

# Environmental OBSERVER

ESRI • Fall 2007

GIS for Environmental Management Solutions

## Regulatory Compliance Simplified with GIS Server Technology

Environmental Protection Agency (EPA) mandates of reporting and compliance require evaluation, collaboration, and reliable assessment of conditions. The EPA uses geographic information system (GIS) technology to build reports to ensure program quality and reduce environmental risk through data analysis, modeling, and reporting. Collaborative efforts between agencies are supported via GIS-enabled Web sites and sharing of information.

Since 1993, members of the Idaho Department of Environmental Quality (DEQ) have monitored and assessed approximately 63,000 miles of Idaho's waters, collecting chemical samples and biological and habitat data from river, stream, and

lake locations. Using GIS, water quality analysts are able to click on a stream or assessment unit and retrieve all the historical monitoring information and background GIS data needed to update and complete status reports for its Clean Water Act reports. The integrated results are displayed online through the Idaho wide area network. Site visitors use Web-based GIS tools to work with the information and apply it to their projects.

To manage and use the massive amount of water quality data, the department implemented a state-wide enterprise GIS in 2001 and integrated its water quality monitoring databases with ESRI's ArcGIS Server products ArcSDE SQL Server and ArcIMS. These enable users to publish and

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deliver maps, data, and metadata on the Web and have spatial data management, visualization, and analysis abilities.

Idaho's water quality standards, or beneficial use identifiers, were linearly referenced to the 1:100K National Hydrography Dataset, which is a nationally comprehensive set of surface water features data provided by the U.S. Geological Survey. The dataset serves as the primary base layer for analyzing, displaying, and reporting the results of stream water quality assessments.

Department GIS analysts have found the ArcGIS Server solution valuable in relating their data to other databases for better analysis of water quality status. The spatial database engine technology accesses geographic databases stored in relational database management systems. This makes it possible for DEQ GIS analysts to spatially join and relate data from multiple SQL Server databases to the National Hydrography Dataset. Stream and monitoring location feature classes are attributed with unique site identification codes that relate to monitoring and assessment data in SQL databases. Attributes are automatically retrieved from various databases through a geographic interface.

United States Forest Service, Bureau of Land Management, and EPA hydrologists use ArcIMS applications to access information needed to locate monitoring sites on specific streams, retrieve fish and insect data, and locate impaired waters. By downloading GIS information from Idaho's statewide GIS clearinghouse, DEQ employees save time because they do not have to process public information requests. Glen Pettit, DEQ



Water Quality Interactive Map and Public Comment Web Application for Idaho's Department of Environmental Quality

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## ESRI on the Road

**NAEP 2008**  
March 25–28, 2008  
San Diego, California  
[www.naep.org](http://www.naep.org)

**ESRI International User Conference**  
August 4–8, 2008  
San Diego, California  
[www.esri.com/uc](http://www.esri.com/uc)

To register for ESRI events, visit  
[www.esri.com/events](http://www.esri.com/events).



## Use ArcGIS Explorer Today

ArcGIS Explorer is a lightweight desktop client for ArcGIS Server, providing a way for you to publish ArcGIS Server capabilities within your organization or to anyone on the Web. Using ArcGIS Explorer, you can connect to content published by ESRI and others and fuse it with your own ArcGIS services or local data. You can create content for ArcGIS Explorer by authoring globes and tasks using ArcGIS Desktop, then publishing them to ArcGIS Explorer via ArcGIS Server.

Learn more and get a free download at [www.esri.com/arcgisexplorer](http://www.esri.com/arcgisexplorer).

## Career Opportunities on ESRI's Natural Resources Team

ESRI is seeking creative, energetic professionals to join its natural resources team and make a difference in the future of the natural resources industry.

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- Agriculture Industry Marketing Manager
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### New GIS for Conservation Web Site

Organizations are using GIS to conserve wildlife, woodlands, and oceans. Read their stories, discover new GIS applications, see maps, and get connected. Visit GIS for Conservation at [www.esri.com/conservation](http://www.esri.com/conservation).

