

Chapter 13 Science, Data and Information

Introduction

Investments in research and development promote economic growth and innovation, ensure American competitiveness in a global market, and are critical to achieving the mission of the U.S. Department of the Interior (DOI or Interior). Investments in Interior's research and development will improve U.S. strategic mineral supplies, water use and availability, and natural hazard preparedness. Sustainable stewardship of natural resources requires strong investments in research and development in the natural sciences. This chapter focuses on information developed by the bureaus through research or systematic data collection, and activities that facilitate the transfer of information to the private sector.

Interior's bureaus are engaged in a variety of activities designed to provide basic research, scientific and technical information, and to transfer technology to decision makers in the public and private sectors. The information produced by Interior is a critical input that helps support private markets, the production processes of private entities, and many public sector decisions. For example, oil, gas, and mineral markets are underpinned by scientific and technical information on resource availability; water use and allocation decisions rely on precipitation and runoff predictions; and preparedness for natural hazards relies on information about the locations and probability of such events occurring. Interior is involved with producing and disseminating all of these types of information, which have an economic value that is at least partly incorporated in the market prices of traded goods and services. In some cases, the economic value of information is associated with reducing the uncertainty facing market participants or decision makers. In other cases the value of information is associated with the impetus it provides for technological change and associated efficiencies.

Interior develops and disseminates scientific information that increases the public's understanding of the Earth and its natural systems, minimizes loss of life and property from natural disasters, and supports the management of public resources like water, ecosystems, energy and minerals. This information is valuable as an input to various production processes, and in supporting a range of markets and market activities. Nevertheless, the full value the scientific information and data produced by Interior is difficult to assess, as there are few markets for pure information.

Background

Information resulting from government research and development activities is often available at little or no cost to the user, providing an inexpensive input to decision making. In general, information and data sources generated through DOI research are used in both the private and public sectors for a variety of end-uses that generate significant societal benefits.

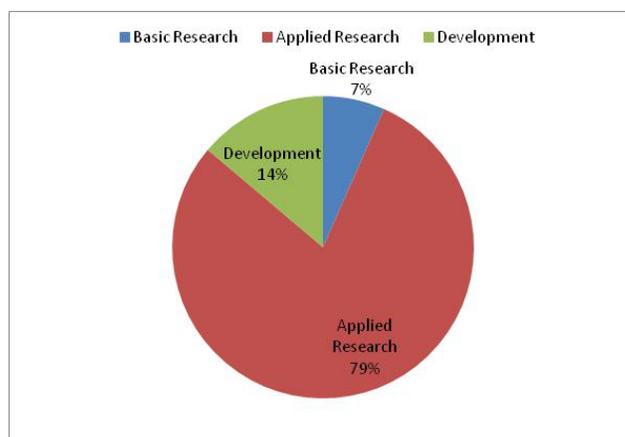


Figure f. Distribution of DOI Research Funding (FY 2012)

Research and development spending at DOI can be broken into the following broad categories: basic research; applied research; and development. Figure displays the distribution of funding across those categories in FY 2011.⁸⁸

DOI generated information and data are used both directly and indirectly as an input to production processes or decision making by federal, state and local governments, private markets, and the general public. For instance, The National Weather Service, U.S. Army Corps of Engineers, the Federal Emergency Management Agency and, through them, the broader public, rely on input from continuous records of streamflow information provided by the USGS streamgaging network for timely and accurate flood forecasts and warnings, flood management, and disaster mitigation. The same streamflow information is directly used by boaters, swimmers, and fishermen in their decisions to pursue their chosen activities.

Providing public access to the variety of data that is generated, managed, and stored by DOI is becoming increasingly important in the digital age. Numerous web and mobile phone applications have been developed, either directly by DOI bureaus or indirectly through the use of DOI data. This has provided the American public with easy access to a wide range of information, including real-time and historical streamflow measurements, flood hazard information, earthquake activity data, and national park websites and maps, to name just a few. Scientists at the U.S. Geological Survey (USGS) are even encouraging the public to think of innovative new applications based on the bureau's ecological and biological datasets through their "App-lifying USGS Earth Science Data" contest.⁸⁹

Data and information generated through Interior's activities are also used to support state and private business activities. For instance, thermal data unique to Landsat satellite imagery has been critical in the development of METRIC (Mapping EvapoTranspiration at high Resolution with Internalized Calibration), a model that computes and maps evapotranspiration based on digital images from the Landsat satellite. The Idaho Department of Water Resources uses METRIC to create water budgets for the state, and METRIC has been used to settle water disputes and monitor water compacts such as the North Platte River decree between Nebraska and Wyoming. METRIC has also been used as evidence in court cases

⁸⁸ FY 2013 Analytical Perspectives, Table 22-1.

