Title: Developing a Shared Vision for Coastal Conservation in Western Lake Erie[1]

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Introduction:

The coastal ecosystems of the western Lake Erie basin (WLEB) – including the nearshore, coastal wetlands, islands, coastal terrestrial systems, tributaries, and the Detroit River – support regionally and globally significant biodiversity (Pearsall et al. 2012). These ecosystems also provide multiple services including world-renowned fishing, hunting, and migratory bird-watching opportunities, many of which contribute important revenues to the region (Allan et al. 2015). Despite these natural assets, the WLEB has been severely degraded due to the effects of high human population densities, intensive agriculture, and significant shoreline hardening (Allan et al. 2013, Allan et al. 2015). Anthropogenic impacts have degraded natural habitat and water quality, reduced native plant and wildlife populations, and diminished many ecological services. There is a resounding call to prioritize conservation action in the Great Lakes (Great Lakes Interagency Task Force 2014). Conservation actions will need to meet measurable ecological goals and sustain the multiple nature-based activities that contribute positively to the region's coastal communities and their economies. Since it is impractical to manage the entire 150-mile (240 km) length of the coastal region, conservation practitioners must understand which stretches of the coast are the highest priority for conservation activities that benefit both ecological systems and people.

In developing a shared conservation vision for the coastal area of the WLEB, our primary objective was to develop a spatially-explicit conservation plan that identifies optimal locations for conservation and restoration actions to meet ecological goals while maintaining or enhancing human well-being values at the lowest financial or social cost. We adopted ecological conservation targets from the Lake Erie Biodiversity Conservation Strategy (LEBCS; Pearsall et al. 2012), and then developed a process for integrating human well-being values into biodiversity conservation planning that can serve as a model for other areas. Second, we employed data not typically used in conservation planning and developed an innovative approach to incorporating social values, which will benefit and complement priority-setting efforts across regional conservation, planning and business sectors. Finally, we examined the influence of human well-being values on the conservation plan in terms of locations of priority areas and the total area and cost required to meet goals established in the LEBCS. The mapped outputs of this

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work comprise the Western Lake Erie Coastal Conservation Vision (WLECCV). The WLECCV benefitted from the input of managers and other partners in Ontario, Michigan, and Ohio, and the process is now being expanded by the Upper Midwest/Great Lakes Landscape Conservation Cooperative (LCC) to cover the US side of the St. Clair – Detroit River System and Saginaw Bay. We hope to expand this approach into adjacent coastal areas of Ontario and Ohio as well.

Methods:

Our project area includes the Detroit River, the entire nearshore of the WLEB (i.e., the waters of the western Basin), and its coastal area up to 25 km inland from the shoreline, as defined in the Lake Erie Biodiversity Conservation Strategy (LEBCS; Pearsall et al. 2012) (Figure 1).

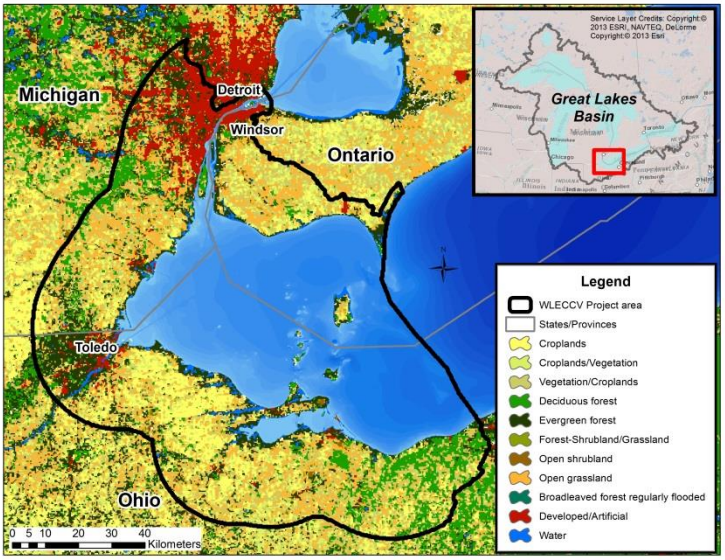

Figure 1. Scope of the Western Lake Erie Coastal Conservation Vision (WLECCV).

Within this area, we utilized the spatial conservation planning software Marxan with Zones (Watts et al. 2009, hereafter "MarxanZ") to identify areas for conservation actions that benefit ecological and human well-being goals. MarxanZ allows mapping of distinct spatial zones for different kinds of activities. The primary components of a MarxanZ analysis include a planning unit framework (10-ha hexagons covering the entire study area), a suite of features (i.e., ecological targets and human well-being values), and costs.

