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2011 Year in Review

Earth Resources Observation and Science Center

Open-File Report 2012–1185

U.S. Department of the Interior
U.S. Geological Survey

"Do not wait; the time will never be 'just right'. Start where you stand, and work with whatever tools you may have at your command, and better tools will be found as you go along."

—Napoleon Hill

Cover. Background: Landsat 5 mosaic of Chesapeake Bay (left); illustration of the Landsat Data Continuity Mission (LDCM), the eighth in the series of Landsat satellites (right). Insets: Operational Land Imager (OLI) being checked at Ball Aerospace; Landsat 7 image of center-pivot irrigation fields near Garden City, Kansas; aerial photo of Missouri River flooding near Omaha, Nebraska; Landsat 7 image of the Wallow Fire, Arizona.

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Earth Resources Observation and Science Center

Compiled by Rebecca Johnson

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U.S. Department of the Interior
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U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2012

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Suggested citation:
Johnson, Rebecca, comp., 2012, 2011 Year in review—Earth Resources Observation and Science Center: U.S. Geological Survey Open-File Report 2012–1185, 30 p.

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Director's

MESSAGE

2011 Year In Review—Annual Report

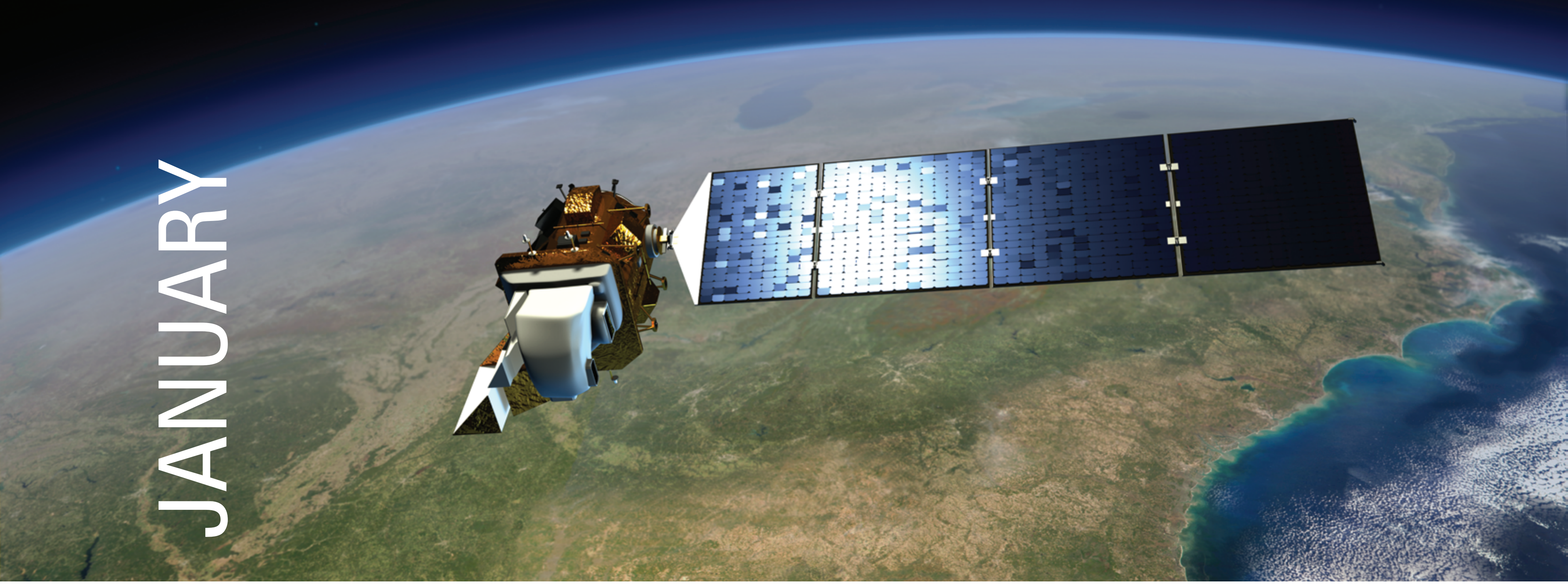
It was with great pleasure and anticipation that I entered on duty in January 2012 as the Director for the Earth Resources Observation and Science (EROS) Center. Shortly after, it struck me how the many employees and EROS directors before me have steadily pursued and maximized on achieving the vision of the late, great geologist William T. Pecora, who was appointed and served as USGS Director from 1964 to 1971. I am exhilarated by the fact that I am joining the EROS workforce and leadership team just as 40 years of earth observations coupled with a growing understanding of a changing world have elapsed.

I can wholeheartedly say that I am excited and ready to begin developing and achieving the vision for EROS and its employees for the next 40 years. The journey ahead will most likely have many unknowns, transitions, and opportunities. These are what keep the broad scope and meaning of EROS work always challenging and motivating. As we look to the future, there is still much to uncover and attain in advancing free data and information distribution; national land imaging; terrestrial monitoring; and remote-sensing based science, research, and applications. At present, my thoughts are focused on learning more about the heritage of EROS while investigating fresh views for the people, science, information management, and business processes at the Center.

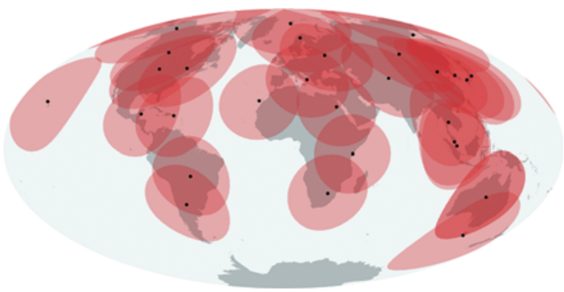
I invite you to join me in reviewing, month by month, the broad scope of EROS accomplishments from 2011. As you look through the pages, my hope is that you, like me, will find these yearly highlights meaningful and informative. I look forward to having you join us as we embark on 2012 and beyond.

Frank Kelly

JANUARY



The Landsat Data Continuity Mission (LDCM), scheduled to launch in February 2013, will be the eighth in the series of Landsat satellites.

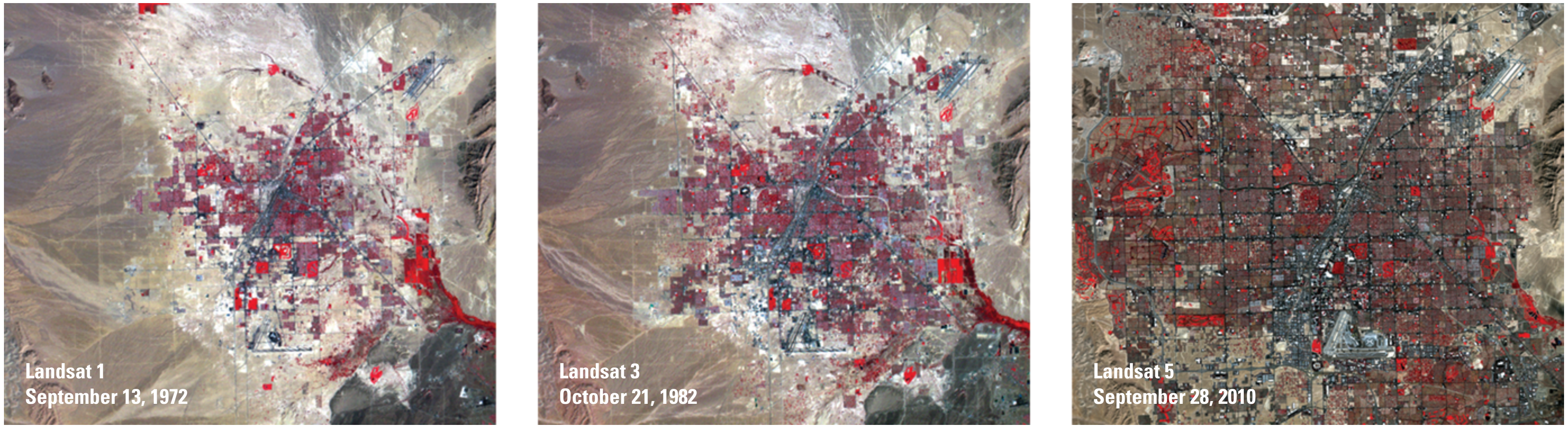


This map shows the network of current and planned Landsat ground stations (black dots). The red circles show the approximate area over which each station has the capability for direct reception of Landsat data.

T-Minus 24 Months

Twenty-four months and counting—that time line was foremost in the minds of Landsat Data Continuity Mission (LDCM) team members as 2011 began. LDCM—a.k.a. Landsat 8—is the long-awaited continuation of the Landsat satellite program, begun in 1972 and managed jointly by the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA). For 40 years, Landsat satellites have been capturing images of Earth's land surfaces and, in the process, creating the world's longest unbroken record of global change as seen from space. Landsat 8 is scheduled to launch into orbit in February 2013.

Throughout 2011, the LDCM team at EROS ticked off one milestone after another on a long list of tasks. Three ground stations that will receive data from the new satellite were established—one in Fairbanks, Alaska; another in Svalbard, Norway; and the primary location at EROS—by June. Batteries of tests confirmed that the stations' ground system will be able to communicate with the satellite once it is in orbit, and that the stations will be ready, on a daily basis, to receive, process,



Landsat images spanning 38 years show the dramatic urban expansion of Las Vegas, Nevada.

archive, and distribute the hundreds of images Landsat 8 will be capturing of the Earth's surface. The LDCM team also monitored the progress of the satellite's two onboard instruments—the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)—as they neared completion. EROS LDCM ground system manager Jim Nelson described 2011 as a year of integration: "It sometimes felt like we had eight million things going on at once, but there was really just one goal—to ensure that the ground system, the spacecraft, and the instruments onboard will all work together as a unified whole."

