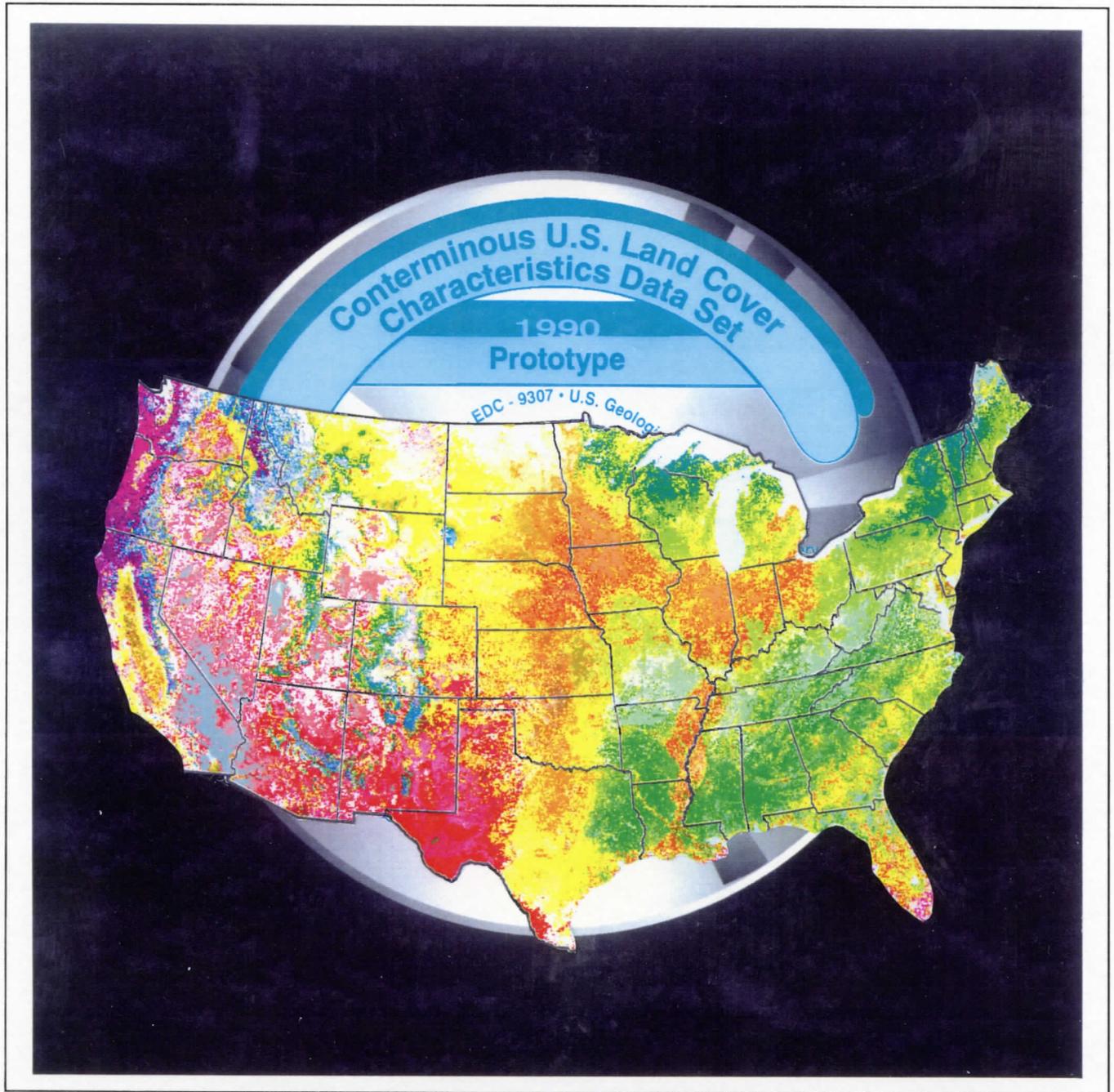


EROS DATA CENTER
ANNUAL REPORT

FISCAL YEAR 1993



**U.S. GEOLOGICAL SURVEY
NATIONAL MAPPING DIVISION**

The EROS Data Center Vision

“We are stewards of land remote sensing and associated data, advancing the availability and applicability of these data for scientific and land management users worldwide.”

FOREWORD

From its inception in 1971, the U.S. Geological Survey's EROS Data Center has been committed to providing remotely sensed land-surface data and technical assistance of the highest quality to national and international organizations involved in land management and environmental assessment activities. In 1993, and in keeping with its commitment, the Data Center provided a wide variety of scientific, production, and data management support to the land management and earth science communities.

The Data Center was pleased to host the 12th William T. Pecora Memorial Remote Sensing Symposium. Over 300 were in attendance as scientists from around the world focused on the theme, "Land Information from Space-based Systems." We were honored to receive the 1993 Federal Leadership Award, expressing excellence in technology, for the Global 1-km Advanced Very High-Resolution Radiometer (AVHRR) Data Set Project. A new initiative called, The Multi-Resolution Land Characteristics (MRLC) Monitoring System project, represents a significant framework for cooperation between several Federal organizations in the development of a regional land characteristics data base. In addition, the Data Center continues to support other major efforts including Landsat data conversion and maintenance, EPA's North American Landscape Characterization (NALC) program, Arctic land processes, international projects largely for the U.S. Agency for International Development (USAID), and the United Nations Environmental Programme/Global Resources Information Database (UNEP/GRID).

We face the future with optimism as the EROS Data Center assumes new and challenging roles as the Earth Observing System Data and Information System (EOSDIS) Land Processes Distributive Active Archive Center (LPDAAC), the Landsat 7 Data Handling Facility (DHF), and as the National Satellite Land Remote Sensing Data Archive. These activities will be part of a comprehensive national satellite land remote sensing data management program. Critical to these efforts will be the Center's building addition scheduled for construction during 1994-95. We also anticipate a strong partnership role with the National Biological Survey, newly established within the Department of the Interior.

To support these and several other major activities, the Center's team of skilled scientists, technicians, and clerical staff work diligently to maintain the EROS Data Center's high level of excellence in the areas of data management, product generation, computer systems development, and spatial data research as reflected in this report.

We are pleased to provide this annual report for fiscal year 1993, which summarizes the activities and accomplishments of the EROS Data Center.

Donald T. Lauer
Chief, EROS Data Center

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COVER

The conterminous U.S. land characteristics data base was developed from 1990 1-km resolution Advanced Very High Resolution Radiometer (AVHRR) data. The data base includes the cover map of seasonal land cover regions and detailed attributes describing a range of land cover, seasonal, and site characteristics. The entire data base, including source data, are available through the USGS on CD-ROM media.

OVERVIEW OF THE EROS DATA CENTER

The Earth Resources Observation Systems (EROS) Data Center (EDC), located in Sioux Falls, South Dakota, is a data management, systems development, and research field center of the U.S. Geological Survey's National Mapping Division (NMD). The Center was established in the early 1970's to receive, process, and distribute data from National Aeronautics and Space Administration (NASA) experimental Landsat satellites. As the National Satellite Land Remote Sensing Data Archive, a legislatively mandated responsibility, the Center maintains a high quality data base of space acquired images of the earth suitable for use in study of global change and related scientific programs. It holds the world's largest collection of space and aircraft acquired imagery of the Earth. These holdings include over 10.2 million frames of photographic data and over 152,000 digital tapes. The Center is also a major focal point for information concerning the holdings of foreign Landsat ground reception stations and data acquired by other countries' Earth observing satellites, and receives and processes image data from the Advanced Very High Resolution Radiometers (AVHRR) on polar orbiting meteorological satellites.

In carrying out its mission, the Data Center conducts a broad range of activities in the management of global Earth observations data, including the development and operation of advanced systems for receiving, processing, distributing, and applying land related earth science, mapping, and other geographic data and information. These data support scientific studies, resource management, and environmental monitoring activities world-wide. The Center's own research activity is supported by a combined multidisciplinary scientific staff in geology, hydrology, cartography, geography, agronomy, soils science, forestry, meteorology and climatology with engineering expertise in systems development, telecommunications, and the computer sciences.

