USGS
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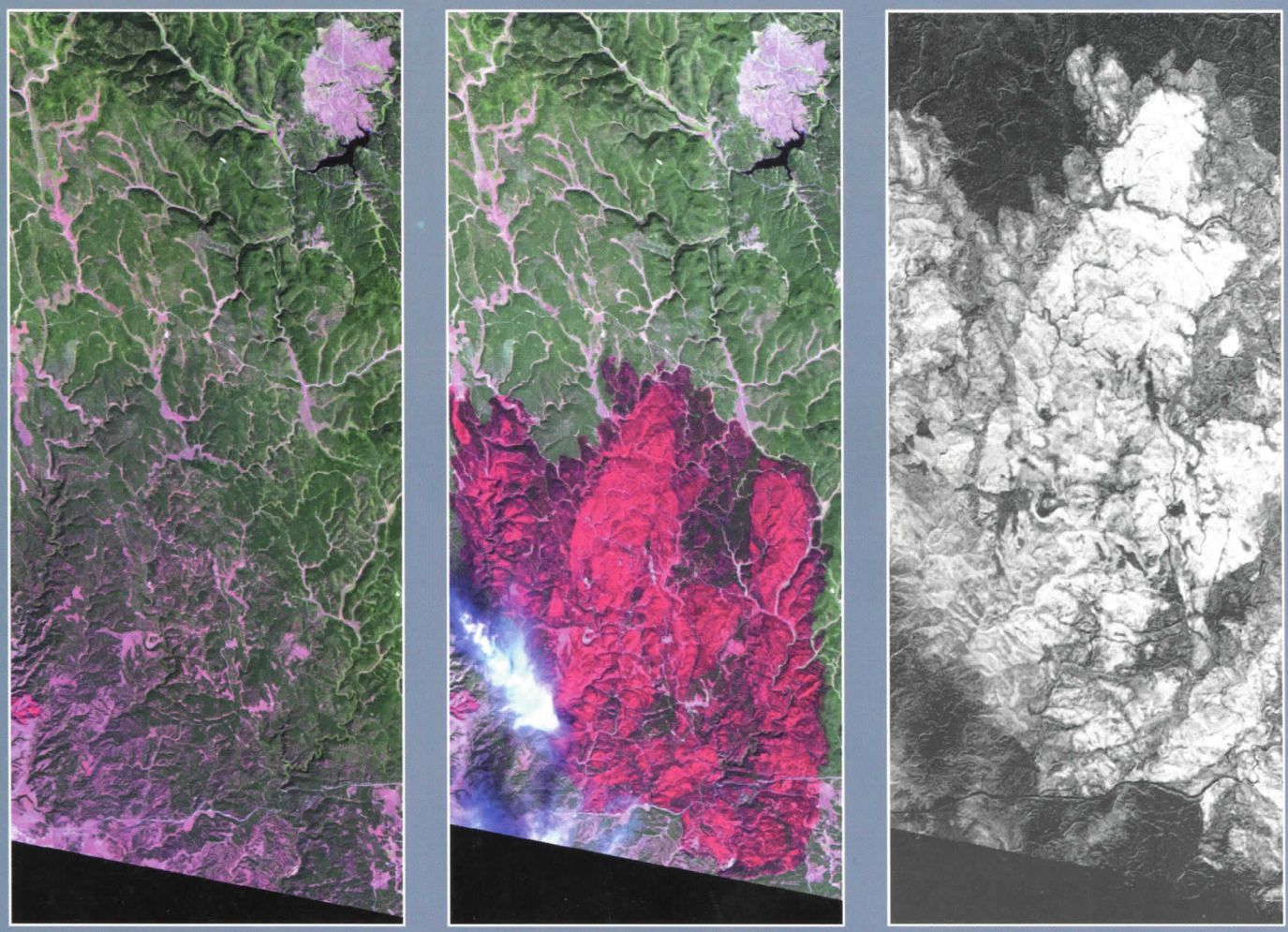
EROS Data Center
ANNUAL REPORT

Jasper Fire – Black Hills, South Dakota



August 20, 2000 | September 5, 2000 | Burn Severity Subset

FISCAL YEAR 2000

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

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PART 1

PURPOSE OF THIS REPORT

The purpose of this annual report is to inform you, our customers, of the programs, services, and activities of the U.S. Geological Survey (USGS) Earth Resources Observation Systems (EROS) Data Center (EDC), one of five field centers of the USGS's National Mapping Program (NMP). The report summarizes the work we have done in fiscal year 2000 to provide reliable, accurate, and useful land data and information that are relevant to society's needs. Just as important, we try to reflect your ideas and feedback, which have been incorporated into our business of providing you with the best possible service.

The report has three parts. Part I provides information about USGS, NMP, and EDC. Part II summarizes EDC programs and activities in fiscal year 2000. Finally, Part III highlights statistical data, selected technical publications, and provides a word in conclusion.

ABOUT THE COVER

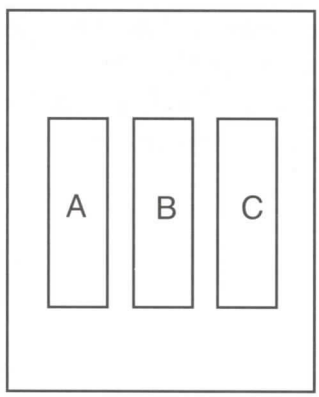
Dry vegetation and gusty winds fueled nearly 50 large wildfires that scorched primarily the western United States and consumed nearly 7 million acres of forest and rangeland during the 2000 fire season. The 2000 fire season - the worst season for fires in more than a decade - began in May with a blaze that left 400 families homeless in Los Alamos, New Mexico, and exhausted the fire fighting resources of many State and Federal agencies. The USGS Earth Resources Observation Systems (EROS) Data Center (EDC) monitored the smoke and damage of many of these wildfires from 438 miles in space using data acquired by the Enhanced Thematic Mapper Plus (ETM+) sensor aboard Landsat 7. The images on the cover were acquired before, during, and after the Jasper Fire in the Black Hills of South Dakota.

Pictured left to right:

A. The Landsat 7 satellite acquired this image of the Black Hills on August 20, 2000 with its Enhanced Thematic Mapper Plus (ETM+) sensor. This image provides a view from 438 miles in space of the region before the Jasper Fire started. In this image vegetation appears bright to dark green. Evergreen forests are generally dark green while leafy plants and riparian vegetation are light green. Rangeland, or more open areas, appears pink to light purple and water bodies are black. Areas with extensive pavement or urban development appear light blue to purple.

B. The Landsat 7 satellite acquired this image of the Black Hills on September 5, 2000 with its Enhanced Thematic Mapper Plus (ETM+) sensor. This image provides a view from space of the Jasper Fire in its final days of activity after it burned an estimated 83,500 acres. In this image, vegetation appears bright to dark green. Evergreen forests are generally dark green, while leafy plants and riparian vegetation are light green. Rangeland, or more open areas appear pink to light purple and water bodies are black. The area recently burned appears dark red and the smoke plume appears light blue to white.

C. The black-and-white image represents the severity of burn that occurred from the Jasper Fire. Landsat 7 data before and after the fire were processed to represent the difference in green biomass. The brighter areas within the fire boundary show areas of greatest change or areas of tree crown fire. Black areas represent no change. The intermediate tones indicate areas that experienced only a ground fire.



THE U.S. GEOLOGICAL SURVEY: A TRADITION OF PUBLIC SERVICE 1879-2000

The U.S. Geological Survey (USGS), established by Congress in the Organic Act, March 3, 1879, provides geologic, topographic, biologic and hydrologic information to the Nation. This information comprises maps, databases, and reports containing analyses and interpretations of water, energy and mineral resources, land surfaces, geologic structures, biologic resources, natural hazards, and the dynamic processes of the Earth.

Key actions conducted by the USGS in fulfilling its mission are:

- Collect and analyze data on the quantity and quality of surface and ground water, on water use, and on the impact of human activities and natural phenomena on water resources.
- Assess energy and mineral resources, develop techniques for their discovery, and evaluate the impact of their extraction.
- Describe the onshore and offshore geologic framework of the Nation and develop an understanding of the formation and evolution of that frame work.
- Assess biologic resources, develop techniques for their preservation and development, and evaluate the impact of their depletion.
- Evaluate hazards associated with earthquakes, volcanoes, floods, droughts, landslides, and toxic materials. Develop methods for the prediction and mitigation of such hazards.
- Produce and update geographic, cartographic, and remotely sensed information in both graphic and digital form.

The USGS cooperates with and coordinates its efforts with nearly 2,000 agencies at Federal, State, county, and municipal levels, and with other nations and international organizations. The headquarters of the USGS is located in Reston, Virginia. Three regional centers are located in Denver, Colorado; Menlo Park, California; and Reston, Virginia. Field offices, such as the EROS Data Center, are located throughout the 50 states, the Commonwealth of Puerto Rico, and the Trust Territories of the Pacific. To learn more about the USGS, go to the following Internet address: http://www.usgs.gov

THE USGS: VISION AND MISSION

Vision

The USGS is a world leader in the natural sciences through our scientific excellence and responsiveness to society's needs.

Mission

The USGS serves the Nation by providing reliable scientific information to:

- describe and understand the Earth;
- minimize loss of life and property from natural disasters;
- manage water, biological, energy and mineral resources; and
- enhance and protect our quality of life.

The MISSION OF THE USGS NATIONAL MAPPING PROGRAM

The mission of the USGS's National Mapping Program is to meet the Nation's need for basic geospatial data, ensuring access to and advancing the application of these data and other related earth science information for users worldwide. In support of this mission, we:

- ensure the production and availability of basic cartographic and geographic spatial data of the country;
- coordinate national geospatial data policy and standards;
- provide leadership for the management of earth science data and for information management;
- acquire, process, archive, manage, and disseminate the land remote sensing data of the Earth; and
- improve the understanding and application of geospatial data and technology.

THE USGS EROS DATA CENTER: VISION AND MISSION

Vision

The USGS Earth Resources Observation Systems (EROS) Data Center's vision is to be the world's leading source of land information for exploring our changing planet.

Mission

- To promote new uses, new users, and new understanding of land information, so that others can better understand our planet.
- To ensure scientists, researchers, businesses, decision makers, and the public have ready access to the land information they need.
- To safeguard and expand the world's largest archive of remotely sensed land data.

EROS DATA CENTER EXECUTIVE STAFF

Donald T. Lauer
Chief

James A. Sturdevant
Assistant Chief, Operations

Wayne G. Rohde
Assistant Chief, Programs

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Chief, Program Management Office

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June M. Thormodsgard
Chief, Science and Applications Branch

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Chief, Computer Services Branch

Bruce K. Quirk
Chief, Satellite Systems Branch

Thomas M. Holm
Chief, Data Services Branch

PART II

RESEARCH AND APPLICATIONS

Remote Sensing Studies

FY 2000 was an exceptionally successful year for the Remote Sensing Studies group, as work progressed well on existing activities, and new activities were added, primarily funded through competitively awarded research initiatives. The Enhanced Thematic Mapper Plus (ETM+), Moderate Resolution Imaging Spectrometer (MODIS), SPOT4/Vegetation, and volcanic deformation activities provided a total of nearly $550,000 in external research funds over 3 years, $200,000 within FY 2000 alone. In addition, new funds were secured for FY 2001, once again through largely competitive channels, for the Monitoring activity ($300,000/3 years, NASA), Microwave ($200,000/2 years, NASA), and Beowulf clustering ($300,000/2 years, National Mapping Program/ (NMD/GRA). In addition to direct funding, the project also accumulated nearly $2 million in data grants for a 2-year period, including FY 2000 for AVIRIS, IKONOS, ERS-1, JERS, and Radarsat data.

Landsat 7

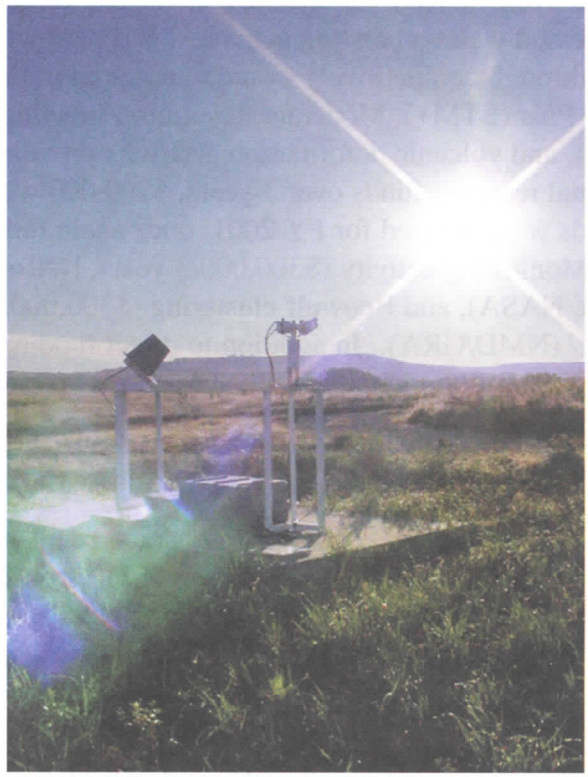
Comparisons between the Landsat 5 and 7 sensor systems were performed using data acquired over the Niobrara Valley Preserve in early summer 1999. The Niobrara dataset was among the best acquired during the underflight period, when the Landsat 7 ETM+ "passed under" the Landsat 5 Thematic Mapper (TM). This allowed for comparison between the two imagers while viewing a given location at nearly the same time. This field campaign allowed the EDC/SDSU (South Dakota State University) team to perform the first vicarious calibration of the ETM+ instrument, and characterization of the differences in the instruments and their subsequent processing. From an applications standpoint, Landsat 7 and Landsat 5 data are very comparable, implying that procedures and products developed with one system will be transferable to the other.

Moderate Resolution Imaging Spectrometer (MODIS)

Work on the MODIS reflectance, fraction of Photosynthetically Active Radiation (fPAR), and Leaf Area Index (LAI) validation in FY 2000 centered on two areas: (1) evaluating the results of the Konza Validation Experiment (KonVEx) in the summer of 1999, and (2)a revisit to Konza (in Kansas) in the summer of 2000 to further develop the validation methodology. Much of the 1999 KonVEx effort focused on the development of a precision geocoding algorithm for AVIRIS data (see "AVIRIS" below). Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) was flown concurrently with Airborne Multi-angle Imaging SpectroRadiometer (AirMISR) in 1999, and EDC collaborated with the European Union Joint Research Centre (JRC) in Ispra, Italy, to develop LAI & fPAR algorithms based on the joint AVIRIS/AirMISR collection. The field operations in the summer of 2000 focused on: (1) the validation of the JRC algorithm, and (2) the demonstration of a remotely-piloted helicopter for Bi-Directional Reflectance Distribution Function (BRDF) studies, developed and operated by Yoshiaki Honda of Chiba University. Direct work on MODIS data has been hampered by the availability of "sanctioned" validation-grade MODIS products. Also, an Aerosol Network AERONET node (a Cimel sunphotometer and Geostationary Operational

Environmental Satellite (GOES) transmitter) was established at Konza using EDC equipment (figure 1). Finally, field methods for estimating biomass automatically and performing classification on digital photography were developed, avoiding the lengthy and labor-intensive activity of clipping for dry weight measurement (figure 2).

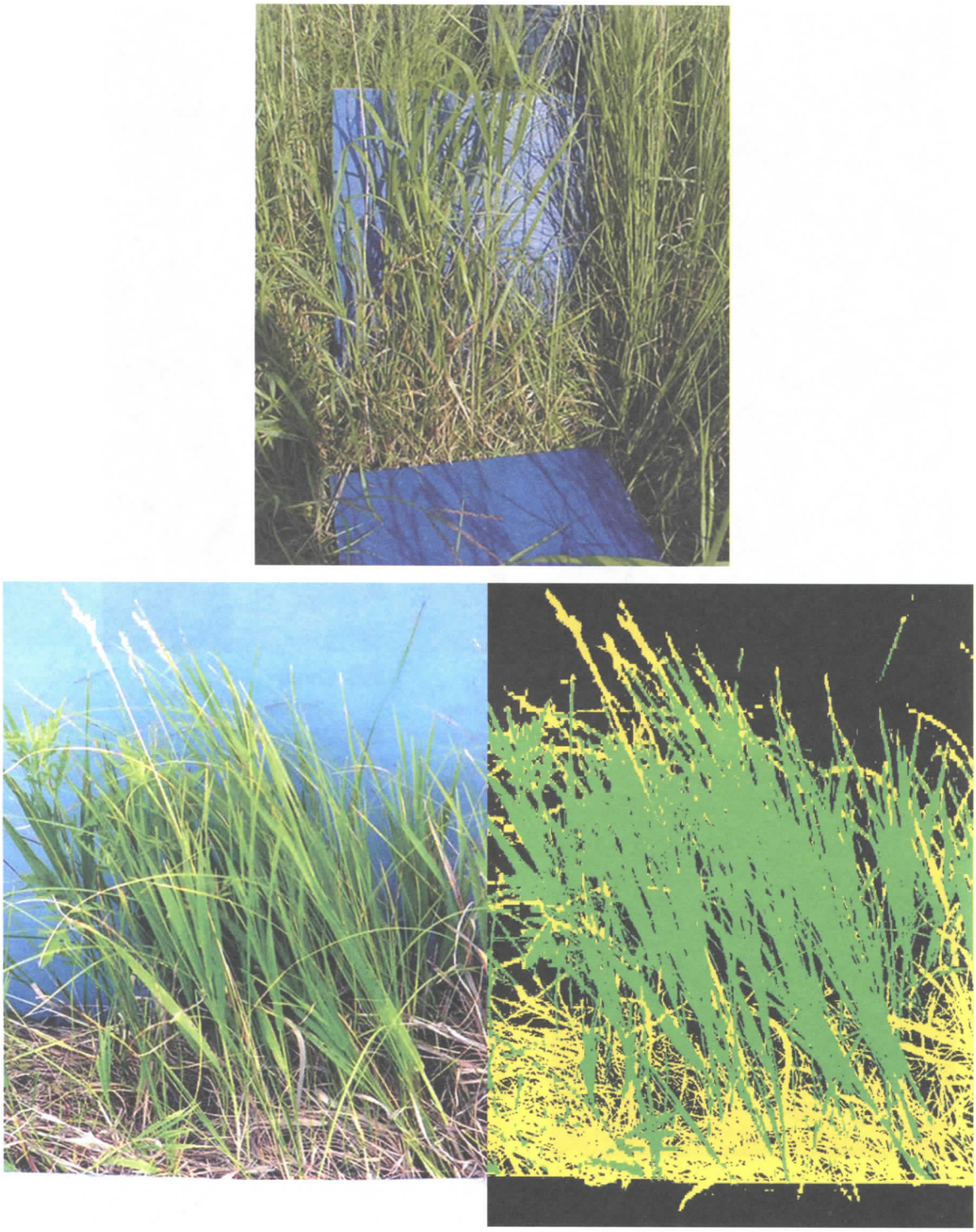
Figure 1



The Cimel automatic sun-tracking photometer, located by EDC Staff at the Konza Prairie Long Term Ecological Research site, is part of the Aerosol Robotic Network (AERONET). The AERONET sites comprise a global network of sunphotometers used to monitor the optical properties of the atmosphere, particularly as they affect electro-optical remote sensing. The Konza site is maintained by EDC, in collaboration with Kansas State University, as a MODIS Validation core site. The sunphotometer itself, along with a similar photometer located at EDC, were funded by the Centre National d'Etudes Spatiales as part of the SPOT4/Vegetation evaluation.

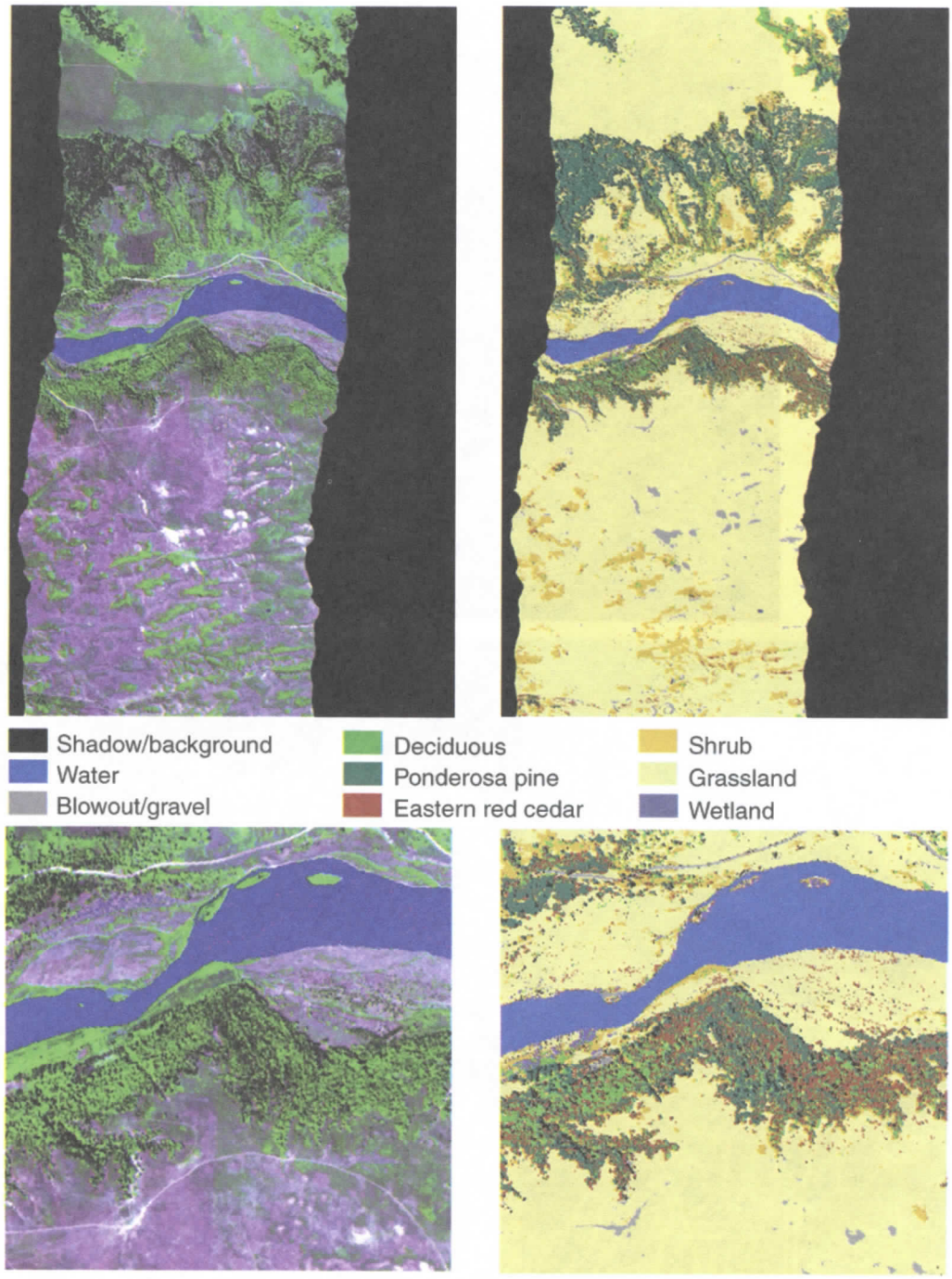
Systeme pour l'Observation de la Terre (SPOT4)/Vegetation

The SPOT4/Vegetation study was completed this year after a 3 year effort. The study combined an evaluation of the instrument technology with a comparison of vegetation to the Advanced Very High Resolution Radiometer (AVHRR) for greenness mapping. The value of simultaneously acquired, spectrally matched, high- and low-resolution images was measured through a comparison of SPOT High Resolution Visible Infrared (HRVIR)/Vegetation mixed resolution acquisitions with AVHRR/ETM+ acquisitions. The primary findings of the study were: (1) differences in spectral response in the red between the various sensors were not sufficient to significantly decorrelate near-simultaneous acquisitions; (2) the off-nadir spatial response of the wide-field vegetation sensor was clearly superior to the AVHRR, and (3) water-vapor effects on the Near Infrared (NIR) channels, a major problem with the AVHRR, did not adversely affect vegetation-derived greenness map.



As part of the SPOT4 and MODIS validation activities, EDC staff have developed numerous techniques for rapid acquisition of field information required to characterize and validate vegetation products developed from airborne and spaceborne imagery. Green biomass is a critically important biophysical quantity, important to a wide range of applications from mapping forgeable biomass for livestock to global carbon studies. Traditional destructive methods for estimating biomass are time-consuming and labor intensive, limiting the number of field plots used to characterize and validate products. EDCStaff has developed non-destructive methods using digital cameras and standard classification methods to estimate green fraction and biomass. The technique is similar to the "chroma-key" methods used in the television and film industries: subjects are filmed against a blue background to isolate them from their surroundings. The top figure illustrates the setup. The bottom left shows an example digital photo, and the bottom right shows the result of classification; black is background or shadow, green is healthy vegetation, and yellow is non-photosynthesizing material within the plot.

Figure 3



Hyperspectral data can be used to discriminate conifer species that are not easily differentiated by traditional multi-spectral methods. A case in point is the expansion of eastern red cedar (actually a juniper) within the Great Plains. As grassland fires are reduced over time, fire-sensitive species like the juniper tend to spread. Along the Niobrara River, the junipers are mixed with western species (primarily Ponderosa pine), complicating the process of mapping their distribution remotely. As seen in this figure, AVIRIS data clearly allow the differentiation of the conifer species.

Airborne Visible and Infrared Imaging Spectrometer (AVIRIS)

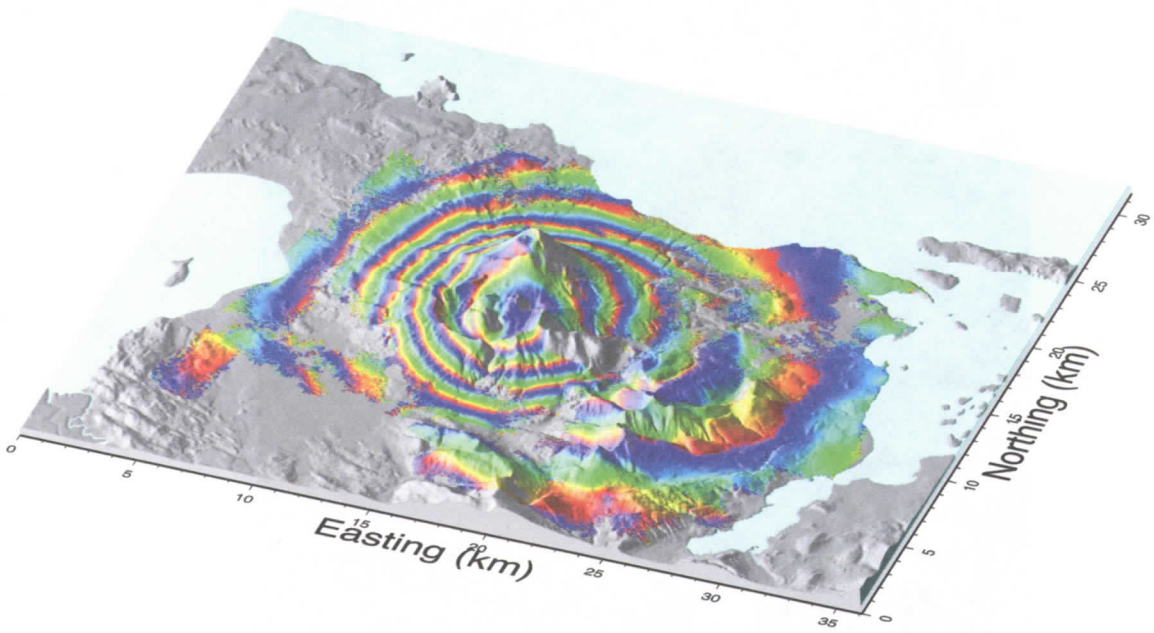
The bulk of FY 2000 work on the AVIRIS woody-species study involved the reduction and analysis of AVIRIS data collected in 1999. Work focused primarily in three areas: (1) precision geometric correction; (2) atmospheric correction and dimensionality reduction; and (3) classification for separating eastern red cedar from ponderosa pine at the Niobrara Valley Preserve in Nebraska. EDC staff developed techniques for precision correction of AVIRIS that are improvements on the systematic

products provided by Jet Propulsion Laboratory (JPL). EDC staff also evaluated the use of Atmosphere Removal (ATREM), Moderate Resolution Transmittance (MODTRAN), and empirical techniques for correcting the atmospheric effect. The empirical algorithms appear to work quite well across multiple-flight line mosaics. Among physics-based models, ATREM's inability to model the coupling of water vapor to aerosol optical effects made it less desirable than MODTRAN. From minimum noise fraction (MNF) images derived from atmospherically corrected data, decision tree methods for classification were compared to matched filtering and spectral unmixing approaches; the decision tree methodology worked quite well (figure 3).

Microwave Studies

EDC staff applied space-borne radar interferometry techniques to study volcanoes in Alaska by mapping and analyzing volcanic deformation signaled by underlying magma processes. This research is a collaborative effort between EDC and Geology discipline staff at Menlo Park, Cascades Volcano Observatory, and Alaska Volcano Observatory. The technique used was to study several active volcanoes known for recent eruptions. These included a 1997 eruption of Okmok volcano, the 1996 earthquake swarm of Akutan volcano, and aseismic magma accumulation of Westdahl volcano. Recently, the technique was also used to prospect for any magma accumulation at dormant volcanoes. Deformation surveys offered by this technique will provide guidance on monitoring strategy, and raise the possibility of a significant advance in our ability to anticipate eruptions (figure 4).

