Environmental
OBSERVER

GIS for Environmental Management Solutions

Northern Ireland's Flood Map

Like many regions of Europe, Northern Ireland has experienced significant flooding over recent years that has caused damage to businesses and homes and brought misery to thousands of people. Climate change predictions indicate increased flooding in the decades ahead. In Northern Ireland, the government is taking a proactive approach in terms of prevention, protection, and preparedness. This includes defining floodplains to avoid inappropriate development, constructing flood defenses, and raising awareness so that citizens can take measures to mitigate losses to their homes and businesses.

Traditionally, the Department of Agriculture and Rural Development's Rivers Agency had concentrated on protection. In response to a number of significant floods and

aided by advances in technology, the agency wanted to develop its ability to support prevention and preparedness. To succeed with this, it knew that information about flood risks should be made more accessible to the public, partners, and stakeholders. The agency therefore decided to develop an online map viewer to display information about past and future flooding risks.

ESRI Ireland worked with the Rivers Agency to develop a mapping service that communicates information about the potential risk of floods. The service presents maps of river and coastal floodplains and makes these publicly accessible.

The outcome of the Rivers Agency project is the Strategic Flood Map (NI)—Rivers & Sea. The public can go to the Rivers Agency website

and, within the map viewer, see

- Historical maps that illustrate areas that have flooded in the past
- Present-day maps that show river and coastal floodplains
- Climate change maps based on forecasts for 2030 that show predicted locations of river and coastal floodplains
- Flood defense maps that indicate the locations of existing walls, embankments, and other defenses and the areas protected by them

Developed using Esri's ArcGIS technology, the Strategic Flood Map provides simple pan and zoom tools and location search features to make it easy for people to find, view, and interpret information about a specified locality. ESRI Ireland hosts the solution from its data center in Dublin.

The Strategic Flood Map was launched jointly by the Northern Ireland Assembly ministers, who are responsibile for flood risk management and land-use planning. The launch generated a lot of media interest, and in the first few days alone, over 15,000 users visited the website to use the map viewer. As the map service host, ESRI Ireland responded quickly

Ireland Floodwaters

Esri Career Opportunity

Environmental Industry Solutions Manager
Use your years of industry experience and knowledge to assess and identify practical applications of GIS in the environmental field. This is a challenging opportunity to provide coordination and management of Esri's strategic marketing and solutions efforts as they relate to the development and use of GIS within the environmental market. Learn more and apply at esri.com/careers/enviro.

2011 Esri International User Conference Is for Environmental Management

Esri invites you to the Esri International User Conference (Esri UC) to learn about the latest geospatial technology trends for environmental management. At this conference, you will see how geographic information system (GIS) technology is being applied to see changes over time, create water usage scenarios, develop climate change policy, assess pollutant levels, support environmental impact reports, and more. Learn how ArcGIS 10 combines imagery and GIS for land-use and trend analysis. Hone your skills at the GIS technology tracks; meet with the largest gathering of GIS consultants in the world; and find the solution you need, from a desktop water analysis project to an enterprise-wide GIS implementation to cloud computing and shared data. Build your professional network by attending Special Interest Group meetings such as the Water Management Group, regional GIS groups, and the EPA group. Come join us and be inspired.

When: July 11–15, 2011
Where: San Diego Convention Center, San Diego, California, USA
Learn more and register: esri.com/events/UC

Environmental Management GIS Users Acknowledged at 2010 Esri UC

Esri presented its Special Achievement in GIS (SAG) awards and commended environmental management projects for their outstanding work using GIS. The list includes the USGS National Geospatial Program and Pacific Basin Islands Office, Hawaii; West Virginia Department of Environmental Protection; and the Environment Public Authority of Kuwait. Also in the environmental category were these winners:

- The Arkansas Department of Environmental Quality created an online application that showed data layers of the department's quality permitted sites and regulated facilities, the National Hydrography Dataset base water layers, the Arkansas Pollution Control and Ecology commission datasets, and properties cited as contaminated with methamphetamine.
- Casey Trees, Washington, D.C., hosts an interactive map that highlights street trees of the nation's capital.
- The Australian Department of Climate Change uses GIS as a strategic tool for its National Carbon Accounting System, a robust system for accounting for emissions and removal of greenhouse gases from Australia's land systems.
- The Chesapeake Bay Program makes geospatial information and data available to the public, allowing citizens to review progress toward bay restoration goals.
- The Environmental Agency of Abu Dhabi of the United Arab Emirates designed the Coastal Resources Atlas and the Environmental Vulnerability Index, which are primary tools for ecological and human use mapping of coastal and marine environments.
- Vermont Sustainable Jobs Fund created the Renewable Energy Atlas of Vermont, an online tool that identifies, analyzes, and visualizes existing and promising locations for renewable energy.

Esri applauds the efforts of these agencies' use of GIS to intelligently visualize, analyze, and manage the environment.

GIS for Wildlife Management Case Studies Available

A collection of stories about how people are applying geospatial technologies to better understand biodiversity and animal threat, *GIS for Wildlife Management* describes best practices from around the world and shows ways GIS has been used to

- Respond to invasive species.
- Manage and facilitate disease prevention.
- Minimize mortality.
- Determine wildlife movement and habitat ranges.