The Center is a key participant in NASA's "Mission to Planet Earth" and plans to process and archive land related data acquired by a family of sensors aboard the Earth Observing System (EOS) polar platforms, the first of which is to be launched in the late-1990's. In its capacity as the Earth Observing System Data and Information System (EOSDIS) Land Processes Distributive Active Archive Center (LPDAAC), the Center is assuming a major role in the management and distribution of land remote sensing data for use by the global change research community.

Co-located at the Center is the United Nations Environmental Programme/Global Resource Information Database (UNEP/GRID) North America Node office. This office is one of several throughout the world that form a network for the distribution of data and research techniques for timely environmental studies by member nations. The Data Center, under a joint partnership with NASA, is the primary source for these data.

The Center supports the Federal Land Remote Sensing Research Program. This Program allows Federal agencies, universities, and other organizations to assign scientists and researchers to the Center on a full-time basis with complete access to analytical equipment, data, and research facilities of the Center.

Facilities at EROS include advanced data and information analysis laboratories, production data processing systems and digitizing capabilities, business and scientific systems, software development, geographic information systems development and implementation, and on-line computerized access to data directory, catalog, and inventory information about the Center holdings and the land data holdings of other facilities.

A Word About the
NATIONAL SATELLITE LAND REMOTE SENSING DATA ARCHIVE

Since the launch of the first Landsat satellite in 1972, the Earth Resource Observation Systems (EROS) Data Center (EDC) has archived and distributed Landsat image data, which provides a multi-year, multi-sensor baseline of historical information about conditions and changes that cannot be provided from any other source and which will give the earth science community a head start for long-term monitoring of the Earth's resources.

The importance of preserving and ensuring long-term access to Landsat and other land remote sensing satellite data is recognized in the Land Remote Sensing Policy Act of 1992, Public Law (P.L.) 102-555, passed on October 28, 1992. The Act re-established a strong U.S. satellite land remote sensing program and assigns joint management responsibility for the Landsat Program to the National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD). The Act further directs DOI to establish and manage a National Satellite Land Remote Sensing Data Archive, the responsibility which has been delegated to the National Mapping Division's EROS Data Center.

The Archive, as defined by P.L. 102-555, provides for the preservation of and access to satellite-acquired land remote sensing data, with related research activity. While Landsat data are currently the largest single element of the Archive, other satellite data are also important elements. In defining the content of the Archive, i.e., the "basic data set," the Act states that the Archive should consist of the Landsat data already archived as of the date of the Act, that the development of the data set should take into account future needs of the science community, especially global environmental change researchers, and that DOI should seek the advice of both the producers and users of remotely sensed data products. The Archive may include data collected by foreign ground stations or sensor systems. The Act further stipulates that after the expiration or relinquishment of any exclusive rights to sell the data in the Archive that may have been awarded to others, the data shall be in the public domain and made available "...at the cost of fulfilling user requests." Figure 1 identifies major responsibilities of the Act related to EDC.

Currently, the Archive includes all U.S.-held Landsat 1-5 data, that was acquired before October 28, 1992, all Advanced Very High Resolution Radiometer (AVHRR), Gemini/Apollo, Skylab, and Shuttle data currently held at EDC, and will include all EOS land processes data acquired by NASA, all Landsat 7 data to be acquired by the U.S. Government, and selected subsets of satellite land data acquired by non-U.S. satellites and ground receiving stations.

The Data Center, in its role as the National Satellite Land Remote Sensing Data Archive, is investigating new techniques to improve the quality and accessibility of products and services from the Archive. To that end, the Archive activities include: determination of the initial and future content of the Archive; science support, definition of product

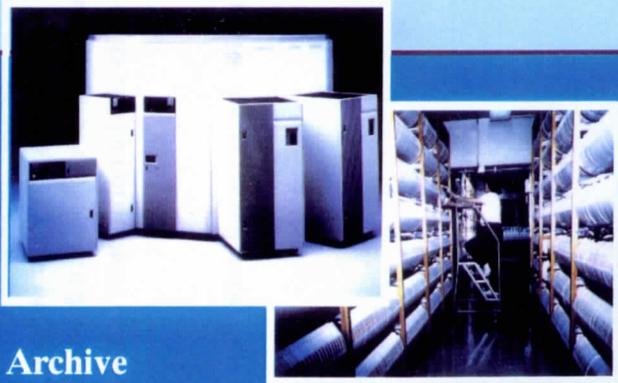
The Land Remote Sensing Policy Act of 1992

(Public Law 102-555)

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

RESPONSIBILITIES

- Develop and manage the National Satellite Land Remote Sensing Data Archive
- Ensure long-term preservation of land remote sensing data
- Receive, process, and distribute to the science community civil satellite data, e.g., Landsat, AVHRR, etc.
- Enhance the Nation's ability to manage its renewable and nonrenewable resources
- Achieve cost savings to Government through centralized archive



Archive

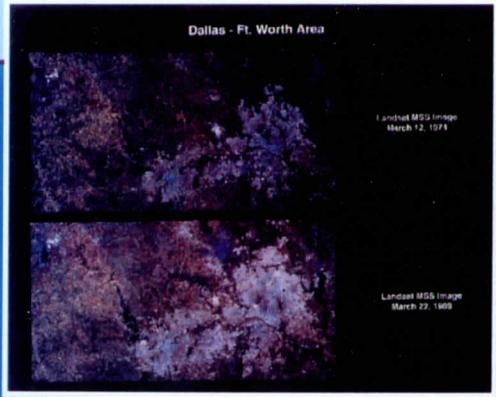


Figure 1

characteristics and community-consensus algorithms to guide data processing systems; systems engineering and development, to continue data conversion of historical Archive data and develop new data conversion systems for future Archive data; archive population and preservation, data ingest and processing of current and future satellite data systems and data preservation; customer services, maintenance and development of information systems to provide information about Archive content as well as references to data held by other land data archives; and production processing, development of systems to provide unenhanced data products from all Archive data sets. The value to global change research scientists for archiving these data sets is shown by Figure 2, which compares, over time, the increase of the Omo River delta on the north shore of Lake Turkana, Ethiopia.

The following are selected activities related to the Archive that occurred during FY 1993.

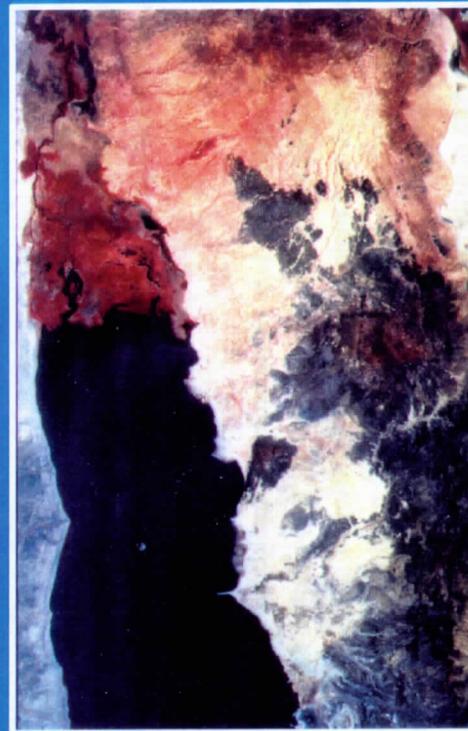
Global Land Data Lake Turkana, Ethiopia



February 1, 1973



January 1, 1979



January 12, 1989

**Landsat Multispectral Scanner Data
Monitoring Change**

NMD-178-93

Figure 2

NATIONAL SATELLITE LAND REMOTE SENSING DATA ARCHIVE

Landsat Operations

Landsat 4-5 Operations

Thematic Mapper (TM) and Multispectral Scanner (MSS) systems are nominal, however, communications system failures impact data acquisition. Landsat 5 has lost data relay capability, but has full direct downlink capability to foreign ground stations and to the Earth Observation Satellite Company (EOSAT) data reception facility in Norman, Oklahoma.

Policy negotiations between the Landsat Program Management team of Department of Defense, National Aeronautics and Space Administration (NASA) and U.S. Geological Survey (USGS) and the EOSAT, regarding data acquisition, archiving, distribution, pricing, and use restrictions have improved recently. If agreement is not reached by September 30, 1993, a report to Congress is due stating alternatives for resolution. The intent of these negotiations is to maximize Landsat 4-5 data availability to government users at minimum prices.