Figure 4



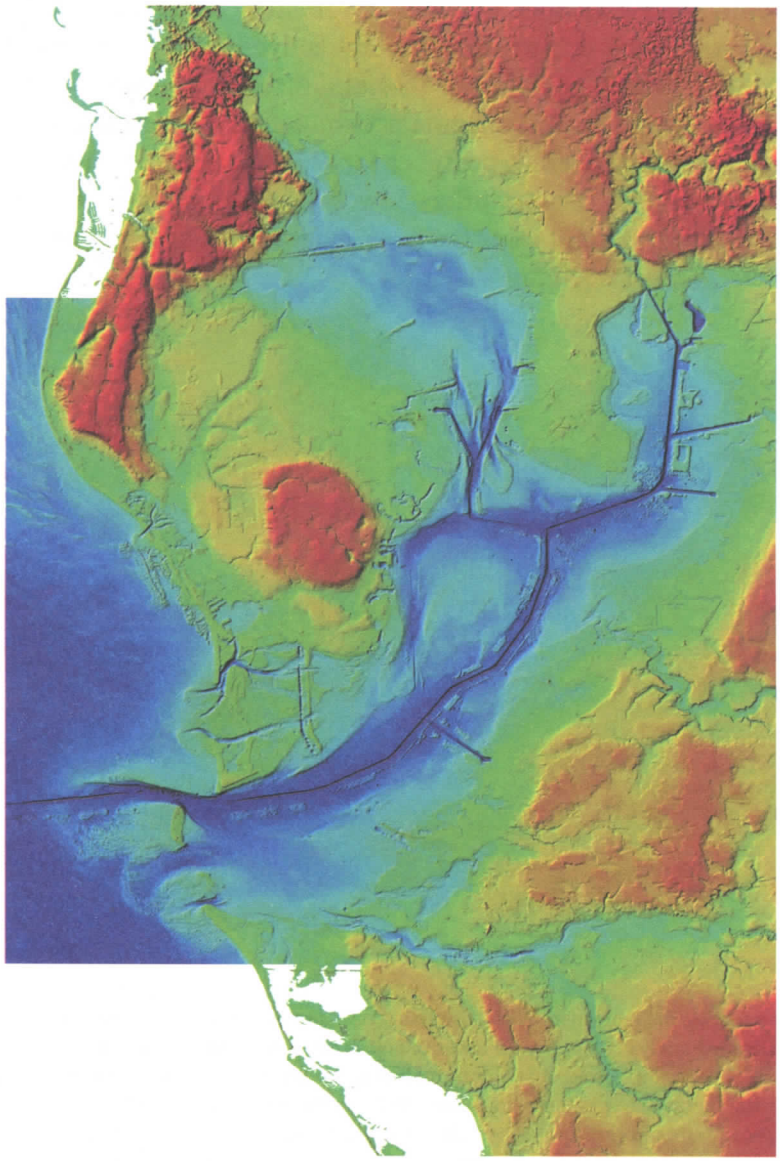
Radar interferometry is used to map the deformation of a dormant Alaskan volcano where the last eruption occurred more than a century ago. Detailed analyses suggest the deformation is episodic. This study demonstrated that satellite radar interferometry has great potential to detect subtle deformation at seemingly dormant volcanoes, warning of a possible reactivation. Mapping deformation at these volcanoes will improve our understanding of magma dynamics and provide scientific guidance on monitoring strategies. One color cycle represents 2.83 cm volcanic deformation. Gray-toned areas represent areas where no useful radar signals can be extracted. A color cycle is an orderly progression through five colors: cyan, blue, red, yellow and green. While a color cycle may begin with any of the previously mentioned colors, it will always follow the order the colors are listed above.

Three proposals were funded by NASA, the European Space Agency, and the Japanese Space Agency to study volcanic deformation with satellite radar imagery. These proposals provide funding for long-term volcano deformation studies.

National Elevation Dataset-Hydrologic Derivatives (NED-H) Collaborators Meeting

A meeting was held at the EROS Data Center on January 25-27, 2000, to launch the development of NED-H. The meeting brought together parties interested in seeing the NED-H become a reality. A broad range of participants attended, representing Federal, State and university interests. The 3-day meeting featured presentations and discussions of the proposed NED-H methodology and implementation strategy, along with a half-day session devoted to seamless data access and distribution issues.

Figure 5

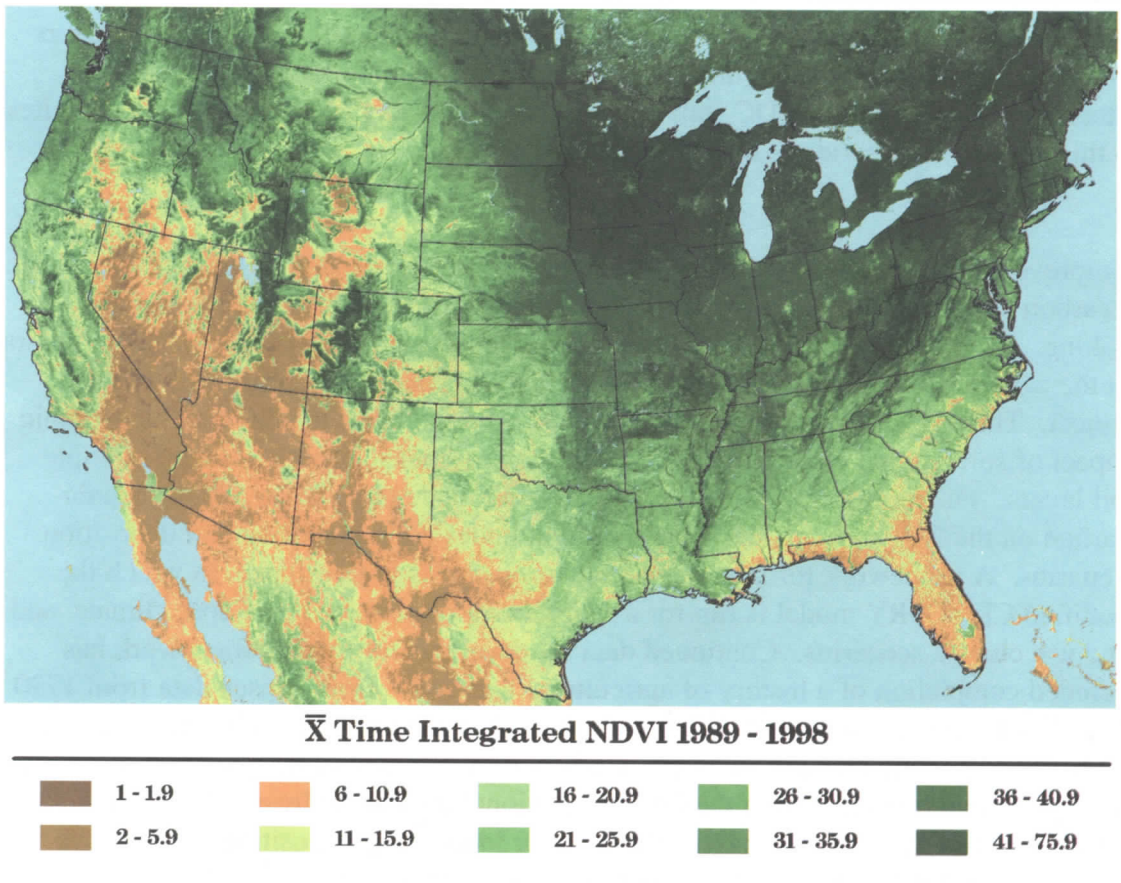


Merged bathymetric/topographic digital elevation model (DEM) for the Tampa Bay, Florida area.

Tampa Bay Topography/Bathymetry Demonstration Project

Collaborative work was done with NOAA's National Ocean Service on developing a seamless merged topographic/bathymetric elevation model for the Tampa Bay region. Topographic data from the USGS National Elevation Dataset were processed and merged with gridded NOAA digital sounding data to produce the model. It will enable local planning, natural resource, and regulatory agencies to make joint use of USGS land data and NOAA hydrography data at the critical land/water interface. In the past such an approach was problematic, as there are many different criteria that can be used to define the shoreline of coastal zones, such as tidal conditions and datums. One advantage of the merged elevation model is that it allows a user to define a shoreline based on specific criteria without being limited by a static representation from one spatial data source (figure 5).

Figure 6



Mean time integrated NDVI (greenness) for 1989-1998. This is a surrogate measure of productivity, contrasting the high production of forest and agricultural areas of the Eastern U.S. to grasslands and shrublands of the West. By comparing yearly values of greenness to recent historical data, the status and trends of production can be assessed.

Monitoring System Development

External funding was secured from NASA's "Investigations that Contribute to the NASA Earth Science Enterprise's Modeling and Data Analysis Research" pathfinder program. This 3-year grant will be used to refine techniques for extracting phenological metrics from time-series AVHRR, to ground-truth these measurements, and expand the

project to a global scale. Another component of the project is to begin investigations addressing transitions to new-era sensors, such as MODIS and SPOT Vegetation.

An Inter-agency Agreement was reached with the Centers for Disease Control to investigate environmental conditions that are associated with hantavirus outbreaks in the American Southwest.

A cooperative study was undertaken with the U.S. Department of Agriculture's Agricultural Research Service on relating time-integrated Normalized Difference Vegetation Index (NDVI) to Carbon Dioxide CO2 flux over Dubois, Idaho. Early results indicate that NDVI measurements, coupled with climate information, can explain nearly 90percent of the variation in CO2 flux. A manuscript describing this study is being prepared (figure 6).

Project staff developed a Java-user interface for the seasonal metrics that allows users to query the 11-year database both for single pixels and for user-defined areas. Users are able to obtain seasonality summaries for each year and by land cover type for interannual comparisons. EDC staff continue to add 14-day AVHRR NDVI composites to this 11-year time series as they become available.

Soil Carbon Research

Improved understanding of the terrestrial carbon cycle is needed to balance the global carbon budget and develop a predictive capability for land management policy making. EDC staff are conducting research on the impacts of erosion and sedimentation on the carbon cycle as part of the interdisciplinary USGS Mississippi Basin Carbon Project. The CENTURY ecosystem model has been modified to simulate the dynamic impact of soil erosion and deposition on soil carbon stocks and fluxes using multiple soil layers. The modified model was applied to simulate the change of soil organic carbon on the Nelson Farm site in Mississippi, under various erosion and deposition scenarios. A framework for large-area simulations is being developed, in which the modified CENTURY model is run for a spatially representative set of soil, climate, and land use change scenarios. Continued data set development for this framework has included completion of a history of agricultural land use – from census data from 1790 to 1997 – by county, and compilation of historical change in crop yield and harvest index due to genetic changes in crops. Carbon stocks, erosion rates, and carbon erosion rates have been modeled using the USDA's National Resources Inventory and State Soil Geographic (STATSGO) databases. Methods for identifying depositional areas have been developed using both digital elevation models and soil databases. To help understand the dynamics of carbon fluxes on a watershed scale, techniques have been developed and applied to delineate the contributing areas above 81 gages in the National Stream Quality Accounting Network (NASQAN) within the Mississippi Basin. Regional forest litter data from the U.S. Forest Service have been linked with forest type data for the conterminous U.S. and Alaska to develop a map of carbon in forest litter, as a contribution to a map of soil carbon stocks in North America being prepared in conjunction with soil scientists in the United States, Canada, and Mexico.

Figure 7

In FY 1999, EDC staff contributed to the National Atlas of the United States project by participating in the design and production of a map of forest cover types of the U.S. The new map depicts 25 classes of forest cover as discrete colors with a shaded relief background to indicate landforms. Forest data were developed from AVHRR imagery by EDC staff working with the U.S. Forest Service.

National Atlas Support

Unlike previous National Atlas printed maps, which showed Alaska at reduced size, this map features a new format developed to show all 50 states at the same 1:7,500,000 scale. EDC staff developed test layouts for review and comment by the design team, and assembled the final layout used for the printed map. Fifty thousand copies of the map were printed to accompany a Forest Service report and for distribution at National Forest offices nationwide (figure 7).

ALASKA LAND CHARACTERIZATION

Multi-Resolution Land Characterization Program 2000 for Alaska

The Multi-Resolution Land Characterization Program, initiated in 1992, was a successful interagency program that provided for the purchase of Landsat TM imagery covering the conterminous United States. The original members of the Multi-Resolution Land Characteristics (MRLC) Consortium included the U.S. Geological Survey (USGS), the U.S. Environmental Protection Agency (USEPA), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Forest Service (USFS). A significant outcome of the purchase was the successful implementation of three different land cover mapping projects that met individual agency needs in providing regional scale coverage for all 48 states from the data purchased by the MRLC consortium.

Beginning with the year 2000, Alaska is part of the MRLC-2000 program that will provide for the acquisition of Landsat 7 ETM+ data for all 50 states. The USGS Alaska Field Office (AFO) has the lead role for coordinating the data acquisition effort, on behalf of participating Alaska agencies. This initiative will provide three Landsat 7 scenes for every path-row in the state. The AFO is also coordinating an interagency effort to conduct land-cover mapping from the MRLC Landsat 7 data base that would result in the first comprehensive, consistent statewide land-cover data base.

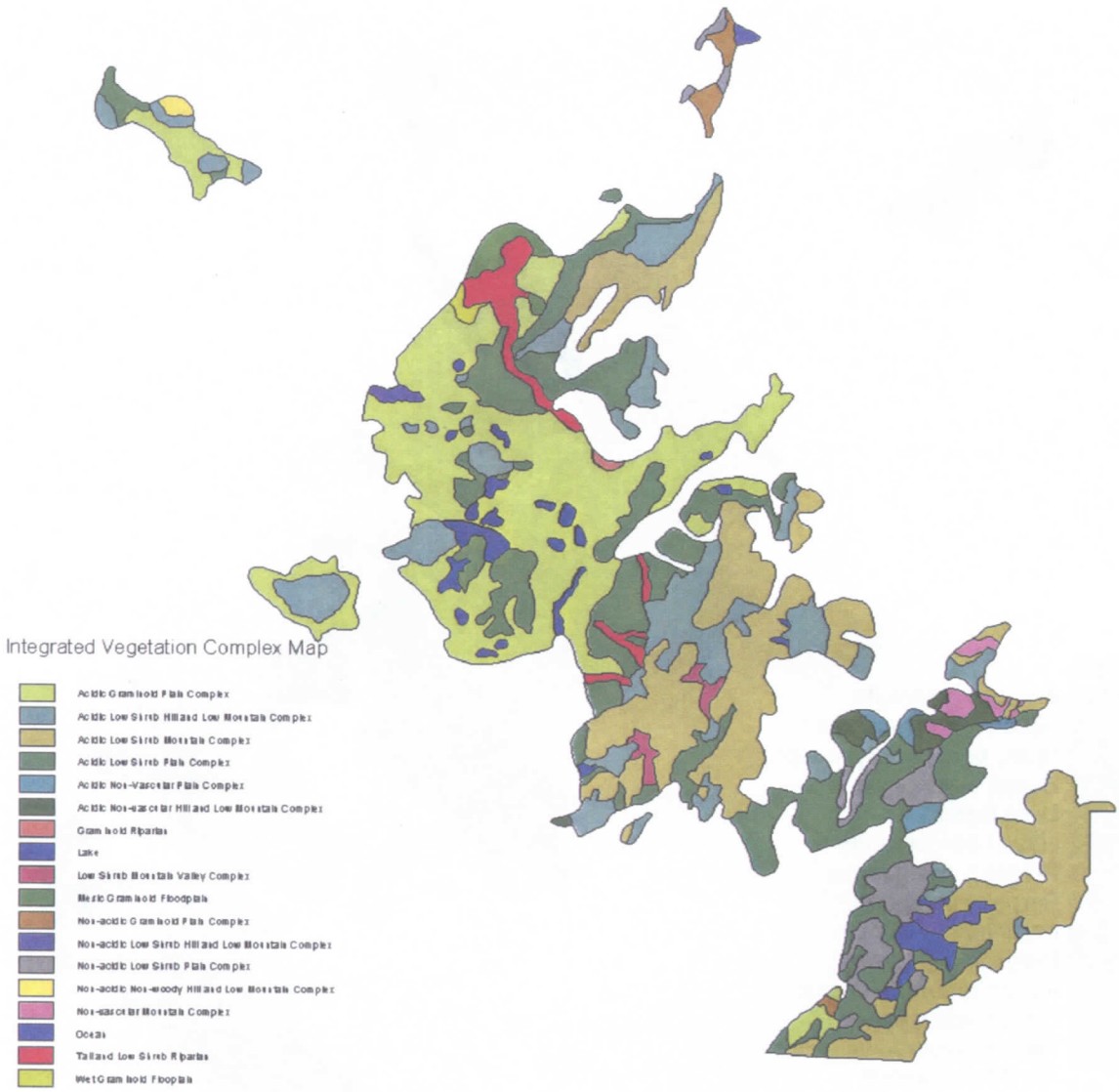
Ecoregions of Alaska

The USGS, USFS, and the National Park Service conducted a series of workshops in FY 2000 on updating the Ecoregions of Alaska Map (USGS Professional Paper 1567) published by the USGS in 1995. Revisions were made through an interactive process of interagency meetings and professional peer review to consider new data not available during the original effort. The resulting interagency product will be published by the USGS in FY 2001. This new Ecoregions of Alaska Map, endorsed by the Alaska Geographic Data Committee, will serve as the standard for the delineation and identification of ecoregion units by Alaska natural resource management agencies and the Alaskan research community. It will be used for a broad range of activities including global change studies, fire management planning, and natural resource inventory and monitoring.

Circumpolar Arctic Vegetation Mapping Project

Working in collaboration with the U.S. Fish and Wildlife Service, the University of Alaska-Fairbanks, and scientists from eight Arctic nations, the USGS AFO continued production of the first comprehensive and consistent vegetation map of the Earth's circumpolar Arctic region. The Circumpolar Arctic Vegetation Mapping (CAVM) project is being conducted in support of the International Conservation of Arctic Flora and Fauna (CAFF) Initiative. The initiative's objective is to identify areas of unique and important biodiversity. The United States and several Arctic nations are working on an international conservation strategy for the protection of unique areas within the context of the Arctic region. Primary products from this project will be false color infrared (CIR) and NDVI circumpolar Arctic image maps derived from the 1992 and 1995 global AVHRR biweekly composite databases assembled by EDC. A circumpolar shaded relief map will also be generated for the circumpolar region from

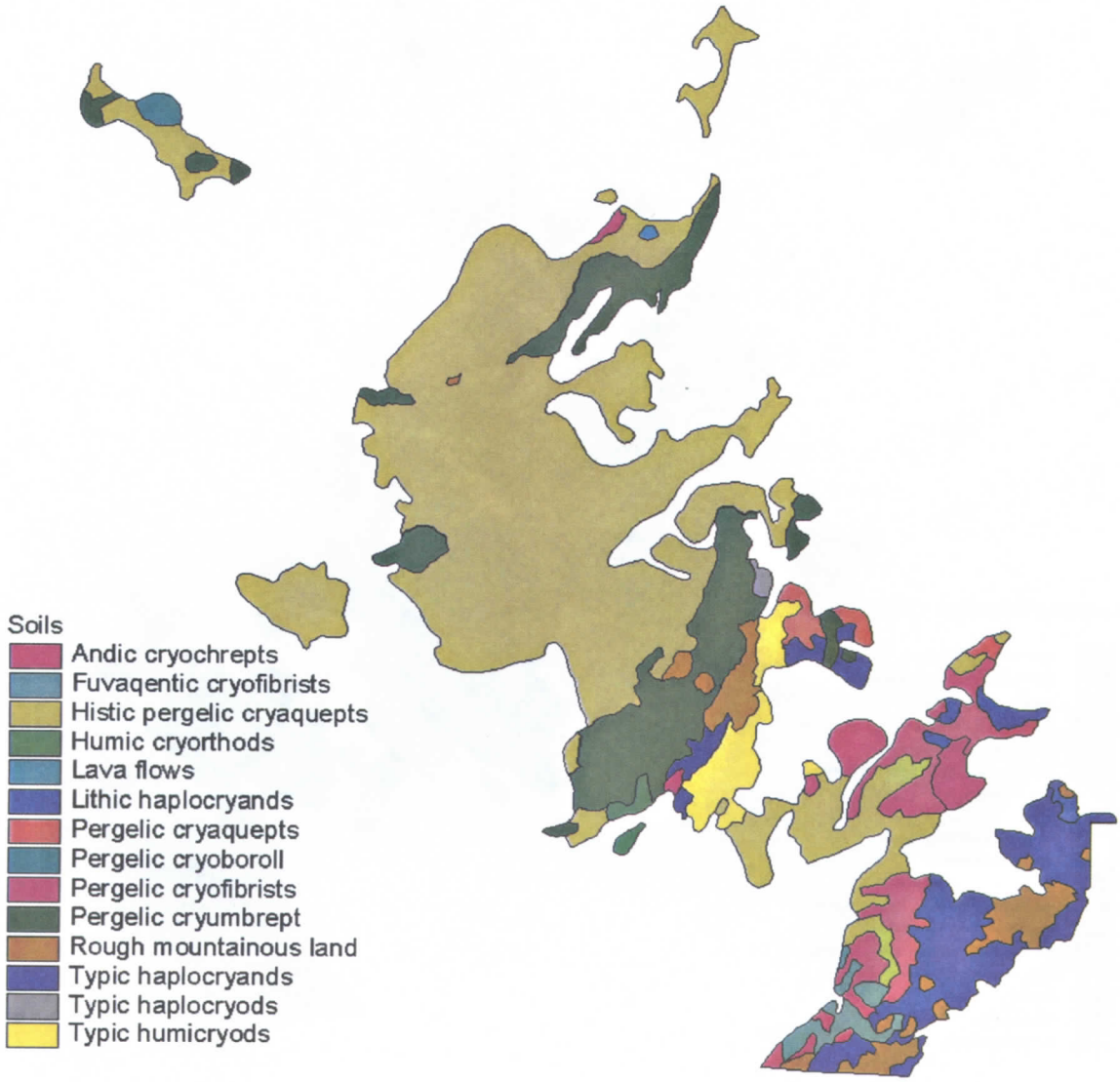
Figure 8



Vegetation map for the Yukon-Kuskokwim area of Southwest Alaska.

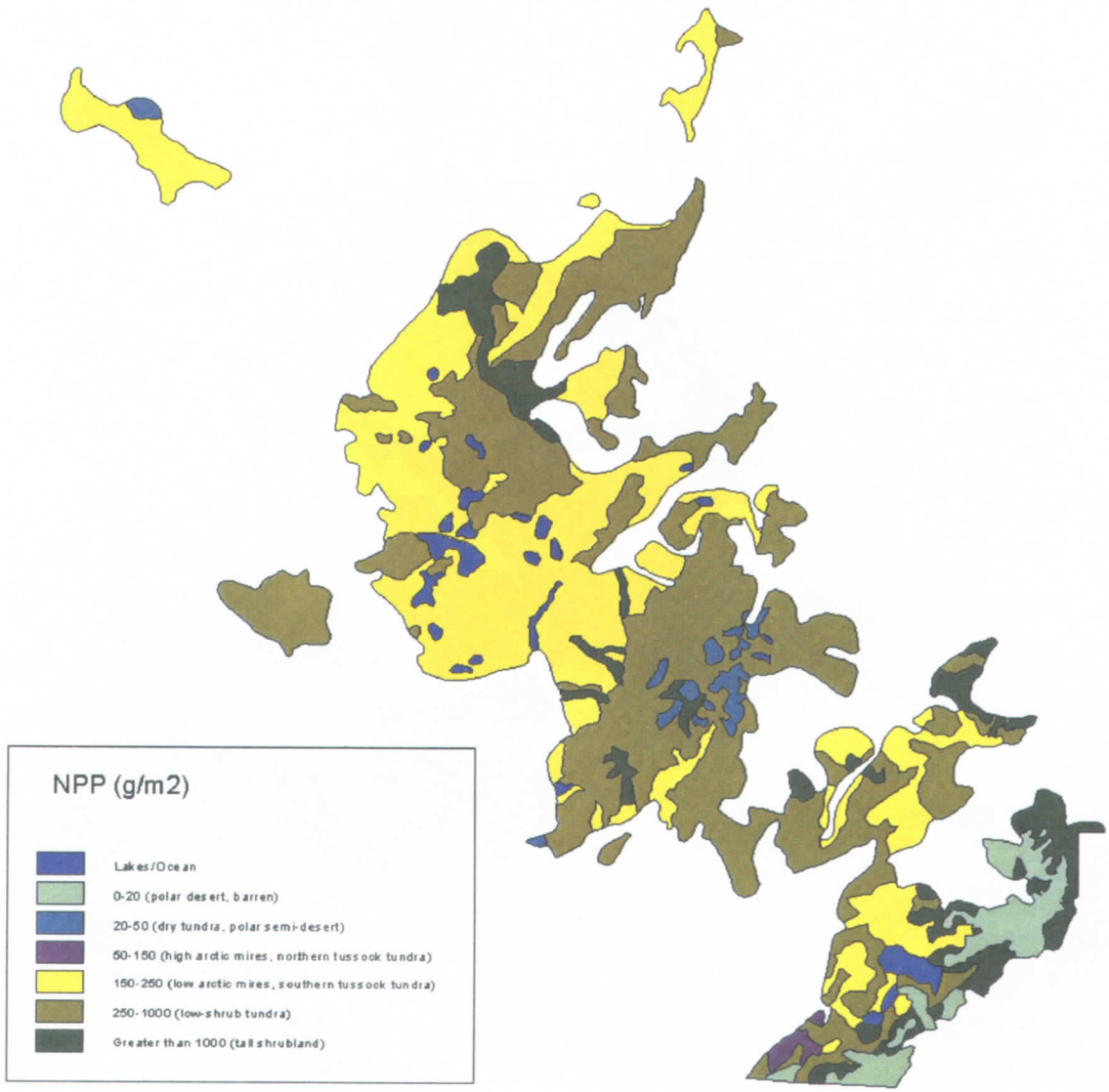
the global Digital Elevation Model (DEM) database. Accompanying these products will be a GIS database containing geo-botanical layers representing vegetation, soils, hydrology, and geology. Each of these layers also will contain a number of attributes. For example, the vegetation layer will include information on primary and secondary species, productivity, and a list of published references for each geographical area (e.g., Alaska). AFO staff is in the final stages of completing its portion of the map for the Yukon-Kuskokwim area of southwest Alaska (figures 8, 9, 10, 11). The final CAVM product is targeted for publication in FY 2001.

Figure 9



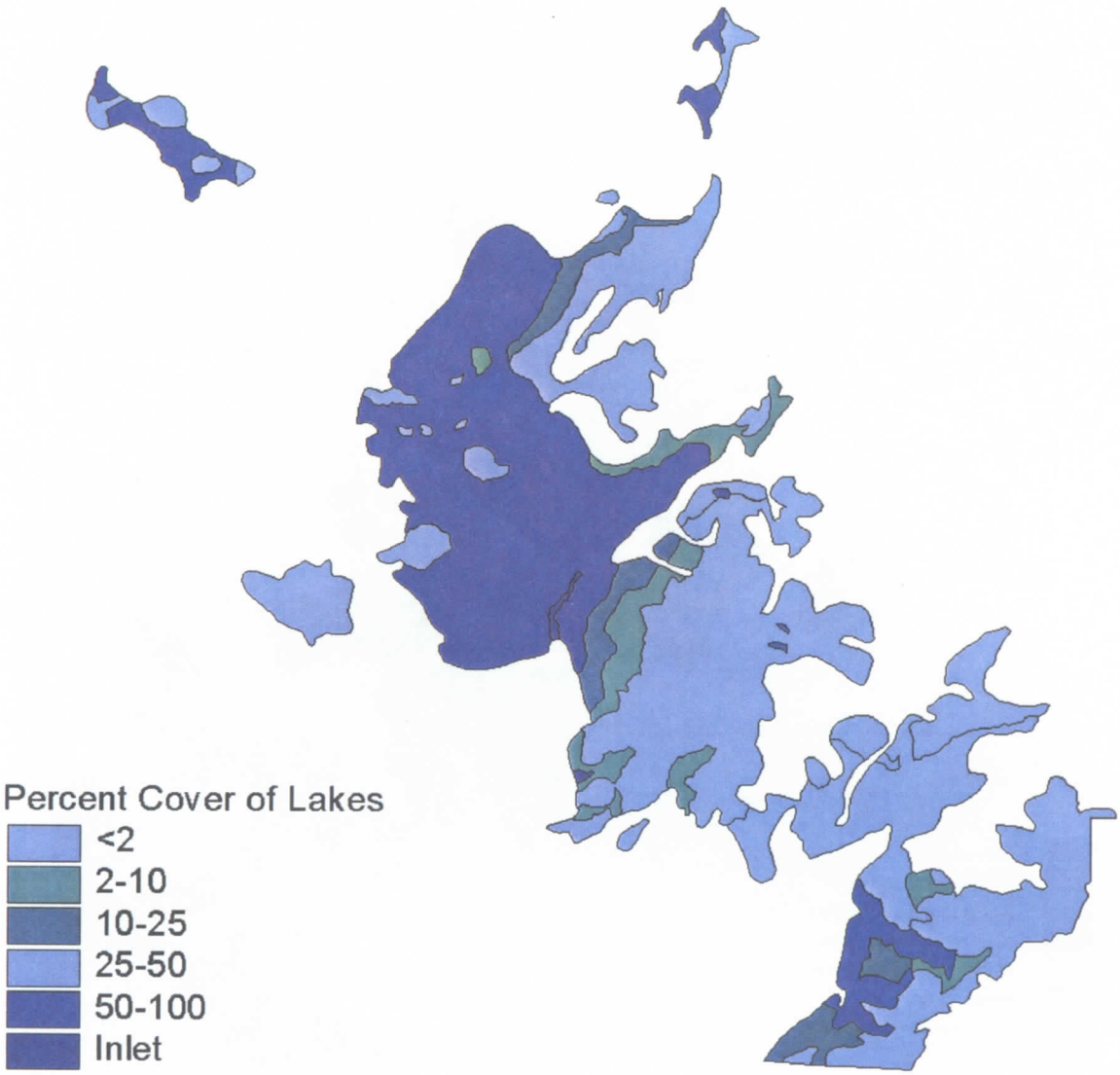
Soils map for the Yukon-Kuskokwim area of Southwest Alaska.

Figure 10



Net Primary Productivity (NPP) map for the Yukon-Kuskokwim area of Southwest Alaska.

Figure 11



Percent cover of lakes for the Yukon-Kuskokwim area of Southwest Alaska.

Alaska Geospatial Data Clearinghouse

Since the early 1980s, Federal and State resource and land management agencies in Alaska have been active users of geographic information systems technology to map, monitor, and manage their lands and fulfill their missions. Tremendous investments are being made in the development of geospatial databases. In 1994, Alaska agencies organized themselves into the Alaska Geographic Data Committee (AGDC) in response to the activities and standards being proposed at the Federal level by the Federal Geographic Data Committee (FGDC). The underlying objective of the FGDC is the creation of the National Spatial Data Infrastructure (NSDI), which encompasses policies, standards, and procedures for all organizations to cooperatively produce and share geospatial data. One of the primary components of the NSDI is establishment of a National Geospatial Data Clearinghouse. The National Clearinghouse is based on Internet Web technology and a distributed network of clearinghouse server nodes in all states and regions of the country. In Alaska, the USGS Alaska Field Office created and now manages the geospatial data Web clearinghouse and NSDI Gateway for the AGDC and its 40 organizations.

