Great Lakes Regional Aquatic Gap Analysis — Preserving Biodiversity in the Great Lakes Basin

Introduction

The goal of the U.S. Geological Survey (USGS) Gap Analysis Program (GAP) is to **keep common species common** by identifying those species and communities not adequately represented in existing conservation areas. Scientists, land and water managers, and policy makers can use this information to make better informed decisions when identifying priority areas for conservation. Only by protecting regions already rich in natural habitat can we adequately protect the animal and plant species that depend on them.

In 2001, the USGS, in cooperation with several state natural resource-management agencies, began a regional Aquatic GAP project in the Great Lakes Basin focusing on the distribution of aquatic species in riverine and coastal habitats. The goals and objectives of the **Great Lakes Aquatic Gap Project** are listed below.

Goals

- **Evaluate biological diversity of Great Lakes aquatic habitats and identify gaps in the distribution and protection of these species and their habitats.**
- **Use an integrated approach in which common methods and protocols are established and results are comparable across the Great Lakes landscape.**

Objectives

- **Build and maintain partnerships with GAP stakeholders.**
- **Develop a central database for Aquatic Gap data.**
- **Classify aquatic habitats in rivers, streams, and coastal zones.**
- **Model species and habitat relationships.**
- **Map actual and predicted distributions of aquatic species.**
- **Complete an Aquatic Gap Analysis for the Great Lakes Region.**

The Great Lakes Basin is a globally unique, geographically distinct, and biologically rich region encompassing 196,250 square miles in the United States and Canada. It contains over 11,000 miles of coastline, a large concentration of wetlands, diverse forests, thousands of tributary streams, and about 18 percent of the Earth's surface freshwater (U.S. Environmental Protection Agency (USEPA) and Government of Canada, 1995). More than 300 species of fish and many other aquatic organisms inhabit the rivers, streams, and coastal areas of the Great Lakes Basin and depend on these habitats during critical life-history stages (Greeley, 1940; Jude and Pappas, 1992).

Preservation of the aquatic biological diversity of the Great Lakes Basin is a regional priority because of its strong connection to the economy and health of the surrounding human population and wildlife resources. These aquatic resources support transportation, tourism, recreation, fisheries, ecosystem function, and water supply for human needs. In 1996, two million anglers fished the Great Lakes, adding more than $1 billion (U.S.) to the regional economy, and the commercial fish harvest brought in more than $43 million (Michigan Sea Grant 2000).

Figure 1. Commercial fishing (Photo by USEPA Great Lakes National Program Office.)

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Despite the value of these water resources, the aquatic biodiversity of the Great Lakes region is threatened by environmental change.

Figure 2. Urban development, Toledo, OH. (Photo by Ohio Lake Erie Commission.)

Factors such as invasion of exotic species, changing land-use patterns, development, contaminants from point and non point sources, and dams have reduced the availability and quality of aquatic habitats and access to historical fish-spawning grounds and nurseries. Great Lakes Aquatic Gap will enable scientists, resource managers, and planners to address these issues by providing information on the current status of aquatic species and their habitats.

Great Lakes Riverine Gap

There are thousands of rivers and streams within the Great Lakes Basin, providing habitats for fish and other aquatic organisms throughout various stages of their life cycles. These streams vary from warmwater streams that support bass to coldwater streams that support breeding populations of native trout. The purpose of the Riverine Aquatic Gap Analysis

Figure 3. Sediment sampling of Detroit River (Photo by D. Reader, USGS.)

project is to identify gaps in the conservation of fish and other aquatic species in the rivers and streams of the Great Lakes Basin. Riverine Gap projects are underway in Michigan, New York, Ohio, and Wisconsin with completion scheduled for 2006. Gap Analysis in Minnesota, Illinois, Indiana, and Pennsylvania is scheduled for 2004 to 2009.

The pilot study for Riverine Gap Analysis was completed by the state of Missouri in 2002, and has served as a model in the development of protocols for Aquatic Gap in the Great Lakes States. Streams are being classified using the Valley Segment Type (VST) stream classification, in which a series of geological and hydrological variables are combined to form an ecologically distinct spatial unit for each stream segment. Catchments are being delineated for each of the stream reaches identified in 1:100,000-scale maps.

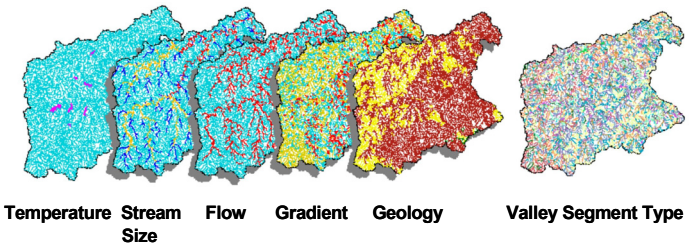


Figure 4. Stream variables and Valley Segment Types.