Landsat 6

Current information about the demise of Landsat 6 indicates that the Titan 2 launch vehicle first and second stages performed as expected. However, it is believed that the apogee kick motor did not ignite at lift off +15 minutes. The planned orbit was not achieved, and the spacecraft, following a high altitude ballistic trajectory, re-entered the atmosphere somewhere over the South Pacific Ocean (October 8, 1993).

Data Management

National Satellite Land Remote Sensing Data Archive Forum

EDC hosted the Data Archive Forum in conjunction with Pecora 12, August 24-26. The purpose of the Forum was to solicit input on the plans and policies of the Archive from representatives of the value-added industry, and from the scientific, academic, government, and industrial/commercial users of remote sensing data. The Forum consisted of a short presentation by EDC on proposed Archive data content, products, services, activities and policies, followed by panelists' presentations and discussion.

Landsat Data Conversion and Maintenance

P.L. 102-555 requires the U.S. Government to maintain Landsat data for long-term scientific analysis and study. To ensure that these data are available in the future, EDC has embarked on a major program to transfer all U.S. Landsat data to a new storage media. After evaluating several types of archival media, the Digital Cassette Recording System-incremental (DCRSI) technology was selected because of its excellent reliability, low cost, high data density (48 gigabytes/ cassette) and high transfer rates (107 megabits/second).

The TM/MSS Archive Conversion System (TMACS) began converting MSS data to DCRSi cassettes in December 1992. Approximately 7,200 high density tapes containing

150,000 MSS scenes have been converted to 193 cassettes. Completion of this effort is scheduled for June 1994. The Landsat TM conversion will start in November 1993, with the conversion of more than 215,000 scenes to be completed by June 1996. About 8,300 MSS scenes on tapes with serious hydrolysis problems (i.e., tape binder absorbs moisture causing the binder to degrade and create a gummy residue buildup on the tape) were recovered after a special baking process for 24 hours at 55°C. EDC has had 100 percent success with the baking procedure which temporarily reverses the hydrolysis process, making tape to cassette copying possible. A routine was developed to monitor cassette tape integrity over time. Logistics were finalized with NOAA and EOSAT to make incremental shipments of Landsat 4/5 TM data over the next two and half years from the D.C. area to EDC.

With the conversion of the Landsat data archive to a digital cassette recording media, a new product generation system is being implemented. A contract for the development and implementation of the National Landsat Archive Production System (NLAPS) was awarded in October 1992 with an anticipated completion date in late 1994. The new system will replace obsolete MSS processing systems and will add the capability to generate TM products. When installed NLAPS will produce fully corrected products from Landsat 1-5 data. The baseline system provides the capability for ground control point collection, image to map correction, elevation correction, and processing data from foreign ground stations. The production system is designed to provide up to 7 TM or 20 MSS minimally processed products per day to satisfy public and value-added users, and 5 to 7 fully corrected products for Federal program requirements. Prior to the implementation of the NLAPS, EDC will continue to provide MSS data from the archive to the user community with the processing system implemented in 1979. The requirements for the Product Distribution System (PDS) which will disseminate products from NLAPS have been identified, with the final PDS design planned for early FY 1994.

*National Landsat
Archive Production
System (NLAPS)*

Global Land Information System (GLIS) was significantly enhanced in April 1993 with the release of its graphical functions in an X-Windows environment, called XGLIS, that is accessible over the Internet. The initial release of XGLIS is the first phase of a full X-Windows graphical user interface. The design of the full XGLIS user interface was completed in August. Implementation and testing of the full XGLIS system is scheduled to be completed by the end of the second quarter of FY 1994.

*Global Land
Information System
(GLIS)*

Registered users of GLIS increased to over 3,000 by the end of FY 1993, represented by 27 percent government, 40 percent academic, and 33 percent private sector and others. This increase represents about 4,000 GLIS query sessions per month. During the year 16 USGS data sets were added to the GLIS system, many of which link automated ordering to the Distributed Ordering, Research, Reporting, and Account Network (DORRAN) system. In addition, over 67,000 AVHRR images were referenced in GLIS.

Following the commercialization of the Landsat system in 1984 (P. L. 98-365), the USGS established a purchasing agreement to assist Federal agencies in obtaining Landsat products and services from the EOSAT Company, the commercial operator of

*Centralized Data
Search and Order
Capability*

the Landsat satellite system. In 1987, a similar agreement was established with the SPOT Image Corporation, the exclusive distributor of SPOT satellite data in the United States. These purchasing agreements eliminated the need for each Federal agency to establish and administer separate agreements for the purchase of civil satellite data and provided a mechanism for each Federal agency to issue a single purchase order for both Landsat and SPOT satellite products and services. While the use of the agreements is optional, since 1985, 30 different Federal agencies have purchased over \$28 million worth of data through these agreements, with \$3.4 million purchased by 17 agencies in FY 1993.

In addition, data purchased by other Federal agencies become candidates for inclusion in the National Archive, ensuring widest possible distribution and long-term preservation of the data. EDC was asked to facilitate the collection of multi-agency requirements in support of the Committee on Earth and Environmental Sciences Global Change Program in order to eliminate duplicate orders and to provide data management support for establishment of a centralized archive and distribution capability.

*Greenness Mapping
Production*

EDC continues to produce comprehensive time series data sets of calibrated georegistered biweekly vegetation greenness condition products. These products are useful for monitoring vegetation condition in a number of ecosystems including forests, agriculture crops and grasslands. Digital files of the final products are distributed on CD-ROM media. During 1993 EDC produced 45 greenness products. These included 21 biweekly periods over the conterminous United States, 6 - ten day periods covering the Newly Independent States of the USSR for June and July 1993, and an additional historical data set covering the same area for June and July 1989. Twelve total biweekly periods were also completed over the Middle East for 1988, 1989 and 1993, one period each month for March, April, May and June.

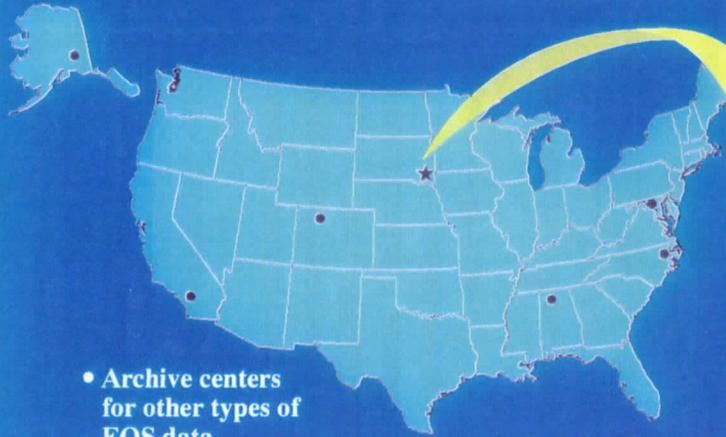
LAND PROCESSES DISTRIBUTED ACTIVE ARCHIVE CENTER (LPDAAC)

In support of NASA's Mission to Planet Earth Program and its EOS program, the EROS Data Center has been designated by NASA as the land data archive in its network of EOS centers. As the LPDAAC for the EOS Program, the Data Center is responsible for the processing, archiving, distribution systems, and related science support for the EOS Program. (Figure 3)

*Earth Observing
System Data and
Information System
(EOSDIS) Planning
and Development*

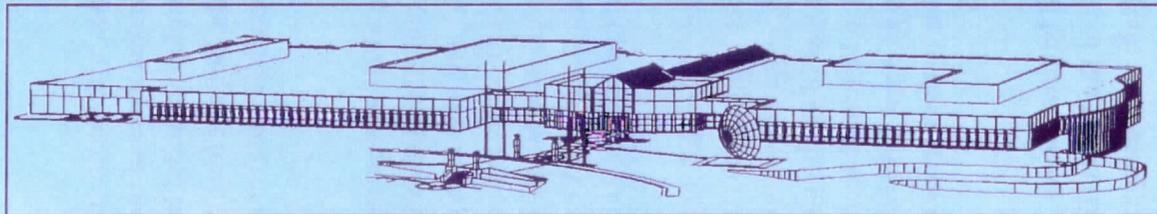
LPDAAC management and engineering staff continued to meet with EOSDIS Project personnel and with DAAC Managers of the other DAACs in the EOSDIS network regarding EOSDIS evolution. In addition, DAAC personnel attended the EOSDIS Core System (ECS) requirements review, held in September 1993, at the Goddard Space Flight Center. That review presented the first real opportunity for EDC staff to review systems requirements from a comprehensive perspective. A major issue of the LPDAAC is the interface between the EOSDIS and the Landsat 7 DHF, which at present is not well defined.