## ESRI News

### Why Use ArcGIS Image Server?

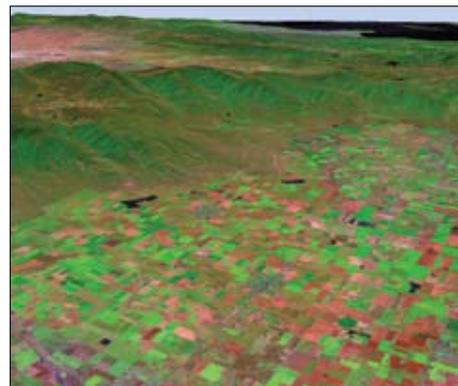
Geographic imagery generated by satellite and aerial photography has a profound effect on the way we assess the environment. Whether evaluating vegetative health or toxic runoff, this imagery is essential to understanding our planet and suggests keys to better management. The amount of data collected from these resources is growing exponentially. Policy makers and decision managers need current, high-quality images to visualize and analyze data for applications from land use to forest health.

Members of the Internet culture are accustomed to immediate access to data. This happens because data is stored in servers, where users from many locations can readily access it without downloading or storing large files locally. ArcGIS Image Server is a unique and powerful tool that provides quick access to vast amounts of imagery.

ArcGIS Image Server also diminishes the interval between when an image is collected and when it is available to users. Traditionally, image processing and distribution were considered two separate stages in image utilization. Imagery was first processed and mosaicked into a large dataset, then put on servers for dissemination. This separation has caused many problems for users including long preprocessing/loading times and data redundancy that exacerbates data storage issues and hinders efficient data management. With ArcGIS Image Server, these two stages are combined into one.

The data received from an imagery supplier can be directly served. This enables administrators to maintain only the primary imagery as well as create multiple specialized products on the fly when required. This is a significant and unique paradigm shift in how imagery is managed, processed, and distributed.

Because ArcGIS Image Server is integrated with



Landsat raster data is quickly displayed with ArcGIS Image Server.

ArcGIS Server, data can also be distributed to Web-based, mobile, and Open Geospatial Consortium, Inc.-compliant clients. This enables an agency to share its valuable imagery with more people, maximizing its investment in that imagery.

A few of the many benefits of implementing ArcGIS Image Server are

- Direct use of multiple file formats and compression
- Fast access to both imagery and important image metadata
- Data security and access logging
- On-the-fly processing including reprojection, mosaicking, and enhancements
- Multiple representations of the same imagery, reducing duplication and storage needs
- Simultaneous viewing of imagery by multiple users

Learn more about ArcGIS Image Server at [www.esri.com/imageserver](http://www.esri.com/imageserver).



Bernie Falls, California

## Environmental Management GIS Users Reach for Excellence

ESRI recognized outstanding effort in the use of GIS for environmental management by bestowing its Special Achievement in GIS award at the ESRI International User Conference (ESRI UC). Awards went to the following organizations:

The American Association for the Advancement of Science, National Weather Service, uses GIS technology to complete a range of tasks such as analyzing weather warnings, producing hydrologic products, and briefing emergency managers on particular situations.

The Society for Conservation GIS, Kenya, uses GIS technology in a variety of ways to promote sustained development and conservation of

Kenya's lands and resources. It is using GIS as a tool to map land-use plans, identify areas in need of conservation, and target suitable sites for eco-tourism developments such as protected parks.

The United Nations Environment Programme—World Conservation Monitoring Centre (UNEP-WCMC), United Kingdom, uses GIS technology to provide biodiversity data on the local, national, and international levels. Using GIS, UNEP-WCMC manages and analyzes data for protected areas, habitats, and species distributions in a uniform way that makes the information needed for preservation of biodiversity compatible across the globe.

The University of California Berkeley &

Wildlife Conservation Society uses GIS technology to produce maps of Madagascar that communicate the conservation needs of various areas to the public. GIS technology allows the society to refine the boundaries of individual parks and situate them in ideal areas for preserving biodiversity and cultivating socioeconomic well-being.