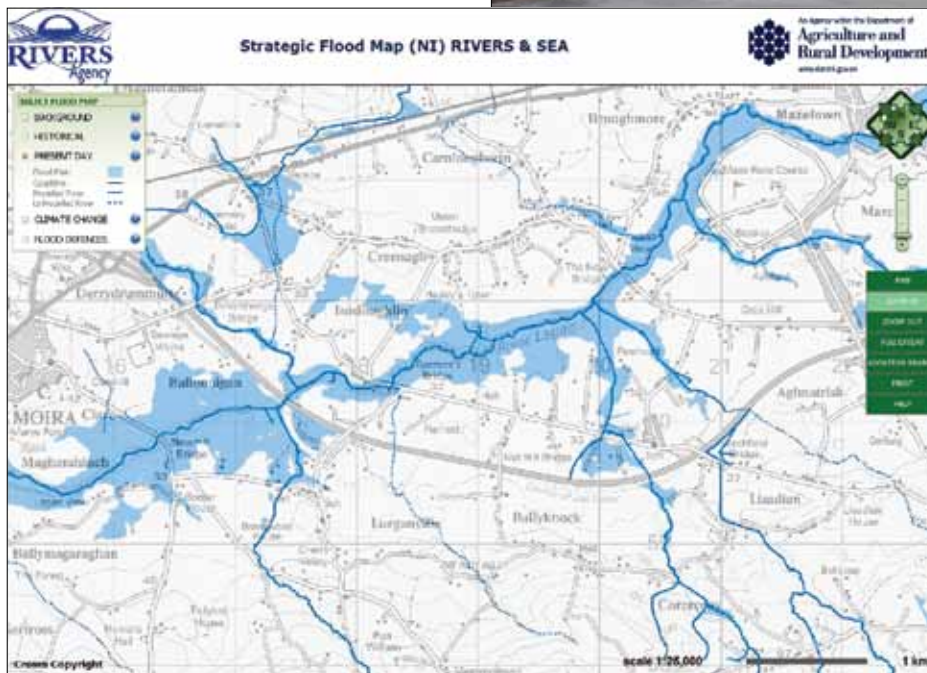Read it online or download this free booklet at esri.com/wildlife-bp.

Northern Ireland's Flood Map

to this massive spike in web traffic and worked with its Internet Service Provider (ISP) to accommodate demand.

The Rivers Agency is delighted with its Strategic Flood Map, which helps it comply with European Union legislation and improves the availability of flood risk information to key stakeholders.

The map viewer has proved to be reliable, and the agency has received very few calls from customers reporting difficulties in using it. The agency wants to expand its services by adding data layers so that users can

Flooding in East Belfast, Ireland

drill down to get more detailed information. It will also incorporate information on flood risk from other sources such as surface water and overland flow. Esri's map service solutions will make these changes achievable and affordable.

To view the Strategic Flood Map, visit www.dardni.gov.uk/riversagency.

Flood Map Built on Esri's Map Service Solutions

Sea Predators Guide Scientists to Vital Ecosystems

By Barbara Shields, Esri Writer

The southern seas and coastlines of Argentina and Chile, known as the Patagonian Shelf, provide a habitat for albatross and southern elephant seal populations. The presence of these top predators is an indicator of a food chain that supports them and the ecosystem necessary for that food chain to thrive. The hints provided by these and others predators, along with scientific analysis and GIS depictions, help nongovernmental organizations (NGOs) better understand and conserve the ecosystems of these waters.

The Wildlife Conservation Society (WCS) and Birdlife International have collaborated to create the *Atlas of the Patagonian Sea*, which contains maps showing key migratory corridors for top predators such as albatross, petrels, fur seals, sea lions, and southern elephant seals. More than 25 scientists from other research institutions and conservation organizations contributed their experience and data to the project. Esri and Aeroterra S.A., Esri's software distributor in Argentina, donated GIS software and support for visualizing and analyzing data.

In an effort to conserve the biodiversity of the Patagonian Sea, WCS launched its Sea and Sky project. "This unprecedented atlas was essentially written by the wildlife that lives in the Patagonian Sea," said Dr. Claudio
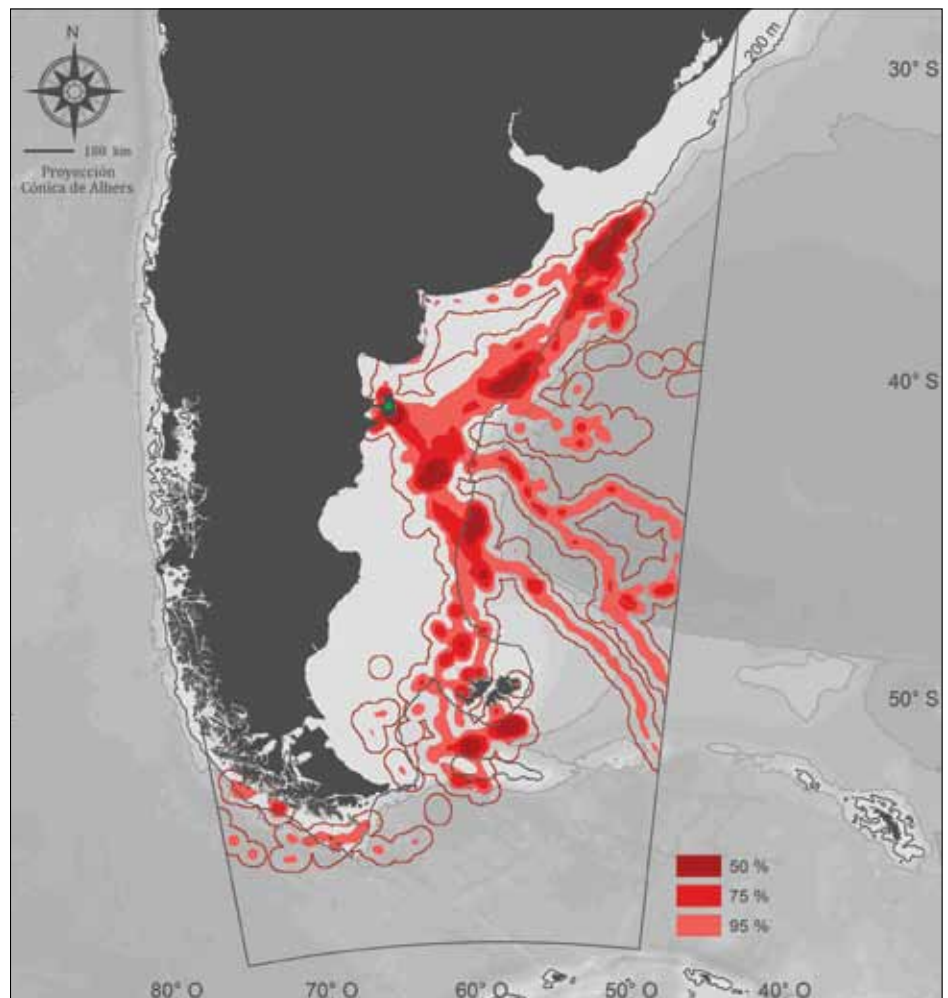
Density distributions are represented by the 50, 75, and 95 percent utilization distribution contours, indicating areas within which tracked individuals spent 50, 75, and 95 percent of their time at sea. The map shows the utilization distribution contours for southern elephant seal juveniles from the Valdés Peninsula in the summer.