Mission to Planet Earth



- Archive centers for other types of EOS data

**Land Processes
Distributed Active
Archive Center**
U.S. Geological Survey
EROS Data Center



Earth Observing System Land Processes Data Management

- NASA designated USGS/EDC as the land data archive in its network of EOS archive centers.
- USGS/EDC facility will be expanded by late 1995 to prepare for increased EOS data management responsibilities.
- Data management activities will begin in early 1996 to provide access to pre-EOS data sets.
- NASA will fund all EOSDIS development, implementation, and operations. USGS will fund data archiving after data are 3-years old (starting year 2001).

Figure 3

***EDC Building
Addition***

The USGS will fund construction of basic facilities (\$5 million in FY 1994 and \$4 million in FY 1995). NASA will fund unique ancillary systems and equipment (about \$3.5 million over FY 1994, 1995 and 1996) required for LPDAAC operations. Construction is scheduled to begin early next Spring to support delivery of ECS equipment beginning in early 1996. The December 12, 1992, NASA/USGS Memorandum of Understanding (MOU) has been revised to be consistent with current plans for the building addition. Architectural renderings of the building's exterior and interior lobby is shown by Figure 4 and 5.

Landsat 7

EDC hosted a Landsat 7 forum in conjunction with Pecora 12, August 24-26. The purpose of the Forum was to provide a current status of the program, space and ground segment, data policy, and studies to develop advanced land remote sensing systems beyond Landsat 7. Formal release of the Request for Proposal for the DHF which will be implemented and operated by the USGS (cost reimbursed by NASA) has slipped into early December.

***Global 1-km
Advanced Very
High-Resolution
Radiometer
(AVHRR) Data
Set Project***

The first prototype 10-day global land 1-km AVHRR vegetation index composite was produced in accordance with processing standards defined by the international science community. The product is the first element of a data set of global vegetation index data that will be used in mapping global land cover, in the study of global ecosystems, as input to atmospheric mesoscale and general circulation models, and other global climate change research. The Normalized Difference Vegetation Index (NDVI) band will be produced on CD-ROM for general distribution. (Figure 6)

The Global 1-km AVHRR Data Set Project received the 1993 Federal Leadership Award, expressing excellence in technology, as one of 26 projects selected from 150 nominations. There is general agreement among the ground station operators to extend the Global 1-km project for one year beyond the initial 18 month period, pending available funding. Approximately 22,000 High Resolution Picture Transmission (HRPT) AVHRR scenes have been archived since the project began April 1, 1992. A browse image and metadata for each scene has been made available to the science community for evaluation, ordering, and distribution using the GLIS.

***Digital Elevation
Model (DEM) Data
Base Development
and Analysis***

Production began for a global 30 arc-second (approximately 1 kilometer) Digital Elevation Model (DEM) using Digital Chart of the World (DCW) contour and hydrology data. Data sets were produced for Haiti and Madagascar. In process were data sets for Japan, Africa, and North and South America.

Evaluation was made of the Canadian 1:250,000 vector data for producing gridded elevation data. Data for part of the Boreal Ecosystem-Atmosphere Study (BOREAS) site in Manitoba, Canada, were processed and delivered to BOREAS team members at the Goddard Space Flight Center for their use. A joint EROS Data Center-Canada Centre for Remote Sensing meeting was held in Winnipeg to discuss the results of the Canadian data and the DCW processing.