*continued from page 1*

### Regulatory Compliance Simplified with GIS Server Technology

water quality analyst, says, "Our enterprise GIS has given us the capability to simultaneously retrieve monitoring locations and biological data from multiple databases and servers, with a few clicks of the mouse, from 400 miles away. This long-awaited integration enables me to spend a

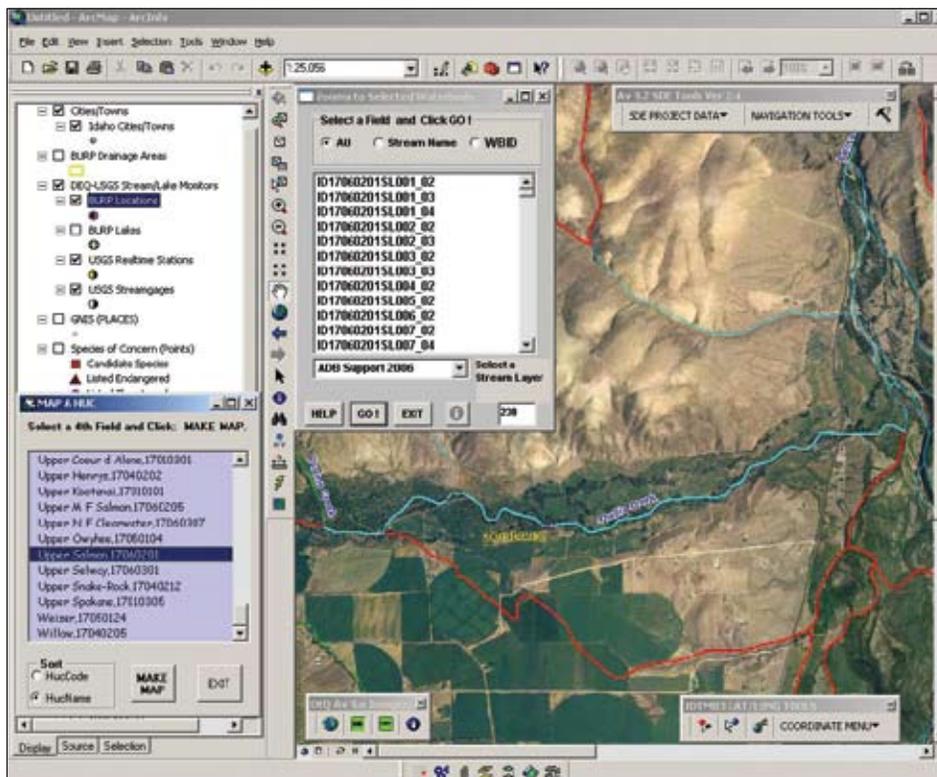
couple extra weeks in the field collecting data, instead of in the office."

EPA's Assessment Database was developed by Research Triangle Institute to post a state's most recent electronic water quality information on the Web. It is a relational database application that

tracks water quality assessment data including use attainment and causes and sources of water quality impairment. DEQ's customized deployment of the Assessment Database provides water quality analysts with a user-friendly, intuitive, menu-driven process for analyzing and monitoring data and reporting water quality status to EPA.

In-house customizations by DEQ have seamlessly integrated the Assessment Database with ArcGIS and ArcIMS. Environmental analysts and other people throughout the Department of Environmental Quality can easily access data to work with a display. Environmentalists use the GIS solution to analyze stream drainage areas with current land-cover, land-use, and aerial photography geospatial data.

Custom toolbars provide point-and-click data automation so that analysts and scientists can easily navigate through Idaho's hydrography and watershed data. Furthermore, hyperlinked features provide real-time access to water quality reports and monitoring data. Because this information is accessible online, organizations across the state can use the data for analysis. With easy data access and automated processes, the members of DEQ can better meet compliance reporting requirements.



Customized ArcGIS toolbars make it easy for users to navigate the water database.

# Infrared Data Sheds New Light on Vegetation Management

By Dal Chappell, M.J. Harden Associates, Inc., a GeoEye Company

From controlling invasive vegetation to studying the health of woodlands, remote-sensing technology is helping people make sound decisions about vegetation management. Environmental assessment plans often include vegetation management objectives. Plans for building transmission right-of-way, contracts for clearing and trimming, assessments for woodland health, and prescriptions for herbicide treatment are all actions that depend on vegetation assessment. To better focus these management efforts, tools such as lidar, satellite imaging, infrared imagery, and photogrammetry provide significant data that can be processed and visualized in GIS.