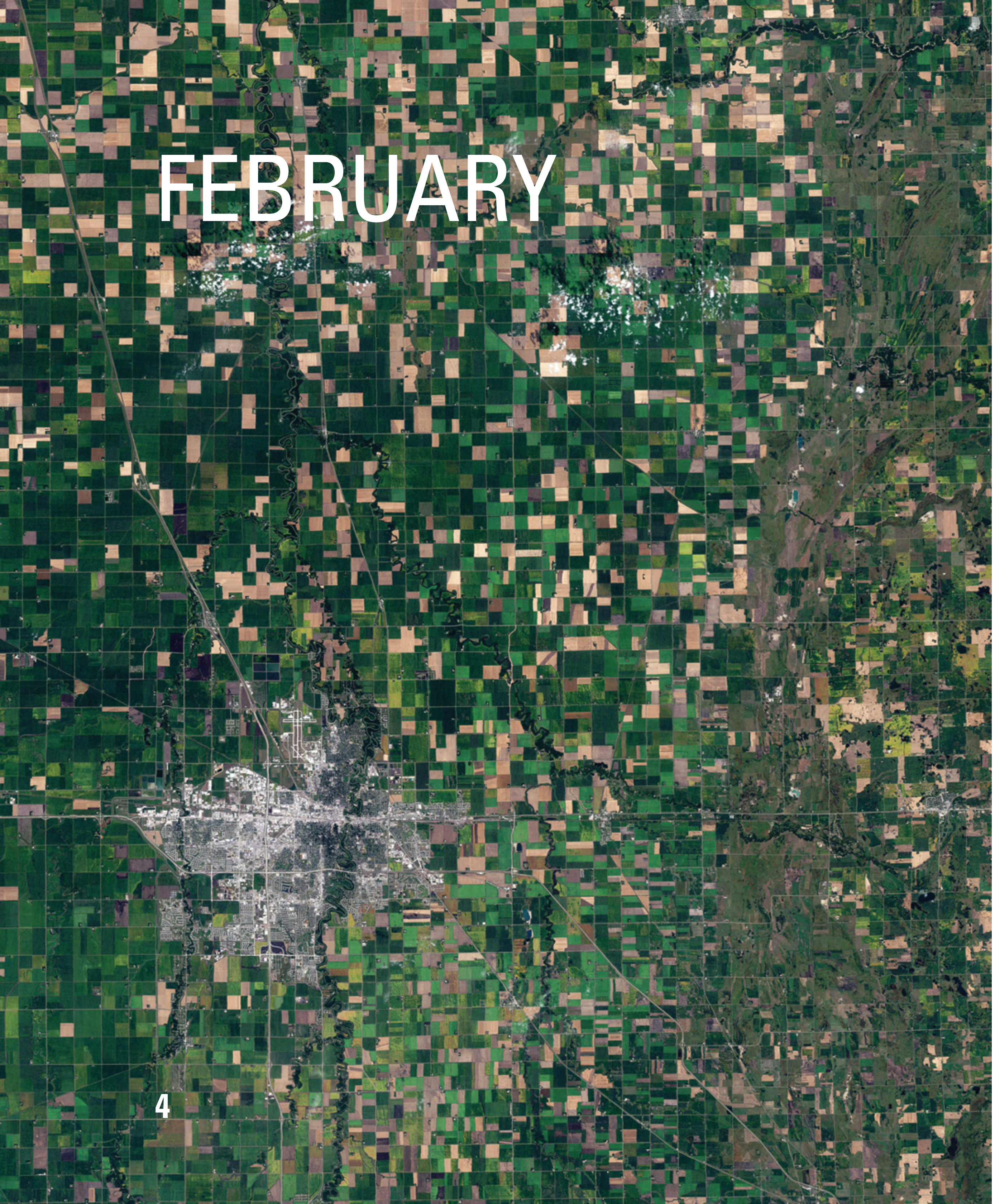
Testing...Testing...Testing

Technicians at Ball Aerospace and Technologies Corporation in Boulder, Colorado, spent the first 6 months of 2011 conducting tests of the Operational Land Imager (OLI), 1 of the 2 main instruments to be carried aboard Landsat 8. In August, the OLI headed to Orbital Sciences Corporation in Gilbert, Arizona, where it was integrated into the spacecraft in October.

OLI represents a major improvement in Landsat sensor technology. With fewer moving parts than its predecessor sensor on Landsat 7, it is less likely to wear out. Using long arrays of thousands of light detectors, OLI will capture images of the Earth's surface using nine different spectral bands (particular wavelengths of light), including an ultra-blue band ideal for coastal and aerosol studies, and another band designed for detecting certain types of clouds.

The intricate workings of LDCM's Operational Land Imager receive a final check from technicians at Ball Aerospace.

side tracks

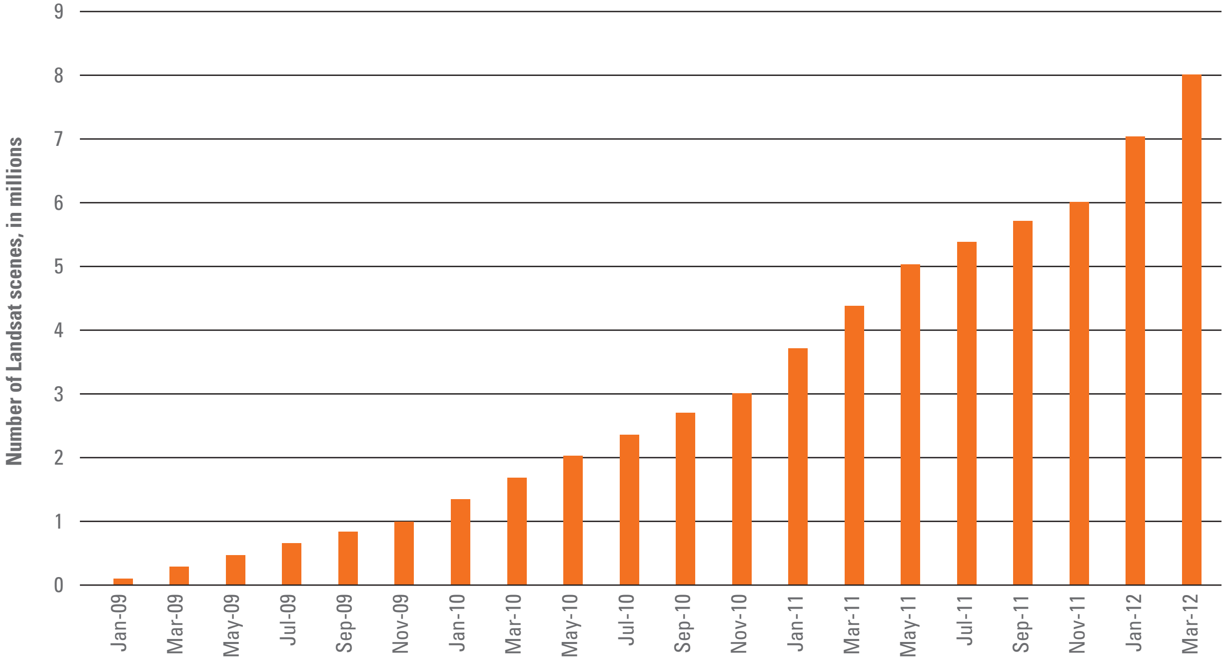


Landsat 5 captured this patchwork of agricultural fields near the twin cities of Fargo, North Dakota, and Moorhead, Minnesota. Colors change during the growing season as crops and conditions change. Satellite imagery can help farmers assess drought and flood effects, target insect infestations, plan pesticide applications, and monitor overall crop health.

Results of a Data Revolution

USGS analysts released the results of the 2009–2010 Landsat User Survey in February, a detailed online study that elicited responses from roughly 2,500 users of satellite imagery, including more than 1,400 who use Landsat data. The survey results underscored the value of Landsat imagery for a broad spectrum of applications ranging from agriculture and forestry to climate-change research, hazard mitigation, and urban planning. Although other types of moderate-resolution satellite imagery are available, Landsat images are unique because they provide complete global coverage, span nearly

Landsat Scenes Distributed at No Charge, 2009–2012



Horticulturist David Ramming examines grapes growing in California's San Joaquin Valley.

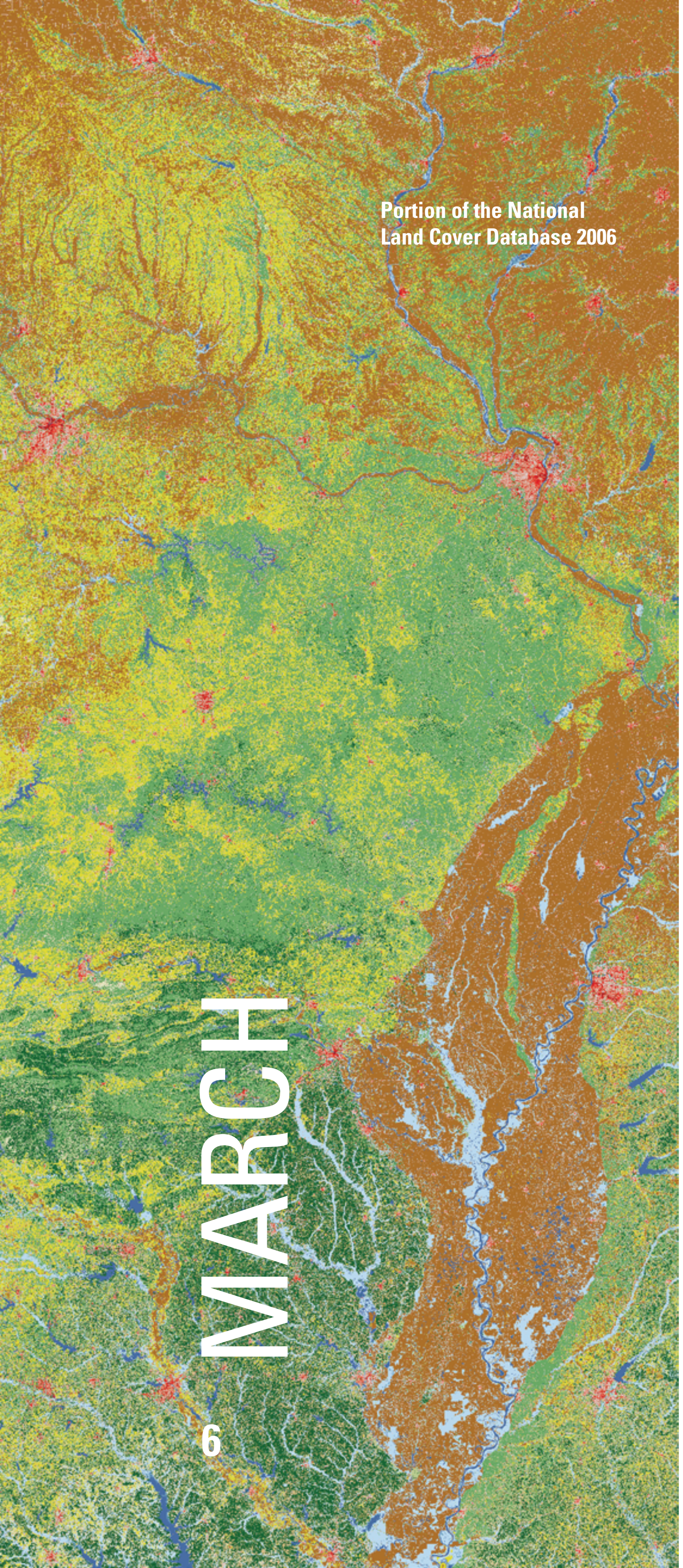
four decades of continuous Earth observation, and are available at no cost.