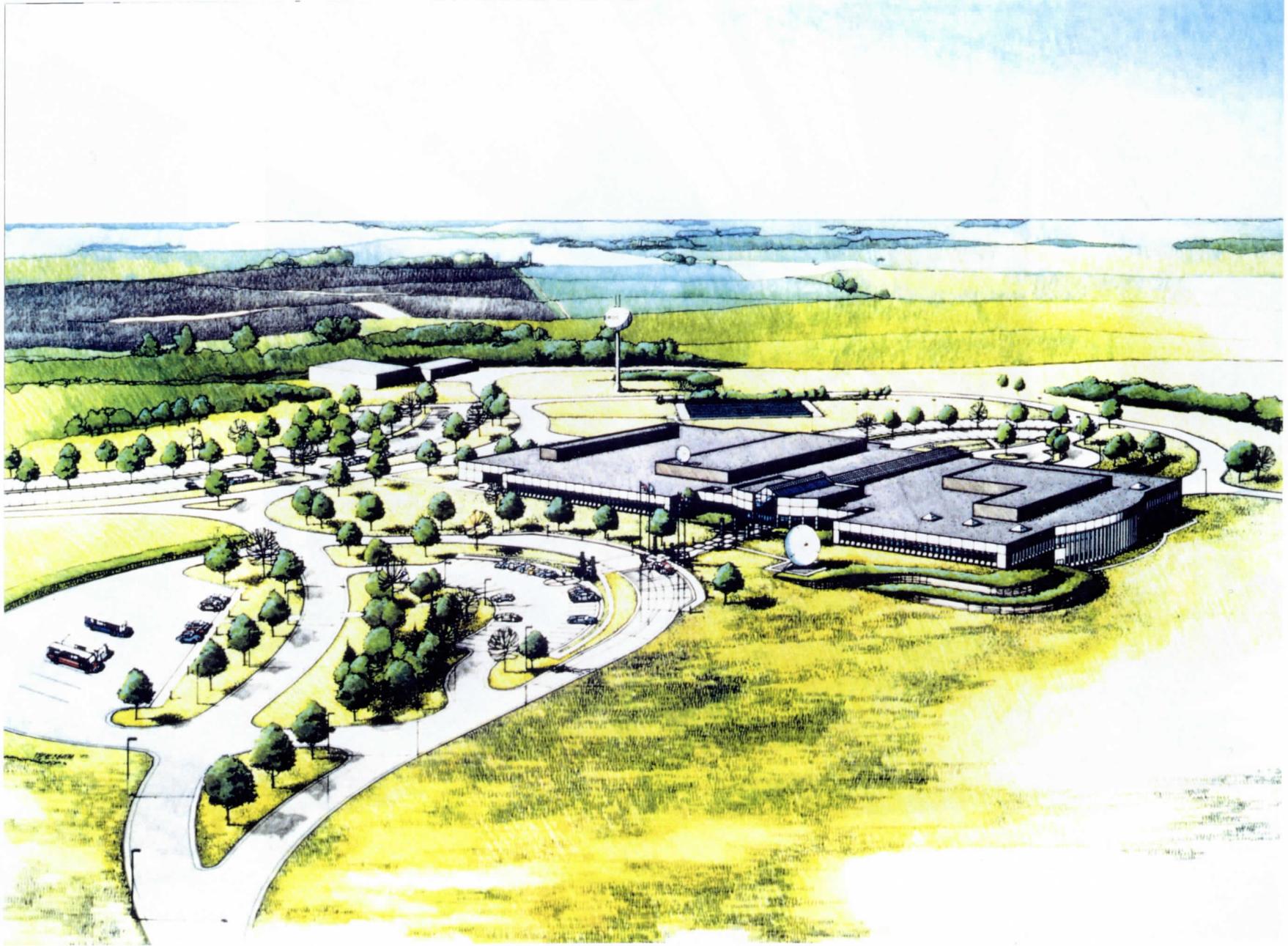


Figure 4

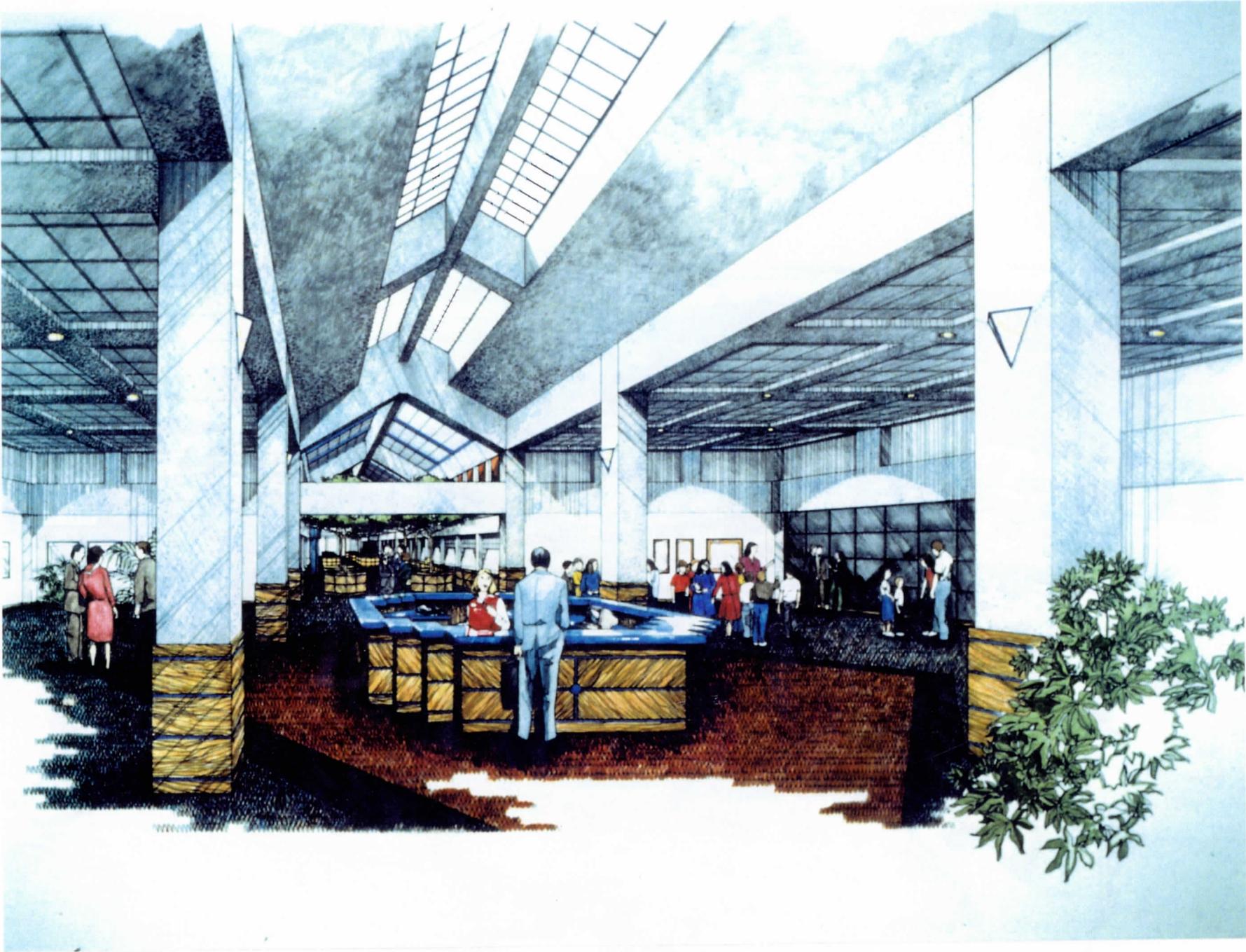


Figure 5



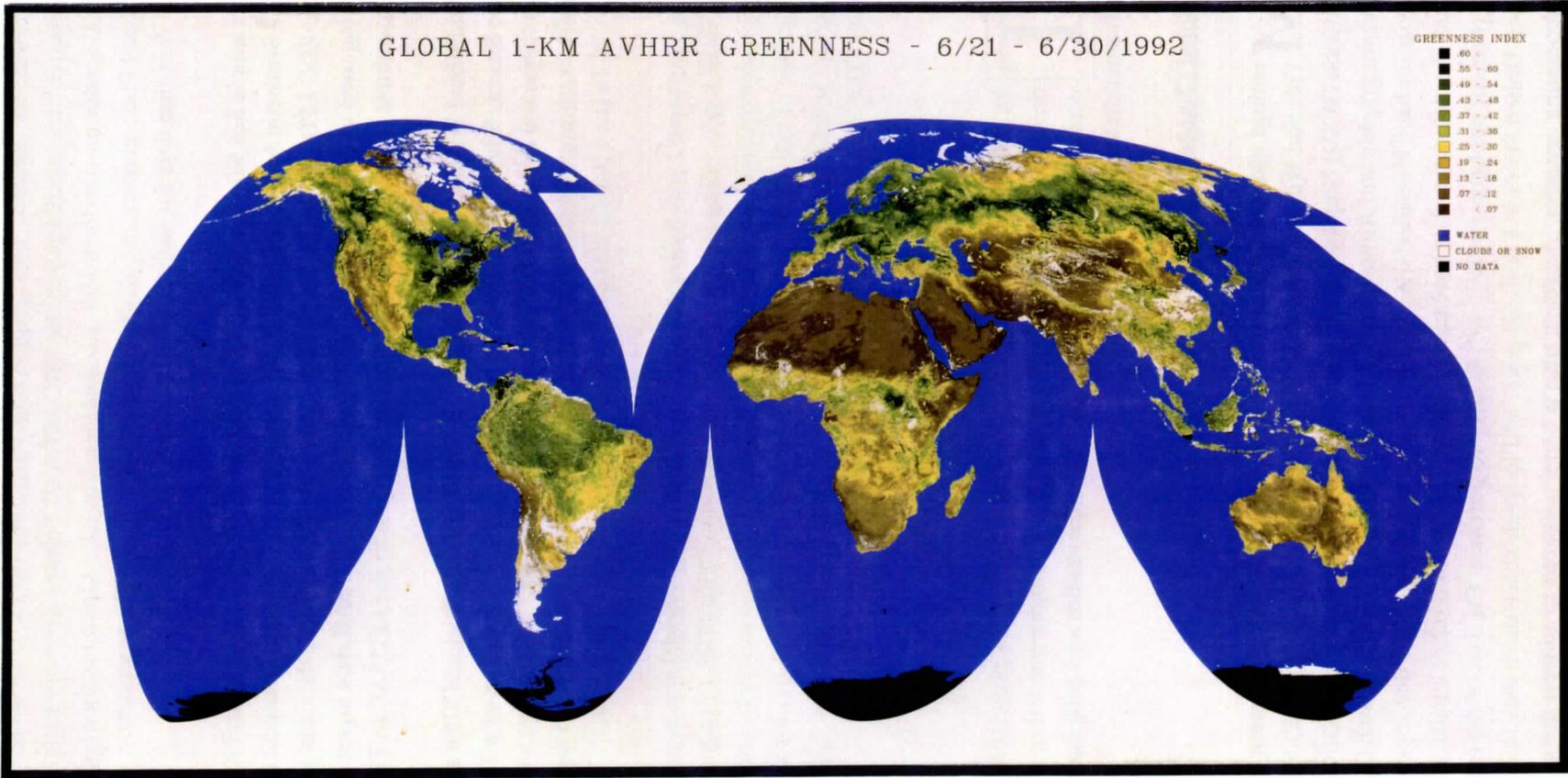


Figure 6

A document entitled "Topographic Data Requirements for EOS Global Change Research" was distributed to the EDC LPDAAC Science Advisory Panel for review. A final version of the document was completed in July. Operator training for the Helava Digital Photogrammetric Workstation began in June. The workstation will generate digital elevation data for various EOS test sites.

Version 0 Data Sets

Sample Sea Satellite (SEASAT), SIR-B (Shuttle Imaging Radar), and AIRSAR processed Synthetic Aperture Radar (SAR) image data and associated metadata were provided to the EDC LPDAAC by Jet Propulsion Laboratory (JPL). These data and metadata are being used to begin the design and development of the SAR data ingest software and procedures to support SAR data transfer from JPL to the LPDAAC in FY 1994.

Additional funding was provided by the NASA EOSDIS Project Office and forwarded to the Stennis Space Center (SSC) to proceed with the development of a Thermal Infrared Multispectral Scanner (TIMS) data transcription system. This system will be used in FY 1994 to support the transcription of SSC TIMS data for transfer and ingest by the EDC DAAC in the same format as the Ames Research Center TIMS data.