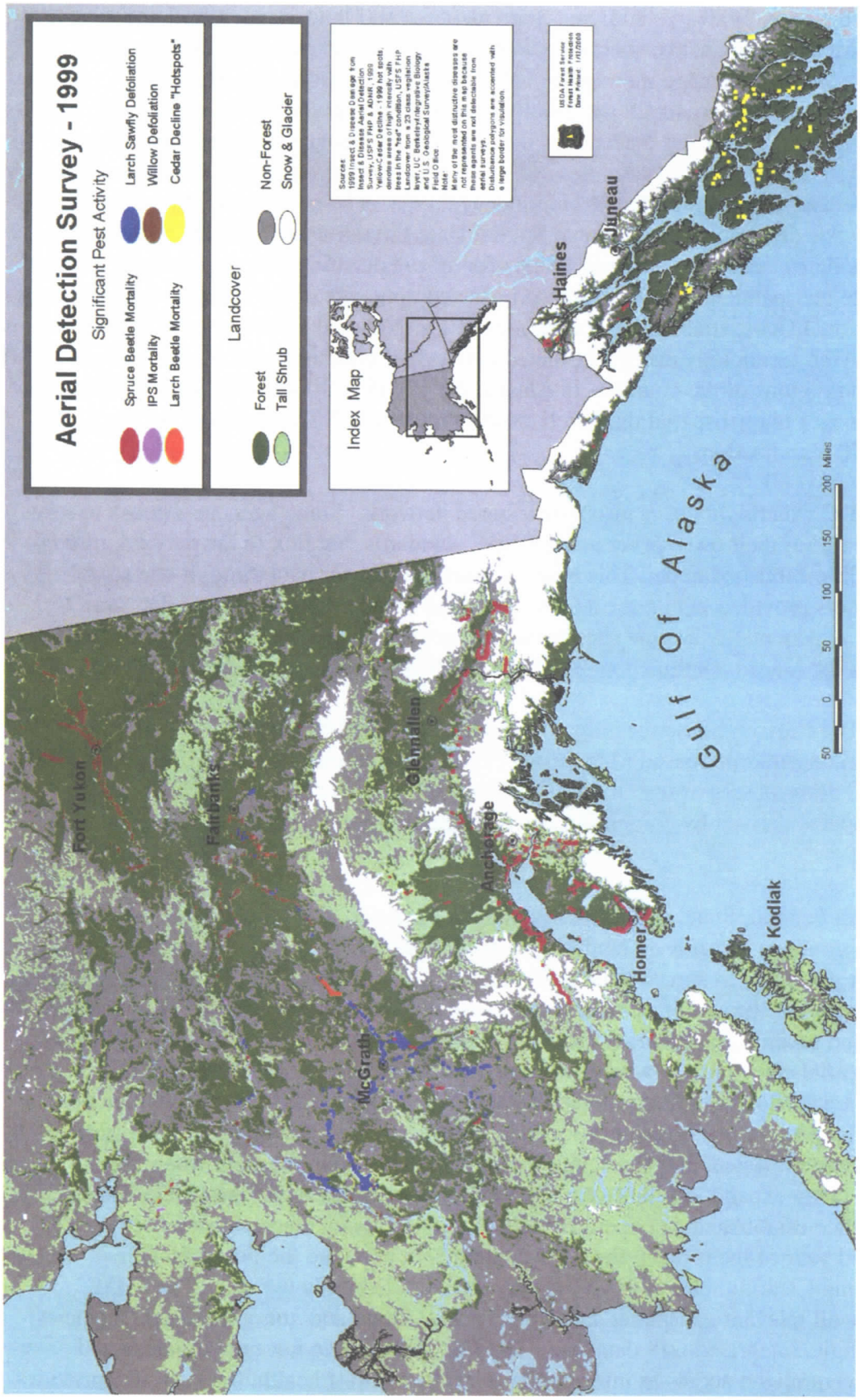
The AGDC Clearinghouse is also a distributed network. Some agencies choose to serve their data from their own server using FGDC standards, but link to the network through the USGS-established node. This enables users to discover data through one set of search tools provided within the AGDC site. The data holdings of the AGDC are growing exponentially as new sites come on-line and are linked, and as USGS Geodata products for Alaska continue to come from the NMP production program.

The AGDC Clearinghouse recently adopted the latest in GIS clearinghouse technology by integrating Internet-based Map Server (IMS) capabilities into the AGDC web site. The IMS allows users to search for and download data, and to construct and display map products derived by combining layers of information found in the Clearinghouse.

Alaska Statewide Forest Health Monitoring

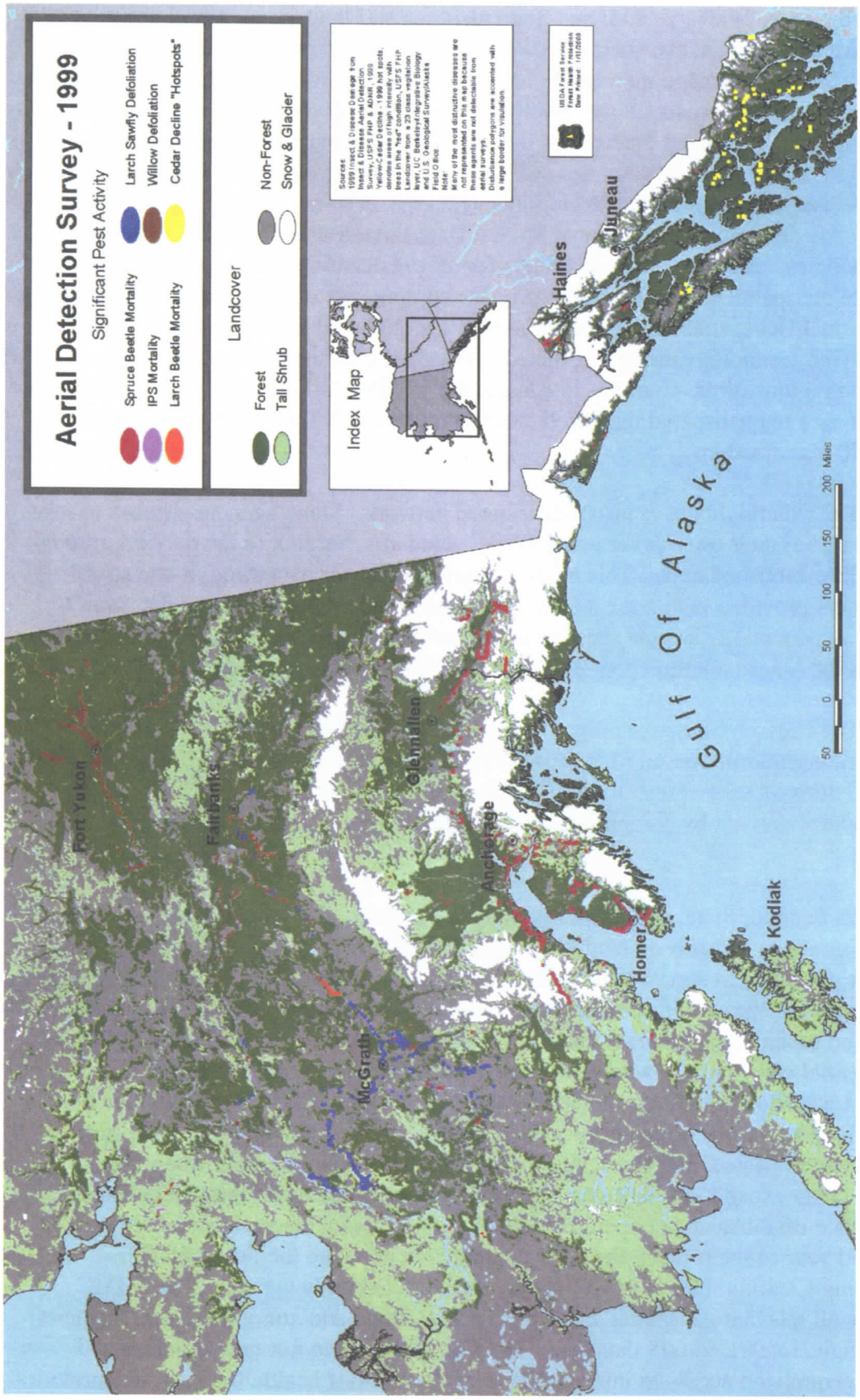
Alaska Federal, State, and local government agencies, as well as Native American corporations and private landowners, have experienced highly significant impacts in recent years due to spruce bark beetle infestations and resultant mortality of several million acres of spruce forest. The exact cause of this epidemic, which is unprecedented in size and severity, is unknown. Many forest scientists are looking at global warming as a potential contributing factor – warmer weather and less summer rainfall has stressed trees while providing more favorable breeding conditions for the spruce bark beetle. To get a more complete assessment of the extent of the epidemic, the value of the resource impacted, and to attempt to predict areas within the state where the epidemic may expand in future years, the U.S. Forest Service and the USGS Alaska Field Office established a cooperative GIS/Remote Sensing research project (figure 12). In the 3rd year of the project, the AFO continues to populate the Forest Health Monitoring Clearinghouse (FHMC) on the AGDC Clearinghouse site. The FHMC compiles all relevant geospatial data from Federal, State and non-government agencies into a single, integrated GIS database. The FHMC serves to not only organize and provide centralized access to information relevant to forest health, but now also provides tools to display and analyze the data to address related land management and planning issues. The FHMC currently holds a number of data sets including:

Figure 12



Location of major forest insect infestations in Alaska for 1999.

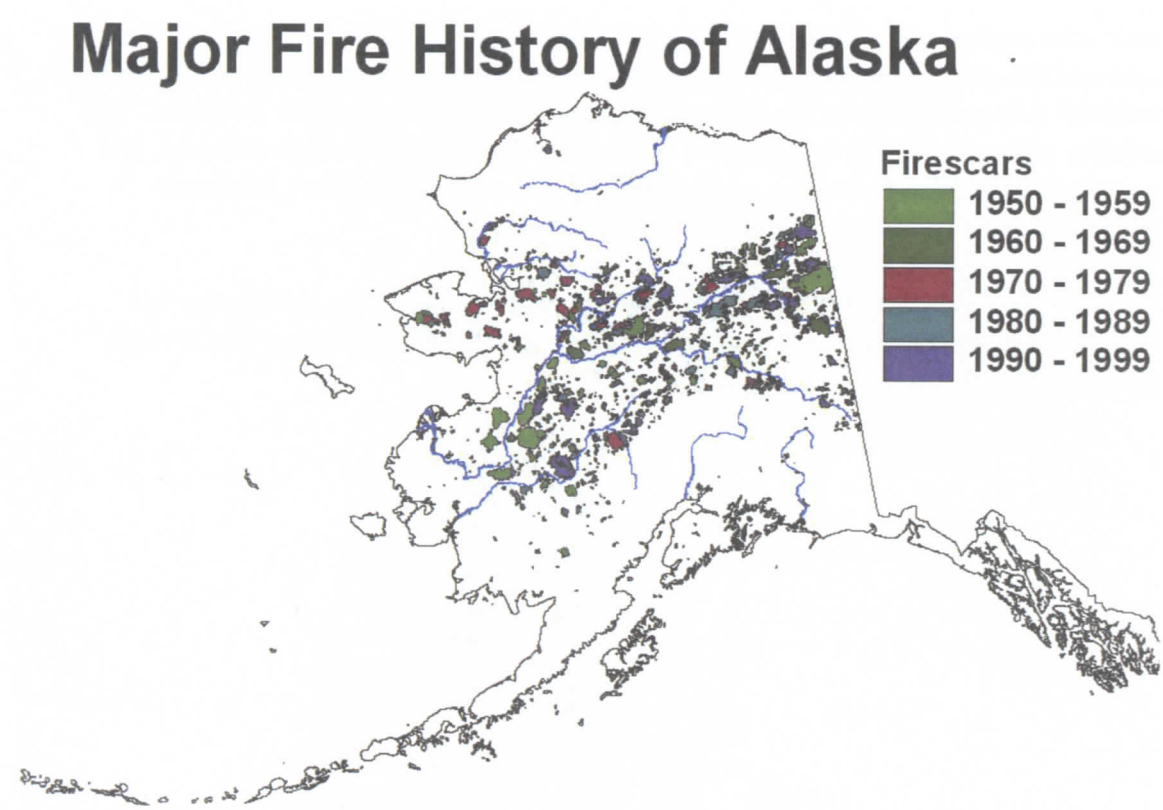
Figure 12



Location of major forest insect infestations in Alaska for 1999.

1. Historical record of insect- and disease-infested areas in the state from the Department of Natural Resources/USFS yearly aerial surveys. Yearly datasets are available from 1989 to 1999 with approximately 25 percent of the state surveyed each year;
2. Datasets indicating areas of the state disturbed by timber harvest;
3. Historical record of the spatial distribution of fire occurrences in the state, summarizing from 1950 to present (figure 13);
4. Anadromous waters of Alaska;
5. A surficial geology of Alaska, compiled by N.V. Karlstrom, et.al 1964 and pub lished by the USGS as a Miscellaneous Geologic Investigations Map I-357 at 1:1,584,000; and
6. The 1980 Geologic Map of Alaska compiled by H.M. Beikman and published by the USGS as a Special Map at 1:2,500,000.

Figure 13



Locations of major fires occurring in Alaska in 10-year periods, spanning 1950-1999.

Cooperative Research on National Parks in Alaska

The USGS Alaska Field Office and the National Park Service, Alaska Office, continue to conduct cooperative research on spatial database development and landscape-level GIS analysis on National parks in Alaska. The most recent work involved completion of a GIS Decision Support System involving bark beetle epidemics in Wrangle St. Elias National Park and Preserve. The GIS database includes a number of different data layers including: land ownership; existing and potential vegetation based on aerial photo interpretation; multi-temporal, satellite-based vegetation phenology; bark beetle infestation maps; models of infestation on forest stands in the

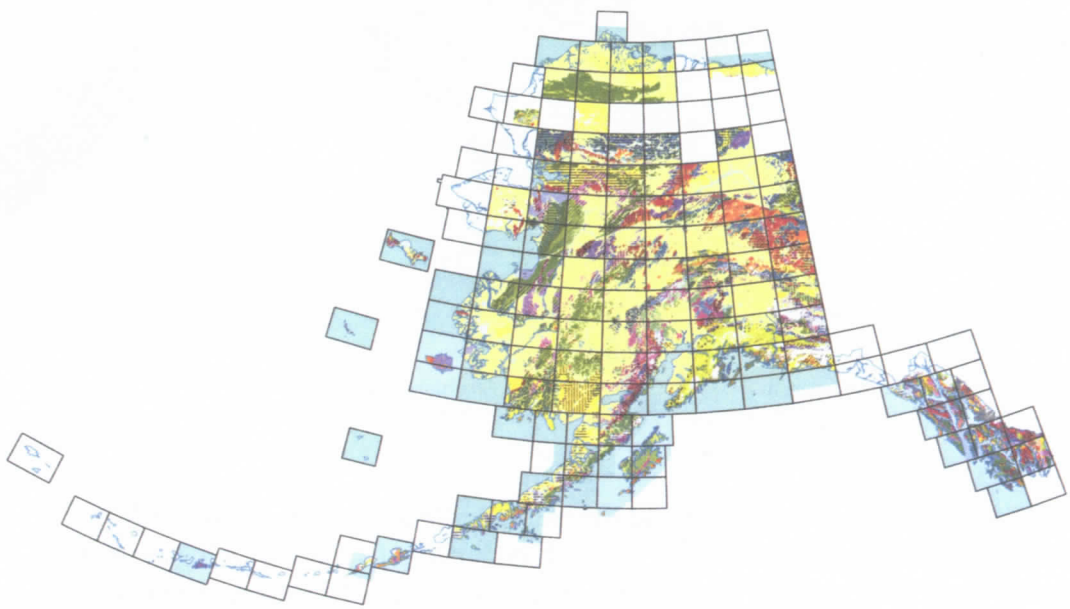
area; and analysis of the effects of beetle infestation on landscape patterns. These data and the final report were distributed on CD-ROM to various Federal and State agencies, private organizations, and the public.

Geology Division GIS Support

The USGS Alaska Field Office staff provided programming and GIS support for the Alaska Mineral Resource Program's Surveys and Analysis Project, the Alaska Resource Data File project, and the Interior Alaskan Surveys and Analysis National Compilation (IASANC). The Alaska Mineral Resource Program's Surveys and Analysis project provides digitally captured 1:250,000-scale and 1:63,360-scale bedrock geology maps of Alaska (figure 14). These data are entered into a GIS in which each data layer is edited and polygons attributed in a single standardized format. The Alaska Resource Data File (ARDF) is a subset of the National Mineral Resource Data System (MRDS) that has been specifically re-formatted and re-designed to better meet the needs of the local user community. This work entailed an automated publishing program that converts the ARDF database files into a Microsoft Word document. Also, the ARDF database was published on the web, enabling web users to search the database. The primary objective for the IASANC is to compile digital geologic, geophysical, and geochemical databases for the selected sub-region, which comprises fifty-four 1:250,000-scale quads, or about one-third of Alaska.

GIS staff also provides digitizing and GIS support for data entry and display of geo-chemical information, such as Talkeetna Mountains Geochemical Data RASS stream sediments of silver, lead, and zinc.

Figure 14



Current status of bedrock geologic mapping in Alaska.

Global Land Cover

Revision of the global land cover database was completed in August 2000. Previously known problems from the first version were resolved, and a new geographic projection was produced. The new version of the Global Land Cover Database and the first validated version are now available on the EDC Landcover Program web page. Land Cover Program staff developed two global-scale maps for the United Nations Food and Agriculture Organization (FAO): a global forest cover map, as a part of the USGS global land cover database, (figure 15), and a global ecological zone map. Efforts are underway to produce a paper version of the global forest cover map for FAO and USGS.

Figure 15

Global forest cover map produced for the Food and Agriculture Organization's Forest Resources Assessment 2000 Program.

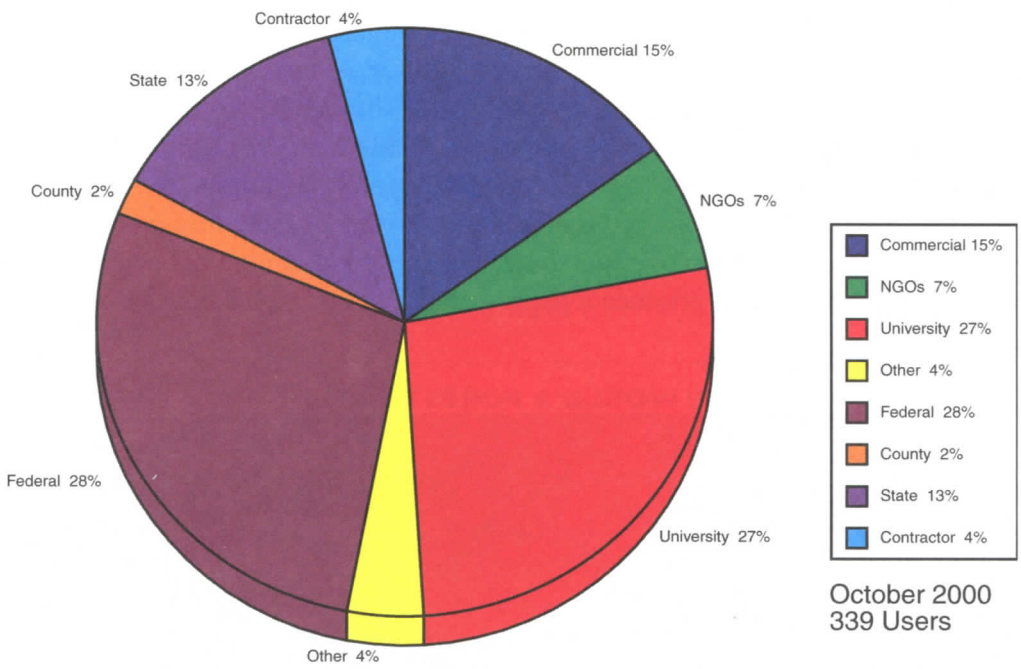
Project staff also collaborated with the MODIS Land Cover Team from Boston University to create a six-biome global classification needed to create the MODIS Leaf Area Index and Fraction of Photosynthetically Active Radiation (LAI/fPAR) product. Global staff published three journal articles in the International Journal of Remote Sensing (Volume 21, Numbers 6 and 7) and Global Change Biology.

Regional Land Cover

The National Land Cover Dataset (NLCD), based on 30-meter Landsat 5 TM data, has been completed and is available for both CD-ROM and Internet distribution (figure 16). Accuracy assessments of the data by Federal regions are in progress, with six of ten regions completed and the remaining four scheduled for completion next fiscal year.

Figure 16

NLCD User Reported Affiliation



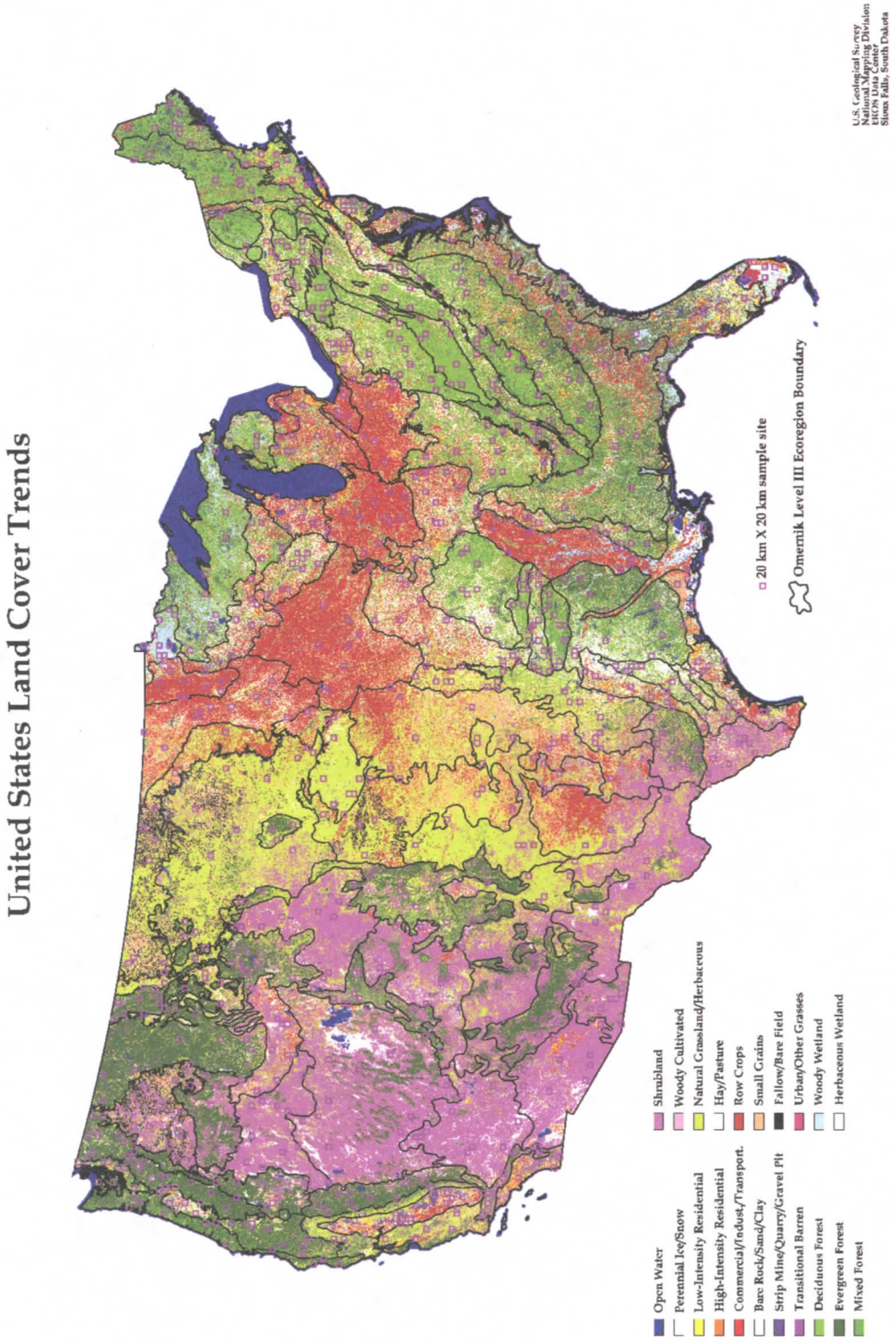
Creation of the next generation of the MRLC has begun. Federal agencies are pooling their resources to acquire three seasonal dates (early, peak and late growing seasons) of Landsat 7 ETM+ data for each path/row within all 50 states. A second generation NLCD is being developed from these data and will feature a flexible database structure, targeted to increase the utility of all elements of the database for users.

Land Cover Trends: Rates, Causes, and Consequences

The Land Cover Trends project is a 4-year collaborative research project between the U.S. Geological Survey, the U.S. Environmental Protection Agency, and NASA to document the rates, driving forces, and consequences of land use and land cover change over the past 30 years for the conterminous United States. The project is based on the hypothesis that land cover changes unevenly over time and space. To understand and manage the consequences of such change, it is necessary to have reliable information on the forces that cause change, and the actual rates of change from time to time and place to place.

During the first year of the project, EDC staff finalized a methodology that uses a probability sample of over 800 20-km by 20-km sites (figure 17), and Landsat imagery covering five dates from 1972 to 2000, to determine the rates of change for 84 regions of the conterminous United States. Using this approach, the analysis of 12 regions was initiated. Preliminary figures show that land cover in some parts of North Central Appalachia in Pennsylvania and New York, has not changed for 20 years (1972-1992). In other areas, such as the Northern Piedmont stretching from New Jersey through Virginia, EDC staff have seen significant conversion of agricultural land to urban uses.

Figure 17



The next step will be to determine the changes that have occurred since 1992, and initiate the analysis of additional regions of the country. In addition, with funding from the NASA Land Use and Land Cover Change Program, EDC staff will assess the role of land cover change on local and regional carbon dynamics.

Figure 17

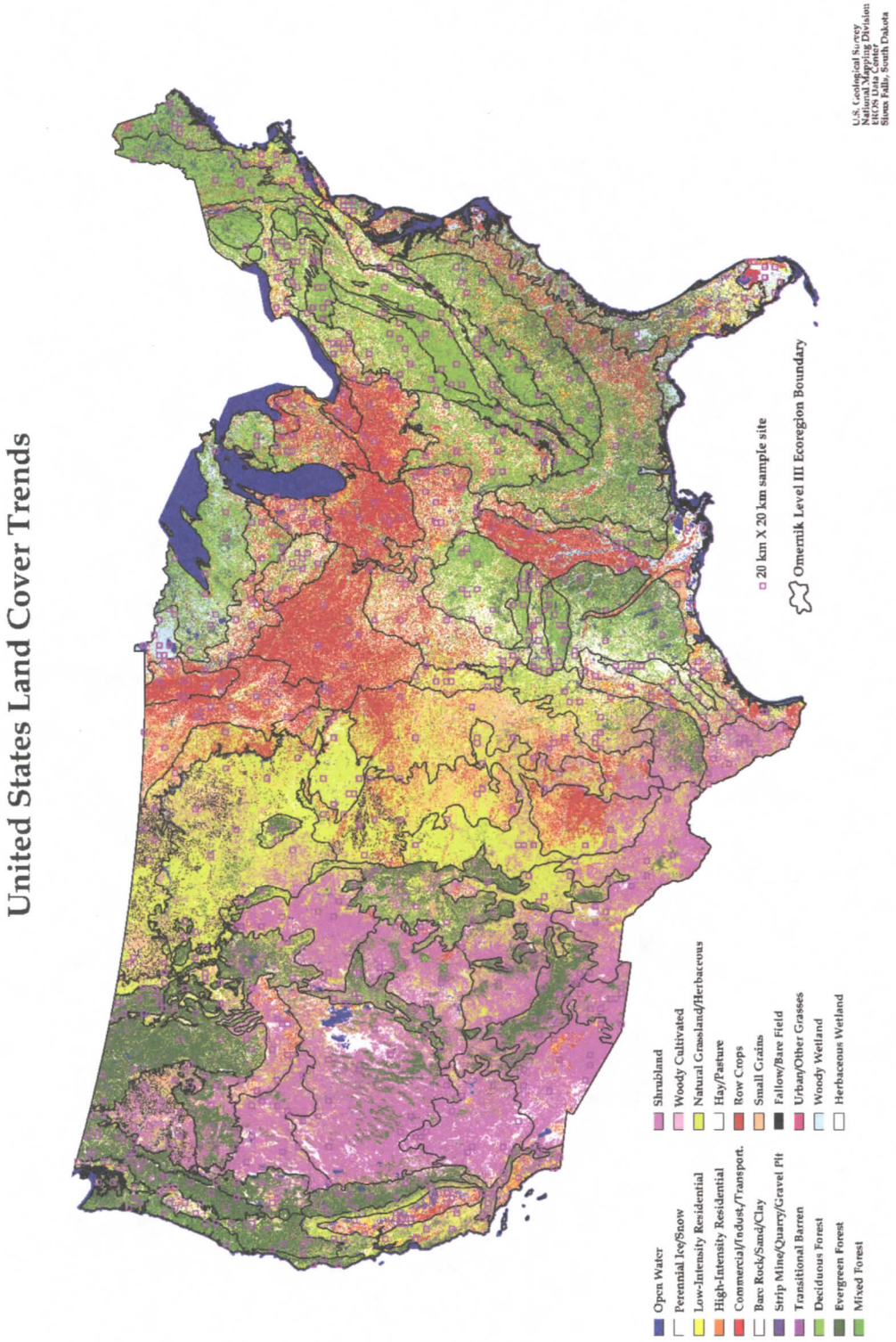


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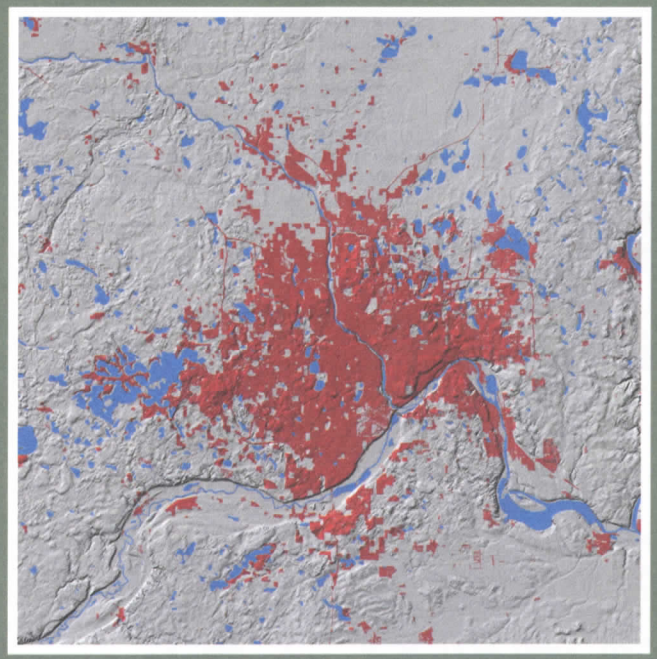
Figure 18

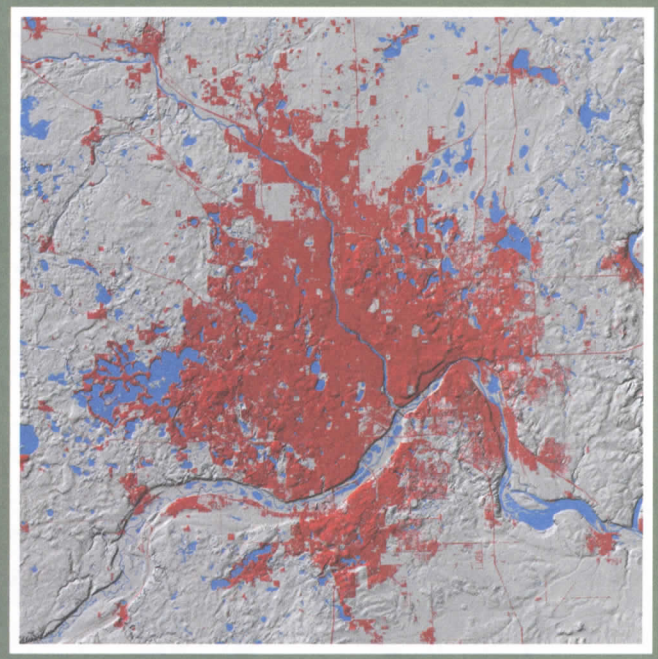
Urban Dynamics Research Program

Minneapolis-St. Paul, Minnesota



1973

Minneapolis is Minnesota's largest city, and together with St. Paul, forms the Twin Cities metropolitan area. The Twin Cities lie at the heart of one of our Nation's most productive wheat and corn growing regions, contributing to Minneapolis and St. Paul becoming markets for the agriculture and timber commodities of the local region in the first half of the nineteenth century. With their continued growth the Twin Cities evolved into a regional railroad hub and the largest metropolitan region of the Upper Midwest. Their urban influence extends over much of Minnesota, western Wisconsin, northern Iowa, eastern South Dakota, North Dakota, and into northern Montana.