Characteristics such as drainage area, slope, drainage density, and surficial and bedrock geology are being tabulated for each catchment. Similar attributes will be identified for the channel and riparian areas along with stream temperature, size, and depth to bedrock . Existing fish data will be used to determine species abundance and distribution and will be linked to the classified stream segments. Maps of known and predicted distributions of aquatic species will be developed by use of species habitat models. Maps of the classified stream segments will be overlain with maps of aquatic species distribution and land stewardship by means of a geographic information system (GIS) in order to determine the conservation status of these habitats. Federal and state natural-resource agencies, tribes, museums, and universities have provided the Gap projects with geo-referenced fish-sampling data dating as far back as 1870. Riverine Gap Analysis is also investigating data on aquatic invertebrate species.

Coastal Gap

The coastal zone is an ecologically important buffer and link between the open water and inland ecosystems of the Great Lakes basin and consists of a wide variety of habitats. The geomorphology of the coast ranges from sandy beaches and mud flats to sheer cliffs and headlands. This rich environment is home to approximately 120 native or established fish species, most of which use the nearshore areas throughout their life cycle.

Table 1. State Aquatic Resources*

	Michigan	New York	Ohio	Wisconsin
River Miles	**36,000**	**72,500**	**44,000**	**32,000**
Inland Lakes	**35,000**	**4,000**	**1,965**	**15,057**
Coastline Miles	**3,200**	**305**	**300**	**1,000**
Fish Species	**147**	**165**	**148**	**147**
Mussels	**46**	**40**	**88**	**42**

* Within entire state boundaries

The Coastal Aquatic GAP Pilot Project is being undertaken in the Great Lakes Basin to improve the understanding of Great Lakes coastal habitats and enhance protection of the diversity of species within them. This project is intended to extend the Aquatic Gap Analysis tools being developed for riverine habitats to the nearshore habitats of the Great Lakes coasts. For this study, the nearshore zone will encompass the area from the shoreline to a depth of approximately 10 meters. Nearshore fish distributions and assemblages are being coupled with deep water fish surveys by the USGS Great Lakes Science Center. Pilot projects are focusing on the nearshore regions of western Lake Erie and eastern Lake Ontario, and work will be extended to all Great Lakes in the future.

Following the general approach of VST classification used by the other components of the regional Aquatic Gap Analysis project, the coastal classification system will use unique serial codes to identify each coastal habitat type. The classification framework includes environmental variables that are representative of conditions at various spatial scales, from the Great Lakes down to the smallest scale of the