Today's geospatial "technical toolbox" is extensive, and having access to dependable geographic data is critical. Geospatial information—that is, information pertaining to a geographic location—is growing rapidly in both volume and application. The use of geospatial information for developing strategies for intelligent natural resource management not only serves conservation efforts but also creates a solid foundation for workable concessions between the needs of industry and the environmental concerns of the public. ESRI provides a high-quality geospatial technology environment for users to create, merge, and manage data available through numerous sources. Fortunately, there is no shortage of tools to help decipher information in ways to make geospatial data useful.

At the convergence of vegetation management and geospatial information is an application for remote sensing. The science of remote sensing provides an alternative perspective not traditionally employed in the area of vegetation management, but it can be a cost-effective tool for managing and monitoring vegetation.

For many years, planimetric maps, which are two-dimensional with only horizontal correction for distances, have been the main type of geospatial product used by various industries. But with the advances in aerial digital imagery and GPS technologies, another function, or tool, can be applied to vegetation management—the concept of using remote sensing. Photogrammetric products derived from aerial imagery have a well-documented history of success.

Photogrammetry has become a more applicable science as new computer scripts and routines are being developed to handle data. It incorporates interdisciplinary methods, such as optics and projective geometry, to create an array of interpretive models.



Tree height values in infrared are displayed as points created from the digital imagery. ArcGIS 3D Analyst is used to identify tree canopies that put power lines at risk.

Such a model might compute 3D coordinates that define the locations of object points in 3D space, or it might produce image coordinates that define object points of images captured on film. Remote sensing has become a profitable industry because of these developments. The National Oceanic and Atmospheric Administration (NOAA) 2005–2015 International Remote Sensing Research report predicts that the aerial digital sector will have the highest revenue growth worldwide in the remote-sensing industry.

Remote sensing with digital aerial imagery can be a powerful tool for many types of applications. Most large-format digital aerial platforms capture black-and-white, color, and infrared data. The infrared data collected with digital aerial cameras contains information beyond what is detectable with the naked eye and can be an effective tool in vegetation management. The NOAA report asserts, "Spectral imaging data allows extraction of features not detectable in conventional imagery." The infrared data collected with the digital camera can be used to map and monitor vegetation health and coverage.

A process for using infrared data in mapping vegetation health would be to transform the im-

agery into a Normalized Difference Vegetation Index (NDVI). This index is an indicator of vegetation hardness. This technique is widely used in the agricultural industry for monitoring crops during the growing season; it can also monitor the effectiveness of herbicide treatments or vegetation regrowth. The approach provides hard data for managing herbicide types, cycle times, or application techniques.

Another application of digital aerial imagery is to create tree canopy models. The distances between vegetation and other man-made attributes, such as trees and power lines, can be computed using lidar data processed by GIS to compute and map relationships such as those between tree canopies and power lines. Point cloud data collected by lidar is postprocessed to design models for utility assets, terrain, and tree surfaces. Digital aerial imagery can be used to create tree canopy surfaces within most standard photogrammetric workflow practices. This allows for efficient turnaround time from acquisition to analysis. Imagery can be analyzed in ESRI's ArcGIS 3D Analyst to identify tree canopies that may be areas of concern because of their proximity to structures and conductors. This information is used to plan future field activities or monitor the effectiveness of current ones.

Both approaches provide environmental managers with useful additional information to incorporate into the decision-making process for vegetation management. The ESRI GIS software environment promotes compatibility among various types of geospatial data. Additionally, the capabilities of mobile GIS can transport these multiple data types from the desktop computer to mobile devices for equipping field personnel with up-to-date and accurate information.

Learn more about M.J. Harden Associates at [www.geoeye.com](http://www.geoeye.com).

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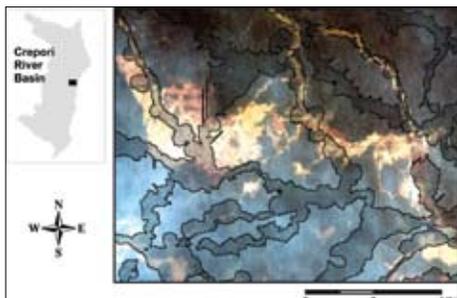
# Remote Sensing Reveals Protected Forests Not So Protected