⁸⁹ See <http://applifyingusgsdata.challenge.gov/> for more information.

such as the A&B Irrigation District case in Idaho and the Antelope Valley Groundwater class action suit in California. Agencies in over fifteen states are using METRIC in innovative ways to solve and prevent problems related to water resource management. Further, METRIC is utilized by the private sector. For instance, E. & J. Gallo, the world's largest family owned winery and largest exporter of California wines, uses the model to estimate potential and actual vineyard water uses. This allows the winery to decrease the amount of water used for irrigation and improve wine quality. This model and the innovative uses it has been put towards would not exist without Landsat's unique, high-resolution thermal data, which can show water use at the individual field level.

Commercialization of new technologies is an important stage in the process of innovation. In some cases, government research and development activities might follow a path from basic research, to applied research, to the development of specific technologies that can be transferred to the private sector, resulting in commercial applications. Such activities may be undertaken collaboratively between DOI and external entities such as industry, universities, trade associations, and state and local governments. Arrangements such as Cooperative Research and Development Agreements (CRADAs) help facilitate partnerships between the Federal government and non-Federal entities, as well as the efficient transfer of federally conceived or developed technology into the private sector.⁹⁰ One such agreement was entered into between the Bureau of Reclamation and Marrone Bio Innovations, who together, conducted field trials of Zequanox, an innovative solution to controlling invasive mussels that have caused billions of dollars in damages to the economy. This product is now commercially available.

Outputs: Research and Technology Transfer

The material below provides an overview of some of the different types of information produced by DOI, and the economic concepts associated with this information. A number of Interior bureaus conduct research and data collection to support their individual mission. Some selected highlights are described below.

Research

The Department has substantial research efforts underway to help understand the impacts of climate change. The DOI Climate Science Centers (CSCs) and Landscape Conservation Cooperatives (LCCs) conduct research and monitoring and

Earthquake Early Warning System

The USGS has been working with academic and private partners to develop an earthquake early warning system for the state of California. This system is still being tested, but was successful in providing thirty seconds of warning time before a recent earthquake hit Anza, California. With additional sensors and system testing and refinement, this pilot project has the potential to be expanded into a publically available statewide network.

⁹⁰ Some of the benefits provided by CRADAs include: enabling both partners to leverage their research budgets and optimize resources; providing a means for sharing technical expertise, ideas, and information in a protected environment; permitting federal scientists to work closely with their non-federal counterparts; offering non-federal partners access to a wide range of expertise in many disciplines; allowing the partners to agree to share intellectual property emerging from the effort; and permitting the Federal Government to protect information emerging from the CRADA from disclosure for up to 5 years, if this is desirable. (Source: Technology Transfer Handbook for the U.S. Geological Survey, 2003).

communicate research findings to improve understanding of climate change impacts and vulnerabilities. The LCCs are also deeply engaged in adaptation planning, thus serving as a key science-management bridge. This joint effort helps to support strategic decisions in response to vulnerabilities: the DOI CSCs will be centers for basic climate change science associated with broad regions of the country; and LCCs will focus on applied science and management decision making at the landscape level. Interior is also conducting climate change vulnerability assessments across the United States in an effort to determine the resources that are most vulnerable and assess the threats to resources that may be exacerbated by climate change.

U.S. Geological Survey

As Interior's primary science organization, the U.S. Geological Survey (USGS) operates many programs which provide easily accessible historical and real-time scientific data to national and international users on a wide array of topics. A considerable amount of the bureau's work is supported through cost sharing and reimbursable efforts. In particular, USGS addresses:

- Energy and mineral assessments;
- Natural hazards;
- Climate and Land use change;
- Understanding of ecosystems;
- Environmental health; and
- Water resources.