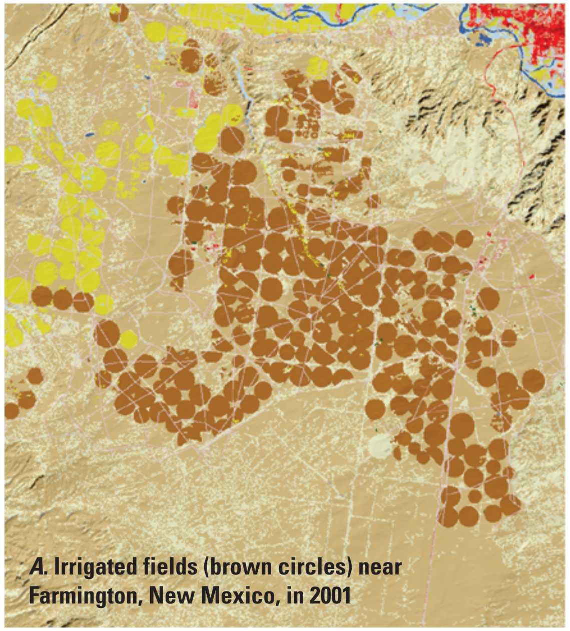
No-cost data access, however, is a relatively recent development. Before 2009, there were always costs associated with ordering Landsat imagery. In late 2008, however, a new data policy revolutionized access to Landsat images by making those already held by USGS in its EROS archive, together with all newly acquired scenes, freely available on the Internet to anyone, anywhere, anytime. The change was arguably one of the most important developments in the history of the Landsat program and it has led to a phenomenal increase in the use of Landsat data. In a little more than 2 years (through December 2011), open access had resulted in the distribution of more than 7.3 million Landsat images. By comparison, users purchased fewer than 25,000 images during 2001. Behind the skyrocketing numbers is an even bigger story: opening the Landsat archive has elevated awareness of the data's potential, spurred the creation of more robust standard satellite data products, triggered an explosion of new scientific applications, and fostered increased international collaboration to meet the Earth-observing needs of the 21st century.

"The opening of the Landsat archive to free, web-based access [was] like giving a library card for the world's best library of Earth conditions to everyone in the world."[1]

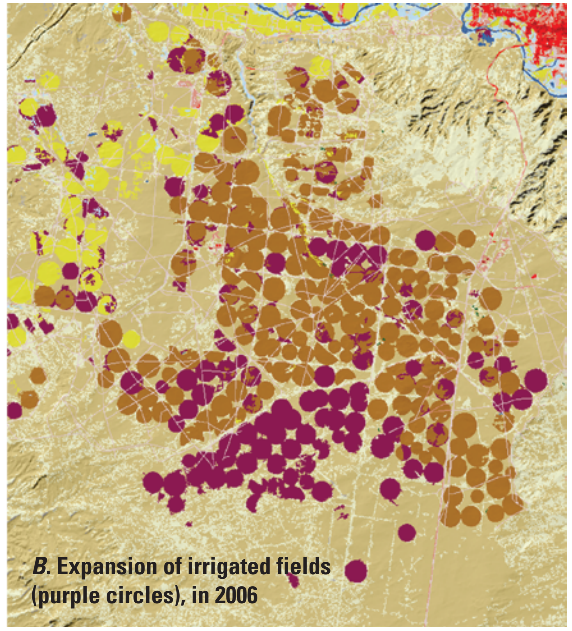
—Adam Gerrand,
Food and Agriculture Organization of the United Nations

[1] *http://landsat.usgs.gov/*





A. Irrigated fields (brown circles) near Farmington, New Mexico, in 2001



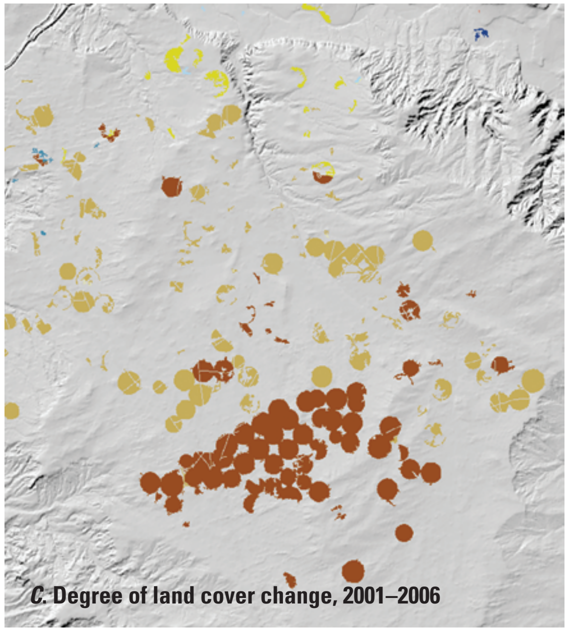
B. Expansion of irrigated fields (purple circles), in 2006

The NLCD 2006 reveals how land cover across the conterminous United States changed between 2001 and 2006 (***A, B, C***).

A New Change-Monitoring Tool

Landsat's unbroken record of Earth observation made a new view of the conterminous United States possible in early spring 2011 when USGS—working in partnership with the 11-member federal interagency Multi-Resolution Land Characteristics (MRLC) Consortium—released the National Land Cover Database (NLCD) 2006. Considered the definitive land cover database for America, the NLCD 2006 updates current knowledge of the Nation's land cover and documents precisely where land cover change occurred between 2001 and 2006 in the conterminous states. NLCD 2006 represents the first database of its kind produced with a 5-year cycle, a time frame designed to meet the need for more frequent land cover monitoring.

At first glance, NLCD 2006 might look like a map, but it's much more. It is constructed from vast amounts of data, all carefully calibrated to describe the land surface conditions of each 30-meter-square (32-yard-square) pixel, or cell, that makes up this digital composite. Users can plumb the cyber confines of each cell for information about the type of land cover it contains; the amount of tree cover, a mathematical tallying of impervious surfaces (concrete or asphalt sidewalks, streets, and parking lots) and how all those parameters changed between 2001 and 2006. NLCD 2006 represents a new



C. **Degree of land cover change, 2001–2006**

change-monitoring tool for studying ecosystems and biodiversity, tracking urban growth, documenting effects of climate change, and highlighting best practices in land management.

"Periodic updating of the NLCD can be compared to taking a new census of the state of our land cover."[2]

—Marcia McNutt,
Director, U.S. Geological Survey

side tracks

When Disaster Strikes

On March, 11, 2011, Japan experienced a magnitude 9.0 earthquake—the worst in its history—that triggered a massive tsunami. It was as if a nightmare had been brought to life. The towering wall of water left a terrifying scene of death and devastation after it thundered ashore 370 kilometers (330 miles) northeast of Tokyo.

From South Dakota, USGS EROS Emergency Operations staff kept a finger on the pulse of the crisis as they helped first responders utilize the Hazards Data Distribution System (HDDS) to access geophysical data, including satellite images, of the battered Japanese coast. On call day and night, the Emergency Operations team has high-priority access to many commercial and government satellite and aerial photography tasking authorities, and can position critical imagery and information on a fast track to reach emergency responders via the HDDS. Following any natural or human-caused disaster, before-and-after satellite images, aerial photography, and other remotely sensed data are indispensable tools for assessing the scope and scale of the catastrophe, and strategizing rescue and recovery operations.

The Japan tsunami wasn't the first event that sent Emergency Operations into action in 2011. By the end of the year the team had supplied more than13 terabytes of satellite imagery (representing 1.5 million individual files) to emergency responders involved in 48 major domestic and international disasters that ranged from earthquakes, volcanoes, and landslides to tornadoes, floods, and wildfires. During the year, the HDDS was upgraded to include a graphic interface that makes it easier to search and acquire—with a few simple keystrokes—essential data that are needed when disaster strikes.

Aerial photographs, taken near Wakuya in northern Japan, show the after effects of the 9.0 magnitude earthquake and subsequent tsunami.

[2]*http://www.usgs.gov/newsroom/article.asp?ID=2704*

Mapping Mangroves

Mangroves are tangled forests of shrubby trees that grow along tropical coastlines. They're typically buggy, muggy, and muddy—except at high tide when they're awash in brackish water.
Yet mangroves have a positive side. They are nurseries for many ocean species, treasure troves of biodiversity, and a first line of defense against destructive waves spawned by tsunamis and hurricanes.

An April 2011 article in Nature Geoscience highlighted another reason why mangroves are important: they're surprisingly efficient carbon sinks, i.e., natural systems that suck up and store carbon dioxide from the atmosphere, helping to put a damper on greenhouse gas emissions. Mangrove forests store as much as four times more carbon than other types of tropical forests. The authors of the article noted, though, that mangroves are disappearing worldwide. No one is more aware of these disappearances than Chandra Giri, a USGS EROS earth scientist who last year headed the effort to create the world's most definitive map of Earth's mangroves. The team—which included researchers from USGS and NASA, visiting scientists from Asia, Africa, India, and South America, and several dozen student interns—systematically analyzed more than a thousand Landsat images and painstakingly pieced together what is now considered the most complete, detailed, and highest-resolution map of mangroves in existence. What the map shows is that mangroves currently cover 137,760 square kilometers (53,190 square miles) of the planet's surface, substantially less than previous estimates.

Mangrove trees planted along the coastline will protect the shore from erosion.

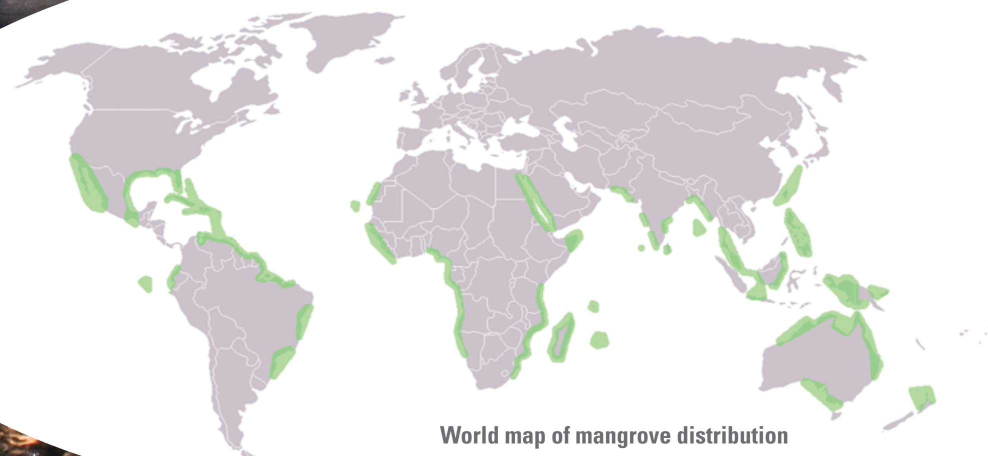
Landsat satellite image shows the Sundarbans mangrove forest, shown in red, of India and Bangladesh.

If seeing is believing, then the new mangrove map provides a strong incentive for making mangrove forests priority areas for conservation. "Seventy-five percent of the remaining forest is found in just 15 countries," Giri noted, "and only a small fraction of that is currently protected."

Healthy mangroves in Jozani Forest, Zanzibar, form a protective barrier between land and sea. Photo by Fanny Schertzer.

"Our assessment shows, for the first time, the exact extent and distribution of mangrove forests of the world at…the highest resolution ever."[3]

—Dr. Chandra Giri,
USGS



World map of mangrove distribution

[3]*http://www.sciencedaily.com/releases/2010/08/100818085932.htm*

Legacy on the Landscape

In late May, an abandoned campfire in the Bear Wallow Wilderness in southeastern Arizona sparked a massive wildfire. The Wallow Fire consumed more than 217,700 hectares (538,000 acres) before it was finally extinguished, making it the largest fire in Arizona history. New Mexico, Texas, and Minnesota also had record-breaking wildfires during 2011.