By Michael Meitner, University of British Columbia

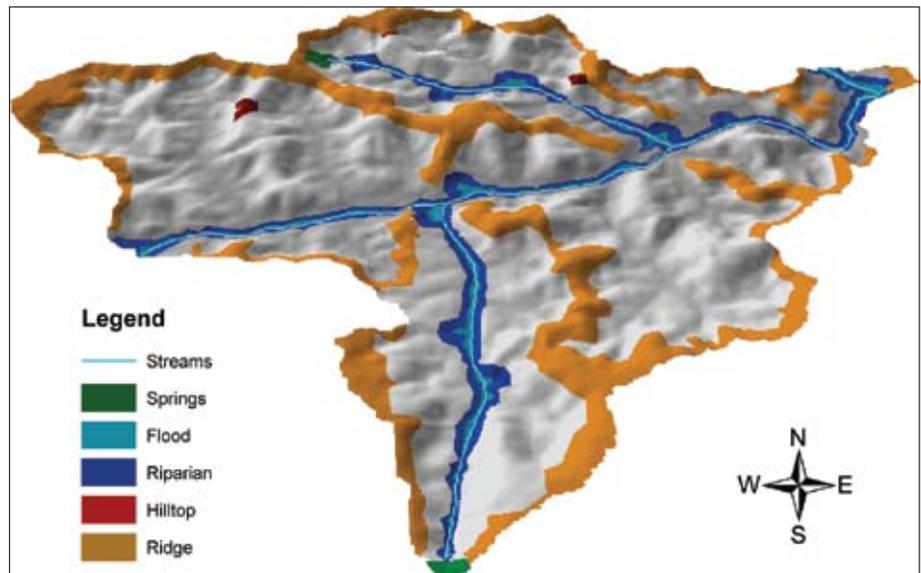
Brazil is home to the Amazon, the Savanna Woodland (the *cerrados*), and the Atlantic Forest. These three different biomes are threatened by the degradation of their forests. Currently, approximately 2.3 million hectares of these biologically diverse lands are lost to deforestation each year. The survival of these forests rests with Brazil's ability to enforce the laws that are already in place to protect these areas. Environmental scientists are using GIS technology to study the extent that deforestation is continuing in Brazil's designated protected areas.

In the 1965 Brazilian Forest Code, two types of protected forests are listed: legal reserves and permanent preservation areas. Legal reserves are a percentage of privately owned land, but permanent preservation areas are defined by their geography. Historically, the delineation of protected areas and subsequent enforcement of land-use restrictions within them has been hampered by the difficulty in determining the physical boundaries of these areas currently expressed only in policy. The lack of appropriate topographic datasets and the expertise needed for manually mapping the preserves made it virtually impossible to enforce the Brazilian Forest Code over an area as large as the Amazon rainforest. As a result, the essence of the environmental legislation gradually faded away, paving the road for a generalized fragmentation of natural habitats in areas that should, by law, be preserved.

A primary step for enforcing Brazil's environmental law is to create a method for accurately mapping legally protected areas using available data. A team of international scientists from the University of British Columbia conducted a project to map the country's permanent preservation areas. This team included Carlos Ribeiro, Michael Meitner, Marcello Veiga, and Brent Chamberlain.



Example map of permanent preservation areas over an existing mining site. Image is taken from IKONOS and was down-sampled to 30m. Shaded and bordered areas represent permanent preservation areas based on project results. Yellow encroachment activities become obvious within the shaded protected areas.



Spatial Distribution of Brazilian Permanent Preservation Areas in a Portion of the Crepori River Basin

Recent advances in GIS technology and greater availability of worldwide high-resolution digital imagery has made it possible for the team to map one of these places. The project provides the basis for a proposal to extend the project to other regions of concern.

Using ArcGIS software to map Brazil's Crepori River basin, the scientists were able to delineate areas that should be protected from deforestation. Permanent preservation areas are defined by their topography, such as the top third of a hill's surface area, ridgelines, upland catchments, and riparian zones dependent on the width of a river's floodplain. To map these areas, the team combined Shuttle Radar Topography Mission (SRTM) data and digital hydrography datasets from the Brazilian Institute for Geography and Statistics (IBGE) to produce a hydrographically correct digital elevation model. This allowed the characterization of the landscape into layers, which depicted each of the defining aspects of permanent preservation areas. These layers were then mosaicked to produce the final map of the permanent protected areas for the basin.

Although the Crepori River basin is a small percentage of the Amazon, the data collected for that area was extensive. Eventually, the team wants to automate the delineation routines used in the study so these can easily be replicated across the rest of Brazil. Creating one map of all permanent preservation areas would make Brazil's progressive legislation enforceable.