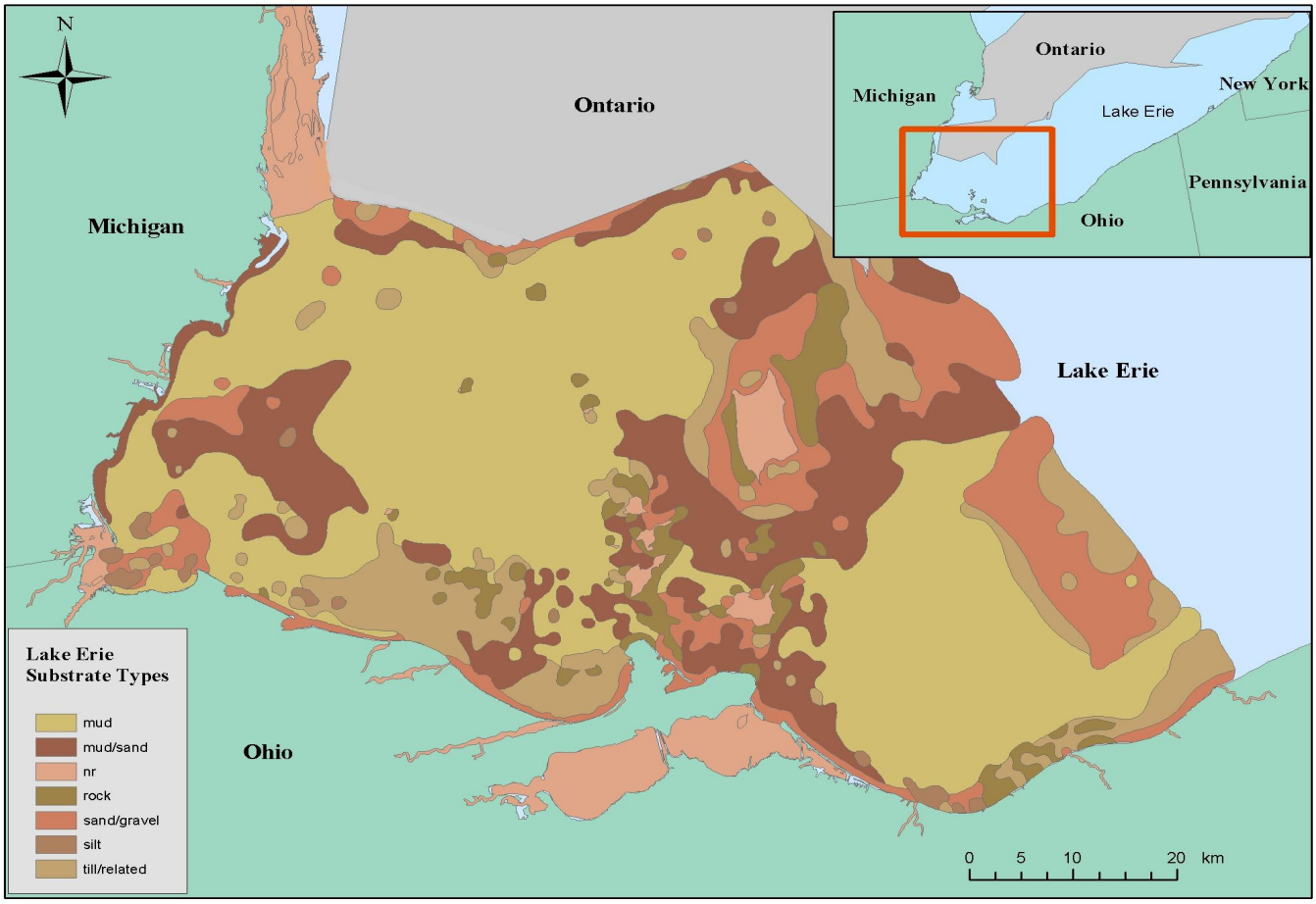


Figure 5. Substrate types in Western Lake Erie. (Substrate data from Environment Canada; Image from S. Morrison, USGS.)

geomorphic segment. The variables analyzed at each scale are presumed to have a significant influence on the aquatic species found there, and include measures of coastal

Figure 6. Beach seining for fish. (Photo by J. McKenna, USGS.)

geomorphology, wind and wave exposure, substrate type, thermal regime, and water-level variability. This framework allows for incorporation of physical conditions and degree of habitat variability into the classification system. Species-environment relationship modeling will help to refine the classification scheme.

Regional Central Database

Geospatially referenced biological and habitat data used for Aquatic Gap Analysis in the eight Great Lake states are being imported into a unified database structure in a regional central database at the USGS Great Lakes Science Center in Ann Arbor, Michigan. Oracle and Microsoft Access database technologies are being used. The database structure is based in part on database designs of The Nature Conservancy and the USGS National Biological Information Infrastructure as well as the structure currently in use for the Ohio Aquatic Gap Analysis Project. Protocols and mechanisms for data sharing based on ownership of the data are being developed. The Great Lakes Aquatic Gap project expects to serve data to Aquatic Gap investigators by means of client-server or Web-enabled tools by 2004.

Modeling Approaches Across the Region

Regional analysis of the status of riverine and coastal biodiversity requires an ability to predict the distributions of fish or other aquatic organisms across all river and coastal systems within the region. One of the objectives of the Aquatic Gap project is to develop and apply a set of predictive statistical models for riverine and coastal fishes in the Great Lakes region. These models will be used to predict presence and abundance of fishes and to predict fish distribution in relation to selected habitat variables. Modeling approaches used by other Aquatic Gap projects in Missouri, Ohio, and South Dakota will be reviewed and assessed for use in this project.

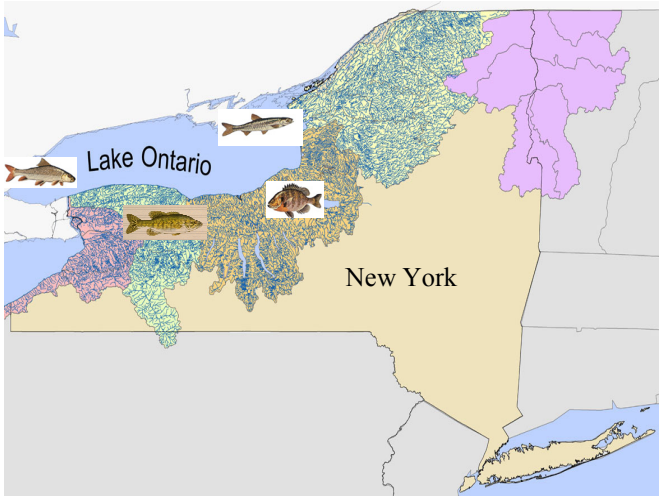


Figure 7. Fish distributions in aquatic habitats. (Image from C. Castiglione, U.S. Fish and Wildlife Service.)

The last phase of the research will be integration among ongoing statewide projects of the Great Lakes Regional Gap Analysis project in order to make seamless biodiversity predictions within watersheds across the region. Integration of riverine and coastal fish-habitat relationships will help to provide a greater understanding of Great Lakes fish species (for example, yellow perch or walleye). These species live primarily in open waters or nearshore areas but may also use tributaries for spawning.