Fires leave scars on the landscape. Known as burn scars, they are natural records of fire events etched onto the face of the land. Landsat and other satellites that capture images of the planet's surface are good at seeing burn scars from their vantage point in space, and scientists with the Monitoring Trends in Burn Severity (MTBS) project—a partnership between USGS EROS and the U.S. Department of Agriculture's Forest Service Remote Sensing Applications Center (RSAC)—are equally adept at using satellite images to analyze the extent and severity of fires, both recent and historical. The digital, geospatial products they create are called burn severity maps.

MTBS team members reached a substantial milestone in 2011 by completing burn severity mapping of more than 13,000 large-scale fires that occurred from 1984 through 2009 in the conterminous United States, Alaska, and Hawaii. The ongoing project is creating a unique fire history of the Nation spanning more than a quarter century (1984 to 2010). The compilation of burn severity maps, reports, and other data form an unparalleled baseline of information that land managers can use to monitor post-fire recovery of burned landscapes, assess the effectiveness of land management decisions, and identify long-term trends in wildfires and their impacts on local, regional, and national scales.

A firefighter battles a wildfire near Noble, Oklahoma.

"Before using Landsat data to assess post-fire conditions, DOI and USFS BAER teams had to conduct the tedious task of hand sketching areas of high burn severity using ground-based surveys, topographic maps, and high cost aerial reconnaissance. With our USFS RSAC partners, we've now mapped over 30 million acres and 1,000 fires since 2001 using Landsat satellite data."

—Randy McKinley,
USGS EROS remote sensing scientist

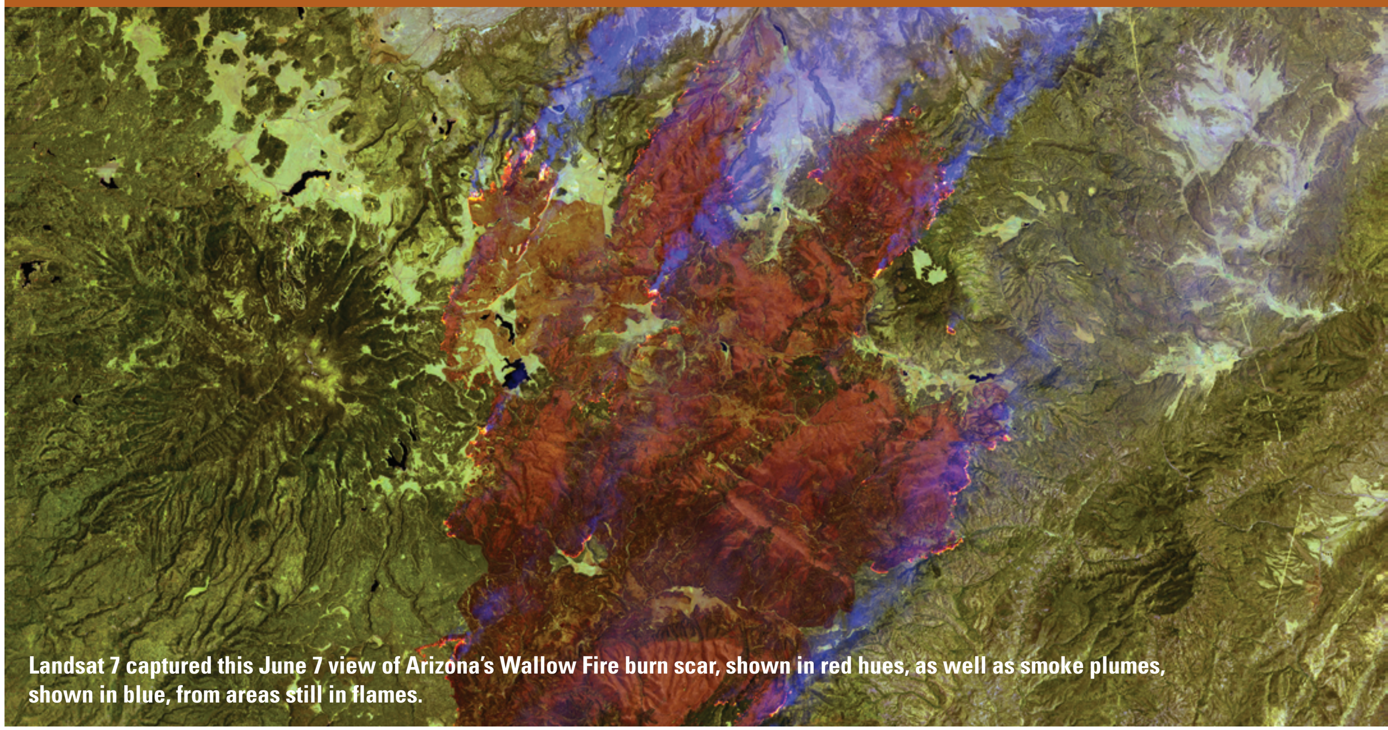
side tracks

Post-Fire Problem Solving

Researchers at EROS routinely use satellite images and other information to create maps and datasets that document drought, vegetation condition, fire fuels, wildfire burn severity, and wildfire danger across the country. When a fire breaks out, fire managers at the scene can use these products to support the fire-fighting efforts. For instance, they can input EROS fire fuels and land cover data into computer programs that model how—and how fast—a fire is likely to spread.

Satellite images and digital maps are also important once a fire has been extinguished. EROS scientists, working jointly with staff at the RSAC, have provided post-wildfire map products to burn area emergency response (BAER) teams for more than a decade. BAER teams are deployed immediately after containment of many large fires in the United States and occasionally at international wildfire events.

Interdisciplinary BAER team scientists often arrive on the scene armed with Landsat-derived maps to help them assess the post-fire conditions, including soil-burn severity. Badly scorched soils tend to shed rainwater rather than soaking it up. As a result, post-fire rains can lead to flooding, serious erosion, and even landslides. The BAER team recommends actions that local land managers can take to stabilize the soil and otherwise help mitigate potential hazards in a burned area.



Landsat 7 captured this June 7 view of Arizona's Wallow Fire burn scar, shown in red hues, as well as smoke plumes, shown in blue, from areas still in flames.

JUNE

"For the first time, we have a comprehensive view of how carbon is cycling through our nation's ecosystems.…This study will not only result in better land use decisions but should also advance our fundamental understanding of one of the most important chemical cycles on the planet."

—Marcia McNutt,
Director, USGS

The initial phase of the Land Carbon project analyzed carbon cycling and storage throughout ecosystems of the Great Plains.

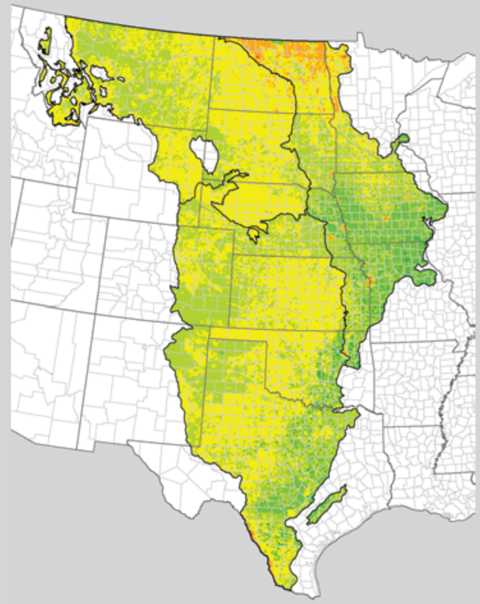
Piecing Together Carbon's Climate Role

June saw the beginning of one of the hottest summers on record in the United States. According to the National Climatic Data Center, more than 26,500 warmest-ever temperature records were set across the Nation during June, July, and August. And the United States wasn't alone in watching the mercury rise. 2011 was the 35th consecutive year (since 1976) that the yearly global temperature was above the 20th century average.

Earth's warming climate is a complex issue. Worldwide, scientists are working to better understand factors that contribute to climate change. They're analyzing everything from natural climate cycles and processes to human activities that add carbon dioxide and other greenhouse gases to the atmosphere. Researchers with the Land Carbon project at USGS supplied an important piece in the climate change puzzle in 2011 by completing the first phase of a National assessment as to how carbon moves into and out of ecosystems in response to land use and land cover changes. This initial phase focused on ecosystems of the Great Plains, encompassing roughly 2,170,000 square kilometers (837,842 square miles) in the Nation's heartland from the Canadian border to the southern tip of Texas.

The Land Carbon team used satellite images, biogeochemical simulation models, land use and land cover models, and other types of data to determine carbon sequestration (storage of carbon in soils and vegetation) and the flux, or movement, of three greenhouse gases (carbon dioxide, methane, and nitrous oxide) through the diverse terrestrial and aquatic landscapes of the Great Plains. The assessment also includes estimates of the capacity for different ecosystems to store more carbon—and so help reduce greenhouse gas emissions from landscapes—both now and in the coming 50 years.

Smoke billows from a prairie fire, near Manhattan, Kansas, that will help rejuvenate wild grasses.



Map showing areas of potential carbon sequestration, shown in green and yellow, and carbon emission, shown in orange and red, between now and 2050.

Total carbon sequestration, in kilograms of carbon per square meter

- <–5.0
- –5.0 to –2.1
- –2.0 to –0.6
- –0.5 to 0.5
- 0.6 to 2.0
- 2.1 to 4.9
- ≥5.0

JULY

Early in 2011, FEWS NET alerted global relief agencies of looming threats of water shortages, drought, crop failure, and starvation in the Horn of Africa.