The results of this study show that permanent

preservation areas create ecological corridors that connect all of the biomes in the area and therefore contribute to the protection of the biodiversity of the region. The results also make clear that some of these legally protected areas are not being conserved.

The team hopes that their maps create awareness of present and potential land-use conflicts, create a focus for where new development should occur so as not to interfere with permanent preservation areas, and provide a framework for setting up natural preserves across Brazil. For more information on this project, contact Dr. Mike Meitner ([mike.meitner@ubc.ca](mailto:mike.meitner@ubc.ca)).

## Shuttle Radar Topography Mission Data Available

SRTM is a specially modified radar system that flew onboard the space shuttle Endeavour to acquire elevation models. SRTM obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth thus far. The data was processed at the Jet Propulsion Laboratory and is being distributed through the United States Geological Survey's EROS Data Center. The elevation models derived from SRTM are used in GIS. They can be downloaded for free over the Internet, and their file format (.hgt) is supported by ESRI's software. Learn more about SRTM at <http://edc.usgs.gov/srtm/data>.

# Conservation GIS Portals Pool World's Data Resources

By Maggie Jones, ESRI

Effective environmental management and conservation programs involve understanding the interactions between the environment, human behavior, and legal systems. Cooperation between environmentalists, communities, and lawmakers is crucial to obtaining information that aids sustainable development strategies. GIS-enabled Web portals allow users to share environmental information, which assists informed decision making.

Data analysis is essential for both setting and achieving environmental protection goals, and GIS portals offer capabilities, such as interactive mapping, that aid analysis of key components of environmental management. For example, interactive mapping tools enable users to overlay specific data onto local, national, or world maps. Interactive mapping is a valuable, visual companion for information portals containing data resources; it completes the process of data analysis with overlay features that enable better analysis of variables and relationships.

A variety of ESRI software can help create and facilitate GIS portals. ArcWeb Services is a tool used to build Web sites and develop Web mapping applications; it also serves as a template for portal construction. ArcWeb Services can be used with ArcGIS Explorer, ArcIMS, and other GIS services to accomplish these tasks.

Specifically designed for portal technology and based on server technology, ESRI's GIS Portal Toolkit offers the complete tools and templates to create a GIS portal. The GIS Portal Toolkit provides functionality for publishers (the ability to enter metadata, upload data, and remove published documents), administrators (the ability to search and sort data and metadata), and users. This toolkit includes a portal Web site template; metadata catalog; and search, mapping, and managing tools. With the toolkit, users can search and sort metadata, customize views, access and use map data, create and manage channels and external links, harvest metadata from ArcIMS and other repository protocols, and access online maps with Map Viewer.

## GIS Portals for Conservation

An example of a GIS-enabled portal is the Conservation GeoPortal, which stores descriptions and links to conservation and biodiversity maps and data. This portal's sponsors include The Nature Conservancy, National Geographic Society, Conservation International, United Nations Environment Programme (UNEP) World Conservation Monitoring Centre, and ESRI. Users can use the site to publish and share



Conservation GeoPortal search tools provide access to a variety of conservation metadata.

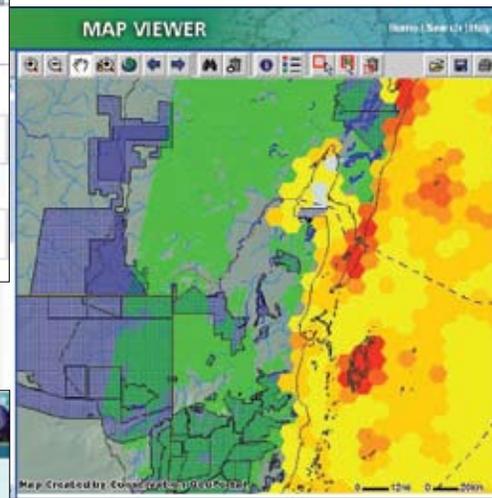


Conservation GeoPortal provides conservation metadata search, mapping, and managing tools.

their data by either entering metadata in a form, uploading metadata files, or registering metadata from another catalog to be accessed by the portal. Participants can become channel stewards who take up the task of finding and managing good metadata for a specific conservation theme to put on the site. Visitors to the Conservation GeoPortal can search for data and maps by keyword, category, geography, or time period. They can also display, manipulate, and combine live Internet map services via the site's Map Viewer application to create and save custom maps as well as publish metadata for their maps and data.