The black-browed albatross is a top predator in the Patagonian Sea.

Campagna, who manages the WCS Sea and Sky initiative. "It helps fill in many gaps of knowledge and should serve as a blueprint for further conservation efforts in the region."

Researchers used satellite transmitters, geolocators, and recorders for Global Positioning Systems (GPS) to track predators during foraging trips. The majority of the data was obtained by satellite transmitters. More than 283,600 geographic positions (localizations) of 16 species of seabirds and marine mammals are stored in the Sea and Sky geodatabase.

GIS is a system that manages and processes data such as wildlife inventories, currents and temperatures, and human use data. From this information, users can create maps, show
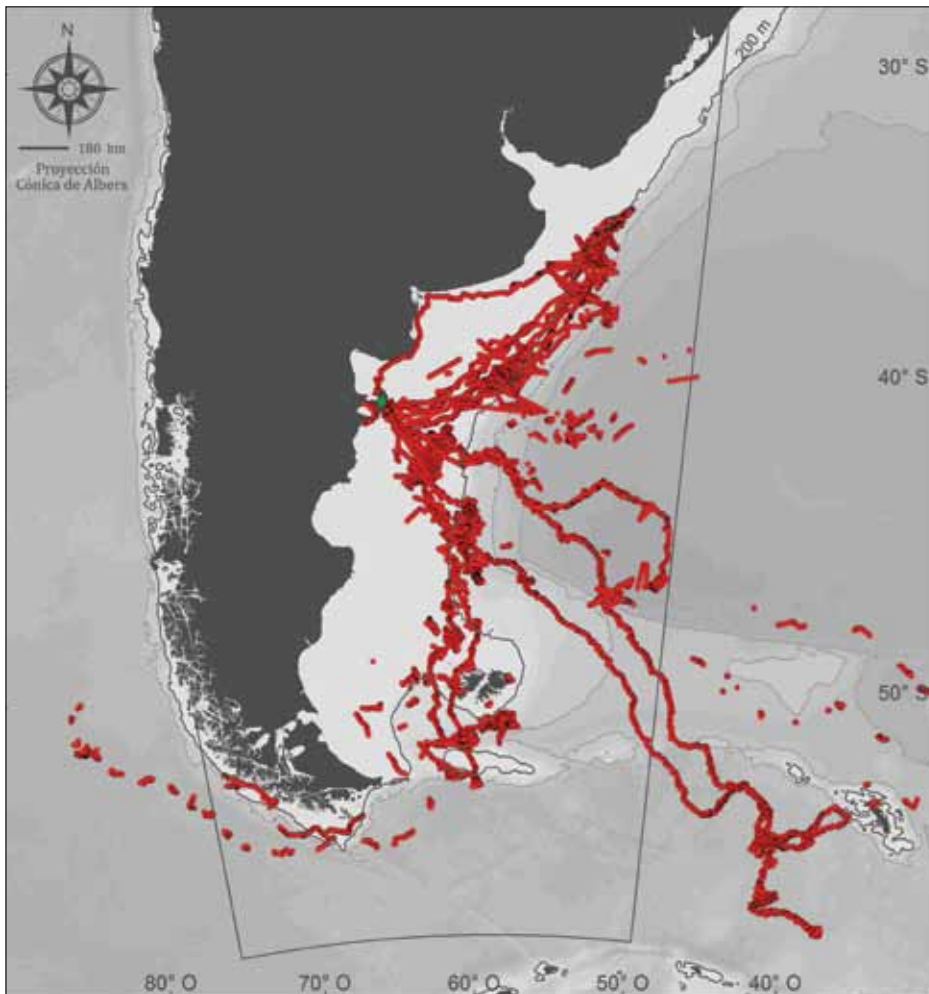
Satellite tracking position of southern elephant seal juveniles from the population on the Valdés Peninsula, recorded in the summer (January–March). Data is resampled at a rate of one location per hour.