"The partnership between USAID and USGS on famine forecasting through the Famine Early Warning Systems Network is a great example of two science-based agencies working together to help mitigate a humanitarian crisis."[4]

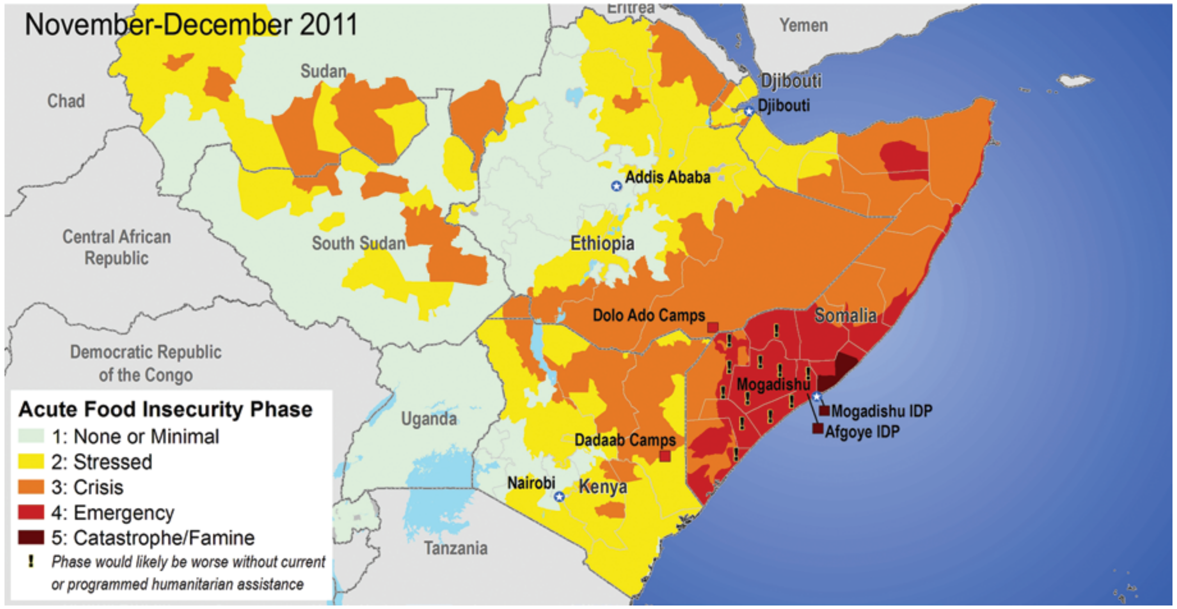
—Dr. Rajiv Shah,
Administrator, U.S. Agency for International Development

Anticipating a Food Crisis

On July 20, 2011, the United Nations declared a famine in parts of Somalia. Extreme drought in the Horn of Africa—which led to crop failures, livestock deaths, and sky-rocketing food prices—had spawned a daunting food security crisis in southern Somalia and parts of neighboring Djibouti, Ethiopia, and Kenya. More than 12 million people were facing severe malnutrition and potential starvation. For the team of researchers at EROS—and their colleagues at the University of California Santa Barbara—who work with the Famine Early Warning Systems Network (FEWS NET), however, the declaration was hardly a surprise.

Almost a year earlier, FEWS NET had begun sounding the alarm that weather and climate conditions were setting the stage for a drought worse than anything eastern Africa had witnessed in several decades. USGS is an active participant in FEWS NET, which is sponsored by the U.S. Agency for International Development (USAID) Office of Food for Peace. The combination of USGS

[4] *http://www.csmonitor.com/World/Africa/2011/1212/While-a-deal-sets-up-new-climate-talks-scientists-help-Africans-adapt-now*



Map showing FEWS-NET-projected food security status in the Horn of Africa for November and December 2011.

climate research and remote sensing applications provided critical input for the drought's advance warning. FEWS NET was among the first to predict that some areas of southern Somalia could slide into famine and that warning was instrumental in prompting humanitarian agencies and organizations to mobilize life-saving food supplies and other forms of assistance before the crisis peaked.

Established in the mid-1980s, FEWS NET was begun long before climate change became a global issue; however, FEWS NET is becoming even more important as countries worldwide face rising temperatures and increasingly unpredictable weather cycles—changes that affect food crop production. As new satellites and remote sensing technologies continue to improve how well scientists can monitor environmental and agricultural conditions on the Earth's surface, FEWS NET expects its ability to identify droughts, crop failures, and at-risk populations to improve.

side tracks

An Eye on the Overflow

While many parts of the United States, and the world, faced scorching temperatures and drought conditions during the summer of 2011, communities bordering the 3,767-kilometer-long (2,341-mile-long) Missouri River were inundated for several months by record-breaking floodwaters. Heavy spring snowfalls and rains in Montana sent unprecedented amounts of water surging downstream into North Dakota, South Dakota, Nebraska, Kansas, Iowa, and Missouri. Satellite images and aerial photographs recorded drowned landscapes—and valiant efforts to keep the muddy waters at bay along the river's length.

Missouri River floodwaters inundate the landscape near Omaha, Nebraska.

AUGUST

Water's Whereabouts

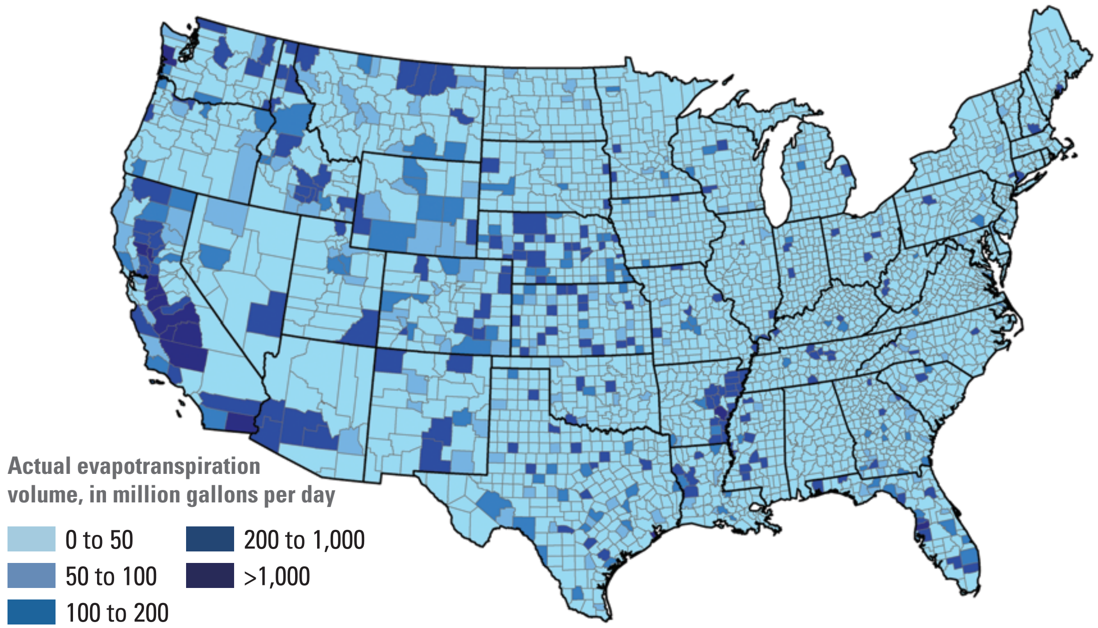
Stroll through any suburban neighborhood on a hot August morning and you'll likely see sprinklers rhythmically pulsing water onto lawns. Massive irrigation systems perform the same task, on a much larger scale, in the countryside as they spray great arcs of water onto thirsty crops. A homeowner's water bill, based on a water meter reading, gives an accurate accounting of water use. But how much water is withdrawn from rivers, lakes, and aquifers to irrigate crops? How does that amount change from month to month and year to year? And how do natural processes that help move water through ecosystems fit into the equation?

One science team at EROS tackled these water-related questions by using satellite images to measure evapotranspiration, a complex process in which water evaporates from the Earth's surface—and from the leaves of plants—and moves into the air as water vapor. Evapotranspiration is a fundamental part of the water cycle, but one that has been notoriously difficult to measure. EROS hydrologists developed a computer model that extracts certain types of information from satellite images, combines it with weather data, and ultimately calculates the amount of evapotranspiration taking place in a given area.

Satellite-based remote sensing of evapotranspiration is cost effective, reliable, and can be carried out on local, regional, and global scales. It represents a new tool for better understanding and managing precious water resources. For example, water managers and irrigation engineers use such evapotranspiration measurements to estimate how much water is being used for irrigating crops. Climatologists can employ evapotranspiration

Irrigation systems help provide consistent crop yields.

Water-Use Estimates Using Remote Sensing Methods

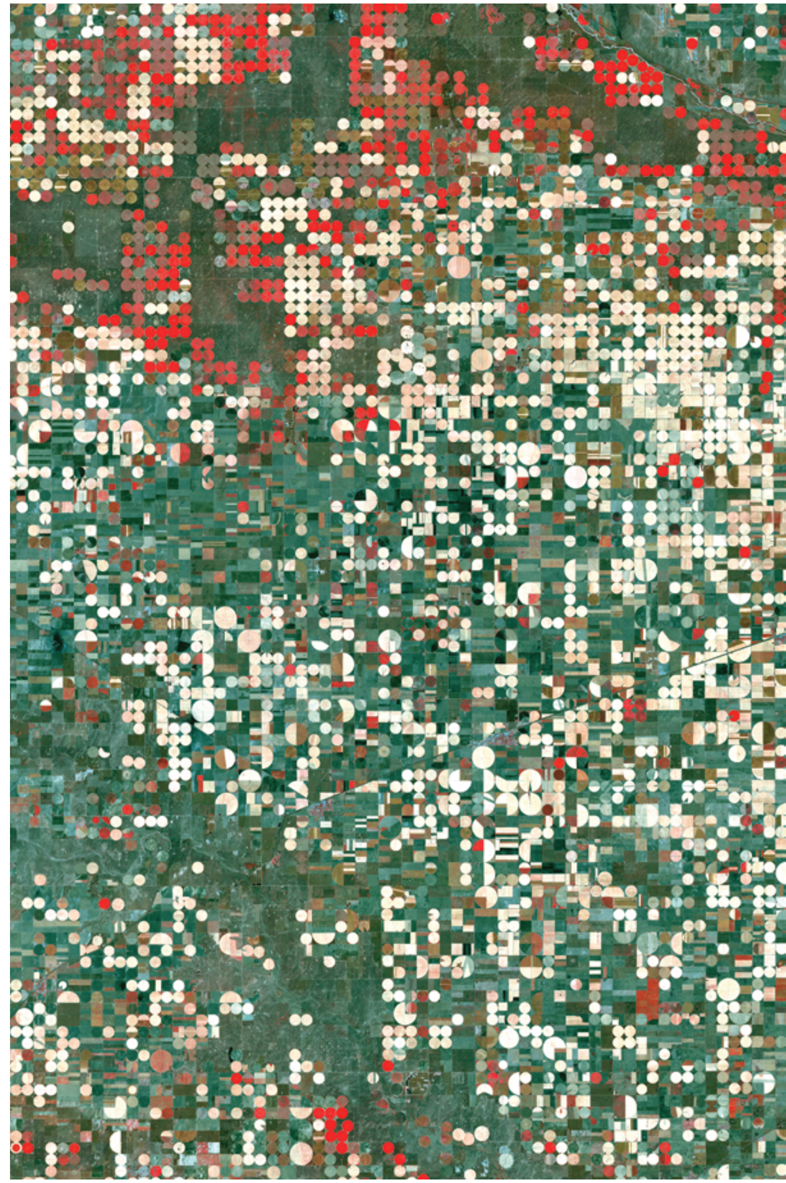


data for tracking drought. And food-security organizations can utilize it for monitoring crops.