Data collected by USGS contribute to an increased understanding of natural resources and hazards, which improves the accuracy of hazards forecasting, societal resilience to natural hazards, land-use planning, and decision making, all of which has considerable economic value. Some example programs include:

- The Earthquake Hazards Program, which provides near real-time maps of ground motion and shaking intensity following significant earthquakes;
- The Volcano Hazards Program, which conducts continuous, real-time monitoring of volcanoes in the United States and issues warnings of impending eruptions to help prevent loss of life and property;
- The National Streamflow Information Program, which provides historical and real-time streamflow data for the Nation;

GeoMine

The OSM's GeoMine Pilot Project is exploring the feasibility of producing a web-based geospatial map of active, idled or reclaimed mine areas in the United States. The pilot-project phase begins with the mines in four Appalachian States — Virginia, West Virginia, Tennessee, and Kentucky. In addition to the four State programs and OSM, contributing partners in this project include the EPA, Corps of Engineers, and the FWS. The interagency team is now in the process of drafting a final report. To date GeoMine has digitized geographic data on 71,000 SMCRA boundaries in the four pilot States. The GeoMine Pilot Project was selected by the Federal Geographic Data Committee for national recognition as one of ten Federal projects to be included in the Administration's GeoCloud II demonstration project.

- The National Water Quality Assessment Program, which provides an understanding of water-quality conditions; whether conditions are getting better or worse over time; and how natural features and human activities affect those conditions; and
- The Land Remote Sensing Program, the Nation's archive for the world's largest collection of civilian remotely sensed data covering the Earth's land masses. After an unparalleled 28 years of providing imagery, Landsat 5 was decommissioned in 2012. During 2013, Landsat 7 operations will continue, as will the collecting, archiving, processing, and making Landsat imagery available through the Internet. In 2012, more than 3 million Landsat scenes were distributed to scientists and other customers worldwide. The Landsat Data Continuity Mission (successfully launched on February 11, 2013 and now known as Landsat 8) is now the main source of Landsat imagery.

Bureau of Ocean Energy Management and the Bureau of Safety and Environmental Enforcement

The Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) manage natural gas, oil and other mineral resources on the Outer Continental Shelf (OCS). These resources provide a significant amount of the U.S.'s energy supply as described in Chapter 4 Energy from Fossil Fuels.

BOEM periodically conducts oil and gas assessments of the OCS to determine the amount of undiscovered technically recoverable resources, as well as the quantity of undiscovered economically recoverable resources. This information underlies leasing and management decisions on the OCS and serves as an important input to energy markets.

To support this work and inform bureau policy decisions, BOEM's Environmental Studies Program (ESP) plans, conducts and oversees world-class scientific research. These environmental studies cover a broad range of disciplines, including physical oceanography, atmospheric sciences, biology, protected species, social sciences, economics, submerged cultural resources and the environmental impacts of energy development. BOEM incorporates findings from the studies program into its environmental reviews and NEPA documents, which are used to determine steps to avoid, mitigate, or monitor the impact of energy and mineral resource development on the OCS. Through the ESP, BOEM is a leading contributor to the growing body of scientific knowledge about the marine and coastal environment. The bureau has funded nearly \$1 billion in research since the beginning of its studies program in 1973. Completed studies are available to the public through the Environmental Studies Program Information System (ESPIS).

The BSEE is the principal Federal agency funding offshore oil spill response research. BSEE research provides leadership to improve the knowledge and capability for the detection, containment, and cleanup of oil spills that may occur on the OCS. BSEE's research program also seeks to develop technologies such as the use of satellite imagery, side looking infrared radar, and other remote sensing tools to improve response tactical decisions and thus improve response and safety of offshore workers. The BSEE Oil Spill Response Research (OSRR) program also funds Oil Spill Response research in five areas: (1) mechanical, (2) chemical, (3) remote sensing, (4) command and control, and (5) recovery in Arctic Conditions. BSEE funded about \$15 million of oil spill research in FY 2012. The oil spill research is funded through the Oil Spill Liability Trust Fund. By funding this research BSEE aims to develop and test the next generation of spill response technologies.