Version 0 Synthetic Aperture Radar (SAR) Product Generation

A Japanese Earth Resources Satellite-1 (JERS-1) SAR model was incorporated into the SAR geocoding and terrain-correction system. Two JERS-1 images were successfully geocoded and terrain-corrected. The JERS-1 images were mosaicked and co-registered to a mosaic of two Earth Resources Satellite-1 SAR images. A false color image of the two mosaics was created and compared to a Landsat derived vegetation map of the same area. The false color image shows promise for vegetation mapping.

RESEARCH AND TECHNOLOGY

The EROS Data Center conducts a variety of research projects to design and develop advanced methodologies and technologies needed by the earth science community in its pursuit of global change studies and geographic and spatial information analysis.

Global Change Research

Multi-Resolution Land Characteristics (MRLC) Monitoring System

Meetings with the EPA Environmental Monitoring and Assessment Program, U.S. Fish and Wildlife Service (USFWS) Gap Analysis Project, (GAP) Water Resources Division (WRD) National Water Quality Assessment Program, and National Oceanographic and Atmospheric Administration (NOAA) Coastwatch-Change Analysis Program have identified the framework for cooperation in the development of a regional land characteristics data base using Landsat TM data and other ancillary data. An agreement has been reached with EOSAT to purchase TM data of the entire conterminous United States at a reduced price, and to freely share these data among the cooperating agencies. A project plan is being prepared to address the requirements for preprocessing the TM data, classification, data management, development of the regional

land characteristics data base, and associated research issues.

The development and applications assessment of the conterminous U.S. land cover characteristics data base from AVHRR and other earth science data was completed. A CD-ROM was published that contains the final seasonal land cover classification, selected derived files, and all source data used in the analysis. Twelve universities and federal research laboratories have participated in the evaluation of the data base for land process modeling. Twenty technical papers have been published by the evaluators describing their findings in the use of the data for land-atmosphere interaction modeling. The U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) have completed the field component of the national accuracy assessment. Data base accuracy figures will be available in early 1994. The foldout map of the conterminous U.S. illustrates the seasonal land cover regions (Figure 7).

*AVHRR Land
Data/Characteristics*

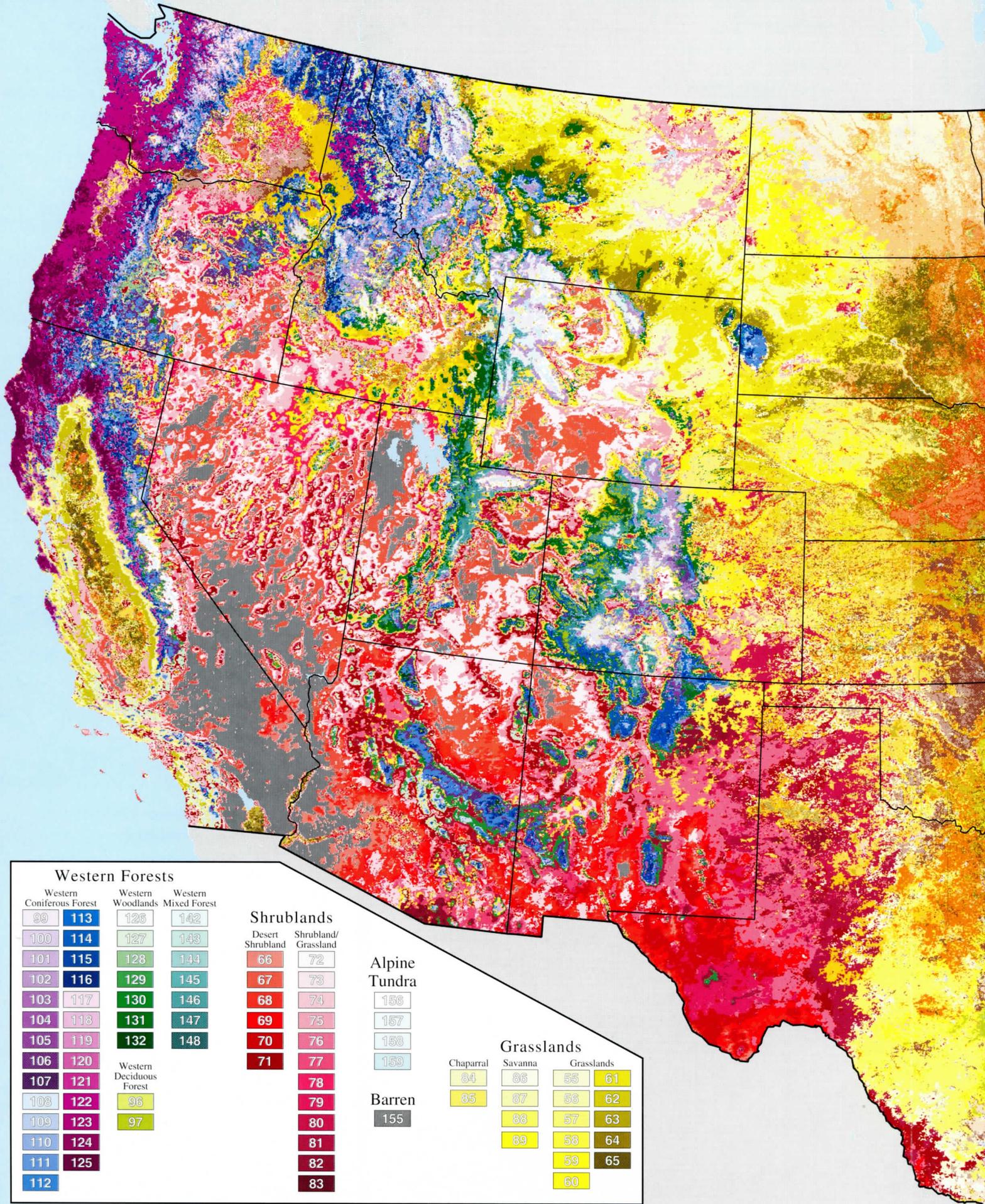
A paper entitled "Integration of Environmental Simulation Models with Satellite Remote Sensing and Geographic Information Systems Technologies: Case Studies" was presented at the Pecora 12 Symposium. This paper outlines the activities of several environmental modelers who are testing and evaluating the land cover characteristics data base. The International Geosphere-Biosphere Programme Land Cover Working Group (LCWG) met in Ispra, Italy to discuss the development of a global land cover data set from 1-km AVHRR data and is looking to EDC to lead this effort.

Terrestrial Ecosystem Regional Research and Analysis (TERRA) staff participated in a series of meetings August 10-12, in Albuquerque and Santa Fe, New Mexico, organized by the BLM headquarters staff, to explore opportunities for cooperative definition of sustainable management of land resources in the Rio Grande Basin. Participants included other Federal agencies (Soil Conservation Service, USFWS, Bureau of Indian Affairs, National Park Service (NPS), USGS/WRD), State agencies (State Engineer's Office, State Land Commissioner, State Department of Fish and Game, State Forester), local governments (Bernalillo County, City of Albuquerque), and the Sustainable Biosphere Initiative of the Ecological Society of America.

*Terrestrial Ecosystem
Regional Research
and Analysis
(TERRA) Laboratory*

A total of 105 geocoded Landsat MSS triplicates were produced and shipped to the EPA Environmental Monitoring Systems Laboratory in Las Vegas, Nevada. Image-to-map registration of United States scenes will be expedited through the use of 100K Digital Line Graph (DLG) data. The DLG data will be used in conjunction with the modified Land Analysis System tie-points software to facilitate image-to-map registration using area features rather than control points. The NALC interim Information Management System is being developed using ARC/INFO tools which will allow interactive query and graphic display of the NALC image data base. This will allow monitoring growth of the NALC data base, tracking of orders and products, and query of the metadata for each triplicate product.