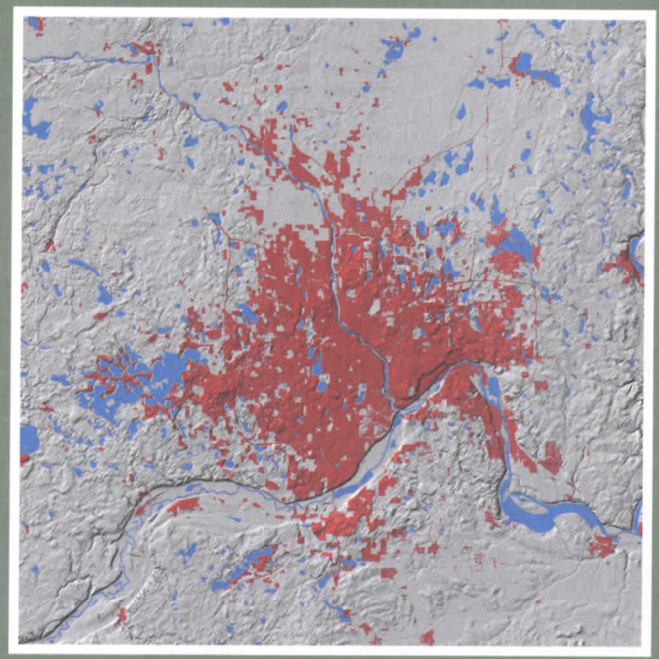


1992

The metropolitan area flourished after World War II and Minnesota entrepreneurship created many corporations that would rise into national significance over time and draw a steady stream of potential workers to the area. The diversified economy and the perceived greater opportunity has continued to be a major draw for new residents, causing both Minneapolis and St. Paul to have experienced tremendous urban expansion in the past few decades.

Urban Dynamics Research Program

Minneapolis-St. Paul, Minnesota



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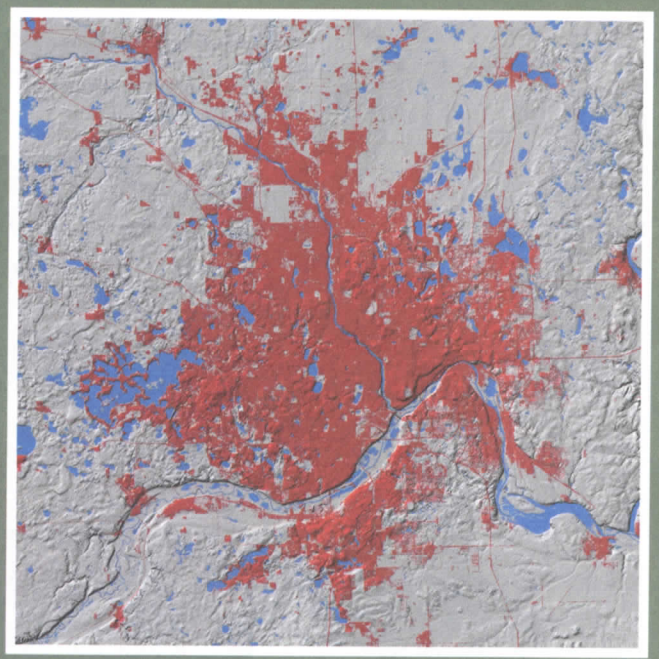

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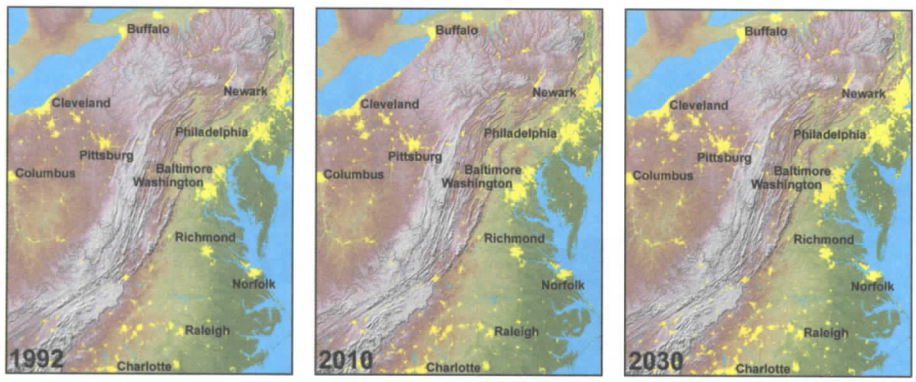
Figure 19

Mid-Atlantic Preliminary Model Prediction



Mid-Atlantic Preliminary Urban Land Use Change Model Prediction, 1992 to 2030.

Urban Dynamics

EDC staff produced forecasts of urban land use change for the mid-Atlantic using the SLEUTH urban growth and land use change model. Projections for 2010 and 2030 were created under a scenario that assumes current growth trends will continue. Change pairs for 50 metropolitan areas were computed showing urban land use change for the 1970s and 1990s (figure 18 and 19). A change pairs booklet, to be published in 2001, will include population data and area statistics.

EDC staff contributed to the planning and coordination of a Congressional Seminar featuring Urban Dynamics activities. The briefing for members of Congress was titled, "Meeting the Challenges of Urban Growth: A National Issue."

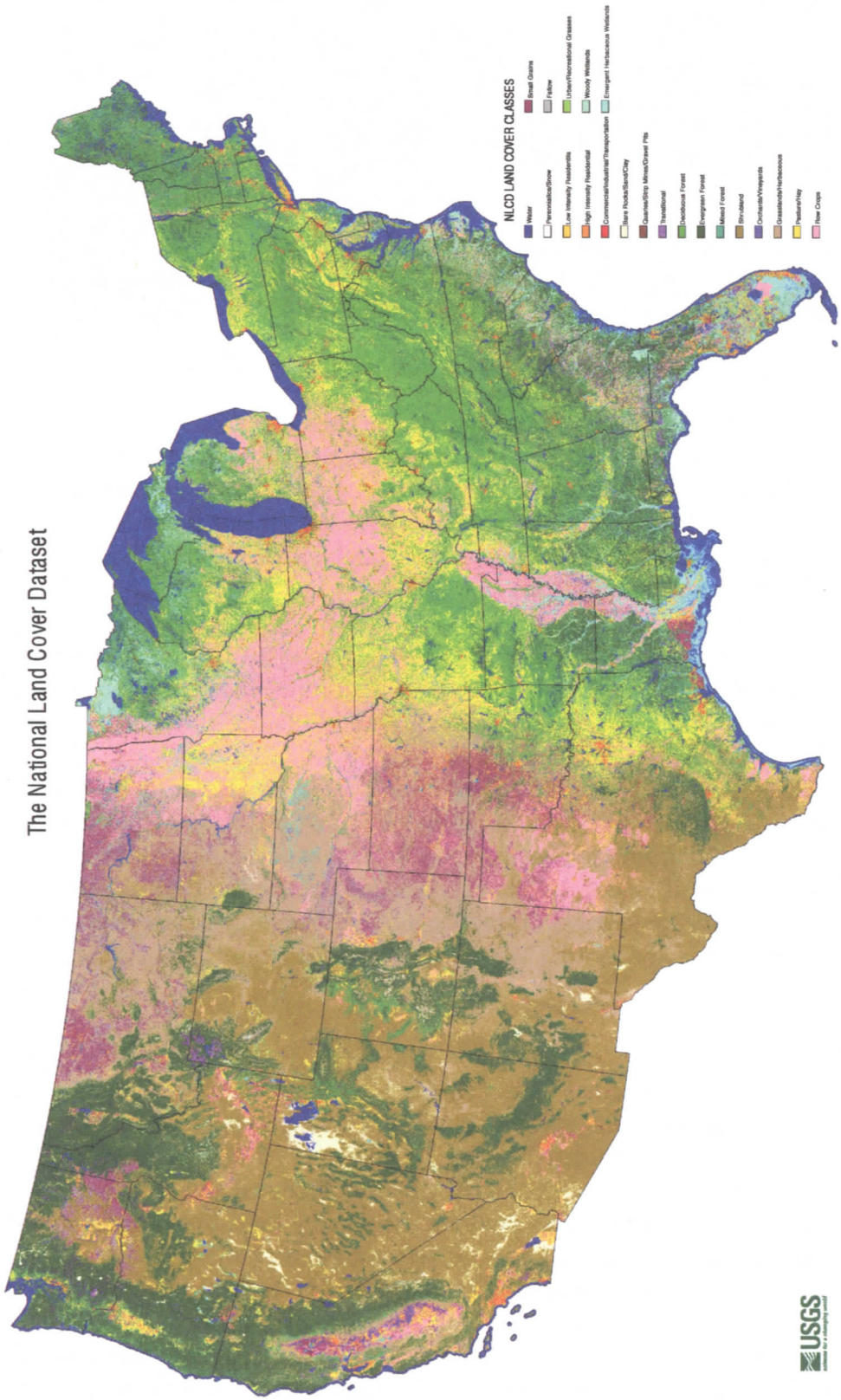
A Smart Places Decision Support demonstration was developed for the Fresno County, California Local Agency Formation Commission (LAFCO). A comprehensive GIS database demonstrating Fresno County decision support activities was developed for use in formulating "what-if" scenarios. Twenty-six GIS data layers were incorporated and include general plans for cities in Fresno County, historical urban land use, annexation history, parcel maps, Landsat 7 ETM+, elevation, transportation, and political boundaries.

Land Cover Applications Center

The Land Cover Applications Center (LCAC), a component of the Land Cover Characterization Program, has been providing scientific and technical support to users of land cover data for nearly 2 years. Since January 2000, the LCAC has provided support to over 350 different users of EDC's Global, National and Landuse/Landcover (LULC) datasets. Support includes pointing users to the available datasets, importing the data into various software packages, reformatting or re-projecting data, and answering questions about data suitability or limitations for particular applications.

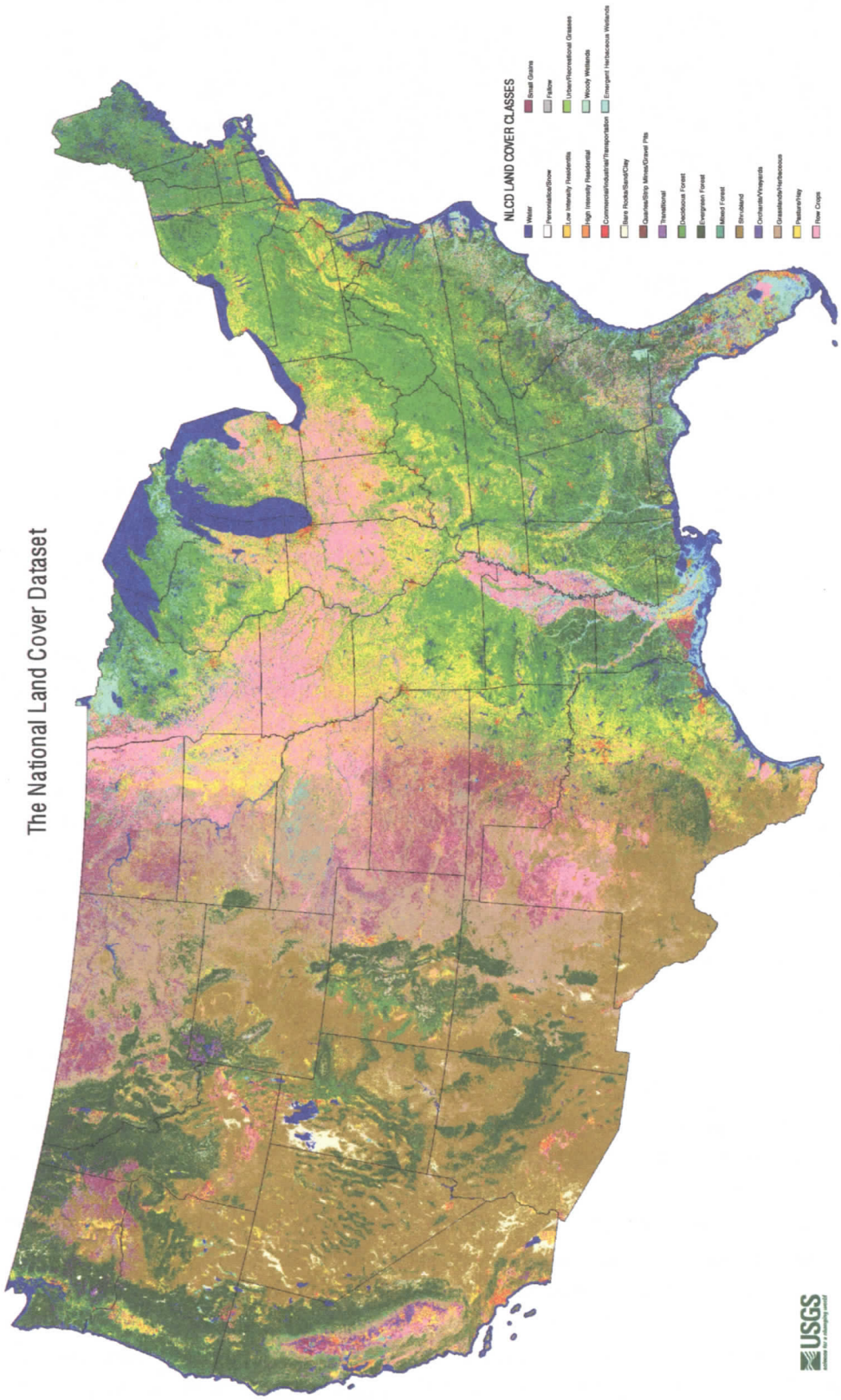
The LCAC also maintains user databases for the global and national land cover datasets. The global user database contains almost 900 entries from all over the world and the national database contains almost 400 users (figure 20). Global data users have reported many applications including: natural resource management efforts, global change, atmospheric and climate studies, and classroom education. Users of the National Land

Figure 20



The National Land Cover Dataset

Figure 20



The National Land Cover Dataset

Cover Dataset include Federal agencies (EPA, USGS/Water Resources Program, Forest Service, Federal Emergency Management Agency, etc.), state mapping agencies, universities, scientific non-governmental organizations and private contractors. Applications include land cover change studies, watershed and water-quality studies, urban sprawl, wildlife habitat, insect disease vectors, hurricane and earthquake risk analysis, and the effects of land cover on wireless telecommunication.

INTERNATIONAL ACTIVITIES

Sahel Land Use/Land Cover

The EDC continues close collaborations with two West African regional environmental monitoring and development agencies, the Regional AGRHYMET Center and the Sahel Institute (INSAH). EDC's primary objective in these collaborations has been to build capacities of these agencies to develop and apply a long-term environmental monitoring framework using satellite remote sensing and modern geographic analysis tools. West Africa is experiencing rapid change on many fronts – climate, natural resources, agriculture, demographics, politics, and socio-economics. As West Africa enters the 21st century, environmental changes are predicted to accelerate, with unknown and potentially serious implications for both its people and the environment. The West Africa region is witnessing a rapid population growth, a growing disparity between food production and food requirements, climatic instability, and increasing environmental degradation.

In the past year, EDC scientists and their African counterparts completed maps of land use/land cover trends at representative study areas in Burkina, the Gambia, Mali, and Niger. The maps are the centerpiece of an investigation of changing land-use patterns from the 1960s to the year 2000. All four areas have experienced dramatic changes as agriculture has expanded into a variety of natural landscapes. Workshops were held in Niger and in Mali to complete the maps using a combination of historical Corona satellite photography, Landsat MSS, TM, and ETM+ imagery, and results from recent aerial and field surveys. Subsequent workshops examined the socioeconomic and policy aspects of these areas, identifying major driving factors of change. Current plans are to build on this experience by carrying out a regional environmental monitoring effort that will quantify land use/land cover trends for nine West African countries over the past 60 years, and make projections for the next 50 years in support of regional and national environmental policy.

Land Cover Performance - Remote Sensing of Human Impacts

Since the drought-induced famine in the West African Sahel in the early 1970s, there has been much interest on the part of African governments and the international community to improve agricultural production systems while sustaining natural resources. Subsequent droughts and human pressures have degraded the Sahel soil and vegetation resources; however, many local areas have escaped the general degradation because they were protected or received sound natural resource management. The Landcover Performance Project evaluates land cover performance across large spatial areas using remotely sensed time-series data and identifies anomalies in both high and low vegetation production that relate to farming conditions, rangeland management,

weather patterns, and climate change. The approach uses vegetation index (greenness) image data from an 18-year time series of 8-km resolution, 10-day NDVI data. The science team investigated a variety of statistical techniques to identify land cover performance anomalies and their trends over time, with a focus on Senegal, where considerable supporting data were available. Several tests successfully highlighted areas of severe land degradation, but the 8-km resolution limited the use of the data for searching for local-scale degradation anomalies. A second phase of analysis was initiated using 1-km resolution NDVI time series data acquired by the AGRHYMET Regional Center in Niger. The expectation is that these data will yield more practical results that can be applied to land performance monitoring over much of sub-Saharan Africa.

In a parallel effort, land-cover performance and land-cover change were assessed using pairs or triplets of Landsat images at several test sites across West Africa. The images were co-registered, then spectrally compared, producing a number of derived products that characterize changes in greenness, brightness, and other variables. Anomalies representing land productivity improvements or degradation were detected. However, the results based on spectral analysis were not always straightforward, requiring careful interpretation and validation with supporting evidence from the field.

Land Cover Performance - Sequestration of Carbon in Soil Organic Matter

This project continued to identify opportunities for developing countries, especially countries in Africa, to participate in activities that support sustainable agricultural development and contribute to climate mitigation. The project activities developed from the recommendations of the international workshop at the EROS Data Center titled "Carbon Sequestration in Soils and Carbon Credits: Review and Development of Options for Semi-Arid and Sub-Humid Africa." The proceedings were followed by informational pamphlets in both English and French for distribution throughout Africa. The project was instrumental in providing input to international workshops supported by USAID, WMO, IFAD, UNEP, and others held in Washington, Sicily, and Geneva. These workshops helped agencies and negotiators define the role of carbon sequestration in soil in the implementation of the Kyoto Protocol for Climate Change, especially through the Clean Development Mechanism. Assessments of opportunities and needs in Africa resulted in the initiation of a feasibility Pilot Project in Senegal. Three geographic areas have been identified to assess the biophysical potential for management strategies to sequester carbon and its economic value and to identify the necessary policy and socioeconomic enabling conditions. A workshop titled, "Sequestration du Carbone dans les Sols," in Dakar, Senegal, October 22-26, attended by more than 100 scientists, including international experts, African soil scientists, international research centers, the UNEP, and donor organizations, evaluated opportunities in semi-arid and sub-humid Africa and developed plans for implementing the feasibility project. This project is now being implemented with the Centre de Suivi Ecologique and other agencies in Senegal.

A new project was initiated when the USAID/USDA CRSP (Competitive Research Support Program) project in Central Asia asked the program to use remotely sensed data sources to extrapolate point-specific carbon flux data across larger spatial areas. Highly

predictive algorithms between reflectance data sources and carbon flux towers have been developed and will now be refined and implemented as this project and the World Bank undertake rehabilitation of degraded land in Central Asia. The project will focus on flux measurements in Turkemistan, Uzbekistan, and a large Pilot Project in Kazakhstan. The project will rehabilitate degraded land resulting from unsustainable wheat agriculture and monitor carbon sequestration as soil organic matter levels and grassland ecosystems are restored.

Land Cover Performance - Organizing Data and Regional GIS Data Access

Extensive research and development activity by EDC staff in Africa, coupled with data distribution and clearinghouse activities resulted in a request to facilitate the USAID-funded Environmental Monitoring Information System (EMIS) for Africa. The project will serve an important coordinating and planning role in Africa for both data suppliers and data users. It emphasizes the standardization of digital geospatial data collection, data clearinghouses, mapping, dissemination, and the role of the EDC in applying these to Africa and developing country contexts. Participants in this project will review the available data and help define a consistent and useful approach to spatial data collection, description, access, and distribution with an identification of appropriate scales, missing data sets or geographic areas, and interactive mapping capabilities. Additional data or map serving should augment the already operational Africa Data Dissemination Server (ADDS) as a portal for Africa data.

Specific objectives of this long-term project will:

- Coordinate efforts among African (e.g. the EIS-Africa Program Office in South Africa), the SADC Remote Sensing Unit (Zimbabwe), the FGDC working group (Washington), international data centers, and other relevant agencies;
- Provide "core" or "baseline" datasets determined by the "community" for all countries in Africa;
- Provide access to datasets that go beyond the "core" or "baseline" datasets;
- Provide mechanisms whereby projects can be accessed through a project tracking database with a search mechanism and where appropriate, a specific World Wide Web (WWW) link; and
- Support agencies in their efforts to register their spatial datasets into Internet clearinghouses. An African stratified clearinghouse search mechanism FGDC (and eventually ISO compliant) will be implemented on ADDS.

Famine Early Warning System (FEWS)

The fourth phase of the USAID-funded Famine Early Warning System Network (FEWS NET) project began in July 2000. The agreement with USAID was amended to modify the role of USGS in FEWS NET. USGS is now responsible for dissemination of all image products (NDVI, RFE, and derivative products such as SOS, WRSI, basin excess rainfall, and stream flow estimates) to regional and country FEWS NET representatives, as well as FEWS NET partners in Africa and elsewhere. USGS will also support FEWS NET with African scientists in the field. EDC has placed a scientist at the AGRHYMET Regional Center in Niamey, Niger (in July 2000), to support food security issues in the Sahel and West Africa region. Scientists will soon be placed in southern Africa (at the SADC/RRSU in Harare, Zimbabwe, November 2000) and East Africa (in Nairobi, Kenya, date TBD) as well.

EDC processed NDVI and rainfall estimate (RFE) images every 10 days for dissemination to food security analysts in sub-Saharan Africa. Products derived from RFE were processed on a regular 10-day basis as well, including moisture index and basin excess rainfall maps for the continent, and start-of-season and water requirements satisfaction index maps for seasonally-appropriate regions of Africa. A hydrologic model for flood risk monitoring was developed, tested, and applied to the Mozambique floods of early 2000. An ArcView GIS interface for the flood model was also developed. FEWS staff gave presentations at climate outlook forums in East and Southern Africa. Special feature pages were prepared for the International Program website on the following topics: application of the flood risk monitoring model to the floods in Mozambique; integrating satellite rainfall estimates with digital river basin maps; satellite rainfall estimation in eastern and southern Africa (workshop report); and failure of the long rains in Kenya. The website may be accessed at: http://edcsnw 3.cr.usgs.gov/ip/ip.html. Web-enabled versions of the FEWS data managers Spaceman (for analyzing NDVI and RFE) and Priceman (for tracking food prices) were released to the public.

Madagascar Conservation

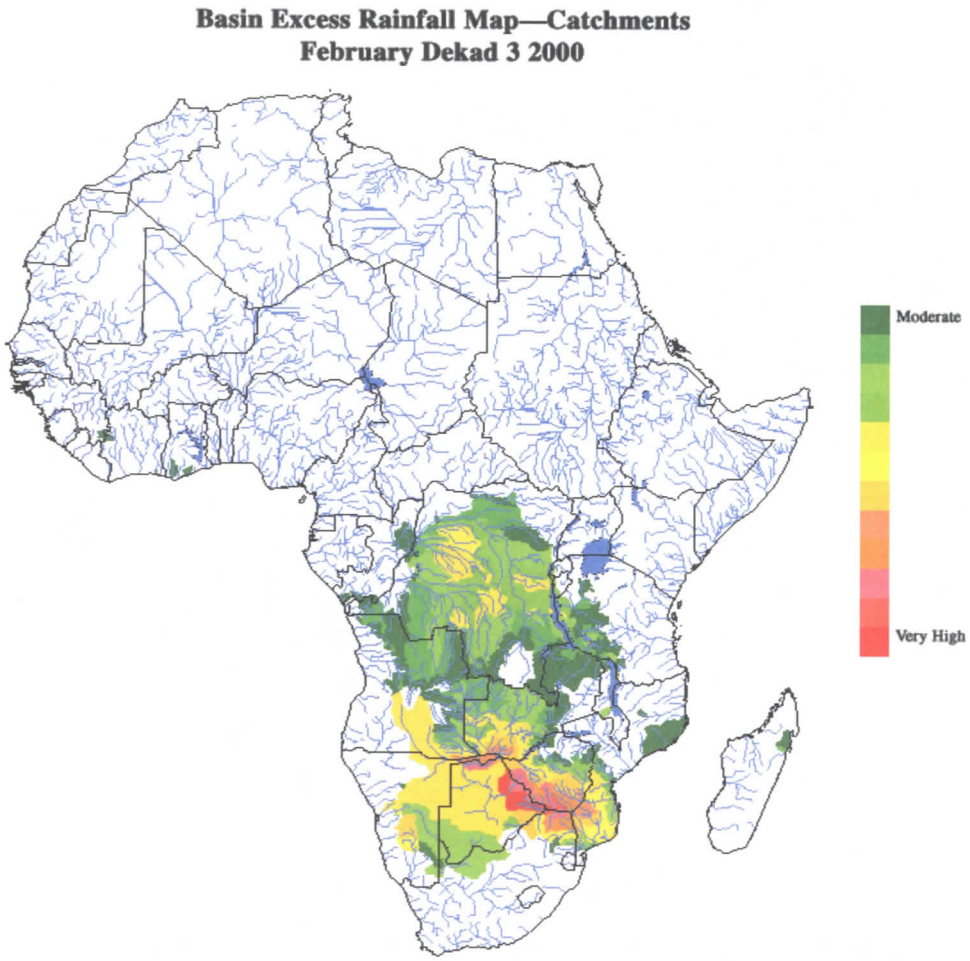
EDC processed fire and cloud data for the 1998 and 1999 burn seasons (August – December) from Defense Meteorological Satellite Program images provided by the National Oceanic and Atmospheric Administration/National Geophysical Data Center. The data were made available to the U.S. Agency for International Development (USAID) and National Environmental Action Plan (NEAP) partners in Madagascar in quasi-real time via file transfer protocol (FTP) in both image and vector format, and in geographic coordinates and Laborde projection. All fire and cloud data for 1992-1997 were also provided on CD-ROM at the end of the season. Support to the National Office of the Environment and other NEAP partners continued for the development of metadata and the implementation of a geospatial data clearinghouse. Landsat 7 imagery from 1999–2000 was acquired for approximately half of the island of Madagascar, to support updating the national forest inventory map.

Integrating Satellite Rainfall Estimates with Digital River Basin Maps

Excess precipitation and flooding can adversely affect food security through reduced crop production and disrupted transportation and market systems. Efforts have focused on new methods of analyzing the spatial and temporal patterns of precipitation to identify these situations. NOAA's Climate Prediction Center produces gridded RFE for FEWS through processing Meteosat imagery, rain gauge data, and model estimates of wind and relative humidity. EROS Data Center staff has developed methods for spatial integration of the RFE over topologically-linked river basins derived from a 1-km digital elevation model. These accumulations were compared with long-term average values to derive a flood risk score. Cartographic products with color-coded basins and drainage networks were made to highlight areas with high scores. Comparison of these products with reports from disaster relief agencies and the press showed that situations of prolonged heavy rainfall associated with flooding and the disruption of human activities are revealed. The disastrous floods in Mozambique during February and March of 2000 were illustrated, including the importance of heavy rains that fell in upstream areas outside the country. A companion product was a map of

estimated runoff travel times, based on digital elevation data and an approximation of the Manning equation for flow in an open channel (figures 21 and 22).

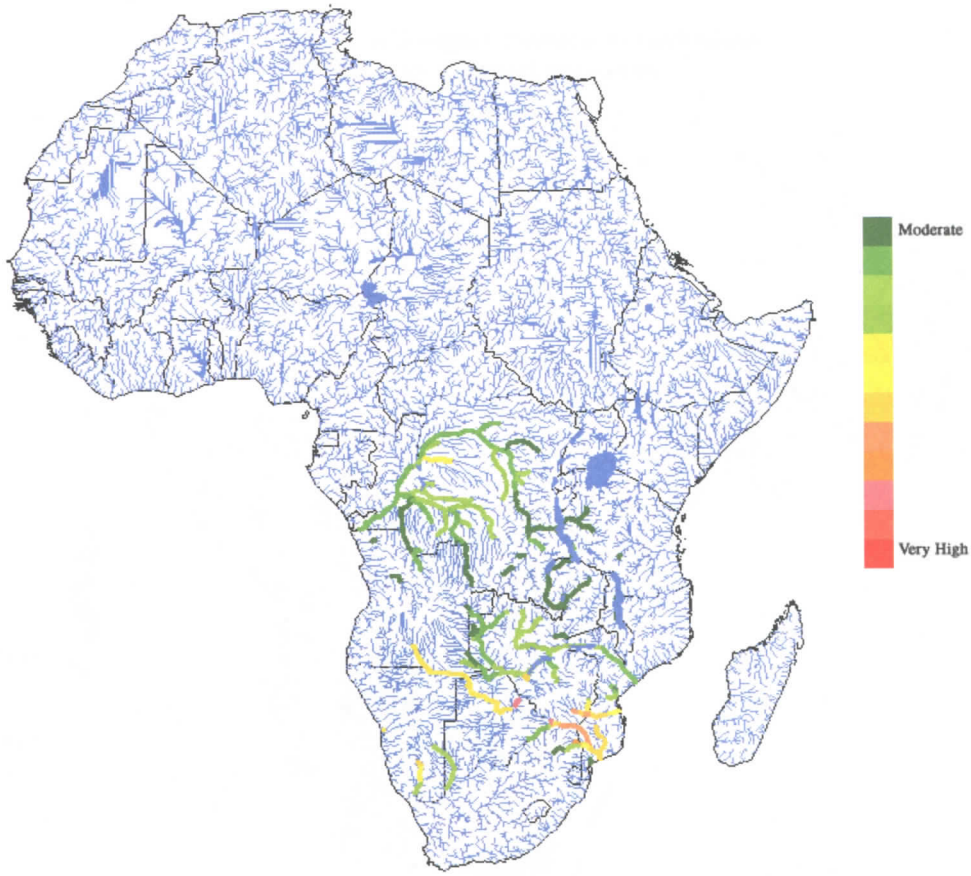
Figure 21



Basin Excess Rainfall Maps: this catchment map highlights sub-basins (out of approximately 3,000 across the continent) receiving above-average precipitation for 10-day period by color coding the relevant polygons. The scale is a scoring system that uses both total rainfall and total cumulative rainfall over a sub-basin for the 10-day period, divided by the same variable for long term average conditions. The greater the ratios, the higher the score.