Ecological and Human Well-being Features

We adopted the LEBCS conservation targets (Pearsall et al. 2012) except for the Open Water Benthic and Pelagic System (which refer to parts of the lake that are >15 m deep; not present in WLEB). We also updated the Aerial Migrants targets based on revised migratory bird stopover maps and new scoring criteria (Ewert et al. 2012). We then obtained or developed spatial data to represent these targets; the data layers comprised ecological features in the MarxanZ analysis (Table 1)

We identified human well-being values by first adopting an established framework based on Smith et al. (2013) and Lovelace et al. (2011). We then identified locally relevant social, cultural, and economic values through reviews of related plans and completion of localized anthropological fieldwork. We tied these values to the framework and associated them with important ecosystem services identified as in surveys conducted for the LEBCS. Finally, we retained those services and values that were likely to be affected by coastal restoration and conservation actions. We then obtained or developed geospatial data that could be used to spatially represent these services and values; these became our human well-being features (Table 2).

Table 1. Ecological targets (from Pearsall et al. 2012) and representative data layers (features) used in the WLECCV. More information on the methods, data layers and sources is available at http://nature.ly/WLEcoastalvision .

Ecological Targets	Representative Data Layers (Features)
Nearshore Zone: *waters less than 15 m in depth, including the coastal margin*	Nearshore Fish Habitat
	Walleye Spawning Sites (lake)
Native Migratory Fish: *Lake Erie fishes with populations that require tributaries for a portion of their life cycle, including Lake Sturgeon, Walleye, suckers and Sauger*	Walleye Spawning Sites (tributaries)
	Walleye Stream Potential Habitat
Coastal Wetlands: *wetlands with historic and current hydrologic connectivity to, and direct influence by, Lake Erie*	Potential Coastal Wetlands
Coastal Terrestrial Systems: *upland systems within ~2 km of the shoreline*	Coastal Terrestrial Biodiversity Significance
Aerial Migrants: *migrating birds, insects, and bats dependent on the Lake Erie shoreline*	Coastal Landbird Habitat
	Inland Restorable Landbird Habitat
	Shorebird Habitat
	Nearshore Waterfowl Habitat
	Inland Waterfowl Habitat
Connecting Channels *(St. Clair Detroit River System?)*	Potential Coastal Wetlands
	Detroit River Spawning Sites (sturgeon, whitefish, walleye)
	Detroit River Walleye Habitat
Islands: *including both naturally formed and artificial islands*	Coastal Terrestrial Biodiversity Significance

Goals for the ecological features were adopted from the LEBCS (Pearsall et al. 2012), with some exceptions. We reviewed all county planning documents throughout the project area and interviewed key stakeholders, and found no objective basis for setting goals for human well-being features. As an alternative, we established goals by surveying regional stakeholders at three workshops held in Monroe Michigan, Toledo Ohio, and Essex Ontario. The MarxanZ software sought to meet all these goals while minimizing costs.

Table 2. Human well-being values and representative data layers (features) used in the WLECCV. More information on the methods, data layers and sources is available at http://nature.ly/WLEcoastalvision .

Human Well-being Values	Representative Data Layers (Features)
HEALTH: *physical and psychological human health + access to quality food and water, air quality*	Drinking water intakes (Lake Erie)
	Drinking water intakes (inland)
	Beaches
	Parks & recreation lands
	Trails
	Birding visits; popularity of birding spots
SPIRITUAL AND CULTURAL FULFILLMENT: *opportunity to meet spiritual and cultural needs + Recreational (cultural) places and activities*	Hunting areas
	Recreational boating
	Recreational fishing (Lake Erie)
	Recreational fishing (stream)
	Shipwrecks (dive sites)
LIVING STANDARDS: *wealth, income levels, housing and food security + housing, economic security, equity, job satisfaction, property values, employment security*	Birding visits; popularity of birding spots
	Commercial fishing
CONNECTION TO NATURE: *the innate emotional affiliation of humans to other living organisms + Recreational (natural) places and activities, park lands, beach quality, scientific resources, coastal development, aesthetics*	Birding visits; popularity of birding spots
	Hunting areas
	Water access sites

Costs

To reflect the varied and substantial costs of conservation and restoration, we developed seven cost layers, four of which are characterized in monetary values derived from local projects, and three of which are cost indices reflecting landscape attributes that affect the feasibility of effective conservation (Table 3). We calculated these costs for every 10-ha hexagon in the planning unit framework.

Results:

The most important areas for coastal conservation on land are concentrated within 3-4 km of the shoreline and in a few areas further inland, such as southern Wayne County, Michigan and southest of Amherst, Ohio, where many of the ecological and human well-being features are located (Figure 2). The coastal wetlands and coastal terrestrial biodiversity significance features are located along the coast and exert strong influence on the conservation vision. Inland priority areas are centered around existing or restorable landbird stopover habitat and along trails.