Similar GIS portals powered by ESRI software are Global Forest Watch, WildFinder, and National Geographic's MapMachine. Global Forest Watch is a portal focused on forest conservation and provides regional and local forestry data. The World Wildlife Fund's WildFinder portal is a map-driven wildlife database containing valuable species distribution information for wildlife across the globe. National Geographic's MapMachine has a variety of thematic maps for environmental concerns around the world.

National, regional, and local governments also sponsor GIS portals that provide citizens with environmental and natural resource information.



Map Viewer enables users to view and interact with geographic data.

Geodata.gov supplies the public with important metadata and maps for the United States in a variety of fields including the environment. The availability of these portals means that time and resources can be saved and important information can be shared, aiding conservation goals and practices.

To get results, environmentalists need to pool their resources. A united front is the primary way that they can combat the onslaught of environment and resource degradation. GIS portals are becoming the go-to data centers of the world, and conservation organizations need to utilize their advantages.

## Conservation Portals of Note

**Conservation GeoPortal:**  
[www.conservationmaps.org](http://www.conservationmaps.org)

**Geodata.gov:**  
<http://gos2.geodata.gov/wps/portal/gos>

**Global Forest Watch:**  
[www.globalforestwatch.org](http://www.globalforestwatch.org)

**World Wildlife Fund's WildFinder:**  
[www.worldwildlife.org/wildfinder/](http://www.worldwildlife.org/wildfinder/)

**National Geographic's MapMachine:**  
<http://plasma.nationalgeographic.com/mapmachine/>

**World Resources Institute's Earth Trends:**  
<http://earthtrends.wri.org/index.php>

# Climate Changes May Impact Whale Feeding Grounds

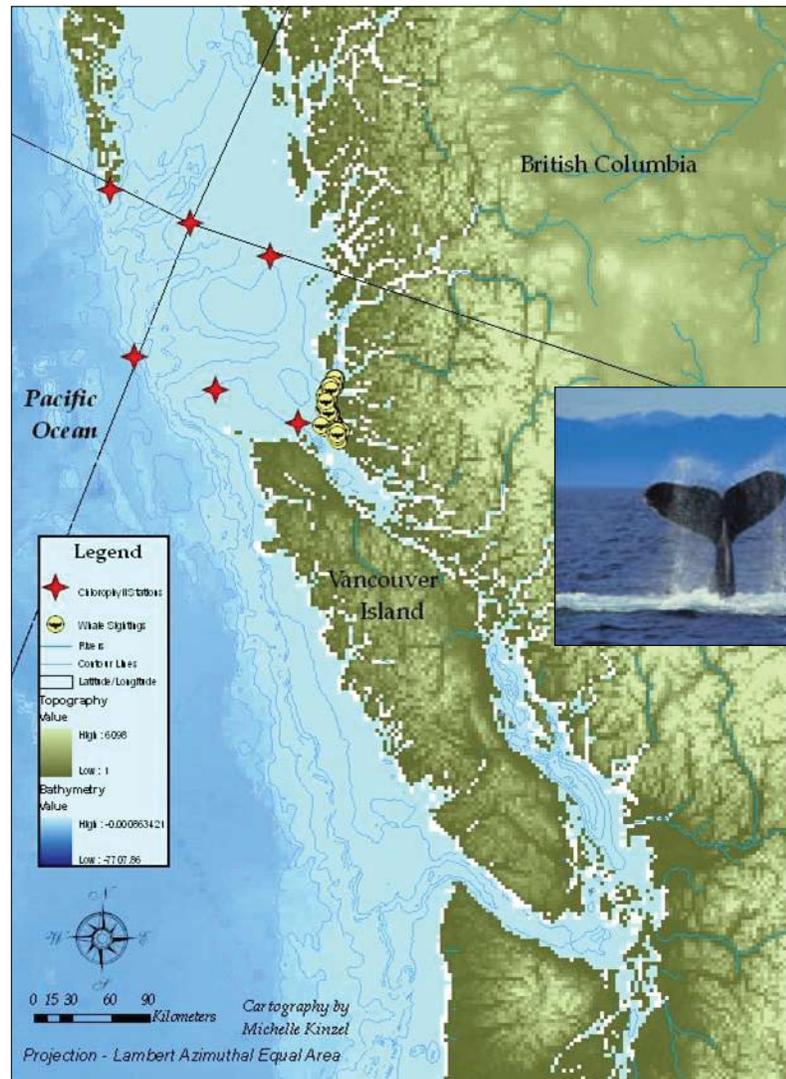
The mammoth, 40-ton gray whale is nourished by microscopic phytoplankton, plants that contain chlorophyll and depend on nutrients in the ocean to survive. Phytoplankton are a link in a remarkable food chain: they serve as the primary food for shrimp and other crustaceans, which are the life source of gigantic gray whales. Researchers at Coastal Ecosystems Research Foundation (CERF), a Canadian nonprofit organization, have attempted to link the concentration of chlorophyll a, the blue-green pigment in phytoplankton, to gray whale distribution to better understand the relationship between whales and their feeding grounds. They are tracking the concentration of chlorophyll a in the ocean using GIS technology, a process that could be crucial in sustaining the gray whale herds that populate the Pacific Ocean.