Southern Elephant Seal Tagged for Satellite Tracking

relationships, and share their outcomes with others. Using GIS, WCS Sea and Sky researchers saw that 50 percent of the localizations of predators were in the Patagonian Sea and corresponded to approximately 1,300 migratory or hunting routes.

WCS created maps to answer guiding questions:

- Where are the areas of the southwest Atlantic with the highest concentration of top predators foraging for food?
- Where are the important areas that require ecosystem conservation?
- Based on the location and timing of foraging phases of sea animals' annual cycles, how can we improve the protection of species?

WCS chose GIS for this study because, rather than a static system that only holds images, it incorporates an entire database management system. Users accessed this to associate information with a feature on a map, such as a seal sighting, along with related information such as feeding and breeding habits. They analyzed the data using tools such as geostatistical analysis and compared it with other data such as sea data, shipping lanes, and jurisdictions. By understanding these relationships, conservationists then determined the suitability of various areas for protection or sustainable management.

For instance, researchers mapped southern elephant seal location data. Because the times that the data was captured were also recorded,

researchers could see on the map how much time the species spent in the area. Researchers generated a contour map that indicated the distribution range of the animals studied and used geostatistical tools to calculate the probabilities of a species being in a given area. A 50 percent contour line indicates the areas of highest density or probability of southern elephant seals being in that location. This same method was applied to each of the study's 16 predator species. Finally, researchers created a composite view of Patagonian Sea ecosystems.

Top predators use large oceanic areas that extend beyond jurisdictions, and they breed and reproduce on ocean fronts and in coastal areas that cross national boundaries and conservation management areas. WCS combined Sea and Sky data with data from nations, protection agencies, and ocean charts to create a comprehensive view that includes the ocean, policies, and species activities. Project researchers then used GIS to view and manage data such as species population, analyze geographic relationships such as species behavior and locations, and model geographic events, which helped them identify ecosystems. This information will be used to scientifically guide and support the creation of marine protected areas and special management actions.

The study concluded the following:

The coastal areas of greatest importance are the waters adjacent to the Malvinas Islands, Staten Island, Diego Ramírez Islands,

Sea Predators Guide Scientists to Vital Ecosystems

the Valdés Peninsula, and the waters stretching from the south of the peninsula to the north of the Gulf of San Jorge.

The important pelagic areas are the oceanographic front associated with the slope of the Patagonian Shelf, the ocean environment adjacent to the Malvinas Islands, the shelf-slope area at the latitude of the Gulf of San Jorge, the areas influenced by the outflow of the Río de la Plata, and the area to the east of the Burdwood Bank.

The waters of the polar front at the southeast end of the target area and a coastal-pelagic corridor between the Valdés Peninsula and the shelf-slope are areas of relevance because they support food sources and migratory passages for sea animals.

Researchers could readily see that none of the pelagic areas identified as important for top predators is under special management for conservation biodiversity. The study provides insight for the biozoning of the ecosystem and gives scientific credence to policy recommendations for open ocean marine protected areas.

"Esri's ArcGIS has been one of the most important tools that the project has used to identify relevant ocean areas and promote the conservation of the Patagonian Sea," said Valeria Falabella, a marine biologist and the assistant director of WCS Sea and Sky. "WCS has promoted this methodology of integrating species and spaces to guide conservation all around the world. Esri and Aeroterra have been fundamental to these efforts by providing software, training, and technical support
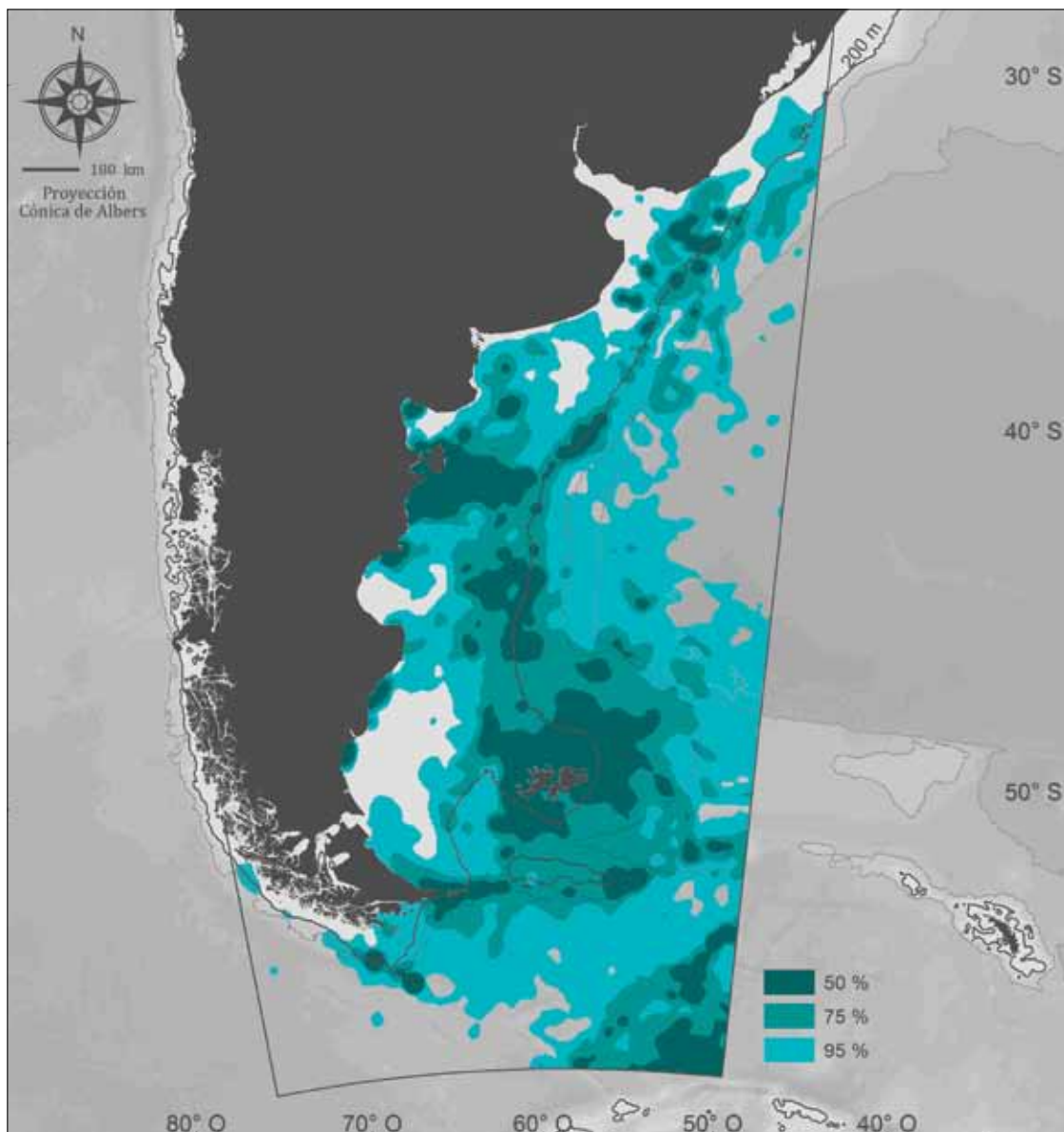
Use of the Patagonian Sea by 16 Species of Top Predators