Applications for Conservation of Biodiversity in the Great Lakes Region

Biodiversity conservation is of growing concern in the Great Lakes Region and elsewhere because the focus of conservation has expanded beyond rare and endangered species to include the biodiversity of common species. The Nature Conservancy (2000) identified 271 sites as important for Great Lakes biodiversity, of which 60 percent were deemed “irreplaceable.” Only 5 percent of these sites were protected.

The Great Lakes Aquatic Gap project has been working closely with non governmental agencies, universities, tribes, and state and Federal agencies charged with management of natural resources to provide useful tools

Figure 8. Johnny darter, caddis flies, native clam (Photos by Ohio Department of Natural Resources, USGS-Tunison Lab.)

for biodiversity conservation efforts. Information generated from the Great Lakes Aquatic Gap project will fill an important piece in the puzzle of biodiversity conservation. Gap data will help characterize watershed management according to different stewardship categories: public land, multiple-use land, conservation-management land (multiple categories), and non conservation land. Status maps will show the connectivity or lack of connectivity in existing conservation land together with management plans. Gap information will be provided to persons responsible for land-use planning, management, and research, as well as to the general public.

Tools for Managers and Decision Makers

Aquatic Gap relies on sound GIS techniques and spatial data. This makes the program a natural candidate for the development of decision support system (DSS) tools.

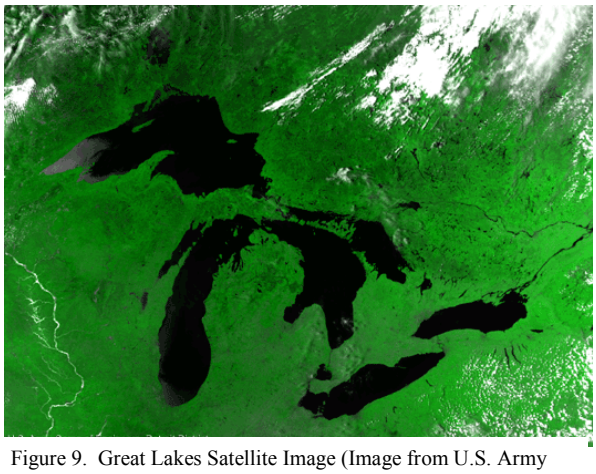


Figure 9. Great Lakes Satellite Image (Image from U.S. Army Corps of Engineers.)

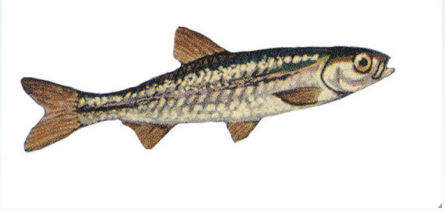
There are many definitions of DSS, but essentially they are systems that package information and tools in a form that can be readily integrated into decision-making processes (Zhu et al. 1998). These tools can provide valuable assistance to land managers and decision makers in understanding the spatial distribution of aquatic resources, in drawing correlations between the distribution of species and underlying physical and chemical conditions, and in planning efforts to estimate and predict future conditions. Several DSS tools have been developed at the USGS Upper Midwest Environmental Sciences Center to predict the habitat needs of terrestrial vertebrates as land use changes across landscapes. These tools provide the capability to highlight specific habitats that are of importance for particular species; these tools will be equally valuable for addressing similar concerns with aquatic conditions and aquatic species. The Great Lakes Aquatic Gap Analysis Project will work with DSS specialists in the National GAP program to provide interpretation and delivery of Great Lakes products.

What You Can Do To Help

The GAP program uses a collaborative approach, drawing upon mutual cooperation of Federal, state, and private natural-resource institutions. Advisory and stakeholder groups have been formed and will continue to be expanded in each state. Information about stakeholder groups and meetings can be found on individual state Aquatic Gap Web pages, through links from the National Gap and the Great Lakes Aquatic Gap Web pages.

How you can participate:

- **Share georeferenced aquatic biological, abiotic, and/or spatial data.**
- **Provide technical advice and input.**
- **Provide expert review of results.**
- **Use Aquatic Gap data for planning and management of Great Lakes resources.**
- **Participate in future stakeholder meetings.**



Great Lakes Aquatic Gap Partners

U.S. Fish and Wildlife Service

New York Department of Environmental Conservation

Ohio Environmental Protection Agency

Wisconsin Department of Natural Resources

Michigan Department of Natural Resources

The University of Michigan

Ohio Department of Natural Resources - Division of Wildlife

Ohio Lake Erie Commission

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The Great Lakes Science Center
http://www.glsc.usgs.gov/GLGAP.htm

The National GAP Analysis Program
http://www.gap.uidaho.edu