Michelle Kinzel, a CERF researcher, and Roberto Venegas, a research scientist with the College of Oceanic and Atmospheric Sciences (COAS) at Oregon State University, collected data on the number and distribution of gray whales visiting the summer feeding grounds since 1996 by means of sight and satellites.

CERF used imagery obtained using a Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) instrument aboard a satellite to study the relationship between whale distribution and concentrations of chlorophyll a. Color in the world's oceans is in the visible light range and varies depending on the amount of chlorophyll and other plant pigments in the water; the intensity of green color in the ocean is a direct measurement of the amount of phytoplankton. Quantification of variations in chlorophyll a levels was derived from the SeaWiFS data taken from various sampling stations off the coast at sites selected using GIS analysis.

To determine where whales were congregating, researchers observed individual whales and referred to their residency patterns, recorded with GPS and processed with GIS. Researchers used ESRI's ArcView software to visualize this data, better understand its geographic context, discover relationships, and identify patterns in whale activity. In addition, by using Animal Movement (an ArcView Spatial Analyst extension), they were able to track and assess whale habitat usage.

Data gathered from 1995 to 2001 was delineated using GIS technology, and maps were studied to analyze trends and correlations between whale home ranges and residency patterns relative to anomalies or fluctuations in chlorophyll concentrations. Kinzel and her team found that the size of gray whale home ranges expanded in 1998 and 1999 compared to 1996 and 1997.



Red stars indicate buoys that collect chlorophyll data near a whale feeding ground. Yellow circles symbolize whale sightings.

The tracked whales expanded their home ranges because they stayed in their typical feeding grounds for shorter periods, then dispersed to find new feeding areas. The years the whales broadened their ranges corresponded with the years of the El Niño and La Niña climate changes. In particular, home ranges were largest during La Niña years. Major shifts in oceanographic processes are caused by the El Niño phenomenon, a warming of the ocean's surface when currents of nutrient-poor tropical water replace the cold, nutrient-rich surface water that supports great populations of fish and other nourishment. La Niña cools the surface of the water, also disrupting marine habitats. Kinzel and Venegas hypothesized that whale residency and site fidelity correlate to the availability and suitability of food.

The climate change seemed to have caused a shift in the primary food dominating shallow water communities, from several species of

swarming mysid shrimp (the gray whales' main nourishment source) during non-El Niño years to schooling anchovy fish (the humpback whales' food) common in the warmer currents of El Niño events. That shift could be a driving factor in the whales' change of feeding ground preference.

Because restrictions such as limited data points hinder making a decisive correlation between chlorophyll a concentration and whale distribution, the jury is still out. Nonetheless, the methodology of employing satellite imagery to better understand ecosystem processes and analyze animal behaviors has prospects for application in other environmental research studies.

To read more about whale research projects in Baja and British Columbia, visit the CERF Web site at [www.cerf.bc.ca](http://www.cerf.bc.ca). To learn more about Kinzel's gray whale project, e-mail her at [kinzelm@science.oregonstate.edu](mailto:kinzelm@science.oregonstate.edu).



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