to the project."

The *Atlas of the Patagonian Sea* web page is an excellent tool for research and education. Site visitors can interact with and download high-resolution maps. See it at atlas-marpatagonico.org.
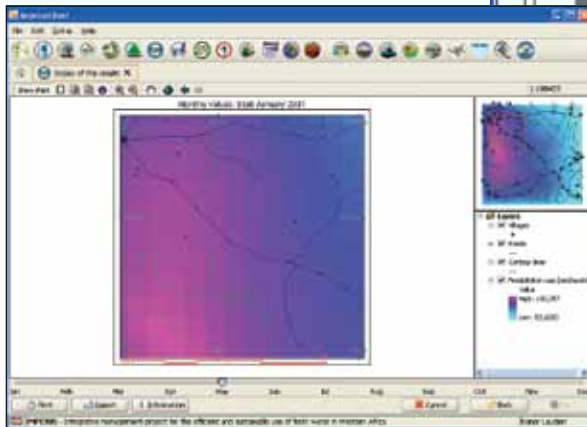
The completion of *Atlas of the Patagonian Sea* is due in large part to the generosity and long-standing support of the Liz Claiborne and Art Ortenberg Foundation for the WCS Sea and Sky initiative, as well as support from Judith H. Hamilton, James M. Large, Christopher B. Hockett, and Isabella Rossellini. WCS's conservation work in this region also receives sup-

Africa Drought Impact Scenarios Modeled in Spatial Decision Support System

By Dr. Rainer Laudien, ESRI Deutschland GmbH

Parts of West and North Africa have experienced 30 years of drought. The shortage of fresh water is expected to be the dominant water problem of the twenty-first century and one that, along with water quality, may well jeopardize all other efforts to secure sustainable development and, in some cases, lead to social and political instability. The current situation north and south of the Sahara is characterized by increasing population, with a growth rate of more than 3 percent per year; increasing degradation of the natural vegetation due to overgrazing (Morocco); demands

ArcGIS map panel shows an estimate of water exploitation of an aquifer for the year 2016 as well as soil salinity.
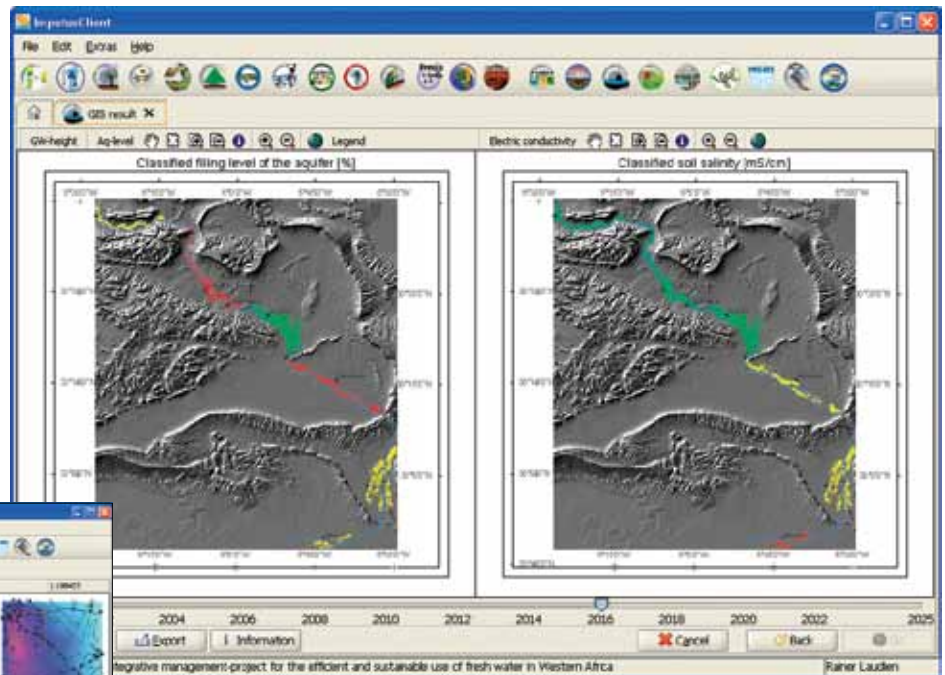