Figure 22

Basin Excess Rainfall Map—Rivers
February Dekad 3 2000



This river map highlights reaches of river receiving above-average amounts of 10-day precipitation according to a similar scoring system. The difference is that a reach of river may receive rainfall from a much larger upstream area than that of the sub-basin polygon in which it lies. Thus, a sub-basin may not be highlighted because only light rain is occurring locally, while the reach of river passing through it is highlighted, due to heavy rains in upstream catchments.

Mitch Clearinghouse

The International Program continues to expand the role initiated by the Inter-American Geospatial Data Network (IGDN) in cooperation with PAIGH (Pan American Institute for Geography and History) to facilitate access to data in Latin America. This is continuing as support in Central America to the Mitch Reconstruction program, which emphasizes capacity-building activities for data development, access, standardization, and distribution in support of national needs, especially as these relate to reconstruction and hazard mitigation. Project activities in the countries of Honduras, Nicaragua, El Salvador, and Guatemala have been facilitated by an EDC regional coordinator working with local in-country coordinators. Clearinghouse nodes have been implemented for all countries and include Instituto Geografico Nacional (IGN), Ministerio de Medio Ambiente y Recursos Naturales (MARN), and Ministerio de Agricultura y Ganaderia (MAG) in El Salvador; Secretaria de Planificacion y Programación (SEGEPLAN), Univ. del Valle Center Computer Science, and Statistics,

IGN, Instituto Nacional de Sismología, Vulcanología, Metereología e Hidrología (INSIVUMEH), Comision Nacional del Medio Ambiete (CONAMA), and Comision Nacional para la Reduccion de Desastres (CONRED) in Guatemala; Instituto Nicaraguense de Estudios Territoriales (INETER), Ministerio Agropecuario y Forestal (MAG-FOR), Foundation Alistar, and Ministerio de Recursos Naturales (MARENA) in Nicaragua; and Universidad Tecnologica Central Americana (UNITEC), IGN, Secretaria de Recursos Naturales y Ambiente (SERNA), Secretaria Technical y de Cooperacion Internacional (SETCO), and Fundacion para el Desarrollo Municipa (FUNDEMUM) in Honduras.

Plans have been developed for clearinghouse implementation and for web site development. Training for web site development, clearinghouses, and metadata production also has been completed. Various administrative levels in the cooperating institutions have been briefed regarding the clearinghouse in each country and written agreements between EDC and the cooperators are in place. Data inventories are in the final stages and prioritization of data for the creation of metadata files is proceeding. Metadata files that have been produced by each cooperator are being verified for staging on the project-provided servers. The first procurement of hardware and software necessary to build the clearinghouse system has been completed, shipped, and distributed. Web site and web page development in support of the clearinghouse is underway and at various stages of completion in the cooperating institutions. Development of the bi-lingual web site at EDC in support of all Hurricane Mitch projects has been initiated and is continuing.

Capacity Building at UNITEC-Honduras

This project is directly related to the Hurricane Mitch project and implements a major capacity-building, data, and training center for Honduras. The EDC provides a full-time coordinator who works with three specialists from Honduras in establishing a permanent capability. Training activities have been carried out in GIS and spatial data analysis, web site and page development, use of the Internet, metadata development, application of Global Positioning Satellites (GPS) principles, ERDAS image processing, orthorectifications and orthrophoto production and applications, geospatial data base development, and data/information distribution. In support of the regional clearing-house activities, the project has been working with the Honduran cooperators in developing data inventories, assisting with and training in data management and the prioritization of data for metadata production, assisting with metadata production, establishing a users network, and assisting with the development of a web site in support of the clearinghouse gateway at UNITEC. The project is coordinating and cooperating with the regional and country coordinators in clearinghouse node establishment and development. The project also provided considerable assistance to USAID in procuring procedures and developing specification for the hardware and software for UNITEC. Support for other Mitch projects, particularly the Municipal GIS project, was provided as needed. Project personnel have participated in training exercises with the World Bank-funded mapping project at SERNA.

World Bank/SERNA Project

The SERNA project was initiated on January 1, 2000 to complete a major short-term project funded by the World Bank to develop the capacity of this organization and to produce GIS products based on remotely sensed images of Honduras as a part of disaster assessment and mitigation activities. Training was completed in the use and analysis of remotely sensed data, digital image processing and classification, application of GIS and GPS data integration, and application of the ERDAS "Imagine" software and interpretation concepts. Practical exercises were carried out in change detection, flood and landslide risk mapping, development of GIS layers and maps, and basic image processing. These exercises resulted in demonstration products of risk maps for the Cuenca Aguan and Cuenca Choluteca areas, a Landsat TM mosaic of a project area in western Honduras, various GIS/thematic maps, and training materials for SERNA's future training needs. The project was called on to provide information and professional opinions on Hurricane Mitch projects and others in a number of Honduran institutions. Briefings were made to Honduran government officials to demonstrate the technology and methods the project had applied at SERNA for planning and other purposes.

IGAD Regional Integrated Information System Project

The Regional Integrated Information System (RIIS) Project is funded by the U.S. Agency for International Development out of its REDSO/ESA office in Nairobi, Kenya, to be implemented by the InterGovernmental Authority on Development (IGAD) located in Djibouti. The mechanism for this information system is to be an Internet-based distributed clearinghouse designed after systems developed in Latin America. A final activity of this project was to assist IGAD in setting up a clearinghouse node and gateway at the University of Nairobi, Kenya, which will serve as the Phase I prototype. This, in addition to submission of a final analysis, completed EDC's RIIS Phase I activities with IGAD.

CarLISES (Dominica / Caribbean)

The Caribbean Land Information System for Environmental Sustainability (CarLISES) is a two-pronged project funded by the U.S. Agency for International Development (USAID) Latin America/Caribbean bureau. USAID is supporting this project to foster agricultural diversification in the region, with the prototype in the island of Dominica. The prototype implements newly developed approaches to land cover mapping and GPS parcel delineation, a thorough database of land use management practices, and on-line displays of agricultural parcels and their relationship to land cover and broad environmental concerns. The land information will use Internet map server technologies and supports a banana certification program to secure premium prices in a niche market and ease the economic transition in these Caribbean Islands as the region transitions to free-trade policies.

Workshops in GIS/ArcView/Spatial Analyst, Metadata Clearinghouse, and GPS/GIS Integration were completed for various resource management agencies in Dominica. The IMS prototype development is continuing and is accessible with a node on the Dominican Banana Marketing Corporation (DBMC) web page, which has been constructed with EDC assistance (www.dbmc-dm.com).

The project will be augmented by land use/land cover mapping of the Caribbean islands by EDC, The Nature Conservancy (TNC), and the International Institute for Tropical Forestry (IITF) from Puerto Rico. This project mapped natural and agricultural areas for the three prototype island sites (Puerto Rico, Jamaica, and Dominica) and in the future will do the same across the remaining Caribbean islands (including the Bahamas). It will provide the region with a standardized land use/land cover baseline that can be used for a variety of applications, including planning agricultural diversification, environmental monitoring, and conservation, biodiversity, and global change studies. Activities in this component will include training, land use/land cover classification, and data distribution through the use of clearinghouse technologies.

Capacity for Aquatic Ecosystem Monitoring and Information Support (Water Hyacinth)

This activity is in support of a regional effort to manage the infestation of water hyacinth in East African lakes and rivers. At the beginning of FY 2000, a cooperative research and development agreement with Clean Lakes, Inc. was signed, marking the official beginning of this project. One major activity was the development and demonstration of water hyacinth monitoring tools, using a multi-sensor approach. Two Radarsat images, five Landsat ETM+ images, and one IKONOS image were acquired, analyzed, and used to demonstrate the value of these systems in determining the location and extent of water hyacinth. EDC scientists documented a major infestation in Winam Gulf, Kenya, which peaked at 18,000 Ha of water hyacinth in November 1998 and subsequently declined to under 1000 Ha by February 2000. High resolution IKONOS data quantified water hyacinth coverage on a remote Rwandan lake slated for water hyacinth control activities (figure 23).

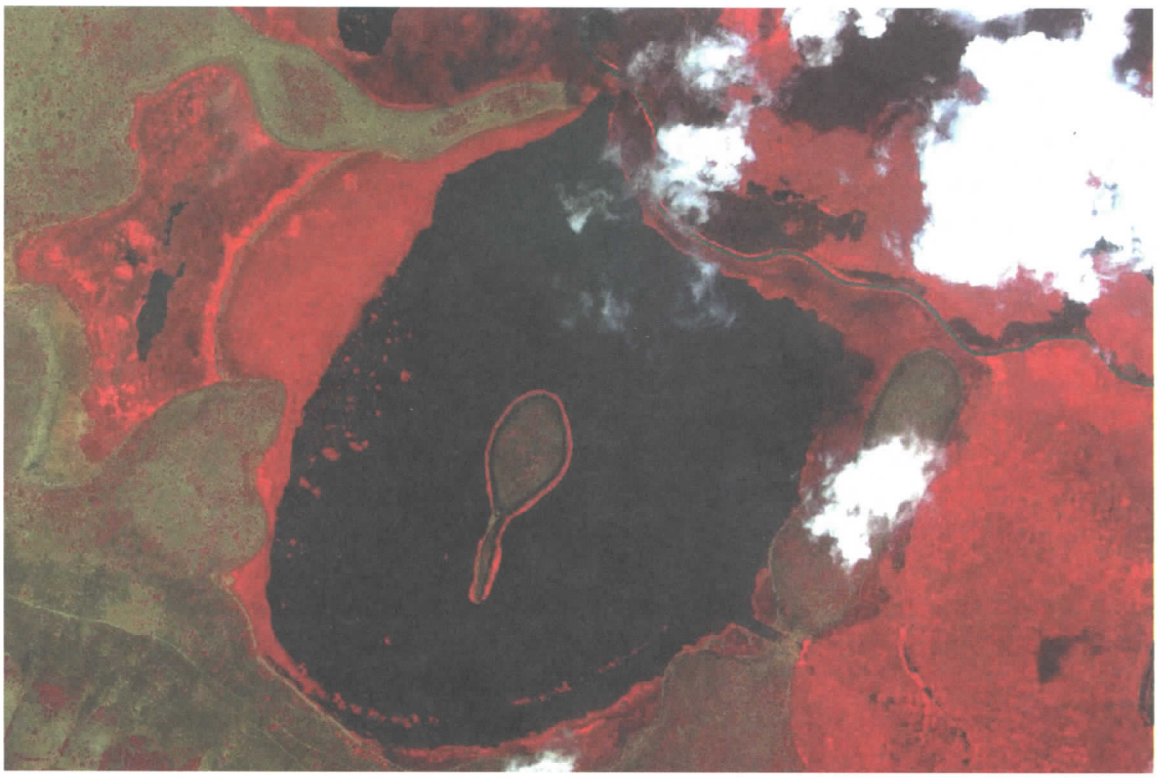
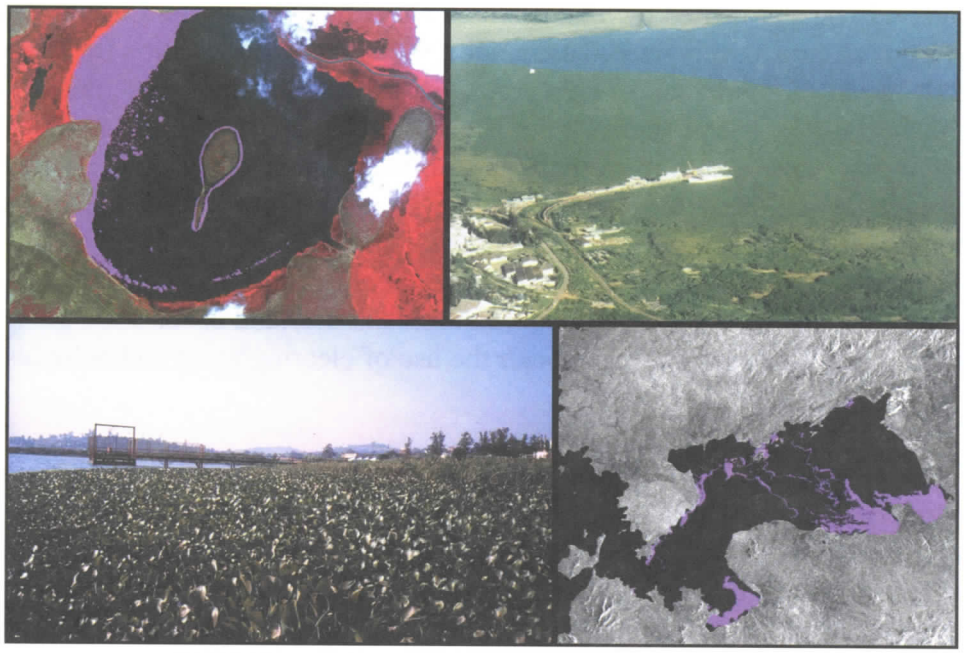


Figure 23

Figure 24



(Clockwise, from upper left) A September 2000 IKONOS image of Lac Mahindi, Rwanda, showing a water hyacinth infestation (magenta) before control efforts were instituted (IKONOS data: " Space Imaging 2000); the pier at Port Bell, Uganda rendered inoperable by an expansive water hyacinth mat in May 1996 (photo: Clean Lakes, Inc.); a November 1998 Radarsat image of Winam Gulf, Kenya showing 69.19 miles area covered with water hyacinth (magenta) (Radarsat data" Canadian Space Agency/Agence Spatial Canadienne 1998. Received by Canada Centre for Remote Sensing. Processed and distributed by Radarsat International); a water hyacinth mat near a water intake pipe on Murchison Bay, Uganda, in January 2000.

EDC staff prepared a report that assessed the numerous monitoring tools available for water hyacinth monitoring. An early warning system was planned for the Lake Victoria basin with the identification of potential partners for a monitoring network and the assessment of current capacities. In cooperation with Clean Lakes, Inc., 18 institutions were visited in Kenya, Tanzania, and Uganda to evaluate monitoring needs and the potential for international collaboration (figure 24).

United Nations Environmental Programme (UNEP)/Global Resource Information Database (GRID)

The UNEP, the environmental voice of the United Nations, has a mandate to analyze the state of the global environment, assess global and regional trends, provide early warning information on environmental threats, and provide policy advice based on the best scientific and technological capabilities available. As a part of this mandate, UNEP maintains a network of cooperating centers around the world to provide environmental data and information to enhance scientific basis for decision making.

The North American node of UNEP's Global Resource Information Database (GRID) hosted by the United States Geological Survey (USGS), EROS Data Center in Sioux Falls, South Dakota, operates in partnership with UNEP, National Aeronautics and Space Administration (NASA), USGS, U.S. Forest Service (USFS), and U.S. Environmental Protection Agency (USEPA). UNEP/GRID-Sioux Falls is a gateway to the global environmental data, information and knowledge resources generated by North American agencies out to the developing world. The Center has an active program

dealing with integration and analysis of data sets from multiple sources to derive policy relevant information about freshwater, biodiversity loss, land cover changes, and population-environment interactions.

The focus of current activities include: monitoring environmental hot spots around the world using satellite data; early warning of emerging environmental threats in Africa; assessing the risks and threats to human health associated with the degradation of ecosystems; assessment of the status of the world's remaining closed forests; rapid response to environmental emergencies; environmental vulnerability assessment; and integrated river basin assessment.

A report on environmental vulnerability assessment was prepared in which a review of various concepts of vulnerability, methodologies for vulnerability assessments, and attempts to develop vulnerability indices was conducted.

A report titled, "Satellite Earth Observation in Wildfire Management," was finalized in consultation with a number of experts around the world as co-chair of the Committee of the Earth Observation Satellites (CEOS) Disaster Management Support Project.

A project titled, "Evaluation of Land Cover Changes in the Tigris-Euphrates Basins and the Wetlands of Lower Mesopotamia in the Arabian Gulf and Coast of Oman," in cooperation with the UNEP Regional Office for the West Asia (ROWA) and UNEP/GRID-Geneva, was completed. NASA provided 43 Landsat images in support of this activity.

To monitor environmental hot spots around the world, a poster series titled, "Our Changing Environment," was begun to document changes using satellite data during the last 30 years.

An analysis using satellite data of the extent and distribution of the world's remaining closed forests, their protection status, and threats to such forest areas due to population pressure was completed. Work continued on the assessment of the transboundary protected areas in the world by geographic location and protection status. The basic goal is to identify the continental distribution of transboundary protected areas to provide basis for international cooperation. By combining several factors, such as land cover and population density, it should be possible to identify transboundary-protected areas that will be under the highest risk for degradation in the future.

In cooperation with U.S. EPA, a review of methodologies for integrating ground-based data and space-borne images for the assessment of transboundary movement of pollutants as an early warning system was conducted.

GRID-Sioux Falls was designated by UNEP as a Task manager on the Global Environment Facility (GEF) medium-sized project "Conservation Action for Priority Sites in Five Eco-regions: Bolivia, Colombia, Ecuador, Panama, Peru" to be implemented by the Nature Conservancy. NASA has agreed to provide 85 Landsat images to support this activity.

GRID-Sioux Falls assembled a mosaic of 18 Landsat TM images and produced posters titled, "The Balkans Landscape from Space," in support of the U.N. Task Force on environmental impacts of the war in Kosovo. Landsat 7 engineering data for 1999 were used for change analysis.

Over 3000 copies of maps in English and Spanish and 500 CDs of "Natural Hazards in Central America: Consequences to People and the Environment" in cooperation with the World Bank were produced and distributed to people in Central America.

A report titled, "Wildfires and the Environment: A Global Synthesis," was released during the UNEP's Governing Council meeting in Nairobi. An analytical report titled, "Early Warning of Selected Emerging Environmental Issues in Africa," with assistance from three scientists from Ghana, Uganda, and Senegal was finalized and released during the UNEP Governing Council. Another UNEP report titled, "An Assessment of Risk and Threats to Human Health Due to Ecosystem Collapse/Degradation," was published and distributed worldwide.

A project related to satellite monitoring and assessment of El Niño and La Niña impacts over eastern and southern Africa, and which may lead to the development of an early warning system, was initiated in cooperation with Clark University and NASA.

A report on "Emerging Threats to Global Freshwater" was released in cooperation with the Pacific Institute for Studies in Development, Environment and Security, California.

An ISO/FGDC-compliant Clearinghouse node for UNEP data was implemented. A Global Energy and Water Exchange Experiment (GEWEX) project also was completed in cooperation with NOAA with advanced Internet data access capability.

Work continued on the development of a GEF Program Tracking and Mapping System. The project leverages advanced Internet technology to connect all GEF projects, and enable them to communicate, exchange information, and perform activities that cut across agency boundaries. The GEF Secretariat Project Tracking System was released to the GEF's web page under "project map" (http://www.gefweb.org/). A presentation and demo of the system was given on October 31, 2000, during the NGO forum and the GEF Council meeting November 1-3, 2000, in Washington, D.C.

EMERGENCY RESPONSE

A major activity of the Emergency Response Program during FY 2000 was to provide remote sensing data to support other USGS scientists, relief workers, and Central American government agencies working in the aftermath of Hurricane Mitch.

A reconnaissance trip to Central America resulted in broadly scoped Letters of Agreement with the national mapping agencies of Guatemala, El Salvador, Honduras, and Nicaragua. Contracts were executed for post-Mitch aerial photography for selected study sites in El Salvador, Honduras, and Nicaragua. An existing National Imagery and Mapping Agency (NIMA) contract for new aerial photography in Guatemala was expanded to encompass USGS project sites in the region (figure 25).
Black-and-white aerial photos were acquired for mapping landslides, debris flows

Figure 25

USGS study sites in Central America for which post-Mitch aerial photographs are being acquired.

associated with volcanoes, and municipalities at risk (figure 26a). Natural-color photos were obtained to determine Hurricane Mitch impacts on coral reefs off the northern coast of Honduras (figure 26b). Effects of the hurricane on mangrove swamps and shrimp farms in the Gulf of Fonseca on the Pacific coast are being assessed from color-infrared aerial photos (figure 26c).

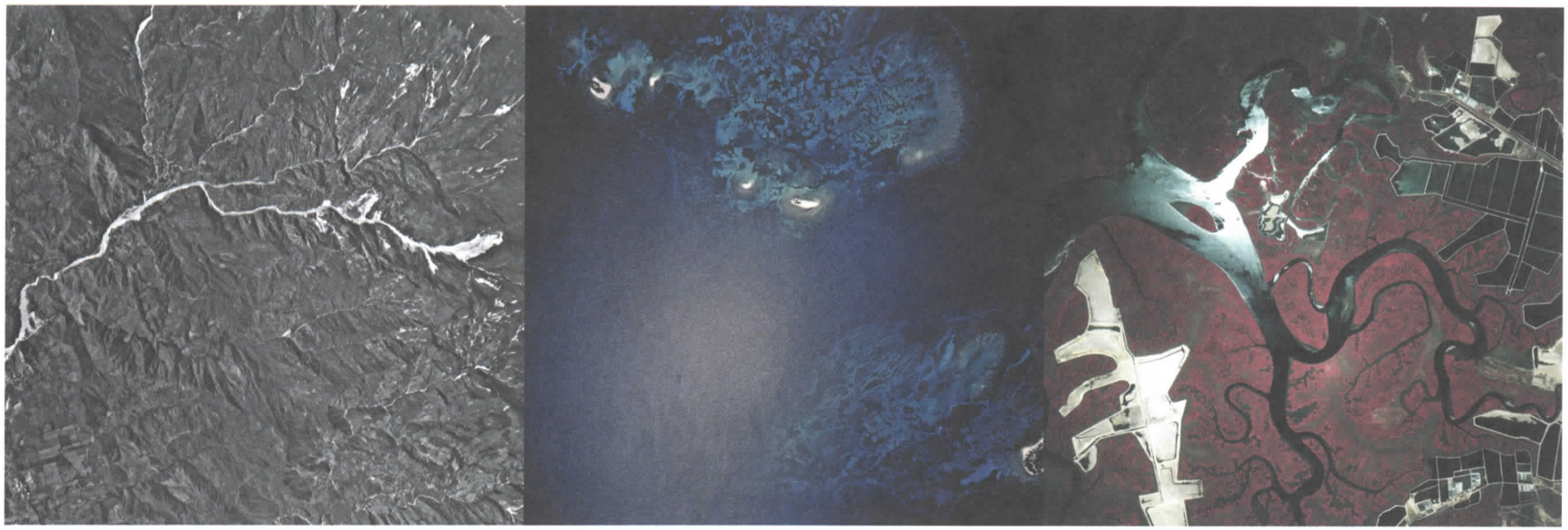


Figure 26a
On black-and-white aerial photographs, fresh landslides are visible as light-toned patches such as those in the upper left.

Figure 26b
Natural-color aerial photographs show submerged coral reefs of Cayos Cachinos, Honduras.

Figure 26c
Color-infrared aerial photography is useful in studying sedimentation in mangrove swamps and shrimp farms around the Gulf of Fonseca.

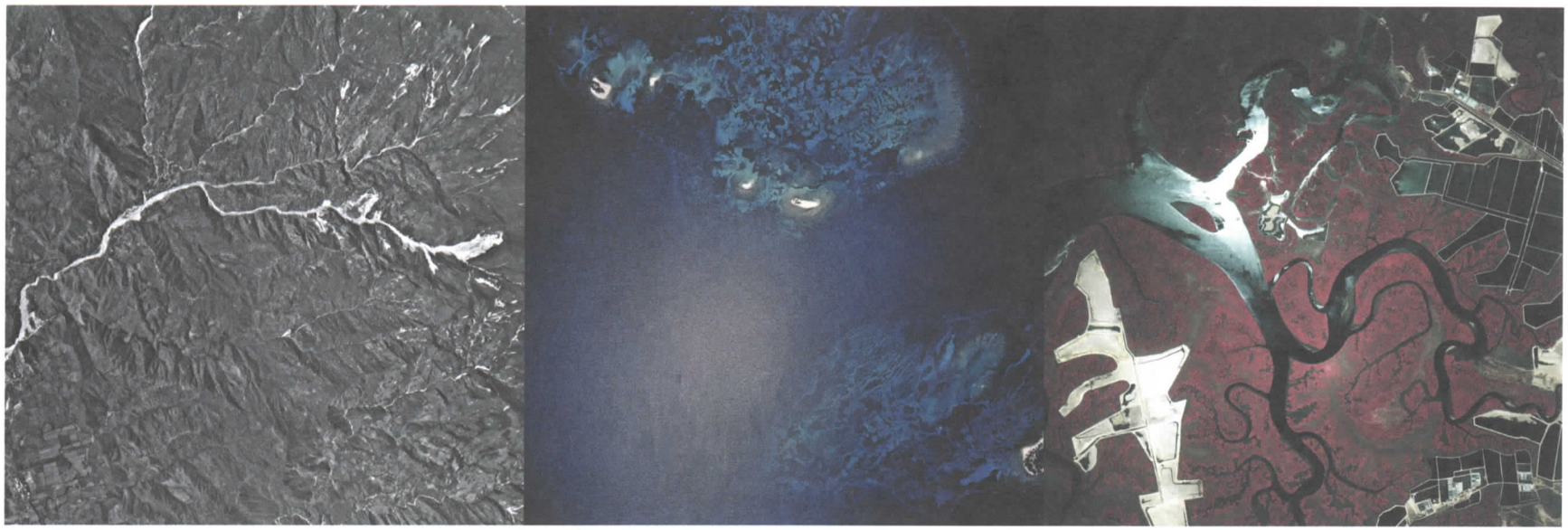
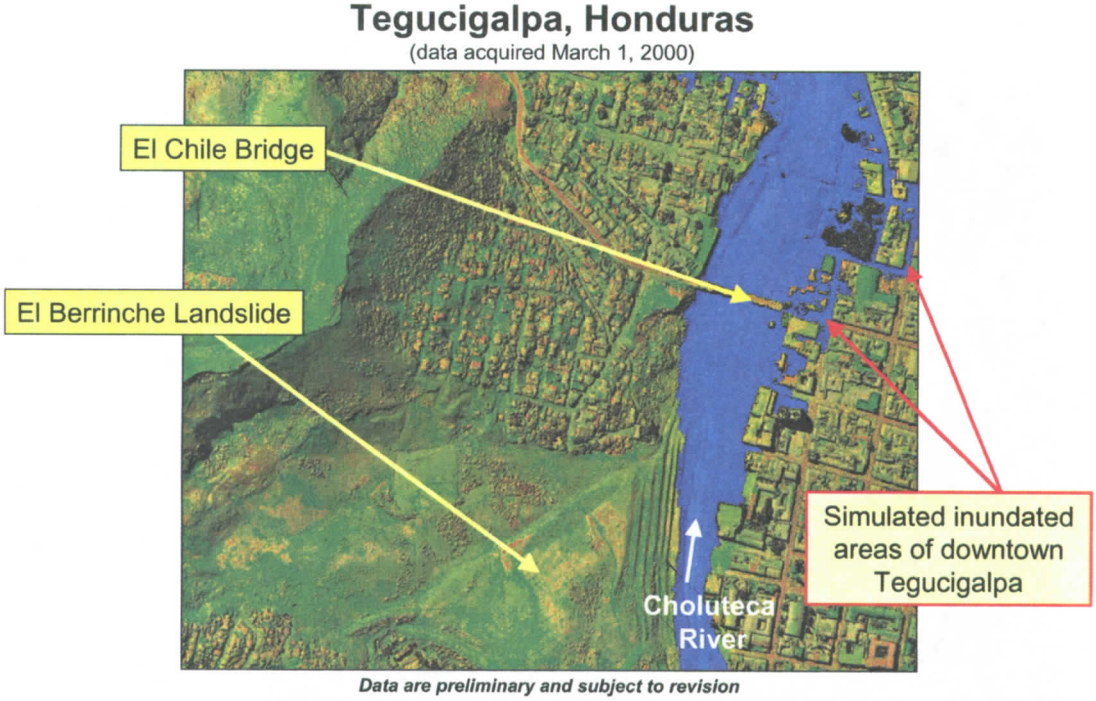


Figure 26a
On black-and-white aerial photographs, fresh landslides are visible as light-toned patches such as those in the upper left.

Figure 26b
Natural-color aerial photographs show submerged coral reefs of Cayos Cachinos, Honduras.

Figure 26c
Color-infrared aerial photography is useful in studying sedimentation in mangrove swamps and shrimp farms around the Gulf of Fonseca.

Figure 27



High-resolution LIDAR elevation data has been processed to create Digital Elevation Models for modeling flood inundation zones.

In addition, a cooperative agreement was established with the University of Texas Bureau of Economic Geology for the acquisition of high-resolution light detection and ranging (LIDAR) elevation data for 15 municipalities in Honduras to facilitate flood studies (figure 27). Orders continue to be received and processed for a wide variety of remote sensing products, including photographic prints and digital data sets. Work continues in placing indices to the various data sets on the Mitch web page and the associated metadata on the Mitch Clearinghouse.

Sets of photographic prints were made from film acquired by the Venezuelan military shortly after the disastrous flooding and landslide event along the northern coast of Venezuela in late December 1999 (figure 28). Prints were delivered to the USGS reconnaissance team to assist in determining the impact of the event.

Other activities included providing scanned digital ortho quadrangles, Landsat 7, and seamless National Elevation Data (NED) in support of wildfire suppression and documentation efforts. Emergency response support relationships are being formalized with strategic customers that include the Federal Emergency Management Agency, Environmental Protection Agency, Office of Foreign Disaster Assistance, and Pacific Disaster Center.

Punta El Caribe, Venezuela

IKONOS 1-Meter Panchromatic

December 20, 1999

Aircraft Panchromatic

December 21, 1999

USGS
science for a changing world

Department of Interior
U.S. Geological Survey
EROS Data Center
Sioux Falls, SD
November, 2000

An IKONOS image and aerial photograph of Punta El Caribe, Venezuela.

Punta El Caribe, Venezuela

IKONOS 1-Meter Panchromatic

December 20, 1999

Aircraft Panchromatic

December 21, 1999

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An IKONOS image and aerial photograph of Punta El Caribe, Venezuela.