The research program addresses technological issues associated with energy and mineral operations, ranging from the drilling of oil and gas exploration wells in search of new reserves to the removal of platforms and related infrastructure once production operations have ceased. The results of these studies have also contributed to the development of a number of BSEE regulations, BSEE NTLs, Industry Standards (American Petroleum Institute; API), American Society for Testing and Materials (ASTM), and International Standards. The material below offers examples of each:⁹¹

- Regulations: Results from an initial shear ram capability study/information helped to inform the requirement for shear ram capabilities found in 30 CFR 250.416(e);
- BSEE issued Notice to Lessees (NTL) No. 2009-G03: Synthetic Mooring System Materials for Floating Facilities intended to demonstrate that synthetic moorings meet or exceed the safety level necessary for chain/wire-rope mooring systems;
- Industry Standards (API): Development of the draft API RP 2RD, Dynamic Risers for Floating Production Installations. In addition to providing the study's work to the API, these same results have been presented to the International Organizations for Standardizations (ISO) for possible incorporation in the equivalent international standard, ISO 13628-12;
- ASTM Standards in Association with BSEE Ohmsett Test Facility: F1607-95 (2008) Standard for Oil Spill Response Pumps; and
- International Standards: A TA&R study laid the groundwork for reviewing the International Electrotechnical Commission Standards for Offshore Wind Farms design standards for applicability on the U.S. OCS. Since then, an American Wind Energy Association(AWEA) effort has been established to 'roadmap' the use of this international standard by supplementing it with the appropriate U.S. standards where there is a variance, and identifying gaps that could potentially be augmented with other standards, and/or gaps that require that additional standards be drafted. Two subsequent TA&R studies will be valuable contributions to this effort.

Bureau of Reclamation

The Bureau of Reclamation's Science and Technology Program is the bureau's primary Research and Development arm, responsible for evaluating and funding research projects to further Reclamation's mission of helping the American West fulfill its growing demands for water, while protecting the environment and the public's infrastructure investments. To address technical and scientific challenges facing the provision of water and power to the 17 Western States, the bureau's Research and Development Office over the past seven years has funded 800 research projects focused on innovative solutions to these challenges.

Current research projects include:

- Conserving or expanding water supplies;
- Advanced water treatment technologies; and
- Water operations decision support.

⁹¹ See BSEE FY 2013 Budget Justification for additional details.

Reclamation also provides near real-time water and environmental data collected by a network of hydrologic and meteorologic monitoring stations, collectively referred to as Hydromet. As DOI's primary water management agency, Reclamation is also playing a large role in the implementation of Interior's WaterSMART (Sustain and Manage America's Resources for Tomorrow) Program, which establishes a national framework for sustainable water use through the coordination of Interior bureaus, states, tribes, local governments, and non-governmental organizations.

Office of Surface Mining Reclamation and Enforcement

One of the purposes of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) is to help States develop and implement their own approved surface coal mining programs. The Office of Surface Mining Reclamation and Enforcement (OSM) achieves this in part by providing technical assistance based on sound science, and training to its State and tribal partners to enhance their ability to maintain effective programs. Although OSM has no formal research and development activities, its Technology Development and Transfer program promotes and disseminates information on technological innovations to better protect the environment during mining and in reclaiming and restoring active and abandoned mines. The program also provides training to ensure that States, Tribes, and the bureau's other partners continue to administer their surface mining programs efficiently and effectively.

Bureau of Land Management

The Bureau of Land Management (BLM) is a multiple-use land management agency within Interior, responsible for administering approximately 248 million surface acres. Activities on these lands include recreation, energy development, mining, logging, livestock grazing, and management of wild horses and burros. To balance these varied

Desalination

During 2012, Reclamation entered into a Material Transfer Agreement (MTA) with Dow Chemical Company (Dow) to evaluate Reclamation's recently patented desalination membrane to purify water while resisting chlorine degradation. A significant deficiency of industry standard desalination membranes is their poor ability to resist chlorine degradation. This is important because chlorine dosing is vital to the water treatment process in order to prevent membrane biofouling. Under the agreement, Reclamation provided Dow with its patented chemical membrane formulation to manufacture a set of full-scale membranes for prototype testing. Dow provided their manufacturing know-how and capability to scale-up the Reclamation formulation into the full size membranes and also provided a set of the current Dow industry-standard membranes for comparison testing. The membranes were tested by Reclamation at Reclamation's Yuma Area Office-Water Quality Improvement Center. Results indicate the new Reclamation formulation performed well, but did not exceed that of the Dow industry standard. The patented Reclamation formulation has many derivations and patent applications for additional new formulations filed by Reclamation during 2012. Reclamation and Dow are now considering an expanded collaborative agreement to jointly evaluate and test a broader spectrum of Reclamation's formulations. If formulations are found to perform significantly better than current industry standards, subsequent collaborative activities would be pursued to mature the formulation(s) into commercially available membranes.

uses, BLM's decisions draw upon scientific data and information sources. Examples of information produced by BLM include:

- Visitor use surveys and research conducted by BLM's National Recreation Office, which incorporate information obtained from the public into resource management decisions;
- The Wild Horse Identification and Management System, a visual database used by federal wild horse managers, federal adoption program managers, individual horse owners, academic researchers, and federal and state land managers to identify wild horses and track information on them; and
- Monitoring data on rangeland conditions.