A land-use change and precipitation tool calculates precipitation values based on various land-use and meteorological variables.

for firewood; and shifting cultivation (Benin). Consequently, soils quickly erode, and salt content rises due to the irrigation practices. These problems are likely to accelerate the degradation and desertification processes of the region in coming decades.

Impetus is an interdisciplinary research project that uses an integrated approach for managing scarce water resources in West Africa (www.impetus.uni-koeln.de). Understanding ways that drought and human impact will affect the region in the future requires managing large amounts of data, anticipating variables, and identifying decision options. Impetus uses a spatial decision support system (SDSS) that integrates GIS into decision processes.

Developers at the University of Cologne in Germany used the Esri developer library ArcGIS Engine to create software that provides spatial analysis functions within computer-based decision tools that are accessible from different platforms. Geodata and single SDSS models are stored in the ArcGIS file-based geodatabase, making them accessible for analysis using GIS.

The developers created several GIS water management tools for Impetus that incorporate a specific ArcGIS map panel and its functionalities, enabling users to select from the geodatabase specific data, models, and locations; visualize them in a map panel; and save the selection to a file.

A land-use change and precipitation tool answers questions on the possible developments of evaporation and precipitation until the middle of the twenty-first century for the Ouémé catchment in central Benin, Africa. GIS depicts Intergovernmental Panel on Climate Change (IPCC) scenarios by calculating precipitation amounts resulting from various land-use and meteorological variables. These are by month and year. Users view these scenarios on maps or as time series graphs, such as bar charts, to help them identify years with a potential for water shortages.

Another tool models the impact of water exploitation on groundwater and soil. Impetus researchers used this tool to study six oases in Morocco. The model approximates the groundwater stock and soil salinity results and generates classified multitemporal thematic maps. Users may also see time series in terms of histograms of a selected oasis.

A water quality tool provides information about the drinking water status of more than 2,000 wells in the area of the upper Ouémé catchment in Benin. It accesses multitemporal water quality data, digital photographs, emergency addresses, and other pertinent information.

For more information concerning the use of ArcGIS Engine for spatial decision support, contact Dr. Rainer Laudien (r.laudien@esri.de) or ESRI Deutschland GmbH (esri.de).

California Department of Fish and Game Implements ArcGIS Server

Will Patterson, California Department of Fish and Game

California is a great state for wildlife. Its varied topography and climate yield a broad range of habitats that are home to a large and uniquely diverse number of species. The foggy and cool conditions of the Napa Valley, arid heat of the Mojave Desert, long expansive coastline along the Pacific Ocean, and rich forests of the Sierra Nevada are some of the many environments that the state hosts for plants and animals.

The California Department of Fish and Game (DFG) monitors, maintains, and inventories the state's wildlife and habitats and oversees the use of natural species for recreation, commerce, science, and education. For more than 20 years, DFG has been using GIS to assist with these efforts. Available from DFG's website are GIS-produced maps and downloadable GIS data layers that illustrate many department functions. The website also offers interactive mapping applications that allow

visitors to view and query data without having to install GIS applications on their computers.

DFG is transitioning the technology it uses to serve map content. For many years, it has been successfully using ArcIMS but has now begun implementing a plan for migration to ArcGIS Server. Reasons for the migration include ArcGIS Server software's more rapid deployment of map services, faster map service delivery through caching, and easier development of web mapping applications. The ArcGIS Server Image extension was also especially appealing because of its ability to quickly serve large amounts of aerial imagery with little preprocessing and no requirement to load and manage the imagery in a database system.

DFG's plan for migration from ArcIMS to ArcGIS Server involves two phases. The already-completed first phase included publishing new statewide map and image services for use as

Migrating geese. Photo courtesy of the California Department of Fish and Game

background layers within ArcGIS Desktop and future web mapping applications. The in-progress second phase involves migrating existing ArcIMS web mapping applications to the ArcGIS Server environment.

The first phase of the migration has provided the following statewide services for DFG and public use. For widespread access, these services are offered from ArcGIS Server in both Esri and OpenGIS Web Map Services (WMS) formats. Some services are unique and not available elsewhere.

Topo maps—Several map services include seamless US Geological Survey topo maps (digital raster graphics [DRGs]) rendered in different ways, including grayscale colors, hillshade background, regular colors, and transparent background. These services are cached for fast display.

Aerial images—Several separate image services offer various years (2005, 2009) and band combinations of US Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP)-related aerial imagery, including four-band, color infrared (CIR), natural color, and Normalized Difference Vegetation Index (NDVI).