SATELLITE SYSTEMS

Landsat 7 Program

In the first full year of operations, the Landsat 7 program was a tremendous success. Landsat 7 completed its twenty-eighth 16-day repeat cycle on September 17, 2000. The EDC archive now contains over 100,000 Landsat 7 scenes. To date, over 10,800 L0 and L1 products have been shipped. Scenes purchased can be categorized by customers as follows: government 41 percent, international 31 percent, industry 16 percent, and academia 12 percent.

Additionally, over 108,000 scenes, averaging approximately 300 scenes per day, have been acquired by the network of 12 ground stations around the world. International cooperation on acquiring and sharing the data has led to increased interest and access to the images acquired by the satellite.

To continue the cooperation with both international and the national agencies involved in the program, regular working group meetings were conducted by EDC Landsat 7 managers.

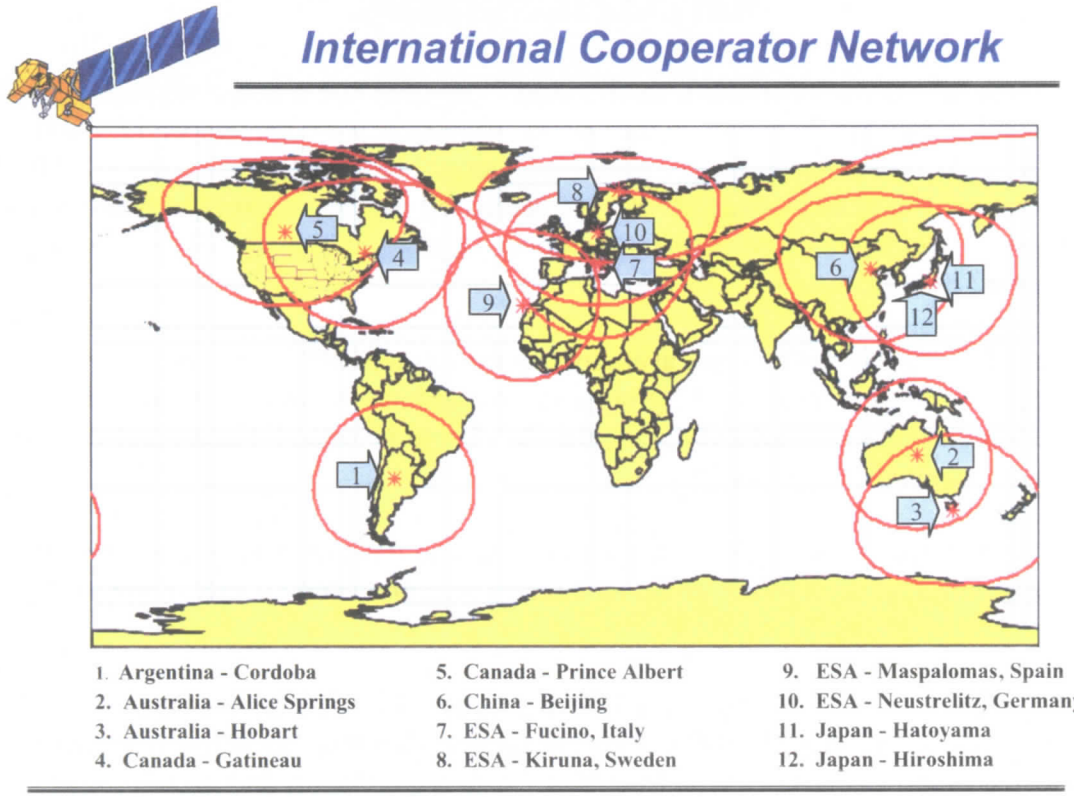
A Landsat Civil Agency Requirements Working Group (LCARWG) meeting was held in Washington, D.C. on May 19, 2000. Representatives from nine government agencies participated in discussions of current Landsat 7 data requirements and agency requirements for future Landsat-type data.

A third "Value-added Processor" workshop and an "Introduction to Landsat 7" workshop were held at the annual meeting of the American Society for Photogrammetry and Remote Sensing (ASPRS) in Washington, D.C. the week of May 22, 2000. Both sessions were well attended by representatives from private industry, academia, and government agencies.

A Landsat Technical Working Group (LTWG) meeting was held in Ottawa, Canada on July 17-21, 2000. Technical staff from nine international cooperators, representing 14 existing and candidate ground stations attended the meeting. Technical issues in the area of data processing were discussed as well as technical approaches for implementing a data exchange annex.

The 29th Landsat Ground Station Operations Working Group (LGSOWG-29) meeting was held in Beijing, China during the week of September 18-22, 2000. Attendance at the meeting included representatives from 10 countries (Australia, Brazil, Canada, China, Italy, Germany, Indonesia, Japan, South Africa and the United States) representing 12 IGSs (figure 29). In addition, representatives from Eurimage, MacDonald Dettwiler and Associates, and SPOT Image (Beijing) were in attendance. The focus of the meeting was on the adoption of a new acquisition prioritization scheme and the data exchange annex to the Memorandum of Understanding between the USGS and the international cooperators. The LGSOWG-29 meeting reached a consensus to implement the three-tiered prioritization scheme for requesting Landsat 7 data. In addition, the data exchange annex was approved in principal with recommended

Figure 29



changes. The meeting in Beijing provided an opportunity to visit the facilities and personnel of the China Remote Sensing Satellite Ground Station (located in Miyun County northeast of Beijing) and the headquarters located in Beijing, the site for most of the meetings.

Workshops on USGS satellite data were given at the Kentucky GIS 2000 conference in Bowling Green, Kentucky; the mid-west regional USGS ESIC conference in Lincoln, Nebraska; and potential user group sessions in Portland, Oregon; Seattle, Washington; Denver, Colorado; and Menlo Park, California.

Proposals submitted for the Landsat 7 Mission Operations Center (MOC) flight operations contract were evaluated in July by a technical team from the USGS, NASA, and Aerospace Company. A final selection was made in September and the contract award will be made at the conclusion of the FY 2001 Federal budget approval process.

MOC engineers conducted a flight operations briefing for USGS headquarters personnel at NASA's Goddard Space Flight Center (GSFC) on August 23, 2000. Additional in-depth training on MOC operations were provided to EDC Mission Management Office staff during the remainder of the week. The briefings were conducted to support the transition of MOC operations responsibility from NASA to the USGS in FY 2001.

EOS Support Program

The Terra satellite was successfully launched by NASA on December 18, 1999. Within weeks, data from the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) sensor packages were processed by systems in Japan and at Goddard Space

Flight Center in Maryland and sent to the EDC Distributed Active Archive Center (EDC DAAC). Prior to launch, the EDC DAAC provided Terra support of operations readiness activities using lessons learned from the Landsat 7 mission. While the Terra sensors provide larger quantities of complex data sets than those provided by Landsat 7, experience with the Landsat 7 data and extra time with the maturing system made operations readiness less stressful and risky.

Checkout of both instruments continued and EDC DAAC staff worked with the instrument teams on various ingest, processing, and data issues common to new systems. MODIS data were released to the public in early spring. Preliminary review of the data suggest the quality is very good and the usability for land science encouraging.

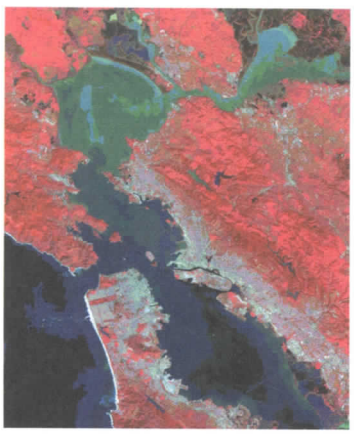
Landsat 7

Landsat 7 images are available as sample products from the EDC DAAC web site (http://edcdaac.usgs.gov). The sample data project allows customers to obtain a sample Landsat 7 product for a low cost and provides information on the various uses of the Landsat data.

The EDC DAAC has more than 100,000 Landsat 7 scenes available through the Earth Observing System (EOS) Data Gateway. There were over 10,000 scenes sold in fiscal year 2000. In addition, the international ground stations (IGS) began sending metadata to the EDC DAAC. Soon, customers will be able to view metadata collections from all the Landsat 7 ground stations through the EOS Data Gateway.

ASTER

Figure 30



This scene of San Francisco, California, (figure 30) was created on March 3, 2000 with data acquired from the ASTER.

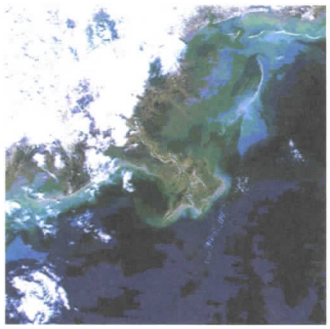
The image reveals suspended sediment in the bays, vegetation health, and details of the urban environment. ASTER's high spatial resolution data will be used to obtain detailed maps of land surface temperature, emissivity, reflectance and elevation.

The EDC DAAC has archived approximately 8 terabytes (TB) of ASTER data since launch. The projected quantity of data during nominal operations is approximately 50 TB per year. Release of ASTER data to general users occurred on November 20, 2000.

MODIS

This image of the Mississippi Delta (figure 31) was acquired on February 24, 2000 by the MODIS. Visible on the image are the classic bird's foot shape of the Mississippi River's channels in the delta, sediment plumes, and ocean color differences.

Figure 31



The scene is a combination of three of the visible bands of the MODIS Land Surface Reflectance product. MODIS data will improve understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere.

Approximately 18 TB of MODIS data are now available in the EDC DAAC. As MODIS production increases, the EDC DAAC will archive approximately154 gigabytes of data per day, or more than 50 TB per year. MODIS will reprocess data after one year of operation, doubling the data ingest quantity. Additionally, once the Aqua satellite launches in FY 2001, the EDC DAAC will receive even more MODIS data.

Version 0 Data Products

The Version 0 (Zero) archive grew this year to include approximately 17.7 TB of data. Approximately 5.8 TB of the archive is NASA SIR-C shuttle radar data. The EDC DAAC, working with the USGS NSLRSDA, completed a transition of the SIR-C data set to the USGS. This is the first of many transitions over the upcoming years, as NASA data sets begin to transfer from the EDC DAAC to the USGS NSLRSDA. (figure 32)

Figure 32

Data Set Description	Archive Media	Average Granule Size	Number of Granules	Total Size – All Granules
Global AVHRR 1Km Comp.	8mm/Nearline	1 gig	930 bands	93 gig
AVHRR Orbital Segments	Nearline	170 meg	26,809	4,558 gig
SIR-C Educational CD's	CD	500 meg	1	500 meg
SIR-C Survey CD's	CD/Nearline	500 meg	125	62.5 gig
Raw SIR-C Precision Scenes	D-1	300 meg	1,351	405.3 gig
Processed SIR-C Precision	8mm	300 meg	17,702	5,310.6 gig
Aircraft Scenes	3480	130 meg	7,302	949.26 gig
NALC Triplicates	3480/Nearline	600 meg	536	321.6 gig
NLDC Scenes - MSS	3480/3490	100 meg	2,760	276.0 gig
NLDC Scenes - TM	3480/3490	500 meg	4,718	2,359 gig
H. T. Forest Scenes	N/A	N/A	N/A	N/A
GTOPO30	8mm/CD/Nearline	87.4 meg	33	2,832 gig
GLC Test Site Data	3490	5 gig	25	125 gig
ASAS	3480/Nearline	500 meg	162	81 gig
AVHRR Global NDVI	CD	650 meg	1	650 meg
EOSDIS Sampler CD	CD	856 meg	45	38.5 gig
AVIRIS	3490	.845 meg	4,904	4.146 gig
N.A. AVHRR 10day Comp.	8mm/Nearline	1.25 gig	36	45 gig
GLCC	Nearline	200 meg	5	1 gig
Master Airborne Simulator	N/A	550 meg	455	250.25 gig

The EDC DAAC distributed over 9,200 scenes on media in FY 2000. The cost for distribution of data is shared with customers who pay $10 per CD-ROM or $15 per 8-mm tape. Total FY 2000 costs for distribution of these products from the EDC DAAC were approximately $149,000. Additionally, several products are freely available via FTP or the web. The EDC DAAC distributed over 160,000 files or 1.1 TB of data to customers via FTP or the web.

Other Initiatives

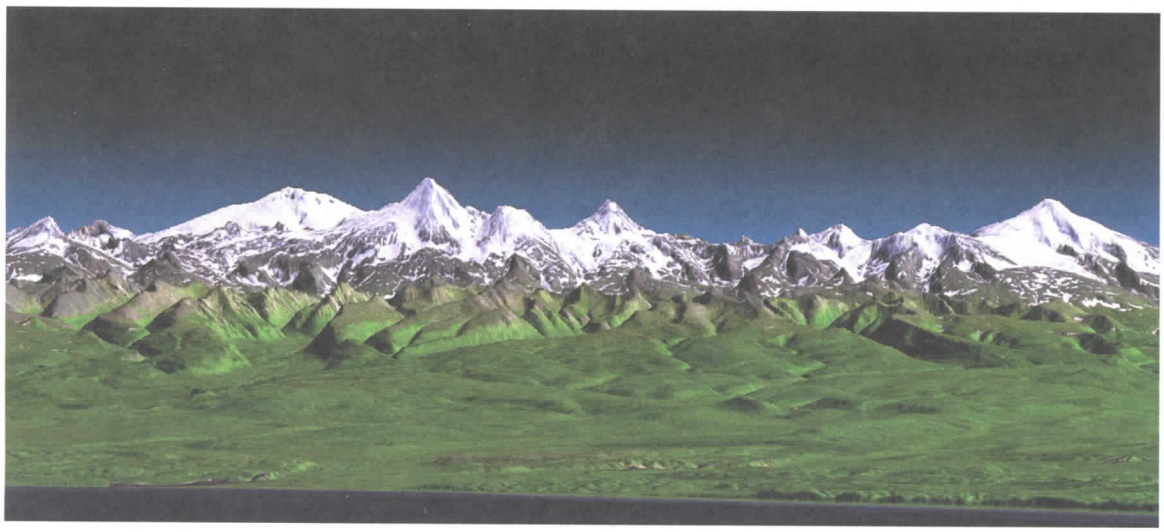
The EDC DAAC also is funded to archive and distribute the GeoCover data currently in production through the NASA Science Data Purchase efforts. The GeoCover data sets consist of ortho-rectified Landsat imagery covering global land areas for two historical time frames. One is MSS imagery collected during the mid 1970s. The other data set will be TM imagery collected around 1990 and will serve as a baseline for studies of change during this decade. The imagery is ortho-rectified to an accuracy of 50 meters (TM) and 100 meters (MSS) using control points from government sources. A third data set will consist of mosaic scenes of the TM coverage for the entire globe.

Various system enhancement activities are in progress or were completed for both the Version 0 system as well as the EOSDIS Core System (ECS). Improvement efforts during this fiscal year have allowed the EDC DAAC to archive and distribute more data than ever before. The systems continue to mature, resulting in better performance, less system down time, and improved accessibility for customers.

SRTM Support

EDC supported Jet Propulsion Laboratory's (JPL) public information activities, during NIMA/NASA's 10-day Shuttle Radar Topography Mission (SRTM) flown on STS-99, by providing JPL with several geometrically-corrected Landsat 7 images of several areas of the world. JPL draped Landsat 7 imagery over high-resolution digital elevation model (DEM) data, derived from the SRTM imagery, to create stunning perspective views (figure 33). EDC staff also provided local print and TV media with copies of the JPL/USGS images and made themselves available for interviews to explain the significance of the successful mapping mission. Sample SRTM products are expected to be delivered to the EDC for public distribution in FY 2001.

Figure 33



Three-dimensional perspective view of the western side of the volcanically active Kamchatka Peninsula, Russia. This image was produced by the Jet Propulsion Laboratory using elevation data derived from data acquired on February 12, 2000 by the Shuttle Radar Topography Mission (SRTM) and a Landsat 7 image acquired on January 31, 2000.

New Satellite Missions

EDC Staff represented USGS at several meetings during the year in which Federal and international users met to discuss the need for new missions to continue and extend the collection of periodic, global remotely sensed images for studying

environmental and climatic change. The missions included: (a) a critical follow-on mission for the highly successful NASA/USGS Landsat 7 mission; (b) a proposed U.S. operational interferometric synthetic-aperture radar (InSAR); (c) a Japan Space Agency mission that combines a steerable interferometric SAR, high-resolution stereo camera for terrain mapping, and a multispectral scanner similar to the U.S.'s Landsat 7 instrument; (d) a Department of Energy research mission that combines high-resolution visible as well as shortwave- and thermal-infrared imaging for future compliance monitoring of international nuclear non-proliferation treaties; and, (e) a DOD/NASA/NOAA interagency mission to collect high precision global land and atmospheric information for DOD/NOAA operational and NASA research users.

SPOT Data Availability

Initial conversion operations commenced on SPOT satellite data acquired during 1997-1998 and procured by the USGS for long-term preservation and distribution. When completed in FY 2001, 725,000 panchromatic and multispectral scenes acquired from 1986 to 1998 will have been retrieved from old high-density digital tapes, converted to computer-compatible tapes, and cataloged for future ordering and distribution. A study was conducted to evaluate alternative designs and to estimate the cost and schedule of implementing a system to transcribe 700,000 scenes of Landsat Multispectral Scanner (MSS) and TM data from digital cassette tapes to computer compatible tape. Plans were made to implement a system by the end of FY 2001, using a combination of in-house and expert programming resources. The system is critical to the preservation of Landsat data that currently resides on special digital tapes that are now 10 years old and increasingly prone to mechanical problems.

EO-1 Activity

Forty members of the Earth Observing-1 (EO-1) science team, comprised of government and academic researchers from the U.S., Canada – and Australia – were hosted for a semi-annual technical exchange. One of the EDC staff is a principal investigator on the science team, responsible for the characterization of radiometric and geometric quality of the Advanced Land Imager instrument (one of three sensors onboard). The EO-1 sensor package was launched on November 21, 2000, and is a planned 2-year technology demonstration mission.

IKONOS Evaluation

Site preparation in an 11-km square area around EDC was made to facilitate the geometric evaluation of panchromatic and multispectral data from the IKONOS high-resolution commercial sensor operated by Space Imaging Corporation. Data were acquired over EDC and Brookings, South Dakota, on June 30, 2000 (figure 34). The data will be assessed after precise ground control information is collected by a ground survey team for several test sites and examined for compliance with published specifications. The data were purchased by NASA as part of its evaluation of future sources of earth science data. A similar evaluation will be conducted on EarthWatch's QuickBird high-resolution data in FY 2001.

Satellite Data Reception Capability

Procurement of a second X- and S-band receiving antenna was completed in September. When delivered in July 2001, the antenna will provide a backup capability for Landsat 7 and allow direct reception of MODIS data acquired by the

Figure 34

This image of the EROS Data Center was acquired June 30, 2000 by Space Imaging's commercial imaging satellite called IKONOS (Eye-con-ohs). The smallest feature on the ground visible to the human eye in this multispectral image is four-meters, or 12 feet. IKONOS is the world's first one-meter (three-feet) resolution, commercial imaging satellite.

Earth Observing System Terra spacecraft. The antenna also has the capability to acquire SPOT 1-2 data on a periodic basis to support emergency response, as well as to receive Landsat 5 TM data should that become necessary in the future.

NATIONAL LAND REMOTE SENSING DATA ARCHIVE

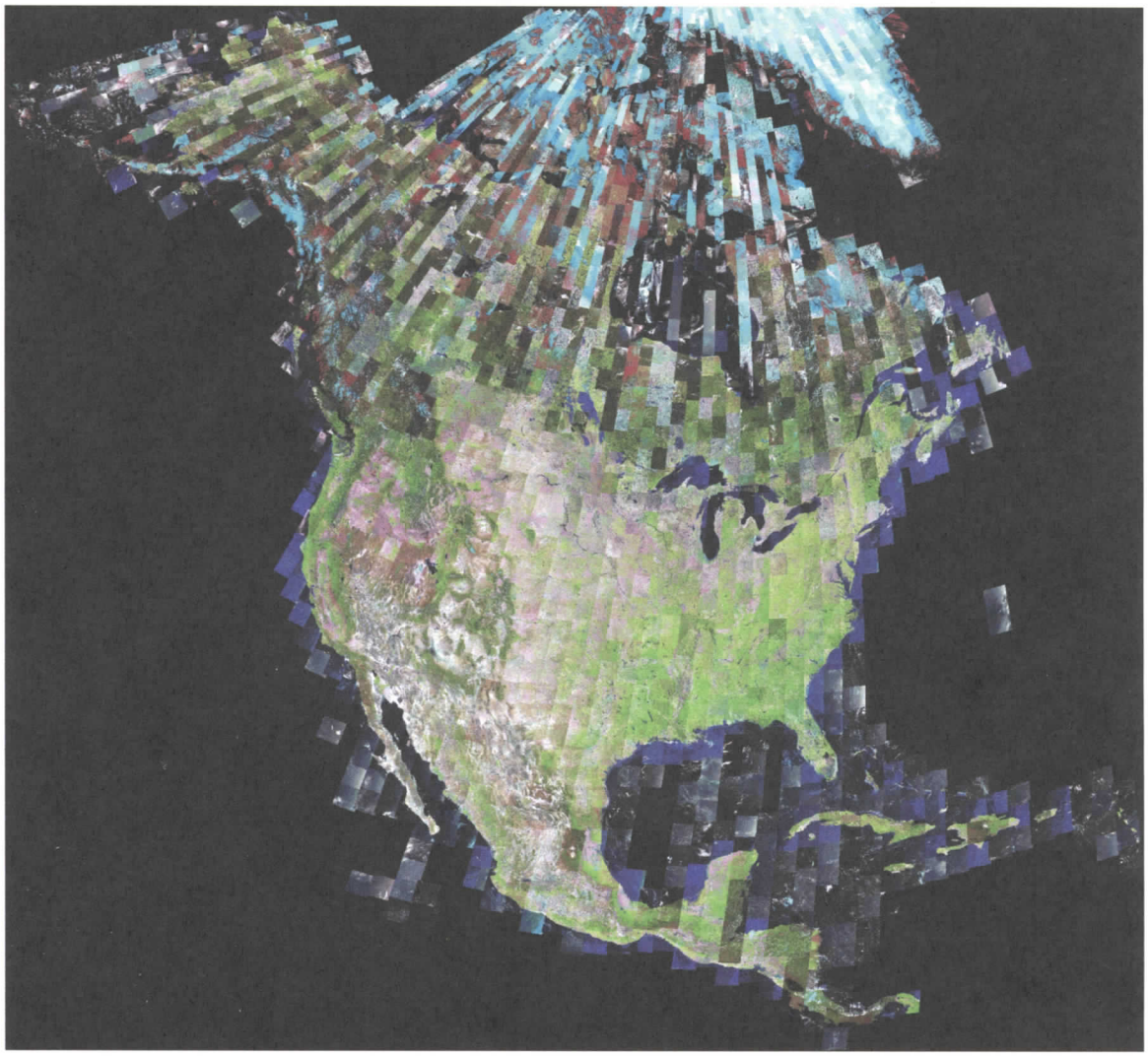
OhioView

In March and August 2000, EDC staff, together with representatives from the NASA Glenn Research Center, met with research faculty from the nine universities of the OhioView Consortium to discuss the status, budget, and research goals of the consortium members. The August meeting included comprehensive briefings on the collaborative research and development project conducted by the consortium and funded by the USGS and NASA. Goals for the research and instructional methods project encompassed the following activities: (1) assess land use and land cover change (especially farmland loss); (2) simplify graphical inventory search and retrieval of local (consortium) archives; and, (3) facilitate student use of graphical information system tools and techniques. Separately, one member of the consortium conducted a comprehensive geodetic evaluation of several Landsat 7 products purchased by the consortium. It was determined that the products consistently were within the one-pixel error margin guaranteed by EDC, and the products were completely satisfactory for current and anticipated applications.

A meeting was held in June at Mission, South Dakota, with representatives of the Sicangu Policy Institute of Sinte Gleska University (SGU), on the Rosebud Sioux Indian Reservation. The group discussed ways that the USGS could help improve instructional materials, technical resources, and access to distance-learning experts in the subject areas of geographic information systems and applications of remote sensing technology. The group concluded that SGU might benefit from becoming a member of the national consortia.

As part of the OhioView Pilot project, EDC staff developed a prototype web-based rapid-query tool to facilitate viewing Landsat and other global medium-resolution images. The tool allows users to quickly access and view Landsat images without knowledge of path and row acquisition grids and without having to specify detailed search criteria. The image viewer allows the user to begin at a global scale with coarse 4-km image pixels, then, with a few mouse clicks, to zoom in on the desired area portrayed with 1-km or 250-m pixels (figure 35). Once the user has displayed a scene from the desired area (based either on most-recent, or least-cloudy criteria), scenes acquired at other times during the satellite's 16-day repeat cycle can quickly be viewed. The viewer is suitable for experienced users as well as users with little experience using information access systems.

Figure 35



Mosaic of 2,359 Landsat 7 browse images covering North America.

Archive Management

Preserving and managing the archive involved receiving 32,734 color-infrared and 26,315 black-and-white aerial photographs from the Mapping Applications Center for duplication and entry into the Aerial Photography archive. An additional 33,204 frames were received from the U.S. Department of Agriculture's Aerial Photographic Field Office for archiving.

Digital cartographic records received during Fiscal Year 2000 included 9,118 Digital Elevation Model files, 42,689 Digital Orthophoto Quadrangles, 14,710 Digital Line Graph files, and 1,044 Digital Raster Graphic files. Migration of digital satellite data involved processing 8,072 Landsat Wide-Band Video Tapes and preserving 102,968 image scenes on newer, more durable media. The archive now manages more than 250 terabytes of satellite, aerial, and cartographic data.

Information Management

Three Landsat data sets – MultiSpectral Scanner, TM, and the ETM+ – were released to the public through the new Earth Explorer data access interface. Also released via Earth Explorer were the National Aerial Photography Program, National High Altitude Photography, USGS Paper Maps, Digital Raster Graphics, Digital Orthophoto Quadrangles, Corona declassified satellite photography, and the Digital Elevation Model data sets. All three data sets were also mapped and released to the Federal Geographic Data Committee Clearinghouse, providing another method for users to locate USGS products. Earth Explorer has been operational since March 23, 2000. Since that time users from 94 different countries have logged 24,277 visits to the site. More than 400 orders have been received for USGS products during this time. Earth Explorer users also requested more than 295,000 digital preview images while conducting 123,000 searches. Some 2,900 users have registered in Earth Explorer, allowing them access to additional features, such as saving the results of their searches (figure 36).

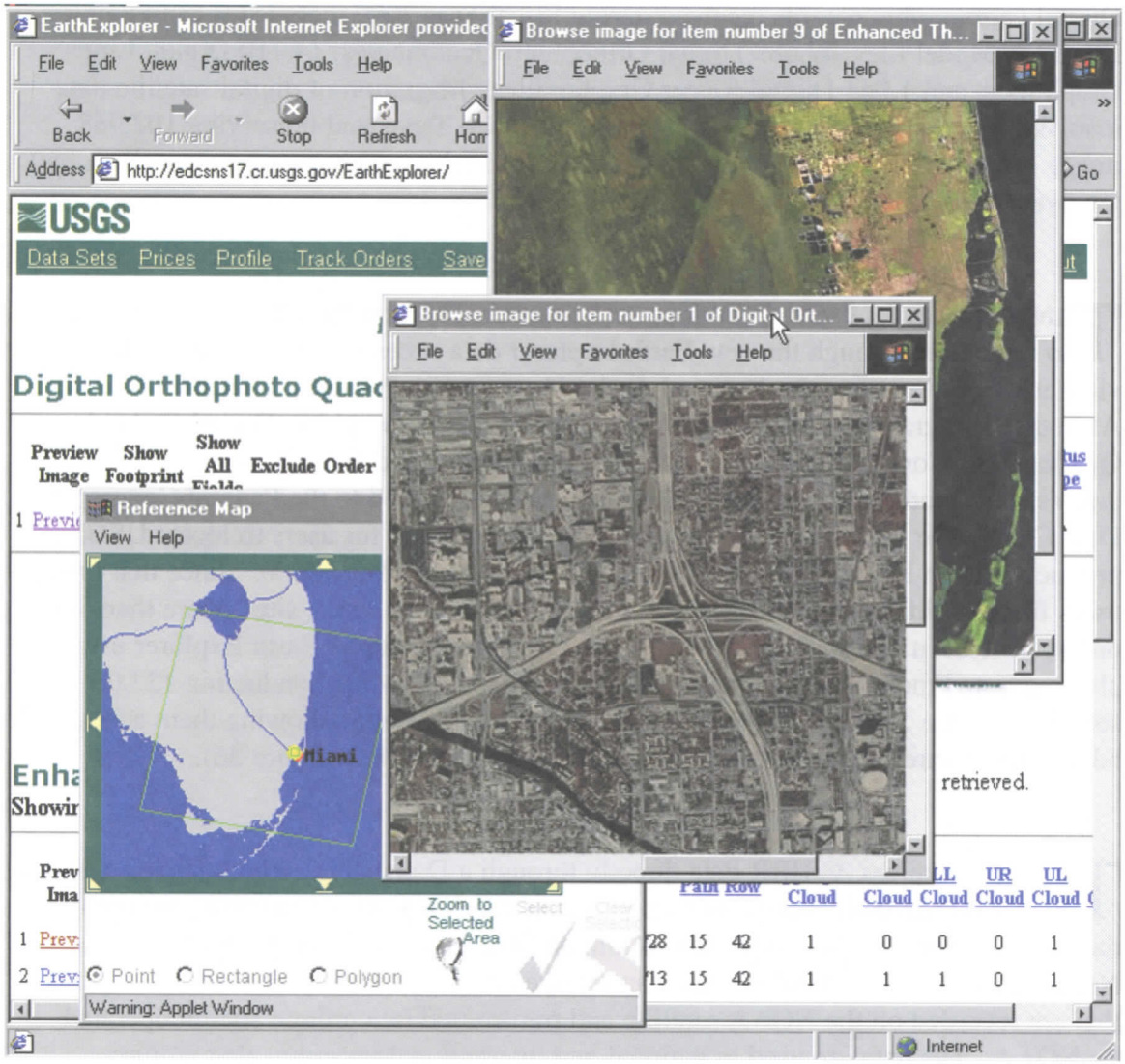
AVHRR Data Reception

The EDC receives AVHRR data directly through a Domestic Communication Satellite System (DOMSAT) relay. Direct reception capability allows the EDC to receive data immediately for the conterminous United States and major portions of the rest of North America. The DOMSAT antenna receives data over Alaska and foreign regions that are recorded on the NOAA satellite and transmitted to a ground station operated by NOAA. The data are used in national and international programs that require coarse-resolution satellite data for land-based environmental studies and global climate change research. The EDC archived more than 17,800 AVHRR scenes during FY 2000, bringing the total to more than 250,000 scenes.

Greenness Mapping

Greenness mapping using AVHRR data from NOAA weather satellites continued for the twelfth year. These data are used to determine the relative vigor of vegetation over large study areas. Greenness data have proven useful for agricultural assessment, mapping land cover, predicting wildfire danger, and monitoring the effects of global climatic phenomena. FY 2000 study sites included the conterminous United States, Alaska, and China.