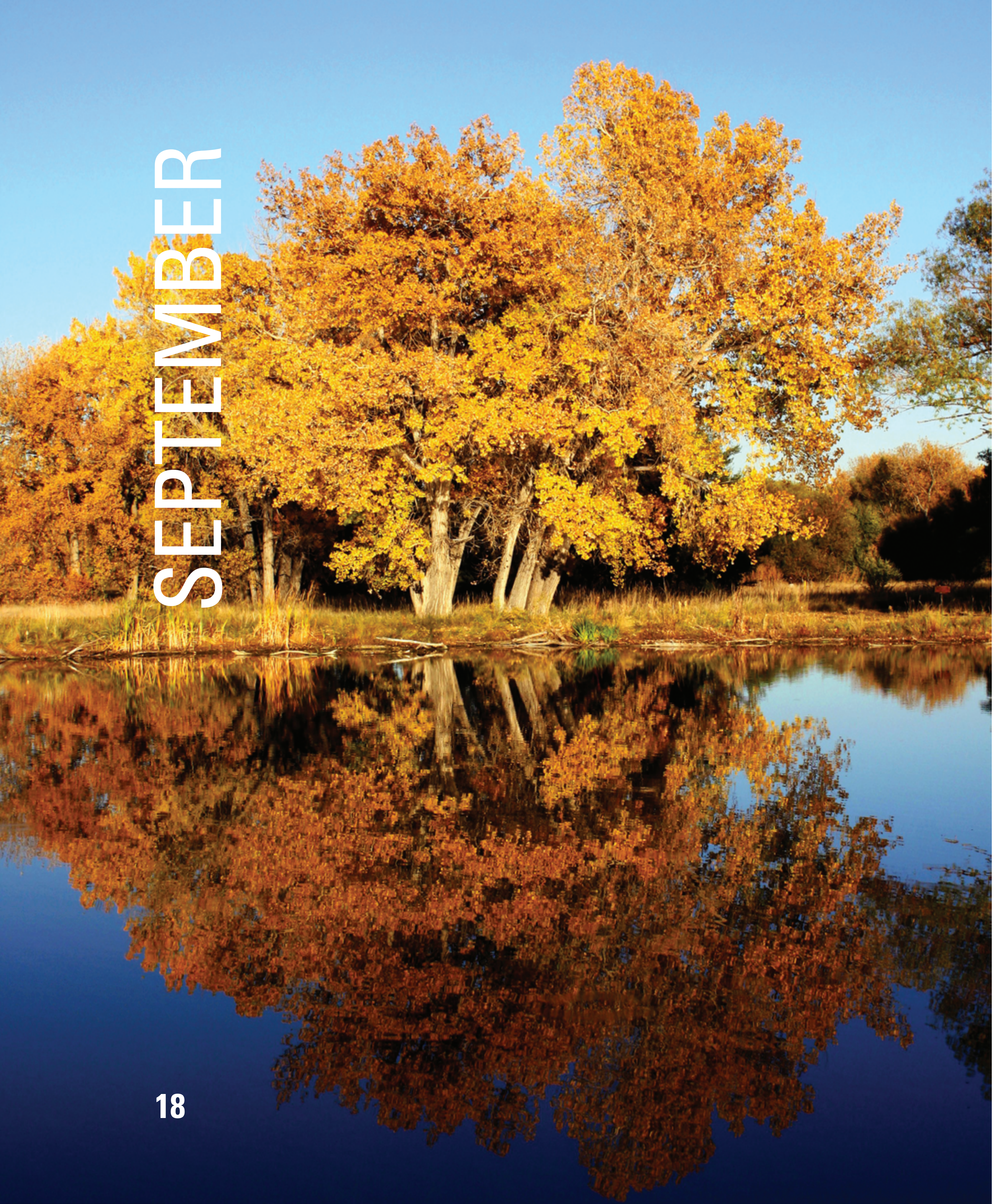
Another project at EROS approached water-use questions from a different angle during 2011. Scientists used satellite imagery to quantify how much land in the United States was under irrigation at a given time and how irrigation patterns changed over time. The researchers integrated satellite-image-derived data about vegetation conditions and land cover for the conterminous United States for 2002 and 2007 with the U.S. Department of Agriculture's published county irrigation statistics.

The modeling resulted in digital maps that provide the locations where cropland was irrigated during those years. Comparing the maps showed how the extent and location of irrigated lands had changed over the 5-year period.

Overall, there was roughly a 3 percent increase in the amount of land under irrigation in the United States from 2002 to 2007, but there were striking regional differences—either increases or decreases in irrigation—that reflected changes in growing conditions, some of which were related to drought events.



Circles visible in this Landsat 7 image are center-pivot-irrigated fields near Garden City, Kansas.



SEPTEMBER

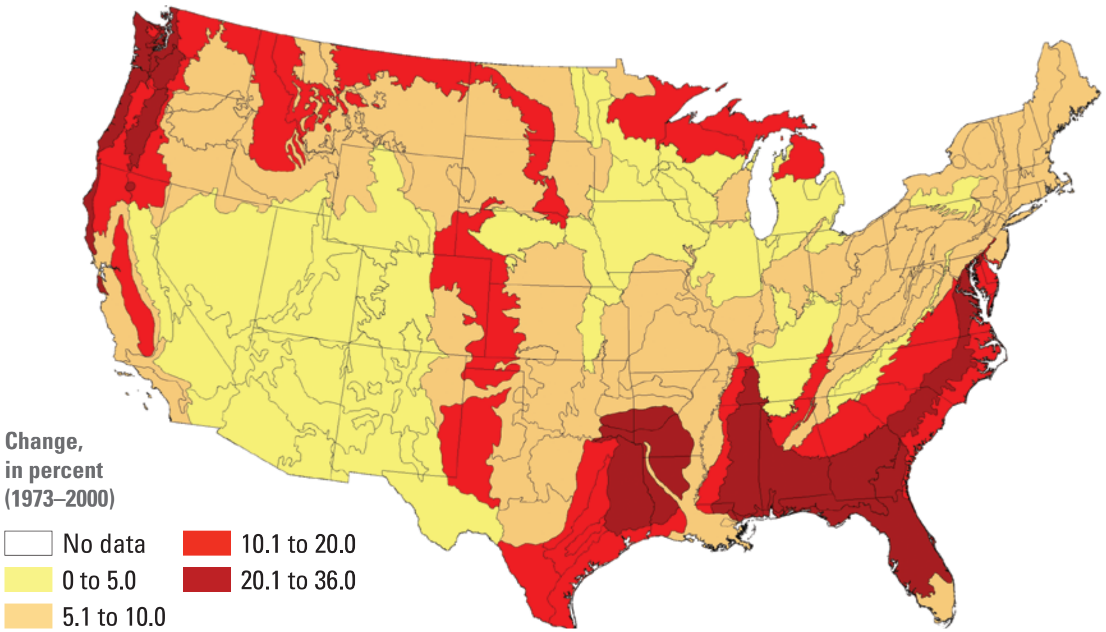
Tracking Trends Over Time

Every September, the autumnal equinox marks the transition from summer to fall. Day-to-day changes can be subtle, but by the end of September the green shades of the growing season have given way to fall's colorful splendor.

Earth's landscapes undergo constant change, both natural and human-caused. Yet much of this change is gradual and, like autumnal changes in September, goes unnoticed until we look back across months, years, and decades. In 2011, researchers with the Climate and Land Use Change Research and Development Program at USGS completed an assessment of nearly 30 years (1973–2000) of land use and land cover change in the conterminous United States. The study, known as the Land Cover Trends project, produced land cover change summaries for 84 ecoregions. The summaries were constructed using satellite images, aerial

Seasons change relatively quickly, but identifying and quantifying long-term changes in land cover and land use require studies that span many decades.

Percent Change in Land Cover/Land Use, 1973–2000



photographs, and other types of data as well as on-the-ground fieldwork. What did this unique backward glance reveal? In terms of overall trends, there was a gradual decline in forest cover across the country, substantial conversion between cropland and grassland, and a steady increase in developed (urban) lands. More detailed analyses, however, revealed considerable geographic variability in the rates and types of change the Nation has experienced. The driving forces behind these changes were equally diverse, ranging from use of natural resources and patterns of agriculture to settlement history, government policies, technology, and even global economics.

Although land use and land cover changes may seem subtle or inconsequential at first glance, over time they can have dramatic, cumulative impacts. The Land Cover Trends' 30-year assessment helps explain where, why, and how change has occurred across the American landscape. It's a body of information that scientists can now use to model and predict future changes, and that policy makers can use to make sure we're ready to face them.

side tracks

Team Effort

A productive five years!—That was the sentiment shared by the 18 scientists and engineers who made up the first USGS/NASA-sponsored Landsat Science Team (LST). Selected via an international competition, team members spent their 5-year term acting as the Landsat advisory panel, investigating issues and making recommendations critical to the continued success of the world's longest-running civilian earth observation satellite program. From 2006 through September 2011, "LST 1" focused on all aspects of the program, including the Landsat Data Continuity Mission, the status of Landsat 5 and 7, the Landsat image archive, future Landsat mission requirements, and synergy with other space-based remote sensing missions. The team also played an instrumental role as a catalyst for major advances in data quality and quantity, and the use of the data in scientific applications.

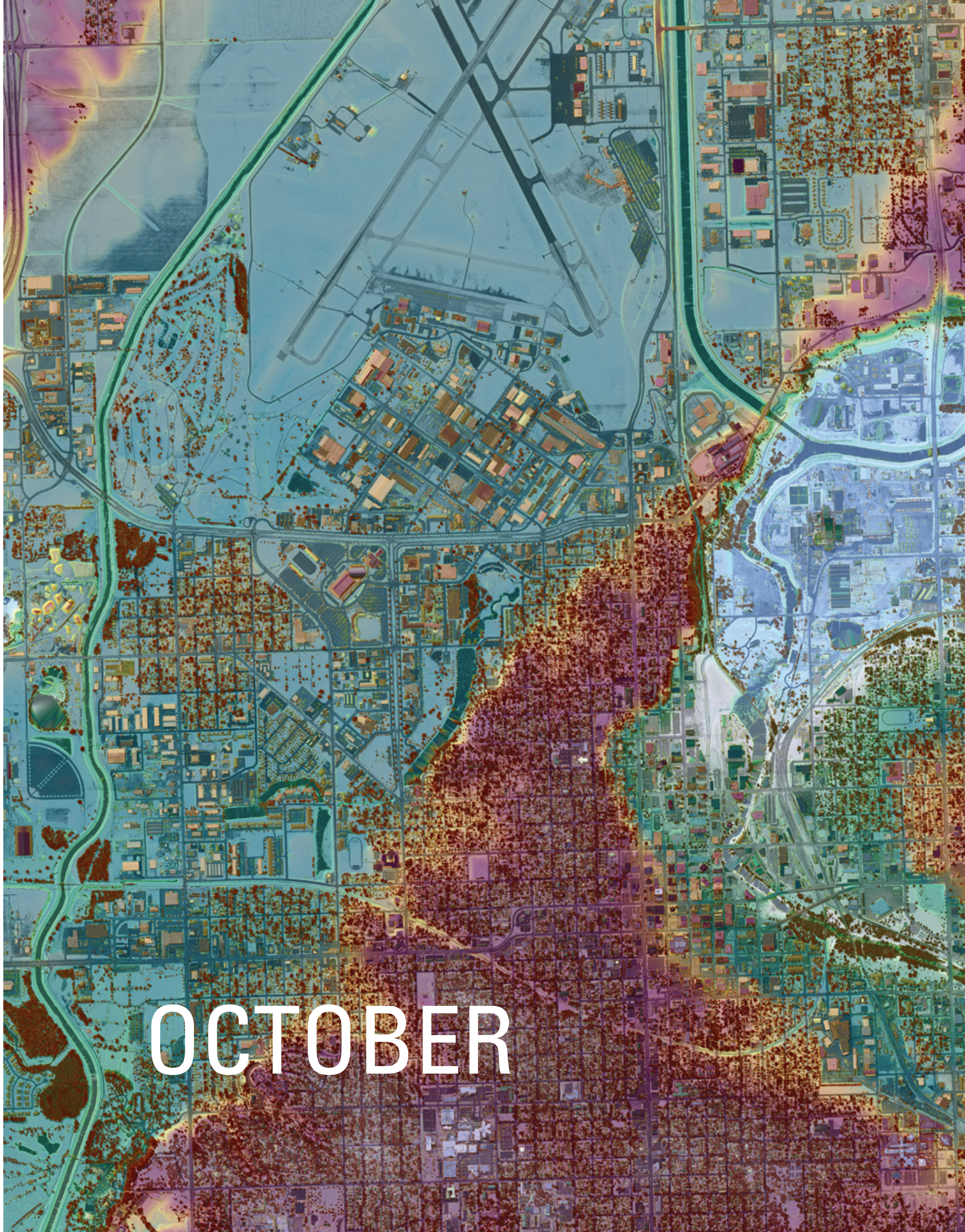
Members of the Landsat Science Team gather outside the USGS EROS Center in Sioux Falls, South Dakota.