Public access to a wide variety of BLM geospatial data and products is available through GeoCommunicator. This publication site provides interactive mapping of public land survey system data, BLM lands and administrative areas, energy corridors, oil and gas sale parcels, wild horse and burro areas, and abandoned mines. All of this information is available for public use in a Geographic Information System (GIS), which offers easy communication via map interface.

National Park Service

The National Park Service (NPS) plays a critical stewardship role, preserving the natural resources on the lands it manages to provide for the enjoyment and education of current and future generations. Much of the scientific information collected by NPS is done within its Inventory and Monitoring (I&M) Program, established in 1992. This program conducts natural resource inventories and monitors the status and trends of various park resources. NPS's I&M Program collects a wide range of natural resource data from the nation's parks. The agency regularly monitors a range of vital ecosystem indicators such as soil structure, water quality, water quantity, wetland and grassland vegetation, among many others, in an effort to improve management of natural resources within the National Park system.

NPS administers twelve "Baseline" natural resource inventories including the Natural Resource Bibliography, base cartography data, air quality data, a vegetation inventory, species occurrence and distribution, and much more. NPS also uses data and information obtained through surveys of the public to inform park management and planning.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) is charged with conserving the nation's fish, wildlife, plants and their habitat. FWS plays a large role in generating and collecting scientific data and information used to meet this objective. For example, the FWS's Migratory Bird Data Center (a partnership with the USGS) houses extensive data sets and information on various bird populations and habitats in an effort to support conservation activities. Data sets collected through bird inventories, surveys, and monitoring programs are used to assess the status and trends of North American bird populations and facilitate planning and evaluation of bird conservation strategies and overall natural resource management. Long-standing surveys such as the Waterfowl Breeding Population and Habitat Survey date back to the 1950s and represent a successful partnership in data collection efforts between the FWS and the Canadian Wildlife Service. This survey provides population and trend information for various North American

duck species and provides critical information used in the establishment of hunting regulations, as well as in waterfowl conservation. Hunter activity and harvest data are also available at this data center.

Technology Transfer

There were a total of 379 active Cooperative Research and Development Agreements (CRADAs) in FY 2012, of which 284 were newly executed. In addition there were 283 other collaborative R&D arrangements with various parties, including 165 that were new in FY 2012. Table 13-1 provides a summary by bureau. Also, in FY 2012, through the publication of over 2,300 reports, books, fact sheets, and other publications, the Department's scientific, technical and engineering personnel engaged in a broad range of cooperative activities to develop and disseminate innovative technologies.⁹² A summary of the activities undertaken in FY 2012 is provided in Table 13-1. Some specific examples of actions in FY 2012 include:

- Disclosure of 10 new inventions. In addition, three patents were filed and three patents were issued.
- Managing 26 licenses for inventions and other intellectual property earning over \$78,000.
- Drafting a new Departmental Manual chapter that will establish Department policies and procedures for implementing and administering technology transfer agreements.

Table 13-1. Collaborative Relationships for Research and Development

FY 2012	USGS	FWS	Reclamation	BSEE	TOTAL
CRADAs, total active in the FY ⁽¹⁾	365	4	10		379
New, executed in the FY	283		1		284
Traditional CRADAs, ⁽²⁾ total active in the FY	17	4	7		28
New, executed in the FY	5				5
Non-traditional CRADAs, ⁽³⁾ total active in FY	348		3		351
New, executed in the FY	278		1		279
Other collaborative R&D relationships					
Collaborative Agreements, total active in the FY	275	n/a		8	283
New, executed in the FY	158	n/a		7	165

Source: U.S. Department of the Interior. Annual Report on Technology Transfer FY 2012 Activities, January 2013.

⁹² The source of the material in this section is: U.S. Department of the Interior. Annual Report on Technology Transfer FY 2012 Activities January 2013.