The most important aquatic areas in Lake Erie as delineated by Marxan are concentrated in the waters of Ohio and Michigan, corresponding to areas highly valued for recreational fishing and recreational boating as well as supporting numerous walleye spawning areas (Figure 2). Recreational fishing is of far greater importance in the U.S. than in Ontario, while commercial fishing is more important in Ontario.

Table 3. List and descriptions of the costs of conservation and restoration in the WLECCV. More details, including data sources, on the cost layers is available at http://nature.ly/WLEcoastalvision.

Cost (units)
Land value ($): *average land value in the WLEB coastal area*
Wetland restoration ($): *The average cost of restoring coastal wetlands in the WLEB*
Phragmites treatment ($): *Cost estimate for removing the invasive common reed (Phragmites australis)*
Marinas (Index): *Index representing marina size. Areas with marinas and lots of boat traffic would make coastal restoration more difficult.*
Lake Erie and Detroit River Stress Index (Index): *Index representing 34 stressors that likely have an impact on biota and ecosystem dynamics*
Landbird habitat restoration ($): *Cost of restoring bird habitat based on land cover and the cost of planting trees*
Walleye stream habitat improvement cost (Index): *Index representing the difficulty of restoring walleye habitat in streams*

Setting high goals for human well-being values resulted in a 4.3% increase in both the amount of land (from 71,190 to 72,440 acres) and an 18.7% increase in the cost of conservation (from $16.9B to $20.1B) required to meet goals for ecological targets, relative to not including human well-being at all. The spatial arrangement of high value areas (i.e., “Top 10%” as shown on the map in Figure 2) was also affected; areas associated with trails and local parks were pulled into the vision as high value areas to meet human well-being goals, though their contribution to ecological goals was comparatively small. This result reflects the tradeoffs related to broad scale land use planning and conservation, while also supporting the idea that conservation can support both ecological goals and human well-being.

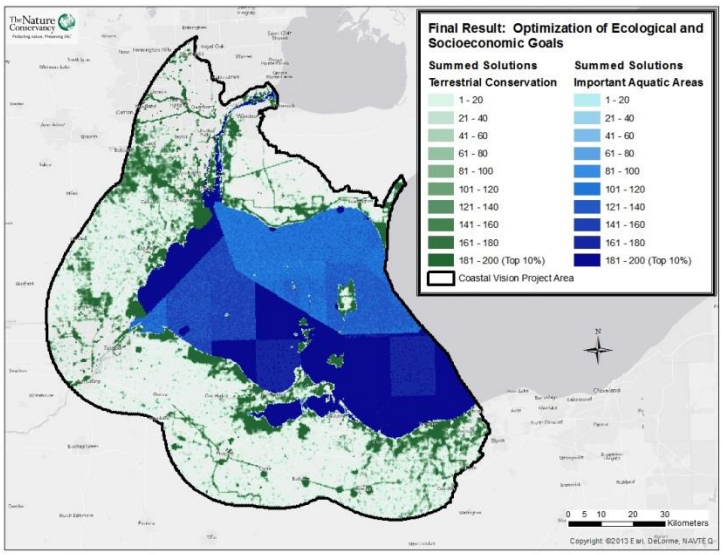

Figure 2. Distribution and extent of areas for coastal conservation and restoration that would best achieve ecological goals and enhance human well-being in western Lake Erie. In MarxanZ, the Summed Solutions represents the number of times out of 200 runs that a particular planning unit was selected as part of the solution. Planning units selected more often are considered more important.

Discussion/Conclusions:

Historically, successful regional conservation efforts were driven by science-based goals for important features of ecological systems. It is increasingly recognized that incorporating human values into conservation planning increases the chances for success by garnering broader project acceptance. However, while goals for ecological attributes are typically based on well-established ecological knowledge and the tenets of conservation biology, methods for defining quantitative goals goals for human well-being values are lacking (Adams et al. 2014). Our approach of identifying regionally important human values, datasets to represent them, and establishing specific goals based on stakeholder outreach and survey is innovative and has been demonstrated elsewhere (e.g., Adams et al. 2014). To our knowledge, ours is the first application of this approach in the Great Lakes, and it could be applied to other areas. Indeed, the Upper Midwest/Great Lakes LCC is now undertaking a Landscape Conservation Design following this approach for the U.S. coast of the St Clair – Detroit River System and Saginaw Bay.

This work has created a process for integrating human well-being values into biodiversity conservation planning to:

- complement priority-setting efforts across regional conservation, planning and business sectors;
- serve as a model for other areas of the Great Lakes and beyond; and
- define total area and cost required to meet regionally-vetted ecological goals and thus priority areas to target for maximum impact.

The primary outcome of this work demonstrates a method for identifying the best places for conservation actions that not only achieve multiple conservation goals but also incorporate places and

things that people value. Detailed maps, data, methods and supporting materials can be found at www.nature.org/wlecoastal.

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