ArcMap 10 Showing NAIP 2009 Color Infrared (CIR) Image Service for California Offered by California Department of Fish and Game

ArcGIS Online Showing Unique Topo Service for California in Grayscale Offered by California Department of Fish and Game

During the second-phase, the following interactive mapping applications are to be transitioned from ArcIMS to ArcGIS Server:

- Biogeographic Information and Observation System (BIOS), with its own catalog of hundreds of layers of biogeographic and habitat data that can be added as needed into its map viewer
- Online Fishing Guide, which provides a map viewer that allows the user to see recommended fishing spots and related services and facilities
- DFG Properties viewer, which provides

the ability to explore DFG lands and facilities throughout the state for possible hunting and wildlife viewing activities

DFG offices are spread throughout California, with some locations having limited network bandwidth and reduced capability to use online GIS resources. From an enterprise GIS perspective, it has been challenging to deliver data, such as specific aerial imagery, to those who need it. One solution has been to copy the imagery onto portable drives and ship them to the offices so that users can make a local copy. However, with imagery storage

requirements growing to terabyte levels, this process has become cumbersome. Fortunately, after implementing the ArcGIS Server Image extension, DFG can host more aerial imagery in one office and serve it on demand through image services to other offices. The image services also have compression settings that can be adjusted by end users to reduce bandwidth requirements.

DFG's topo map and aerial image services have been cataloged in ArcGIS Online for easy discovery along with content published by other contributors. In the future, DFG plans to use other already-published services, such as those from Esri, whenever possible to reduce the need to develop its own services.

Special thanks go to DFG's server team for setup, configuration, and maintenance of the Windows servers that host the department's ArcIMS, ArcGIS Server, web server, and data storage environments.

More information about ArcGIS Server and the ArcGIS Server Image extension is available at esri.com/arcgisserver. More information about DFG's GIS services and web mapping applications is available at www.dfg.ca.gov/biogeodata/gis. Explore ArcGIS Online content at arcgis.com.

Mule Deer. Photo courtesy of the California Department of Fish and Game

Lidar and GIS Fast-Track Water Resource Pipeline Project

The Wimmera Mallee's historic stock and domestic water supply system—10,800 miles of open, earthen channels—has supplied water to farms and residents of northwestern Victoria, Australia, since the early 1890s. Low water levels, brought on by drought, revealed the inefficiency of the system. Of the 120,000 megaliters of water released into the channel system, only 17,000 were used by customers, and the rest—up to 80 percent—was lost from the open channels due to evaporation and leakage.

To increase the efficiency of water distribution, the Commonwealth of Australia, the Victoria state government, and Grampians Wimmera Mallee Water (GWMWater) agreed to fund the Wimmera Mallee Pipeline Project (WMPP), an initiative to improve the water system with pipelines and pump stations. Although the timeline to complete the project was 10 years, the community needed the water sooner to maintain their farms and livelihood.

GWMWater was responsible for the project. Its engineers knew that capturing and analyzing the required amount of data over such a large and diverse area of terrain and vegetation would best be managed in a file format-friendly GIS software platform. Working with AAMHatch, an Australia-based firm specializing in geospatial services and products, GWMWater aimed to fast-track the project from a 10-year to a 5-year schedule. To do so, it used light detection and ranging (lidar)-based imagery of the entire project area, packaged in GIS spatial datasets. The enterprise GIS was

The Wimmera Mallee open-channel system was losing drastic amounts of water due to evaporation and leakage.

put to work managing lidar and orthophotography and other data, enabling engineers to speed up the 8,800-kilometer (5,468-mile)-long pipeline project, as well as save time, resources, and money.

Air crews captured data, surveyors processed GPS and laser scanner data, and analysts worked on data processing. Using Esri's terrain data type, which allows massive surface datasets to be stored in an ArcGIS geodatabase, AAMHatch created terrain datasets of the project area comprising 1.3 billion points. ArcGIS terrains optimized performance at multiple resolutions through the use of terrain pyramids that quickly retrieved only the data needed for the required level of detail in a given area of interest. The digital terrain model datasets had approximately 15-centimeter vertical accuracy at one sigma on open areas, with an average laser strike spacing of 1.3 meters. The terrain data was easily and quickly processed and analyzed using the ArcGIS Server 3D extension and was complemented by orthoimagery data with 60-centimeter image resolution to provide a complete picture. Stored in the GWMWater GIS, the lidar and orthoimagery data provided continuous coverage of the land use, land cover, and terrain—all data that was essential for engineers to efficiently design, model, and construct the pipeline.

In April 2010, the Wimmera Mallee pipeline was officially opened five years ahead of schedule. Since replacing the inefficient open-channel system, water restrictions for farms and residents have been eased, and the region's reservoir levels have returned to 60 percent of their capacity. GWMWater continues to use the WMPP terrain data and orthoimagery for engineering of earthworks to fill in the miles of redundant open channels.

