Lakes Regional Data Exchange (RDX)
  - Great Lakes Observing System (GLOS)
- Rethink the existing Great Lakes Environmental Atlas (website last updated in 1995)
- Develop the data infrastructure need to assess the progress of the Great Lakes Restoration Initiative.



# Promoting Regional Coastal Atlas Networks

- Develop robust use cases for linked coastal web atlases
  - Coastal Hazards, Marine and Coastal Spatial Planning
- Provide technical assistance to make existing coastal web mapping sites fully interoperable
- Explore how coastal web atlases relate to national efforts such as the Digital Coast
- Support regional coordination of coastal atlases
  - West Coast Coastal Atlas Workshop (Seattle, WA - April 2009)
  - ICAN-Americas (Madison, WI – September 2010)

# Questions?

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*<http://maps.aqua.wisc.edu/>*

*<http://www.seagrant.wisc.edu/gis/>*

Water is the most critical resource issue of our lifetime  
and our children's lifetime.

The health of our waters is the principal measure  
of how we live on the land.

*-Luna Leopold*