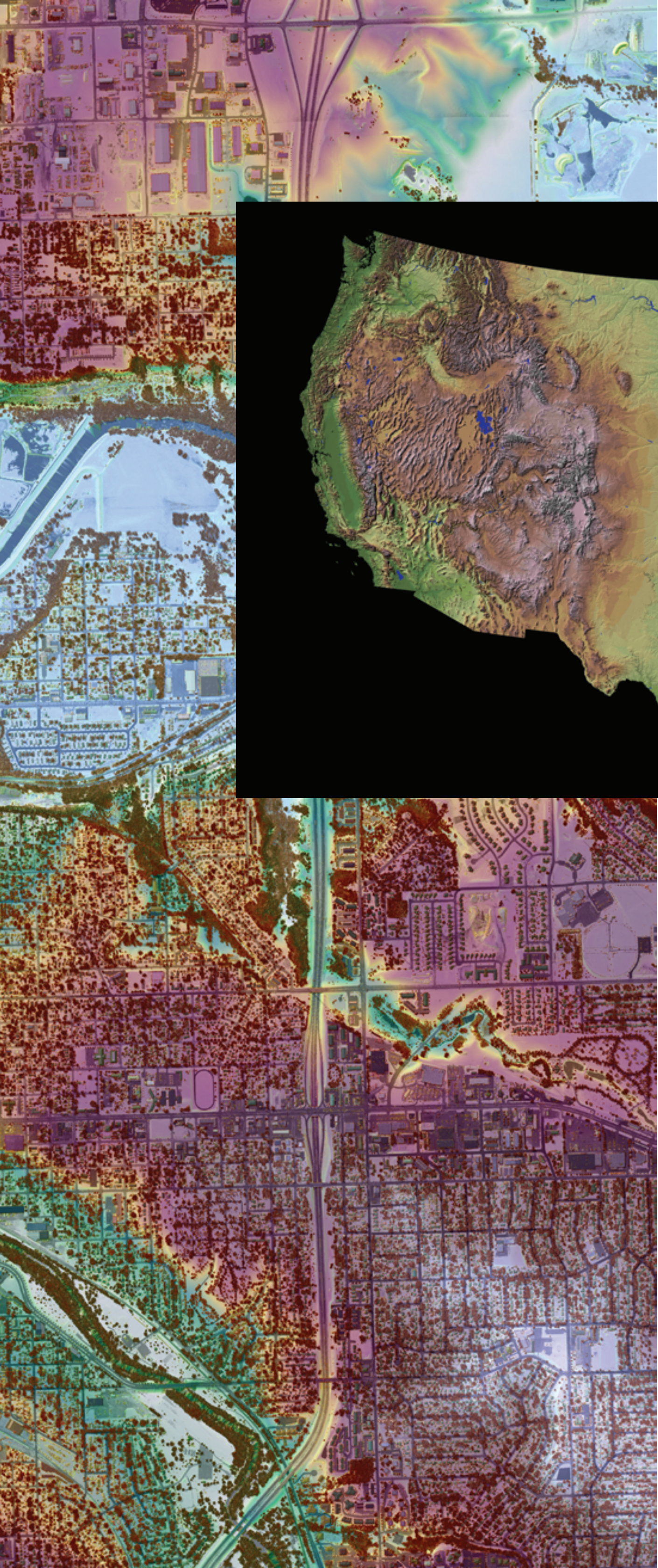
Relative landscape elevation of Sioux Falls, South Dakota, modeled from high-resolution lidar data

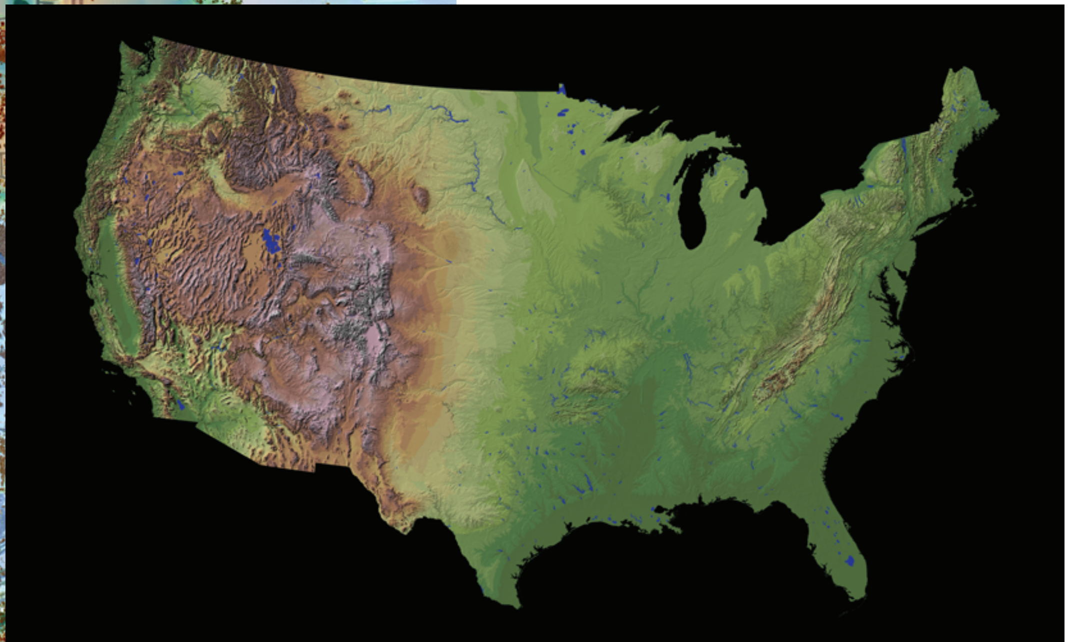
Updating the NED

The wings of a hummingbird in flight are just a blur, beating between 50 and 80 times per second. That's pretty fast, but it's nothing compared to lidar. Light detection and ranging (Lidar) is a remote sensing technology that uses pulses of laser light fired in rapid succession—an astounding 400,000 times per second—to measure distance with extraordinary accuracy. Equip an airplane with a lidar system and you have the means to measure elevation across a landscape that's accurate to within a few centimeters.

Lidar is key to improvements being made to the National Elevation Dataset (NED). NED is the primary elevation product at USGS and forms the elevation layer of The National Map, providing topographic information for the United States and its territories. USGS produces and distributes NED in partnership with the National Geospatial Program. NED is continually updated using various types of data. Since 2003, the USGS team that works with NED has been incorporating lidar-based elevation data into the NED database as the data become available. October 2011 marked NED's 62d update, and by the end of the year, lidar upgrades had resulted in 580,343 square kilometers (224,072 square miles) of additional high-resolution, high-vertical-accuracy elevation data being added to this remarkable, dynamic database.







National Elevation Database shaded relief of the conterminous United States

Who uses NED? Anyone who relies on precise and accurate topographic information, such as fire fighters, natural resource managers, urban planners, conservationists, emergency responders, and communications companies. NED's applications are almost endless; they range from creating shaded relief images of topographic surfaces and generating 3-dimensional visualizations of landscapes to identifying features, such as mountain peaks and mining pits, and modeling potential landslides, avalanches, and watersheds.

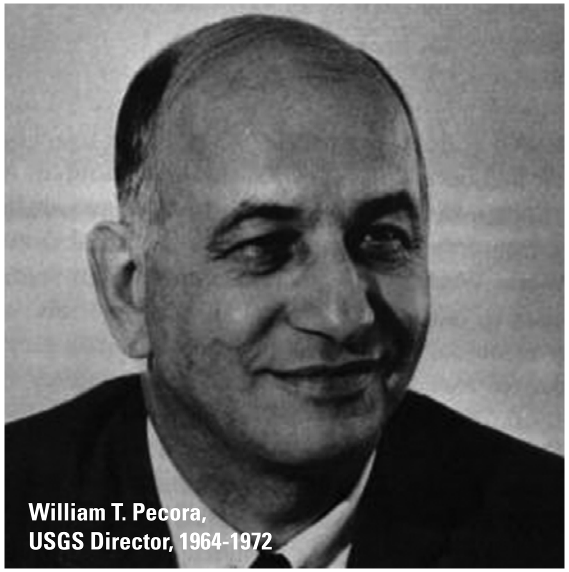
Lidar and Sea-Level Rise

side tracks

Climate change predictions include warnings of rising sea levels. Faced with the threat of salty ocean waters creeping inland along the Nation's coastlines, urban planners, natural resource managers, and risk mitigators need accurate maps as they try to gauge the potential impacts of sea level rise. Variations of a few feet, or even a few inches, in elevation could make all the difference as to what might—or might not—be underwater in the years to come. The problem is, many coastal elevation maps currently in use aren't completely accurate, but EROS researchers are working to solve this problem. They're using high-resolution lidar data (the same type of data that are being incorporated into the National Elevation Dataset) to generate new, much more accurate maps of coastal areas. Better maps mean less uncertainty when it comes to predicting the extent of, and preparing for, sea level rise.

Melting ice can contribute to rising sea levels.