*North American
Landscape
Characterization
(NALC) (EPA)*



Western Forests

Western Coniferous Forest		Western Woodlands		Western Mixed Forest	
99	113	126	142		
100	114	127	143		
101	115	128	144		
102	116	129	145		
103	117	130	146		
104	118	131	147		
105	119	132	148		
106	120				
107	121	Western Deciduous Forest			
108	122	96			
109	123	97			
110	124				
111	125				
112					

Shrublands

Desert Shrubland	Shrubland/Grassland
66	72
67	73
68	74
69	75
70	76
71	77
	78
	79
	80
	81
	82
	83

Alpine Tundra

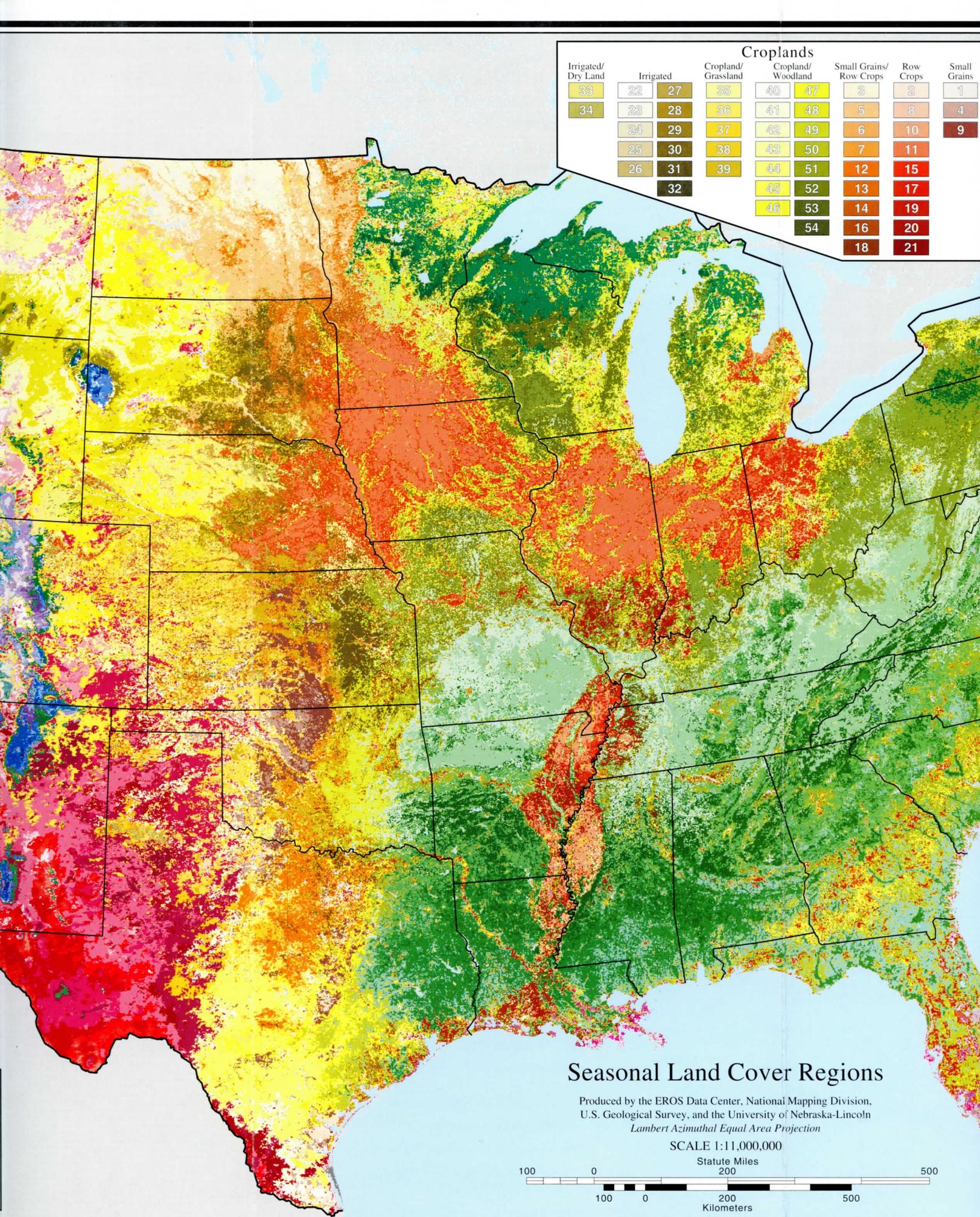
156
157
158
159

Barren

155

Grasslands

Chaparral	Savanna	Grasslands	
84	86	55	61
85	87	56	62
	88	57	63
	89	58	64
		59	65
		60	



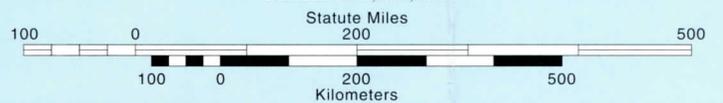
Croplands

Irrigated/ Dry Land	Irrigated		Cropland/ Grassland	Cropland/ Woodland		Small Grains/ Row Crops	Row Crops	Small Grains
33	22	27	35	40	47	3	2	1
34	23	28	36	41	48	5	8	4
	24	29	37	42	49	6	10	9
	25	30	38	43	50	7	11	
	26	31	39	44	51	12	15	
		32		45	52	13	17	
				46	53	14	19	
					54	16	20	
						18	21	

Seasonal Land Cover Regions

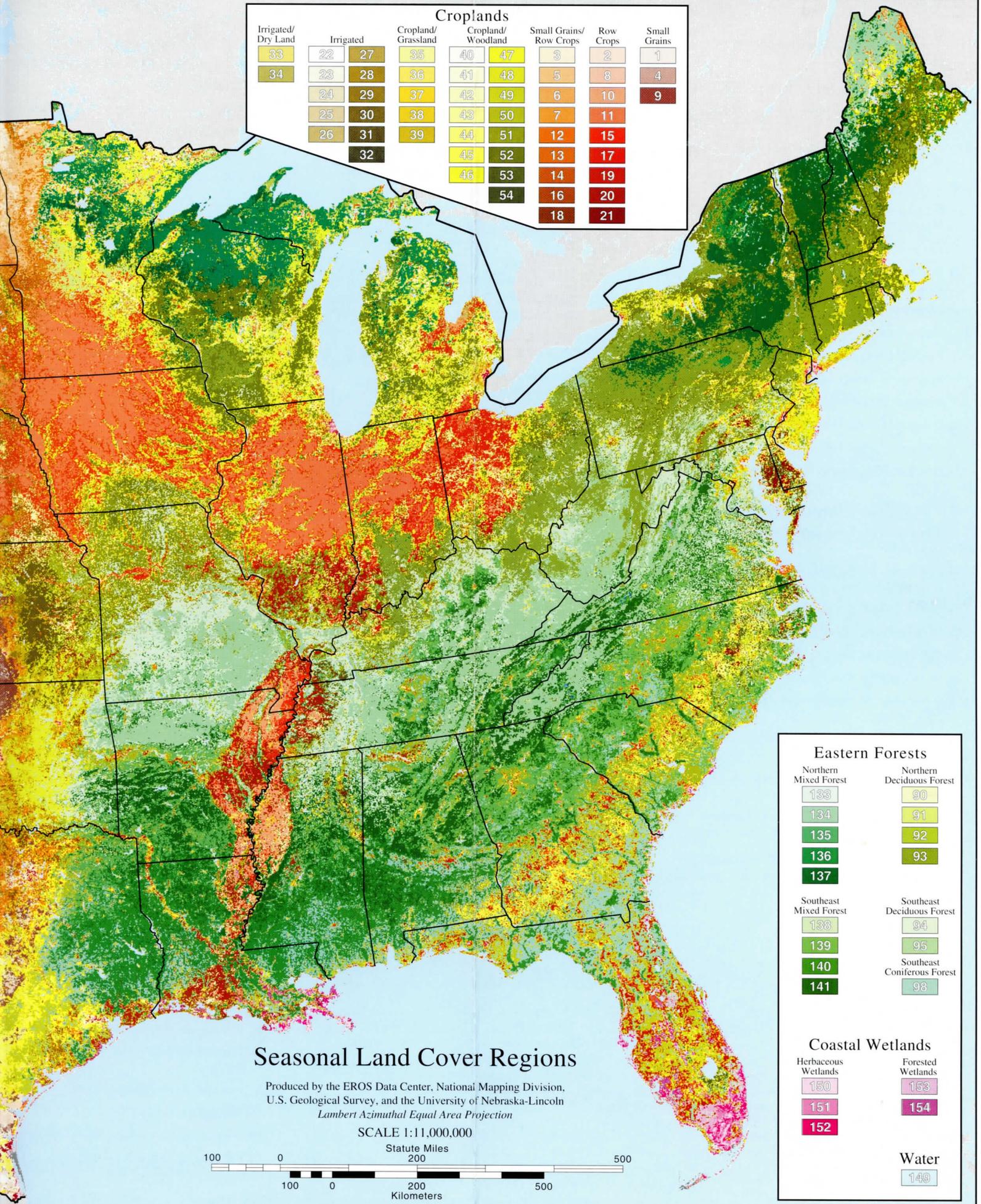
Produced by the EROS Data Center, National Mapping Division,
U.S. Geological Survey, and the University of Nebraska-Lincoln
Lambert Azimuthal Equal Area Projection