Economic Value

Information is a valuable economic resource. It improves decision making by reducing the uncertainty of outcomes. Publically provided scientific data and information sources generate significant societal benefits, and quantifying the return on the public's investment in the development of scientific information and transfer of federal technology has become increasingly important. In concept, the value of information can be evaluated using standard economic techniques such as benefit-cost analysis. However, evaluating the net economic benefits of the scientific information provided by DOI presents some challenges, one of which is related to the "public good" nature of the data and information provided.⁹³

An additional challenge stems from the fact that the information generated through DOI research has a variety of national (and sometimes international) uses, providing economic benefits that could be monetized in different ways. Further, this information is often shared freely among users, making quantification of its total value to society challenging. One of the key components to developing estimates of value is identifying the full range of existing users and uses of a particular data or information source. . However, few such studies have been conducted to date. In addition, much of the information provided by Interior bureaus has few or no substitutes, so it may not be possible to use secondary sources to quantify its value. Despite these challenges, significant advancements have been made in communicating the economic value of data and information sources, through both qualitative and quantitative approaches.

Within Interior, the U.S. Geological Survey (USGS) has carried out a number of studies monetizing the economic benefits associated with the uses of scientific and technical data and the information these provide. Beginning in the 1990s, a number of studies have estimated the value of geologic maps (Bernknopf et al., 1993; Halsing et al., 2004; Bernknopf et al., 2007); earth science information (Bernknopf et al., 2001); and satellite imagery (Miller et al., 2011). These studies all provide estimates of the economic value for a sample of the end uses which publically provided data and information sources are put towards. However, for reasons mentioned previously, these estimates are neither comprehensive nor certain.

⁹³ *Public goods*, as defined by economists, are goods which have the characteristics of *non-rivalry* and *non-excludability*. Goods with these characteristics are often, but not always, provided by the public sector. *Non-rivalry* implies that, in general, the additional cost of one more person using this type of good is typically zero. For example, if one individual goes to the USGS Earth Resources Observation and Science Center website and downloads a particular satellite image, this does not affect the availability or cost of providing this same image to other users. *Non-excludability* implies that individuals cannot be prevented from using the good. In direct contrast, private goods are both *rival* and *excludable*, and are provided through private markets. In the absence of market failures, forces of supply and demand set an efficient market-clearing price.

Exploring the Value of Landsat Imagery

Landsat satellites provide remotely sensed imagery, archived back to 1972, allowing for broad-area analyses over several decades. The imagery has been collected globally on a regular basis, providing unique repeat coverage. This imagery is available at no cost and with no restrictions from the U.S. Geological Survey (USGS). Since Landsat imagery is provided at no cost, there is no market price for it, which makes determining the value of the information provided by the imagery more difficult. Landsat is used in a huge variety of applications by hundreds of thousands of people, implying substantial value. The free and open data policy resulted in a hundredfold increase in scenes distributed annually from USGS and a tenfold increase in the number of users registered with USGS. These trends indicate that the value of Landsat is increasing.

In 2012, a survey of more than 11,000 Landsat users registered with USGS was conducted by the Policy Analysis and Science Assistance Branch at the USGS Fort Collins Science Center to explore the value of the imagery to users. By exploring the value of Landsat imagery with a variety of metrics, a comprehensive picture of the value of the imagery was created. The majority of users felt Landsat was important to their work and said they were moderately to very dependent on the imagery to complete their work. This dependence on the imagery is also demonstrated by the 62% of users who stated that they would have to discontinue work if archived and new Landsat imagery was no longer available. On average, these users estimated they would discontinue half of their current work. Additionally, almost a third of users believed their costs would increase if Landsat imagery was no longer available. These users estimated their average increase in costs would be 82%. Though all Landsat imagery is unlikely to disappear, there was a gap in new imagery provision from Landsat 5 before and during the survey. A large majority of users (79%) reported using Landsat 5 imagery in the year prior to the survey and, during this data gap, more than 40% of these users decreased or ceased their use of Landsat imagery. Close to 30% of Landsat 5 users felt their work had decreased in quality and scope, just over a quarter said their work was more time consuming, and 18% said their work was more expensive. Given that Landsat 7 was still providing new imagery during this time period (albeit with some missing data) and the entire archive of Landsat was still available, the impacts of the loss of new Landsat 5 data for a short period of time appeared substantial for some users. The results of the survey show that Landsat imagery was valued highly by these users. The value of Landsat will most likely increase as the free and open data policy becomes even more widely known, the new imagery from Landsat 8 begins to be used, and emerging issues facing the nation and the world, such as climate change, become more pronounced and require increasing amounts of reliable global-scale data.