NOVEMBER



William T. Pecora,
USGS Director, 1964-1972

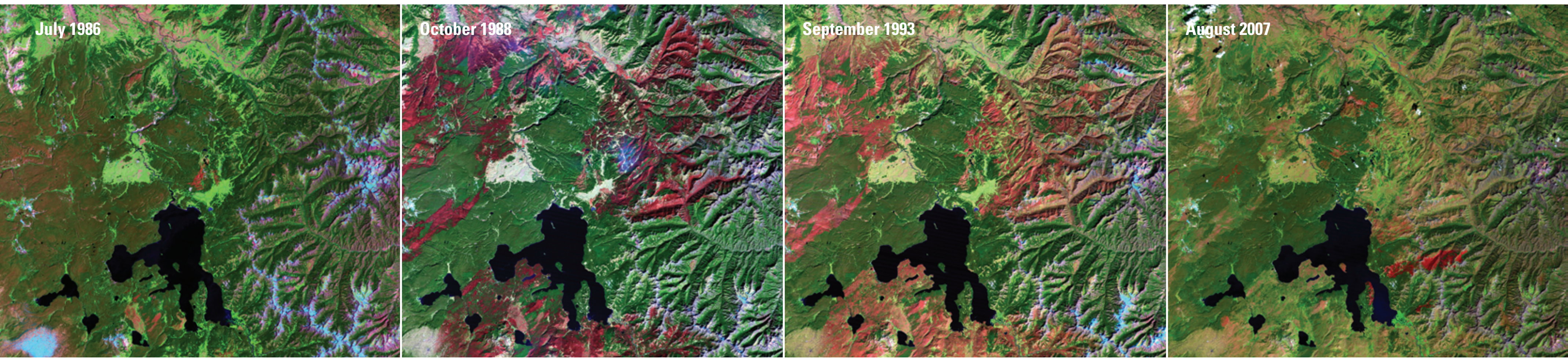
PECORA 18

Geologist William T. Pecora—known as Bill to his friends—had a vision.

Appointed Director of USGS in 1964, Pecora understood the possibilities for land-imaging satellites. His vision was for the Department of the Interior to acquire remotely sensed data from satellites in the simplest possible way, deliver the data to the user community in an uncomplicated form, and ensure their easy use. To accomplish his vision, Pecora worked to promote a remote sensing satellite program for surveying the Earth from space that led to the establishment of the Earth Resources Observation Satellites Program in 1966 and ultimately the development of the Landsat satellite program.

Unfortunately, just days before the launch of the first Landsat satellite in 1972, Pecora died unexpectedly at the age of 59. To honor his memory and his efforts in helping make the Landsat program become a reality, USGS and NASA jointly established the Pecora Symposium series as a forum to foster the exchange of ideas, data, and applications related to satellite remote sensing of Earth's land surfaces.

In mid-November, hundreds of scientists, academics, land and resource managers, and policy makers met in Herndon, Virginia, for the 18th Pecora Symposium, sponsored by USGS and NASA, and co-organized by the American Society for Photogrammetry and Remote Sensing. The symposium's theme was "Forty Years of Earth Observations: Understanding a Changing World."



This sequence of Landsat images shows how, over a 20-year period, the landscape of Yellowstone National Park gradually recovered from an outbreak of wildfires during the summer of 1988.

For 4 days, participants shared insights into how four decades of Landsat and other Earth-observing missions have shaped current understanding of a changing Earth and created the foundation for the next generation of land remote sensing endeavors.

Bill would have been proud.

Last Days For Landsat 5?

Although many hoped that Landsat 5 would continue functioning forever, everyone knew the end was inevitable (even nonfunctioning, Landsat 5 is still in existence). On November 21, 2011, USGS stopped acquiring images from the 27-year-old Landsat 5 satellite because of a malfunctioning electronic component. Landsat 5 was launched in 1984 and designed to last 3 years. It had been remotely revived from various complications several times before during its remarkably long tenure in orbit, but this time the problem wasn't immediately fixable.

There's still a flicker of hope, however. Engineers shut down the satellite's imaging activities before the component actually failed. They decided to leave it off for several months while they explore every possibility for restoring satellite-to-ground image transmissions. Regardless of the outcome, Landsat 5 has certainly exceeded all expectations for longevity.

Science as Art

First and foremost, Landsat images are scientific tools, data-rich views of Earth's surface that can only be captured from space, but many of them are also strikingly beautiful.

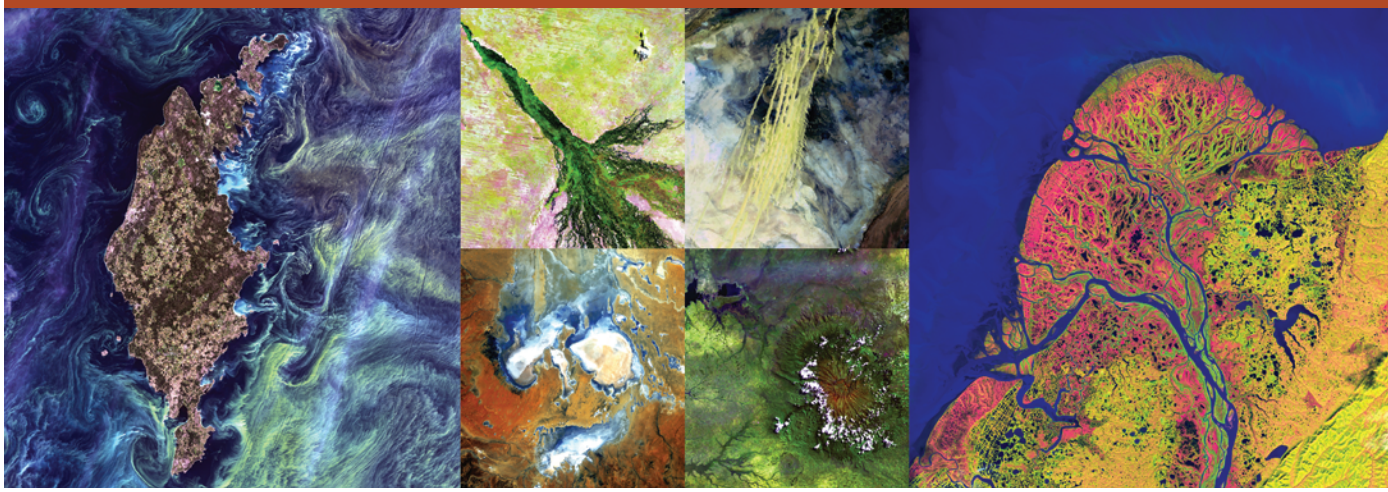
2011 brought the launch of Earth as Art 3, the third in a series of art exhibits created by USGS EROS showcasing 40 satellite images selected solely for their aesthetic appeal. Images that seem at first glance to be abstract art are windswept deserts, mountain ranges, cloud formations, ocean circulation patterns, river deltas, islands, and glaciers. Although many of the images that make up Earth as Art 3 look like oil or watercolor paintings, they are digital photographs created by printing the wavelengths of light that Landsat 5 and 7 "see" reflecting from Earth's surface in colors visible to the human eye.

The traveling exhibit headed to a number of different venues during the year, including the Library of Congress, where it will remain on display until the end of May 2012.

"The collected images are authentic and original in the truest sense. These magnificently engaging portraits of Earth encourage us all to learn more about our complex world."[5]

—Matt Larsen,
USGS Associate Director for Climate and Land Use Change

side tracks



Earth as Art 3 images

[5]*http://news.nationalgeographic.com/news/2010/11/photogalleries/101119-satellite-pictures-earth-as-art-australia-glaciers-mountains-clouds/*

Milestones in Data Management

Back up your files—Who has not heard that familiar refrain? At USGS EROS—home to 40-plus years' worth of irreplaceable satellite images and other data that comprise an incomparable record of global change—backing up, safeguarding, and otherwise managing data is a very, very big deal. It's a job that requires staying on top of rapidly changing technologies and small armies of data managers.

In 2011, EROS data management teams accomplished several major milestones while caring for its vast and diverse archive. They created an off-site backup copy of the entire data archive after copying all the raw Landsat data onto the Computer Room 1 Mass Storage System (CR1MSS), the heart of the EROS' archive. This system, which provides archival services as a shared resource for all USGS EROS projects, surpassed the 3.5 petabyte mark for stored data during the year. A petabyte is 1,000 terabytes (or 1 quadrillion bytes) of digital information.

EROS also added a high-speed optical network, dubbed StarLight, to increase its capacity to distribute data to users worldwide. With StarLight, network capacity increased fourfold. StarLight became the conduit for more than one-half of the 690 terabytes of data EROS received and 2,280 terabytes of data it distributed around the globe in 2011. To provide a measure of comparison, the Library of Congress has 15.3 million online digital files, totaling 74 terabytes. EROS transferred the equivalent of the entire Library of Congress' digital holdings roughly every 9 days during the year.

DECEMBER

Robotic mass storage systems make much of the satellite information immediately available to scientists working at desktop workstations at EROS and around the world. One robotic mass storage system holds 5 years of Landsat data.

side tracks

Continuing the Countdown

When 2011 began, the anticipated launch of the Landsat Data Continuity Mission (Landsat 8) was still 2 years away. For many, that may have felt like a fairly long time. By the end of the year, however, the countdown was reduced to a mere 13 months. Much remains to be done before Landsat 8 heads into space, but as January 2013 edges nearer, the excitement is hard to contain.

The side of LDCM that will point toward the sun, also referred to as the "-Y side," is where the solar array will be located.

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Jeffery C. Eidenshink

Deputy Director

Thomas R. Loveland

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Communications Specialist

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Jennifer A. Sabers

Chief, Remote Sensing Branch

Charles M. Trautwein

Chief, Science and Applications Branch

Major Contractor Partners

The EROS Center is owned and activities are managed by the Department of the Interior, U.S. Geological Survey. Several private companies, under contract to the USGS, or under contract to partnering Federal agencies, support the mission of the USGS EROS.

Stinger Ghaffarian Technologies (SGT)

Technical Support Services Contractor

ASRC Research and Technology Solutions (ARTS)

Science Support Services Contractor

Honeywell Technology Solutions, Inc.

Landsat 5 and 7 Flight Operations Contractor

Aerospace Corporation

Engineering and Scientific Services Contractor

Raytheon Intelligence and Information Systems

ECS Operations and Maintenance Contractor to NASA

DKC Enterprises

Facility Operations and Maintenance Contractor

Pleasant Valley Cleaning

Janitorial Services and Supplies Contractor

Tech Systems, Inc. (TSI)

Warehouse Logistics Contractor

ADC Management Services, Inc.

Physical Security Services Contractor

EROS Cafeteria

Food Service (via the Business Enterprise Program of the Service to the Blind and Visually Impaired)

Research and Technical Publications

In 2011, there were 146 scientists, engineers, and information professionals from throughout the USGS EROS Center who contributed to the Center's extensive publishing record. The complete record for the year totaled 235 publications, which included:

- 90 journal articles (19 of which were published in a "top-tier" journal such as "Remote Sensing of Environment, Nature, or Global Ecology and Biogeography");
- 16 reports;
- 3 book chapters; and
- 126 conference presentations (full papers, abstracts, posters, and powerpoints).

The following 19 bibliographic citations are provided for those journal articles published in the top-tier journals. To search all EROS publications, see *http://eros.usgs.gov/#/Publications*.

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Director's Message

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January

Page 7 (OLI) NASA/Ball Aerospace and Technology Corp

February

Page 9 (Grapes) Bob Nichols, USDA ARS

March

Page 11 (Earthquake/tsunami) left and right images: U.S. Navy photo by Mass Communication Specialist 3rd Class Alexander Tidd

April

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May

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June

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July

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August

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September

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October

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November

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December

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