Figure 36



Earth Explorer search-result screen with a map reference and digital previews.

INFORMATION AND DATA SERVICES

Business Partners

Satellite data were added to the lines of products available to USGS Business Partners for redistribution. At year's end, about 60 Business Partners acted as resellers of digital cartographic data, about 60 as resellers of aerial photographs, and 24 as resellers of satellite data, currently limited to Landsat 7 imagery.

Total sales for the year through the Business Partner activity at the EDC came to more than $1.3 million, and more than half of that resulted from Landsat 7 sales. Also during the year, the Business Partner web pages were revised to make more effective referrals of customers to the Partners. Partner feedback has been positive.

Customer Services

Customer Services handled $18.8 million in product sales this year (figure 31), a $3.7 million increase over the previous year. The number of items delivered actually decreased slightly, from 1.4 million to 1.2 million (figure 37). The increase in revenue

is primarily due to Landsat 7 data sales, which amounted to more than $6.7 million. Digital Raster Graphics were the most popular of the geodata product lines, with sales tripling compared to FY 1999. A breakdown by general product lines is shown below:

Figure 37

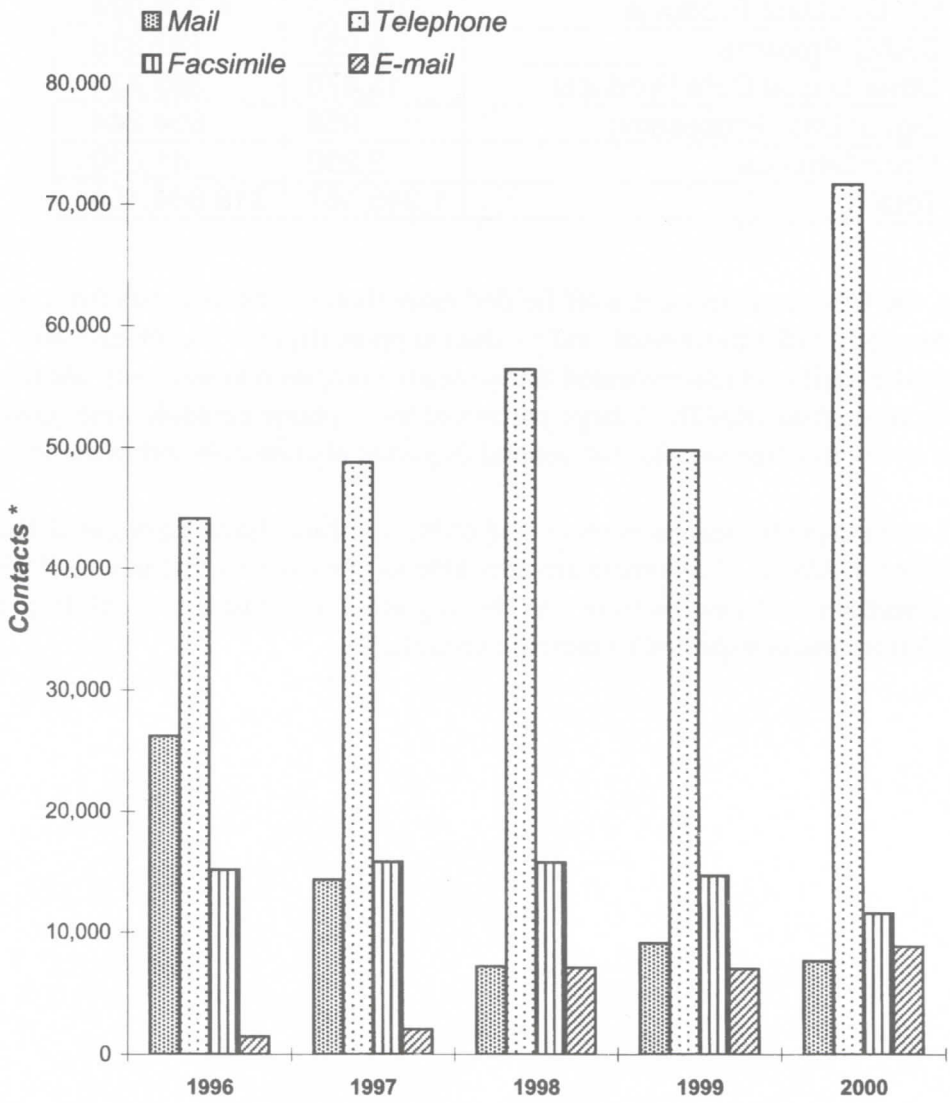
Products and Services	Items	Dollars
Photographic Products	383,071	$ 4,013,466
National Landsat Satellite Archive	15,049	2,629,845
Landsat 7 Products	21,546	6,736,773
US GeoData Products	801,930	4,226,924
DAAC Products	4,937	137,338
Other Digital Data Products	15,476	383,734
Digital Data Processing	958	694,244
Miscellaneous	2,200	41,830
Total	1,245,167	$18,864,154

In addition, the Customer Services staff fielded more than 92,000 requests from users regarding research, order placement, and product support (figures 38, 39, and 40). While fax and e-mail contacts remained fairly steady compared to last year, phone calls increased by more than 20,000. A large portion of these phone contacts were payment related, but a new toll-free number for general inquiries also contributed to the increase.

The EDC's newest public search, browse, and order inferface, Earth Explorer (EE), quietly debuted in March. Customers are now able to place orders and pay for them online via a secure credit card website. As the migration of datasets to Earth Explorer nears completion, use is expected to increase considerably.

Figure 38

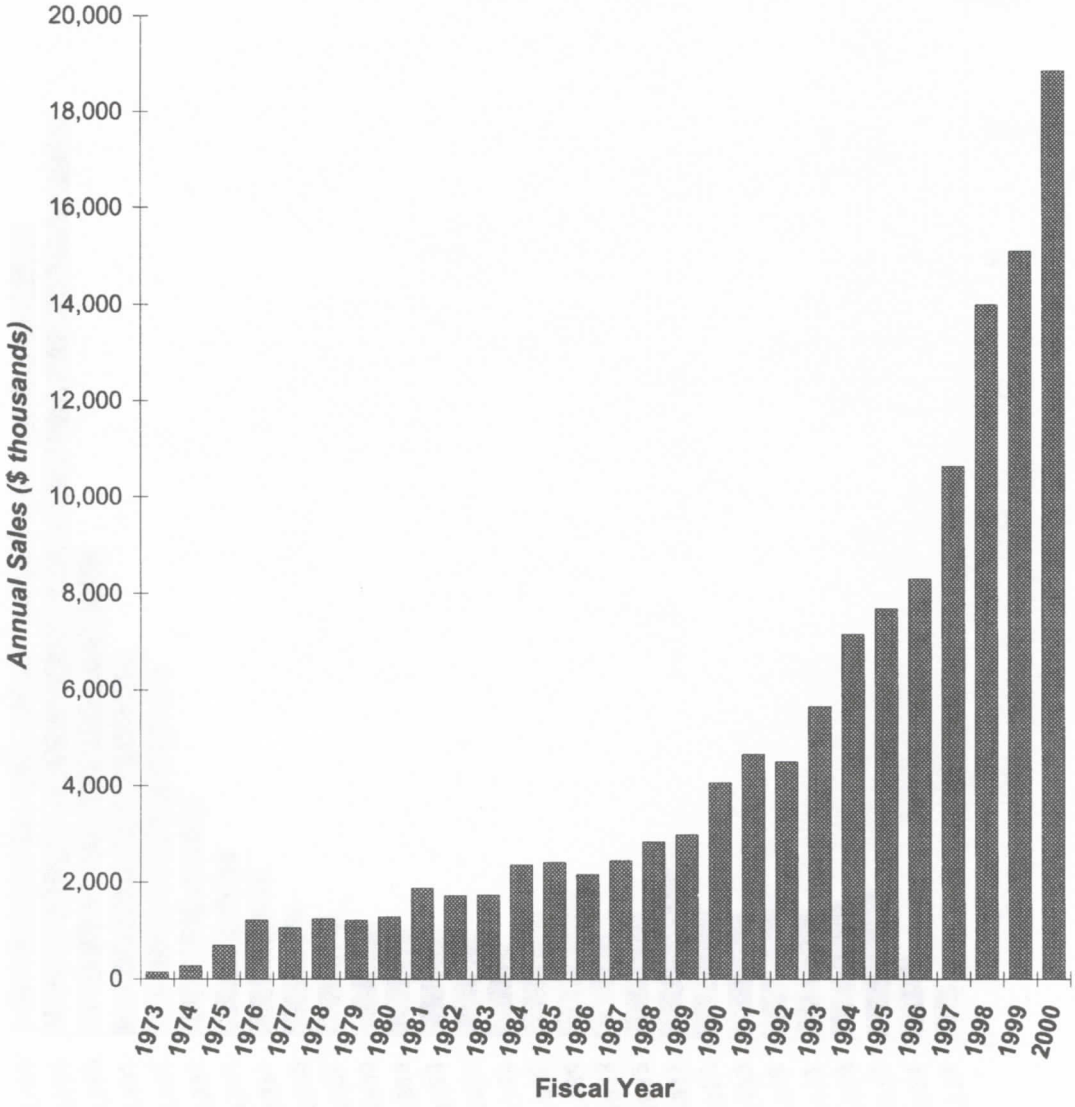
EDC Customer Contacts for Remotely Sensed and Digital Cartographic Products Fiscal Years 1996 - 2000



* Contacts include mail, telephone, facsimile and e-mail, and excludes GLIS inquiries.

Figure 39

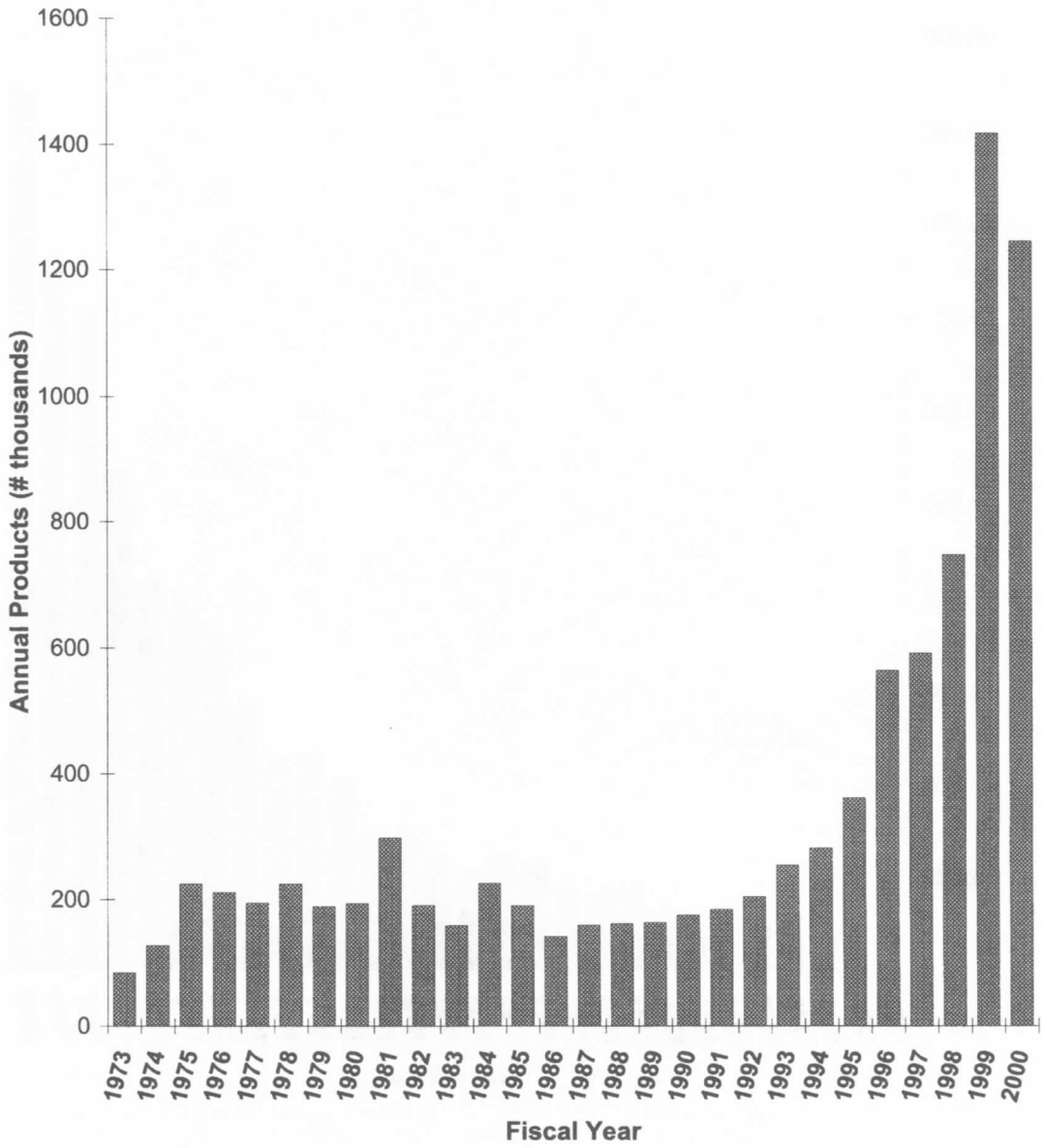
EDC Product Sales Dollars *
Fiscal Years 1973 - 2000



* Includes direct customer sales, EDC repay projects and sales to USGS customers.

Figure 40

EDC Sales Items *
Fiscal Years 1973 - 2000

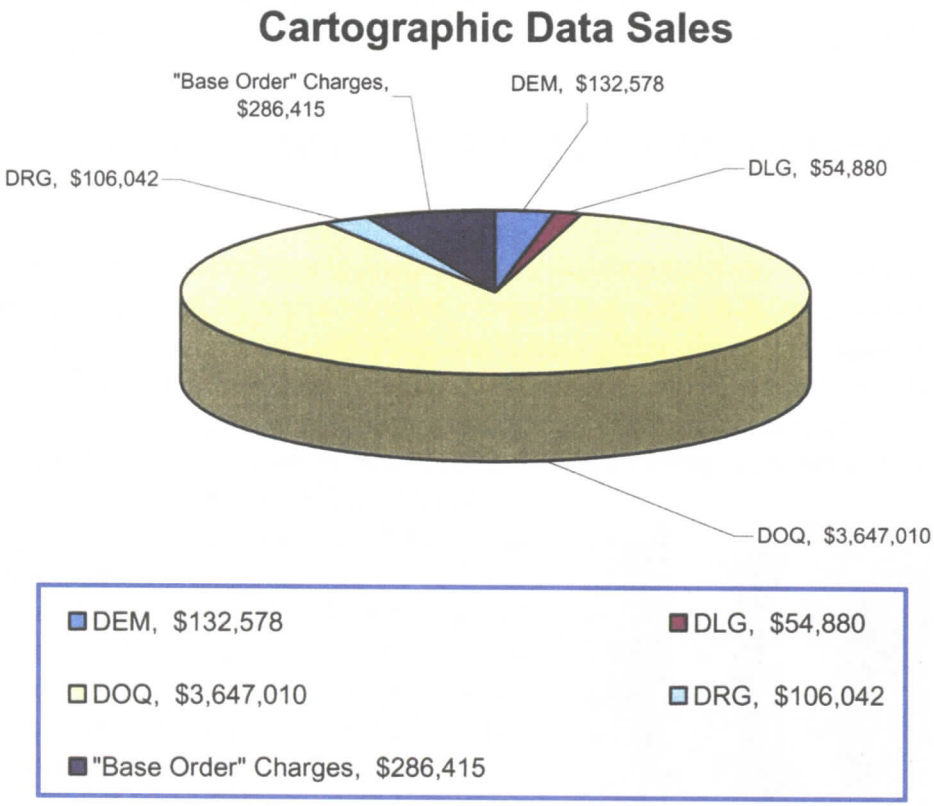


* Includes direct customer sales, EDC repay projects and sales to USGS customers.

Cartographic (US GeoData) Data Sales

The Sales Data Base holdings now total more than 508,000 products and all may be ordered online. Figure 41 represents EDC cartographic data sales for FY 2000.

Figure 41



Diapositive Production

The EDC produces diapositive film, paper print, and digital images for the National Mapping Program's Digital Orthophoto Quadrangle (DOQ) program. These products are generated from the original aerial photographs, some of which are archived at the EDC and some at the Department of Agriculture's Aerial Photographic Field Office (APFO) in Salt Lake City. In FY 2000 about $600,000 worth of these products were purchased by the USGS from the APFO for DOQ production.

The EDC also participates in innovative partnerships with states to produce DOQ products. One such partnership with the State of Georgia resulted in scanning original aerial color master film to make DOQ products. During FY 1999, the EDC completed the pilot phase of the Georgia Project, demonstrating that scanning the original film would meet project specifications. Phase two, begun during FY 2000, includes the scanning of about 300 images per month. The Project, when completed, will total approximately 3,700 images.

Data Production and Distribution Infrastructure Development

To keep up with the increased demand for EDC-held digital data, major developments completed during FY 2000 improved EDC's data production and distribution capacities. These enhancements included augmenting the digital data production system with memory and disc upgrades to the high-speed computer and an improved robotic-arm retrieval mechanism in the data storage silo system. Systems providing access to online products also were enhanced, resulting in faster service.

The Product Distribution Silo System also received four new tape drives designed to decrease dramatically the storage data tape reading time. More than 760,000 data image files were distributed in FY 2000 to meet customer media demands for satellite and cartographic data products.

SYSTEMS INFRASTRUCTURE DEVELOPMENT

Automated System Backups

In previous years, server backups were a largely manual task performed by EDC's computer operations staff. The task involved running scripts on individual servers, manually mounting and dismounting media, and manually transporting the media to the digital library for storage. As the number of servers has increased, combined with a continuing expansion of online disk capacity, performing manual system backups became cumbersome, error prone, and increasingly inefficient in the use of hardware, media and staff resources.

Figure 42

In FY 2000 the Information Technology Services (ITS) program in the Computer Services Branch obtained funding to automate the computer system backups process. Acquired for this automation process were a Sun Enterprise Unix server, Legato Networker software, and a StorageTek 700-cartridge automated library with four DLT 7000 tape drives (figure 42). The ITS staff integrated the components for the automated backup system during FY 2000 and achieved full operation in October 2000.

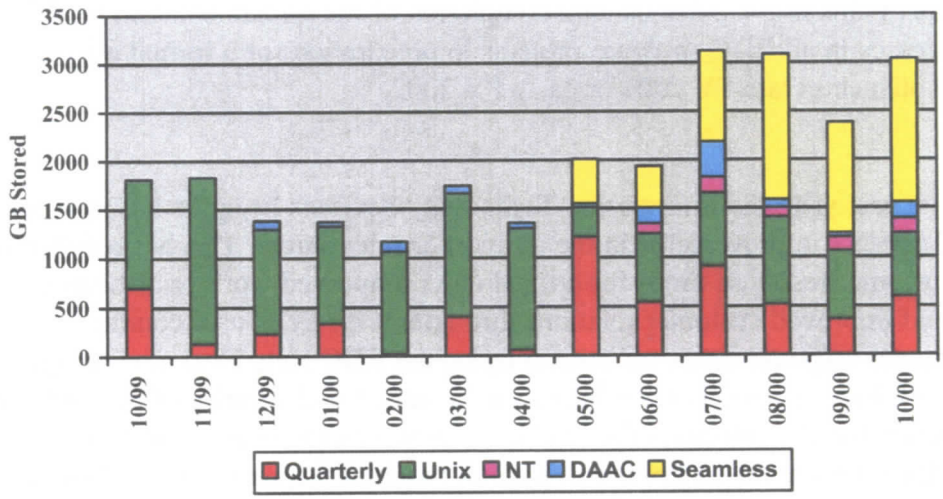
The automated backup server requires minimal system administration and has accommodated the continued growth in computer system backup requirements. In addition, the Legato interface results in 100 percent usage of media, provides a single interface to restore data, and allows for shorter backup windows for critical databases such as the DORRAN, Inventory, Earth Explorer, and Seamless projects. The following graph (figure 43) illustrates the amount of data backed up on a monthly basis during FY 2000.

Network Activities

One of the most significant Local Area Network (LAN) efforts in FY 2000 focused on network security, specifically the planning and implementation of two network firewalls to protect USGS and NASA computing resources at EDC from unauthorized access and malicious attacks. The initial testing and limited rollout of the firewalls was accomplished in FY 2000, and a full production implementation is due to be completed in the first quarter of FY 2001. In other areas of LAN activities, upgrades were performed to augment core technologies, enhance performance and reliability of the EDC LANs, and to meet specific project-driven requirements and needs. Some of these upgrades included augmentations to increase the redundancy of the network, the

Figure 43

Monthly Data Backed Up During FY 2000



installation and testing of Gigabit Ethernet in the core (with plans being developed to expand availability to the work areas), testing and limited implementation of wireless networking, and the replacement of older, shared-network equipment with newer switched-network technologies.

Wide-Area Network (WAN) activities this past year included investigations, planning, and initial testing for such technologies as IPv6, IP Multicast, IPSec, data encryption, VPNs, quality of service (QoS), voice over IP (VoIP) and vBNS/Internet2 peering. Partnerships were explored and agreements developed with various cooperators such as NASA, the Great Plains Network (GPN), Abilene (Internet 2), and the SouthDakota-net. Plans were also being developed for vBNS+ (the USGS GeoNet replacement) integration and testing. These activities resulted in the implementation of a 45Mb/sec Internet2 link, redundant 45Mb/sec Internet1 links, a 45Mb/sec vBNS+ connection, and several new connections to other USGS agencies including the Bureau of Indian Affairs, the USGS Water Resources Division, and the Environmental Protection Agency. The aggregate total bandwidth of WAN connections coming into EDC is approximately 500Mb/sec. The amount of data carried over those connections increases almost daily.

Software Engineering Process Improvement

The Software Engineering Process Improvement (SEPI) project is a multi-year effort to improve the overall quality and efficiency of EDC software development projects. The goals are to improve customer satisfaction through reduced development time and improved quality, and to improve the work environment for the software engineering staff through improved processes for workload management and issue resolution. The effort involves the establishment and deployment of processes encompassing the software development life cycle, from customer request to product delivery. The project is utilizing the Carneggie-Mellon Software Engineering Institute's Capability Maturity Model (CMM) as the roadmap for their efforts. The EDC software engineering group is currently pursuing CMM Level 2 compliance. The key software process areas being addressed within CMM Level 2 include requirements, software

project management, software quality assurance, subcontract management, and configuration management. SEPI Project efforts in FY 2000 were focused on process definition and documentation, training, and initial implementation of the Level 2 key process areas. Plans in FY 2001 include completion of the implementation of all Level 2 processes in all EDC software projects in preparation for a formal assessment of Level 2 compliance in late FY 2001 or early FY 2002.

IT Support Service Improvements

During the past year, the Information Technology Services Program has implemented several process improvements in the Support Services area. This has resulted in shortened customer response times for critical tasks, improved work prioritization processes, and improved customer relations throughout the EDC user community. To shorten customer response times for critical tasks, the EDC Help Desk now assigns a priority to each logged customer call based on the nature and severity of the problem. By assigning each call a priority, other technical areas can better plan their work schedules. Each priority also carries a minimum required response time so that the customer has a better idea of when their concern will be handled. To expedite the setup and delivery of new PCs, the Micro Support group now loads multiple PCs at one time with a single system image, instead of loading each PC individually. This process not only saves time, but also decreases the potential for error in the setup process. To foster better customer relations, the EDC Help Desk has improved the process for logging customer problems. Specialized Help Desk software has been installed that improves logging and tracking of user requests. This software gives the Help Desk the opportunity to obtain metrics on the types and numbers of calls received and support continuous customer relation process improvements. These metrics have already helped in the development of a more responsive training program for customer trouble areas, and facilitated greater accountability for technical areas that respond to customer needs.

Y2K Preparation and Transition

Y2K activities this past year involved finalizing preparations for, and executing, plans to accommodate the rollover to January 1, 2000. Planning documents were generated for all mission-critical and mission-essential systems. Test systems were loaded with production software and thoroughly tested. Any problems found were corrected to ensure a smooth transition into 2000. On the evening of Friday, December 31,1999, approximately 40 staff members were on-site to support system testing after the clocks rolled over to January 1. All critical- and mission-essential systems were evaluated for any problems to ensure that normal operations could continue on Monday morning. All systems checked out and the whole event turned out to be rather quiet. Final reporting to the Department of the Interior was completed by Sunday, January 2, 2000. Some additional Y2K related activities took place on February 29 to accommodate the leap year. System tests were performed in similar fashion to those performed before January 1, 2000. Again, all systems checked out fine. This wrapped up the Y2K activities for EDC.

OUTREACH ACTIVITIES

Pecora 14/Land Satellite Information III Conference

The USGS was a major sponsor of the Pecora 14/Land Satellite Information III Conference held in Denver, Colorado, December 6-10, 1999. The Chief of the EDC served as conference chair, and staff from the EDC had responsibilities for portions of the technical program, the poster session, and many of the administrative and logistical duties for the conference. Three hundred eighteen full registrations and nearly 400 partial, speaker, or exhibitor registrations led to overflow attendance at many of the sessions. Following the conference theme of "Value of Satellite Data," attendees exchanged ideas on the utility of the data and, in an era of new satellite systems, discussed satellite data distribution policies.

As adjuncts to the conference, staff from the EDC offered two opportunities to discuss USGS satellite data distribution policies. A workshop for the commercial value-added processors community gave the 31 registered attendees and 20 observers a forum for specific consideration of USGS policies and plans. In addition, a seminar was held at the Rocky Mountain Mapping Center, during which 100 regional scientists and managers were told about the characteristics, distribution policies, and availability of Landsat 7 data.

Education and Public Outreach

Center staff participated in many outreach activities of significance to the USGS and EDC during fiscal year 2000. The bulk of EDC outreach efforts involved the planning, coordination, graphic art, publication, public presentations, and audio visual support for many EDC programs and activities. EDC staff supported a USGS initiative involving an educational "relationship" with Sinte Gleska University (SGU), in Mission, South Dakota. This long-term "relationship" involves the USGS and EDC helping SGU establish a sustainable environmental science curriculum based on geographic information systems technology. EDC outreach staff also helped to host a Native American intern from Sinte Gleska University during the summer of 2000. EDC staff initiated an educational partnership with the Dakota Interactive Academic Link (DIAL) school consortium. EDC hosted onsite DIAL educator, Wes Hilton, who represented projects involving Corsica, Stickney, and Armour schools in South Dakota.

As part of EDC's outreach efforts, Center staff hosted a number of groups during fiscal year 2000 for meetings and/or tours. A partial listing of these groups include: 130 seventh grade students participating in a NASA program called EarthKAM - an educational partnership offering middle school students the unique opportunity to photograph the Earth using a digital camera mounted aboard the Space Shuttle; a group of 38 biology/ecology students from Northwestern College, Orange City, Iowa; and 60 young women at the National Girl Scout Jamboree, "Destination Dakota 2000", in Brookings, South Dakota.

During fiscal year 2000, 359 public tours were given, and 9,521 visitors came to the Center. EDC staff also participated in state and regional science programs that included three water festivals for over 4,000 fourth grade students, South Dakota Space Day for 2,400 students and educators, and 27 presentations to classrooms. In addition, several

presentations were provided to civic, church, and service clubs in southeast South Dakota, northwest Iowa, and southwest Minnesota.

EDC Outreach staff produced an 8-minute video for the USGS Urban Dynamics project. The video, titled "Graphics of Growth," featured animations of urban growth for a dozen U.S. cities and was used at a Department of the Interior news conference. EDC audio/visual staff also produced a 6-minute video for the EDC Annual Meeting. This program highlighted accomplishments and activities of EDC employees through the calendar year. Finally, EDC video staff documented the Signing Ceremony between the USGS and Sinte Gleska University by shooting video of USGS Director Chip Groat in Mission, SD.

In addition to the outreach activities mentioned above, EDC staff supported the following National Mapping and Bureau exhibit shows: National Indian Education Association, Oklahoma City, OK; Radio Television News Director's Association, Minneapolis, MN; American Society for Photogrammetry and Remote Sensing, Washington, D.C.; and the ERIM Conference, San Diego, CA.

Globe Support

The EDC supported NASA's Global Learning and Observations to Benefit the Environment (GLOBE) program by producing unique data sets for each of 1,393 schools in the United States and 539 international schools. These data sets include floppy disks containing Landsat TM data centered over each school, and color prints of the derived images.

PROGRAM MANAGEMENT

Program and Budget Planning

The Program Management Office initiated a formal programmatic and budget planning process for the EROS Data Center, which was used in formulating plans for the Center's FY 2001 activities. The objectives of this process were to ensure a thoughtful Center-wide plan that fosters coordination between programs and USGS Headquarters and allows time for staffing adjustments and review by Center managers prior to the start of the year.

Software Process Improvement

The PMO sponsored the Software Engineering Process Improvement (SEPI) project, an initiative within the computer Services Branch that establishes and deploys policies, processes, and procedures encompassing the software development lifecycle from work request to delivered product. The goals of SEPI are to enhance customer satisfaction through reduced development time and improved quality, and to improve software development processes for the benefit of the customer and the software engineering staff. A secondary objective of the project is to adopt the Software Engineering Institute's Capability Maturity Model (CMM) as a framework for software engineering process improvement.

The key process areas that were the focus of the past year's effort included: peer reviews, requirements management, software project planning and estimation, software project tracking and oversight, software quality assurance, and software configuration management. In addition, the project deployed the Process Assets Library, a www-based resource that provides templates, documents, roadmaps, training materials, and other materials for use by the software staff in the process improvement effort.

Project Management Training

A comprehensive curriculum and syllabus were prepared for a training course, "Introduction to Project Management." The course consists of 20 modules, ranging from topics such as project and team organization, project planning and development, budget planning, scheduling, and quality reviews to change management, project management tools, and reporting. The course is specifically tailored to EDC requirements. The course syllabus is over 400 pages in length, and includes supplements to the lectures and viewgraphs, case studies, supplementary readings, and project planning diagrams, worksheets, and checklists. The course is designed to be taught in 12 two-hour sessions, over a period of 6 weeks. The first course using these materials was presented to 18 EDC managers comprised of a mix of government and contract employees. There is currently a waiting list of over 50 other individuals who wish to take the course, so it will be repeated as necessary.