For more information, contact Shane Schwarz, network coordinator, GWMWater (e-mail: shane.schwarz@gwmwater.org.au).
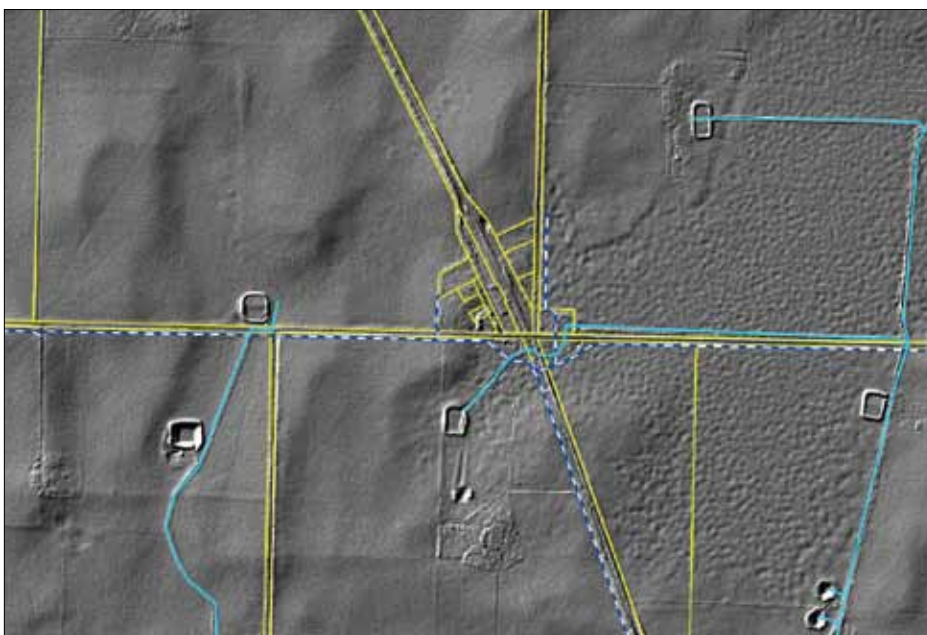
Two-meter hillshade elevation grid created using ArcGIS data processing tools. Visible features include redundant on-farm storage dams as well as the open-channel network.

GIS Training for Conservationists

The Nature Conservancy (TNC), Wildlife Conservation Society (WCS), and World Wildlife Fund (WWF) have developed an introductory online GIS course that teaches students GIS skills and introduces them to conservation applications.

Introduction to GIS for Conservation is a beginner-level course helping students establish a solid foundation of GIS skills. The free, interactive, self-paced course has an instructor-led feel with audio, text, video, demonstrations, and exercises. Within its modular structure, the student progressively learns about GIS, digital mapping, attributes, coordinate systems, spatial data, and GIS databases.

Through interactive activities, students learn GIS concepts and experience the look and feel of Esri's ArcGIS software. Students do not need to have the ArcGIS software on their computers to participate; they simply need an Internet connection.

The course is located at www.conservationtraining.org, a website dedicated to conservation training for working professionals. With support from Remote-Learner.net, The Nature Conservancy started the site in an effort to bring together the best content from the world's leading conservation organizations. Built on the open source learning management platform Moodle, it gives course providers the ability to create a virtual, online classroom by tracking students' access to course content while building a collaborative learning environment. The GIS course is just one example of how successful the site has become.

This e-learning project was started because TNC, WCS, and WWF recognized the importance of developing GIS capacity in their international programs. These organizations estimate that between them, they have 1,200 GIS users in 68 countries. To meet the growing demands for GIS support, they needed an easy and inexpensive way to train their employees. "The instructor-led training provided in the TNC Learning Center classrooms is limited to 15 students per class," noted Jamie Chesser of TNC, who helped develop the course. "This online training is more accessible and more convenient to our staff, students, and managers who are busy working on conservation projects around the world." Over a two-year period, developers from the three organizations used their years of teaching experience, GIS expertise, and conservation knowledge to carefully develop the course.

In June 2010, the pilot course was launched and met with great enthusiasm as 700 people from around the globe registered for it. The developers sought input and feedback from the GIS conservation community, which they included in the final course, officially launched in November 2010.

The partners' collaborative effort broadened the GIS expertise and teaching experiences brought to the course. In addition, from the very beginning, the development team felt it was necessary, given the complexity of the topic, to establish a network of mentors to help students through the course. Moreover, they thought it was important for these mentors to be conservation GIS professionals working throughout the world. The mentor team currently consists of 31 conservation GIS professionals working around the globe.

Collaboration continues as TNC, WCS, and WWF look to develop other GIS-related courses. Conservation organizations' training budgets are small, and this free course is a big boon for the conservation community. Members of the conservation community who need a basic understanding of GIS are encouraged to register for the course at www.conservationtraining.org.

esri®

Environmental Observer is a publication of the Environmental Solutions Group of Esri.

To contact the Esri Desktop Order Center, call

1-800-447-9778

within the United States

or

909-793-2853, ext. 1-1235, outside the United States.

Visit the Esri website at **esri.com**.

View *Environmental Observer* online at **esri.com/environment**.

125490
81.4M5/11sp

Advertise with Us
E-mail ads@esri.com.

Submit Content
To submit articles for publication in *Environmental Observer*, contact Barbara Shields at bshields@esri.com.

Manage Your Subscription
To update your mailing address or subscribe or unsubscribe to Esri publications, visit esri.com/manageyoursubscription.

International customers should contact an Esri distributor to manage their subscriptions. For a directory of distributors, visit esri.com/distributors.

Circulation Services
For back issues, missed issues, and other circulation services, e-mail requests@esri.com; call 909-793-2853, extension 2778; or fax 909-798-0560.

Esri Environmental Management Team
Geoff Wade
Natural Resources Manager
E-mail: gwade@esri.com
Tel.: 909-793-2853, ext. 1-2391

Belinda LeSage, Natural Resources Coordinator
E-mail: blesage@esri.com
Tel.: 909-793-2853, ext. 1-2021

My Esri News keeps you connected with GIS users and events in your area. Sign up today at esri.com/myesrinews.

380 New York Street
Redlands, California 92373-8100 usa

esri®