Strategic Planning

The strategic plan for the EDC is being reviewed and updated by the Center's senior managers. A survey was conducted to solicit input from the Center's management staff and the previous strategic planning team to provide input to the revision process. The revision process began with the preparation of a number of "future scenarios," written by the Center's senior managers detailing their vision for the future. These scenarios will form the basis for further discussion and long-term planning at the Data Center. Topics addressed by the scenarios were:

- Leadership and Management
- The EDC Workforce
- Facilities
- The EDC Technology Infrastructure
- The Science Agenda
- The EDC Archive
- User Services
- Data Reproduction and Distribution
- Data Access
- EDC's Role in Satellite Missions
- Outreach at EDC

PART III

STATISTICAL DATA

EDC Annual Sales Report
Fiscal Year 2000
(Dollars)

	DIRECT REPAY CUSTOMERS	EDC REPAY PROJECTS	USGS CUSTOMERS	TOTAL
PHOTOGRAPHIC DATA				
AERIAL IMAGES				
NAPP	1,509,089	89,389	1,568,298	3,166,777
Other	431,544	8,864	85,248	525,657
SATELLITE IMAGES				
Corona Satellite Photography	61,693	1,469	1,629	64,791
Landsat / Other	14,095	6,525	74,035	94,655
Photo From Digital Source	2,213	13,913	53,865	69,990
Other Photographic Data	2,940	23,839	64,818	91,597
TOTAL PHOTOGRAPHIC DATA	**2,021,574**	**143,999**	**1,847,893**	**4,013,466**
NATIONAL LAND SATELLITE ARCHIVE				
Landsat MSS (Satellites 1 - 5)	847,789	80,000	24,935	952,724
Landsat TM (Satellites 4 - 5)	1,380,230	20,550	129,715	1,530,495
** Landsat Derivative Products (Satellites 4 - 5)	41,475	2,020	21,245	64,740
** AVHRR Images	62,705	17,269	1,912	81,886
TOTAL NATIONAL LAND SATELLITE ARCHIVE	**2,332,199**	**119,839**	**177,807**	**2,629,845**
LANDSAT 7 PRODUCTS				
Landsat 7 / ETM				
Level 0R	4,331,142	83,885	149,625	4,564,652
Level 1 R/G	1,477,978	28,125	194,300	1,700,403
Level 1 P/T	255,387	38,200	146,085	439,672
Landsat Derivative Products (Landsat 7)	9,332	4,752	17,962	32,046
TOTAL LANDSAT 7 PRODUCTS	**6,073,839**	**154,962**	**507,972**	**6,736,773**
*** US GEODATA PRODUCTS**				
"Base Order" Charges	230,330	6,090	49,995	286,415
DEM	102,776	279	29,523	132,578
DLG	37,305	9	17,566	54,880
DOQ	2,160,059	34,343	1,452,608	3,647,010
DRG	100,708	2,811	2,523	106,042
TOTAL US GEODATA PRODUCTS	**2,631,178**	**43,532**	**1,552,215**	**4,226,924**
DAAC PRODUCTS	**18,868**	**118,344**	**126**	**137,338**
OTHER DIGITAL DATA PRODUCTS	**148,546**	**15,313**	**219,875**	**383,734**
OTHER DIGITAL DATA PROCESSING	**113,988**	**43,268**	**536,987**	**694,244**
TOTAL DIGITAL DATA PRODUCTS/PROCESSING	**11,318,618**	**495,258**	**2,994,982**	**14,808,858**
MISCELLANEOUS PRODUCTS AND SERVICES	**39,224**	**788**	**1,819**	**41,830**
GRAND TOTAL	**13,379,416**	**640,044**	**4,844,694**	**18,864,154**

* Does not include no-charge electronic distribution of data.

** Includes DAAC Products.

EDC Annual Sales Report
Fiscal Year 2000
(ITEMS)

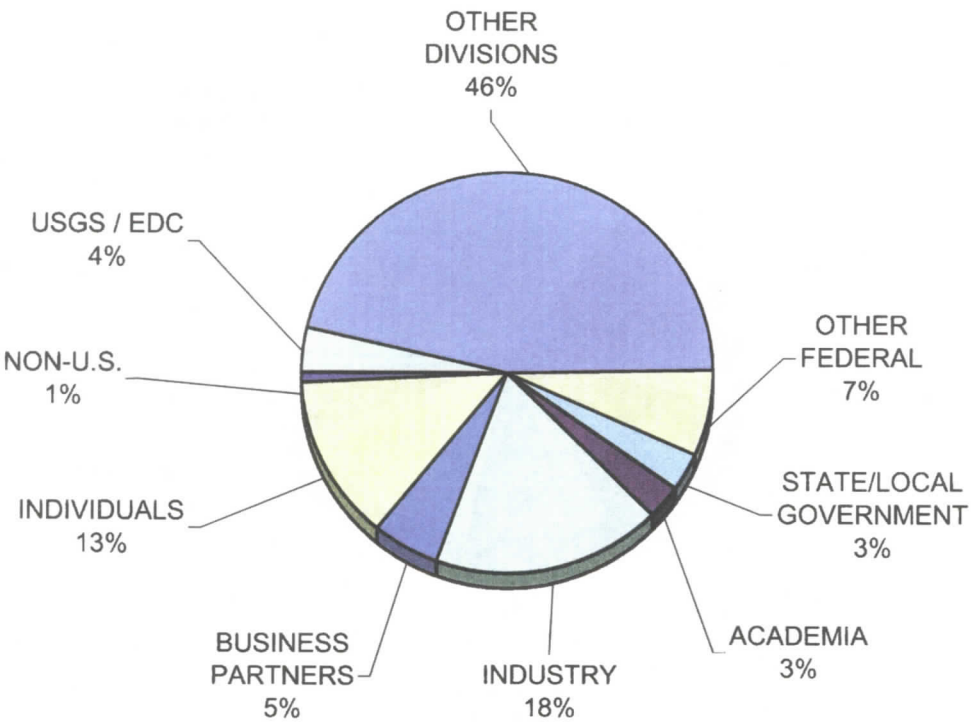
	DIRECT REPAY CUSTOMERS	EDC REPAY PROJECTS	USGS CUSTOMERS	TOTAL
PHOTOGRAPHIC DATA				
AERIAL IMAGES				
NAPP	77,781	9,017	225,054	311,852
Other	36,106	977	16,921	54,004
SATELLITE IMAGES				
Corona Satellite Photography	3,570	69	128	3,767
Landsat / Other	817	86	1,937	2,840
Photo From Digital Source	29	150	591	770
Other Photographic Data	113	2,818	6,907	9,838
TOTAL PHOTOGRAPHIC DATA	**118,416**	**13,117**	**251,538**	**383,071**
NATIONAL LAND SATELLITE ARCHIVE				
Landsat MSS (Satellites 1 - 5)	4,766	182	92	5,040
Landsat TM (Satellites 4 - 5)	3,336	56	590	3,982
** Landsat Derivative Products (Satellites 4 - 5)	1,776	42	241	2,059
** AVHRR Images	1,164	2,770	34	3,968
TOTAL NATIONAL LAND SATELLITE ARCHIVE	**11,042**	**3,050**	**957**	**15,049**
LANDSAT 7 PRODUCTS				
Landsat 7 / ETM				
Level 0R	9,524	192	430	10,146
Level 1 R/G	9,893	111	510	10,514
Level 1 P/T	384	90	193	667
Landsat Derivative Products (Landsat 7)	155	22	42	219
TOTAL LANDSAT 7 PRODUCTS	**19,956**	**415**	**1,175**	**21,546**
*** US GEODATA PRODUCTS**				
"Base Order" Charges	6,080	141	1,161	7,382
DEM	135,063	279	21,070	156,412
DLG	44,790	9	17,569	62,368
DOQ	323,826	3,673	141,338	468,837
DRG	101,596	2,811	2,524	106,931
TOTAL US GEODATA PRODUCTS	**611,355**	**6,913**	**183,662**	**801,930**
DAAC PRODUCTS	**3,644**	**1,281**	**12**	**4,937**
OTHER DIGITAL DATA PRODUCTS	**12,034**	**327**	**3,115**	**15,476**
OTHER DIGITAL DATA PROCESSING	**418**	**164**	**376**	**958**
TOTAL DIGITAL DATA PRODUCTS/PROCESSING	**658,449**	**12,150**	**189,297**	**859,896**
MISCELLANEOUS PRODUCTS AND SERVICES	**2,043**	**112**	**45**	**2,200**
GRAND TOTAL	**778,908**	**25,379**	**440,880**	**1,245,167**

* Does not include no-charge electronic distribution of data.

** Includes DAAC Products.

Customer Profile
EDC Photographic Products
Fiscal Year 2000

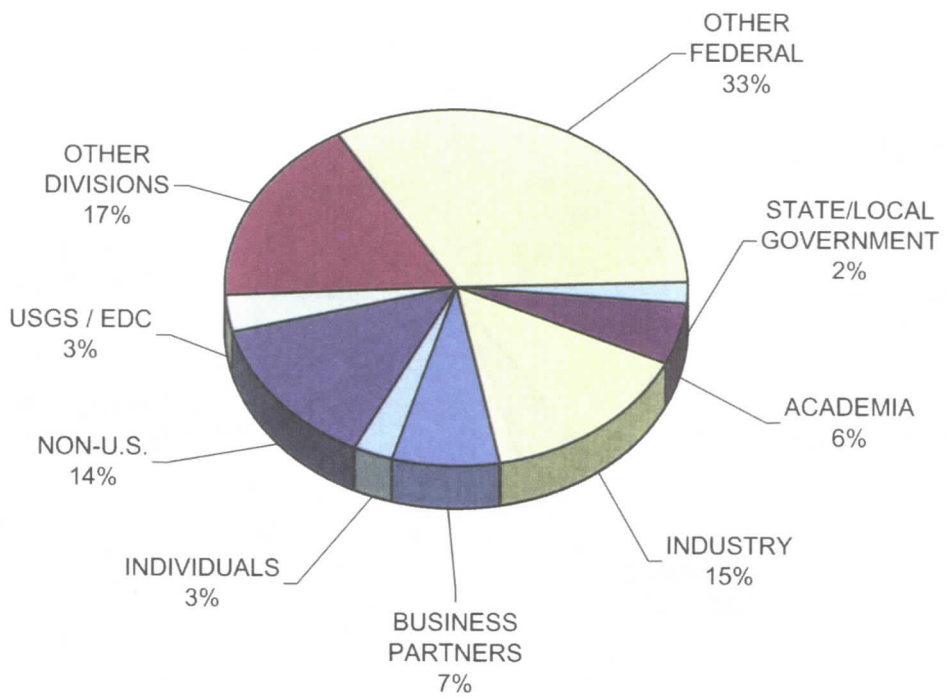
CUSTOMER CATEGORY	ITEMS	DOLLARS
USGS / EDC	13,117	143,999
OTHER DIVISIONS	251,538	1,847,893
OTHER FEDERAL	18,971	278,286
TOTAL FED. GOVERNMENT	**283,626**	**2,270,177**
STATE/LOCAL GOVERNMENT	10,966	124,563
ACADEMIA	8,712	112,026
INDUSTRY	33,760	721,128
BUSINESS PARTNERS	11,877	214,315
INDIVIDUALS	32,227	541,358
NON-U.S.	1,903	29,898
TOTAL	**383,071**	**4,013,466**



Customer Profile
EDC Digital Data Products
Fiscal Year 2000

CUSTOMER CATEGORY	ITEMS	DOLLARS
USGS / EDC	11,986	451,990
OTHER DIVISIONS	188,921	2,457,995
OTHER FEDERAL	203,248	4,674,088
TOTAL FED. GOVERNMENT	**404,155**	**7,584,073**
STATE/LOCAL GOVERNMENT	29,125	247,883
ACADEMIA	17,482	788,321
INDUSTRY	149,922	2,126,320
BUSINESS PARTNERS	192,982	1,040,044
INDIVIDUALS	55,149	393,984
NON-U.S.	10,123	1,933,991
TOTAL	**858,938**	**14,114,615**

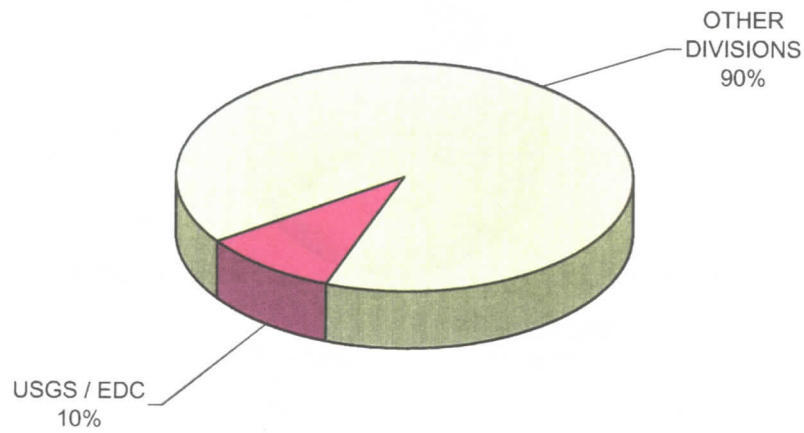
* Does not include no-charge electronic distribution of data.



Customer Profile
EDC Landsat 7 / ETM
Fiscal Year 2000

Photographic Data

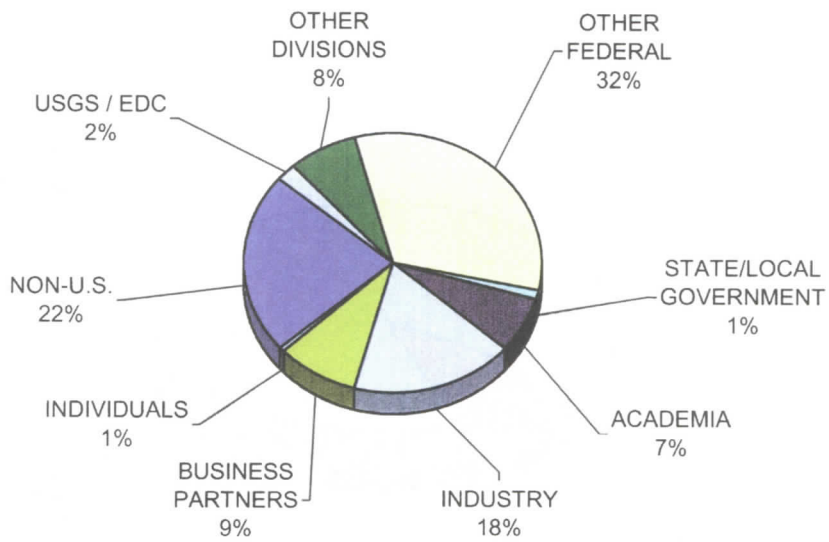
CUSTOMER CATEGORY	ITEMS	DOLLARS
USGS / EDC	63	4,800
OTHER DIVISIONS	1,133	45,141
OTHER FEDERAL	0	0
TOTAL FED. GOVERNMENT	**1,196**	**49,941**
STATE/LOCAL GOVERNMENT	0	0
ACADEMIA	0	0
INDUSTRY	0	0
BUSINESS PARTNERS	0	0
INDIVIDUALS	0	0
NON-U.S.	0	0
TOTAL	**1,196**	**49,941**



Customer Profile
EDC Landsat 7 / ETM
Fiscal Year 2000

Digital Data

CUSTOMER CATEGORY	ITEMS	DOLLARS
USGS / EDC	415	154,962
OTHER DIVISIONS	1,175	507,972
OTHER FEDERAL	7,493	2,177,980
TOTAL FED. GOVERNMENT	**9,083**	**2,840,914**
STATE/LOCAL GOVERNMENT	173	84,790
ACADEMIA	1,280	461,181
INDUSTRY	3,877	1,194,394
BUSINESS PARTNERS	1,825	597,275
INDIVIDUALS	155	49,208
NON-U.S.	5,153	1,509,011
TOTAL	**21,546**	**6,736,773**



EROS DATA CENTER ARCHIVES AND DATA BASES

This section describes those data archives, both digital and photographic, that are maintained by the EDC to preserve and catalog remotely sensed, cartographic, and other earth science data. In addition, several databases refer to data held elsewhere that are of interest to EDC customers.

As of the end of fiscal year 2000, the EDC had archived more than 12.3 million frames of photographic data and 237,170 tapes. This includes nearly 2.9 million frames of Landsat photographic data and 22,870 Landsat data tapes. The International Landsat Data Base maintained by the EDC refers to more than 1 million Landsat scenes archived in the United States, and more than 2.6 million scenes of Landsat data held by foreign ground stations.

Digital Data Processing Workload
Fiscal Year 2000

Digital Data Production	Total Items Processed
NLAPS Registrations	
Systematic	9,705
Precision Corrected	1,101
Level 0	44
AVHRR Greenness Maps	
United States	52
Alaska	28
China Historical	72
AVHRR Single Scene	
China	250
China Historical	2,152
Humid Tropical Forest Inventory	142
National Elevation Data - NED	487
GLOBE Data Sets	
United States	1,393
International	539
Custom Image Processing	143

Image processing or data capture tasks, such as, image registration and mosaicking, vector data capture, data base development, and image manipulation for greenness monitoring.

Digital Data Processing *

CUSTOMER CATEGORY	ITEMS	DOLLARS
USGS / EDC	164	43,268
OTHER DIVISIONS	376	536,987
OTHER FEDERAL	418	113,988
TOTAL FED. GOVERNMENT	**958**	**694,244**

* Image processing or data capture tasks, such as, image registration and mosaicking, vector data capture, data base development, and image manipulation for greenness monitoring.

Data Archive Report
As Of September 12, 2000

PHOTOGRAPHIC DATA ARCHIVED AT EDC

AERIAL PHOTOGRAPHY		
SOURCE	**ROLLS**	**FRAMES**
US Geological Survey	17,308	2,594,157
NAPP/NHAP	13,748	2,085,146
Bureau of Land Management	591	118,269
Bureau of Reclamation	298	59,653
National Park Service	81	13,635
Bureau of Indian Affairs	48	9,638
TOTAL DEPARTMENT OF THE INTERIOR	**32,074**	**4,880,498**
Army Map Service	1,743	206,136
US Air Force	3,116	300,167
US Navy	6,462	435,838
Corps of Engineers	98	24,076
TOTAL DEPARTMENT OF DEFENSE	**11,419**	**966,217**
Ames Research Center	5,080	606,149
Johnson Space Center	7,628	1,181,132
Other	1,386	127,948
TOTAL NASA	**14,094**	**1,915,229**
OTHER SOURCE AGENCIES	**2,225**	**363,923**
TOTAL AERIAL PHOTOGRAPHY	**59,812**	**8,125,867**

SATELLITE PHOTOGRAPHY		
SOURCE	**ROLLS**	**FRAMES**
Landsat MSS 70 mm Film (1/2/3)	7,708	1,342,187
Landsat MSS 9" B&W Film	10,628	1,338,195
Landsat TM 9" B&W Film	2,924	175,665
Color Composites, MSS	N/A	18,271
Color Composites, TM	N/A	1,866
Skylab	621	50,728
Apollo/Gemini/Apollo-Soyuz	127	18,371
Shuttle (Incl. LFC)	3,539	324,704
Declassified Intelligence Satellite Photography	17,391	945,801
TOTAL SATELLITE PHOTOGRAPHY	**42,938**	**4,215,788**

N/A = Information not available.

Data Archive Report
As Of September 12, 2000

DIGITAL DATA ARCHIVED AT EDC

SOURCE	MAGNETIC TAPES	SCENES / FILES
AERIAL IMAGE DATA		
NASA Data		
TIMS / NS001	1,732	7,323
National Park Service	94	N/A
Side-Looking Airborne Radar (SLAR)	2,523	2,928
TOTAL	**4,349**	**10,251**
SATELLITE IMAGE DATA		
* Landsat MSS/TM Digital Data	22,870	1,083,724
Landsat ETM Digital Data	N/A	159,127
AVHRR		
HRPT Data (EDC Direct and DOMSAT)	27,474	52,497
LAC Data Received via DOMSAT	29,272	67,790
Data Received From Other Sources	21,507	110,756
AVHRR 1-KM Orbital Segments	9,658	26,809
NASA Data		
SIR-C	1,556	16,781
ASAS	166	162
NALC	2,531	2,531
NDLC	10,186	6,324
SPOT Data	1,195	89,162
SPOT MSI Data	367	1,337
Department of Defense Multispectral Imagery Data	8,954	4,890
Other	974	974
TOTAL	**136,710**	**1,622,864**
USGS GEO DATA (Digital Cartographic Data)	***QUADS***	***PRODUCTS***
7.5' DIGITAL ELEVATION MODEL (DEM)	54,208	76,124
15' DIGITAL ELEVATION MODEL (DEM)	2,886	3,647
30' DIGITAL ELEVATION MODEL (DEM)	N/A	1,571
250k DIGITAL ELEVATION MODEL (DEM)	N/A	1,385
7.5'k & 15' DIGITAL LINE GRAPH (DLG)	34,636	158,179
100k DIGITAL LINE GRAPH (DLG)	1,842	21,829
1:2 M DIGITAL LINE GRAPH (DLG)	49	323
LAND USE LAND COVER (LULC)	521	2,749
GTOPO 30	N/A	35
3.75' DIGITAL ORTHOPHOTOQUAD QUARTER QUAD (DOQ QQ)	N/A	185,445
7.5' DIGITAL ORTHOPHOTOQUAD FULL (DOQ)	991	991
DIGITAL ORTHOPHOTOQUAD COUNTY CD'S (DOQ)	N/A	323
DIGITAL RASTER GRAPHICS (DRG)	N/A	56,170
NATIONAL ATLAS	N/A	89
TOTAL	**95,133**	**508,860**
EARTH SCIENCE DATA		
National Uranium Resource Evaluation (NURE/LIL)	957	7,941
Geophysical Research Program	21	N/A
TOTAL	**978**	**7,941**
TOTAL DIGITAL HOLDINGS	**237,170**	**2,149,916**

N/A = Information not available.

* Scenes no longer include RBV Data.

Data Archive Report
As Of September 12, 2000

SUMMARY OF DATA ARCHIVED AT EDC

PHOTOGRAPHIC DATA	ROLLS	FRAMES
AERIAL IMAGES	59,812	8,125,867
LANDSAT SATELLITE IMAGES	21,260	2,876,184
OTHER SATELLITE IMAGES	21,678	1,339,604
TOTAL	**102,750**	**12,341,655**

DIGITAL DATA	MAGNETIC TAPES / QUADS	SCENES / FILES / PRODUCTS
AERIAL IMAGE DATA	4,349	10,251
LANDSAT SATELLITE IMAGE DATA	22,870	1,083,724
LANDSAT ETM DIGITAL DATA	N/A	159,127
* OTHER SATELLITE IMAGE DATA	113,840	380,013
DIGITAL CARTOGRAPHIC DATA	95,133	508,860
EARTH SCIENCE DATA	978	7,941
** **TOTAL**	**237,170**	**2,149,916**

* Includes 257,852 AVHRR scenes.

** Reduced outdated physical media.

Landsat International Data Base Summary
As Of September 12, 2000

References Landsat data archived by U.S. and foreign ground stations.
Input provided via LGSOWG data exchange format tape.

COUNTRY	SCENES	LAST UPDATE	ACQUISITION DATE RANGE
USA	630,708 MSS 453,016 TM 159,127 ETM	DAILY	07/72 - 10/92 08/82 - 08/00 06/99 - Present
BRAZIL	32,617 MSS 108,689 TM	05/90 05/95	05/73 - 09/87 03/84 - 01/95
CANADA	466,225 MSS 188,616 TM	04/96 04/96	07/72 - 04/96 08/82 - 04/96
EARTHNET:			
ITALY	398,865 MSS 135,843 TM	04/95 04/95	04/75 - 12/93 04/84 - 03/95
SWEDEN	479,622 MSS 188,600 TM	04/95 04/95	04/75 - 12/93 04/84 - 03/95
MASPALOMAS (Spain)	23,918 MSS 3,058 TM	08/91 04/95	07/84 - 12/90 11/87 - 07/94
SOUTH AFRICA	58,502 MSS 38,630 TM	11/93 03/97	07/80 - 09/93 01/89 - 12/96
AUSTRALIA	210,671 MSS	09/91	09/79 - 08/91
JAPAN	185,459 MSS 130,490 TM	06/99 03/00	01/79 - 01/99 04/84 - 08/99
PAKISTAN	3,256 MSS 4,583 TM	06/90 06/90	05/89 - 12/89 05/89 - 12/89
	2,489,843 MSS **1,251,525 TM** **159,127 ETM**		
TOTAL SCENES	**3,900,495**		

(**2,657,644**) = LGSOWG TOTAL SCENES / NON-EDC

TO DATE, EDC HAS NOT RECEIVED INTERNATIONAL DATA BASE UPDATES FROM:
INDONESIA, THAILAND, PEOPLE'S REPUBLIC OF CHINA, SAUDI ARABIA, INDIA.

NOTE: FOREIGN/USA NUMBER OF MSS SCENES NO LONGER CONTAIN RBV DATA.

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ACRONYMS

ADDS - Arctic Data Dissemination Server
AFO - Alaska Field Office
AGDC - Alaska Geographic Data Committee
AGRHYMET - Agriculture, Hydrology, Meteorology
APFO - Aerial Photographic Field Office
ARDF - Alaska Resource Data File
ASPRS - American Society for Photogrammetry and Remote Sensing
ASTER - Advanced Spaceborne Thermal Emission and Reflectance Radiometer
ATREM - Atmosphere Removal
AVHRR - Advanced Very High Resolution Radiometer
AVIRIS - Airborne Visible and Infrared Imaging Spectrometer
CAFF - Conservation of Arctic Flora and Fauna
CARLISES - Caribbean Land Information System for Environmental Sustainability
CAVM - Circumpolar Arctic Vegetation Mapping
CD - Compact Disk
CD-ROM - Compact Disk - Read Only Memory
CEOS - Committee on Earth-Observation Satellites
CIR - Color infrared
cm - centimeters
CMM - Capability Maturity Model
CONAMA - Comision Nacional del Medio Ambiete
CONRED - Comision Nacional para la Reduccion de Desastres
CONUS - Continental United States
CRSP - Competitive Research Support Program
DAAC - Distributed Active Archive Center
DEM - Digital Elevation Model
DLT - Digital Linear Tape
DOD - Department of Defense
DOI - Department of the Interior
DOMSAT - Domestic Communication Satellite System
DOQ - Digital Orthophoto Quadrangle
DORRAN - Distributed Ordering, Research Reporting and Accounting Network
ECS - EOSDIS Core System
EDC - EROS Data Center
EE - Earth Explorer
EMIS - Environmental Monitoring Information System for Africa
ENSO - El Niño Southern Oscillation
EO-1 - Earth Observing Science Team
EOS - Earth Observing System
EOSDIS - Earth Observing System Data Information System
EPA - Environmental Protection Agency

EROS - Earth Resources Observation Systems
ETM+ - Enhanced Thematic Mapper Plus
FAO - United Nations Food and Agriculture Organization
FEWS NET - Famine Early Warning Systems Network
FGDC - Federal Geographic Data Committee
FHMC - Forest Health Monitoring Clearinghouse
fPAR - Fraction of Photosynthetically active radiation
FTP - File Transfer Protocol
FUNDEMUM - Fundacion para el Desarrollo Municipa÷
FY - fiscal year
GEF - Global Environment Facility
GEWEX - Global Energy and Water Experiment
GIS - Geographic Information System
GLOBE - Global Learning and Observations to Benefit the Environment
GOES - Geostationary Operational Environmental Satellite
GPN - Great Plains Network
GPS - Global Positioning System
GSFC - Goddard Space Flight Center
IASANC - Interior Alaskan Surveys and Analysis National Compilation
IGAD - InterGovernmental Authority on Development
IGDN - Inter-American Geospatial Data Network
IGN - Instituto Geografico Nacional
IGS - international ground stations
IITF - International Institute for Tropical Forestry
IMS - Internet based Map Server
INETER - Instituto Nicaraguense de Estudios Territoriales
INSAH - Sahel Institute
InSAR - interferometric synthetic-aperature radar
IPv6 - Next Generation Internet Protocols
ISDN - Integrated Services Digital Network
ISITE - name of software
INSIVUMEH - Instituto Nacional de Sismologia, Vulcanologia, Metereologia e Hidrologia
ISO - International Standards Organization
ITS - Information Technology Services
JPL - Jet Propulsion Laboratory
JRC - Joint Research Center
km - kilometers
KonVEx - Konza Validation Experiment
LAFCO - Fresno, County, California Local Agency FOrmation Commission
LAI - Leaf Area Index
LAN - Local Area Network
LCAC - Landcover Applications Center
LGSOWG-29 - Landsat Ground System Operations Working Group
LIDAR - Light detection and ranging
LTWG - Landsat 7 Technical Working Group

MAG - Ministerio de Agricultura y Ganaderia
MAG-FOR - Ministerio Agropecuario y Forestal
MARN - Ministerio de Medio Ambiente y Recursos Naturales
MARENA - Foundation Alistar and Ministerio de Recursos Naturales
Mb/sec - megabits per second
MOC - Mission Operations Center
MODIS - Moderate Resolution Imaging Spectrometer
MOU - Memorandum of Understanding
MQUALS - MODIS Quick Airborne Looks
MRDS - Mineral Resource Data System
MRLC - Multi-resolution Land Characteristics
MSS - multispectral scanner
NASA - National Aeronautics and Space Administration
NASQAN - National Stream Quality Accounting Network
NDVI - Normalized Difference Vegetation Index
NEAP - National Environmental Action Plan
NED - National Elevation Dataset
NIMA - National Intelligence Mapping Agency
NIR - Near Infrared
NLCD - National Land Cover Data
NMD - National Mapping Division
NMP - National Mapping Program
NOAA - National Oceanic and Atmospheric Administration
NPP - Net Primary Productivity
NSDI - National Spatial Data Infrastructure
PAIGH - Pan American Institute of Geography and History
PRB - Program Review Board
QoS - quality of service
RFE - Rainfall Estimate
RIIS - Regional Integrated Information System
ROWA - Regional Office for West Asia
SAR - Synthetic Aperature Radar
SDSU - South Dakota State Universit6y
SEGEPLAN - Secretaria de Planificacion y Programacion
SEPI - Software Engineering Process Improvement
SERNA - Secretaria de Recursos Naturales y Ambiente
SETCO - Secretaria Technical y de Cooperation Internacional
SGU - Sinte Gleska University
SIR-C - Shuttle Imaging Radar - C
SPOT - Systeme pour l'Observation de la Terre (France)
SRTM - Shuttle Radar Topography Mission
STATSGO - State Soil Georgraphic data base
TB - Terabytes
TM - thematic mapper
UNEP/GRID - United Nations Environmental Programme/Global Resource Information Database
USAID - U.S. Agency for International Development

USDA -	United States Department of Agriculture
USEPA -	United States Environmental Protection Agency
USFS -	United States Forest Service
USFWS -	United States Fish and Wildlife Service
USGS -	United State Geological Survey
VoIP -	voice over IP
WAN -	Wide Area Network
WMO -	World Meteorological Organization
WWW -	World Wide Web
Y2K -	Year 2000

A WORD IN CONCLUSION

In closing this report EDC staff reaffirm their dedication to customer satisfaction. We understand that the value of the data we provide is in its usefulness to our customers. While we remain actively aware of the changing needs of our customers, we encourage our customers to let us know how we are doing and to share with us possible improvements. If you desire more information about our products and services, please contact the EDC Customer Services office at:

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