SCALE 1:11,000,000



Croplands

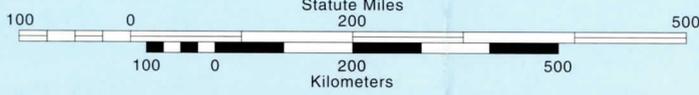
Irrigated/ Dry Land	Irrigated		Cropland/ Grassland	Cropland/ Woodland		Small Grains/ Row Crops	Row Crops	Small Grains
33	22	27	35	40	47	3	2	1
34	23	28	36	41	48	5	8	4
	24	29	37	42	49	6	10	9
	25	30	38	43	50	7	11	
	26	31	39	44	51	12	15	
		32		45	52	13	17	
				46	53	14	19	
					54	16	20	
						18	21	



Seasonal Land Cover Regions

Produced by the EROS Data Center, National Mapping Division,
U.S. Geological Survey, and the University of Nebraska-Lincoln
Lambert Azimuthal Equal Area Projection

SCALE 1:11,000,000



Eastern Forests

Northern Mixed Forest	Northern Deciduous Forest
133	90
134	91
135	92
136	93
137	
Southeast Mixed Forest	Southeast Deciduous Forest
138	94
139	95
140	
141	98
	Southeast Coniferous Forest
	93

Coastal Wetlands

Herbaceous Wetlands	Forested Wetlands
150	153
151	154
152	

Water

149

Croplands

Irrigated/Dry Land

- 33 Sorghum, Small Grains, Irrigated Agriculture
- 34 Irrigated Agriculture, Mixed Row Crops

Irrigated

- 22 Irrigated Agriculture
- 23 Irrigated Agriculture
- 24 Irrigated Agriculture
- 25 Irrigated Agriculture
- 26 Irrigated Agriculture
- 27 Irrigated Agriculture
- 28 Irrigated Agriculture
- 29 Irrigated Agriculture
- 30 Irrigated Agriculture
- 31 Irrigated Agriculture
- 32 Irrigated Agriculture

Cropland/Grassland

- 35 Bluestem, Grama, Wheatgrass, Small Grains
- 36 Grama, Buffalograss, Wheat, Sorghum
- 37 Small Grains, Sorghum, Blue Grama
- 38 Wheatgrass, Needleandthread, Wheat, Peas, Lentils
- 39 Bluestem, Wheatgrass, Wheat, Sorghum

Cropland/Woodland

- 40 Riparian Woods, Irrigated Agriculture, Blue Grama
- 41 Soybeans, Cotton, Rice, Corn, Oak, Tupelo
- 42 Corn, Soybeans, Sorghum, Irrigated Agriculture, Mixed Woodlots
- 43 Mixed Pine, Oak, Soybeans, Corn
- 44 Pasture, Small Grains, Douglas Fir, Oak
- 45 Soybeans, Corn, Peanuts, Cotton, Oak, Pine
- 46 Maple, Birch, Beech, Corn, Soybeans, Pasture
- 47 Oak, Hickory, Pine, Soybeans, Corn, Pasture
- 48 Citrus, Pasture, Slash Pine, Longleaf Pine
- 49 Loblolly Pine, Slash Pine, Soybeans, Corn, Peanuts, Cotton
- 50 Pine, Oak, Soybeans, Corn, Pasture
- 51 Pasture, Hay, Corn, Soybeans, Oak, Hickory
- 52 Forage Crops, Hay, Woodlots (Oak, Maple)
- 53 Oak, Pine, Soybeans, Corn, Cotton, Peanuts
- 54 Soybeans, Cotton, Rice, Corn, Oak, Pine

Small Grains/Row Crops

- 3 Small Grains, Mixed Row Crops
- 5 Small Grains, Mixed Row Crops
- 6 Mixed Row Crops (Corn, Sunflowers, Soybeans), Small Grains
- 7 Mixed Crops (Wheat, Sorghum, Corn, Alfalfa, Oats)
- 12 Small Grains, Mixed Row Crops, Pasture
- 13 Small Grains, Mixed Row Crops, Pasture
- 14 Mixed Crops (Wheat, Sorghum, Corn, Alfalfa, Oats)
- 16 Corn, Soybeans, Alfalfa, Flax, Wheat
- 18 Mixed Cropland, Pasture, Woodland

Row Crops

- 2 Soybeans, Corn, Cotton
- 8 Soybeans, Cotton, Rice, Corn
- 10 Soybeans, Cotton, Rice, Corn
- 11 Corn, Soybeans
- 15 Soybeans, Cotton, Corn
- 17 Corn, Soybeans
- 19 Soybeans, Corn, Cotton, Vegetable Crops
- 20 Corn, Soybeans, Pasture
- 21 Corn, Soybeans, Loblolly Pine

Small Grains

- 1 Spring Wheat
- 4 Small Grains
- 9 Winter Wheat

Eastern Forests

Northern Mixed Forest

- 133 Maple, Beech, Birch, Jack Pine, Red Pine
- 134 Maple, Birch, Beech, Spruce, Fir
- 135 Spruce, Pine, Wetlands, Northern Hardwoods
- 136 Oak, Maple, Ash, Beech, Birch, Jack Pine, Red Pine
- 137 Beech, Birch, Maple, Spruce, Fir, Hemlock

Northern Deciduous Forest

- 90 Maple, Birch, White Pine, Red Pine
- 91 Oak, Maple, Ash, Pasture
- 92 Maple, Birch, Beech
- 93 Beech, Birch, Maple, Oak, Pasture

Southeast Mixed Forest

- 138 Slash Pine, Longleaf Pine, Oak, Palm, Mangrove, Wetlands
- 139 Loblolly Pine, Slash Pine, Oak, Gum, Soybeans, Corn, Cotton
- 140 Loblolly Pine, Longleaf/Shortleaf Pine, Slash Pine, Oak, Gum, Cypress
- 141 Loblolly Pine, Slash Pine, Shortleaf Pine, Oak, Gum, Poplar

Southeast Deciduous Forest

- 94 Oak, Hickory, Mixed Cropland
- 95 Oak, Hickory, Poplar, Beech, Walnut

Southeast Coniferous Forest

- 98 Loblolly Pine, Longleaf Pine, Slash Pine, Shortleaf Pine

Coastal Wetlands

Herbaceous Wetlands

- 150 Fresh/Saltwater Marsh
- 151 Fresh/Saltwater Marsh
- 152 Fresh/Saltwater Marsh

Forested Wetlands

- 153 Fresh/Saltwater Marsh, Bald Cypress, Mangrove, Oak, Gum
- 154 Fresh/Saltwater Marsh, Oak, Gum, Cypress

Water

- 149 Water

Western Forests

Western Coniferous Forest *

- 99 Fir, Spruce
- 100 Douglas Fir, Pacific Silver Fir, Western Hemlock
- 101 Western White Pine, Ponderosa Pine, Douglas Fir, Lodgepole Pine
- 102 Lodgepole Pine, Ponderosa Pine, Western White Pine, Fir, Spruce
- 103 Lodgepole Pine, Ponderosa Pine, Western White Pine
- 104 Western White Pine, Ponderosa Pine, Lodgepole Pine, Douglas Fir
- 105 Lodgepole Pine, Ponderosa Pine, Douglas Fir
- 106 Ponderosa Pine, Lodgepole Pine, Western White Pine, Juniper
- 107 Lodgepole Pine, Ponderosa Pine, Western White Pine
- 108 Ponderosa Pine, Pinyon Pine, Juniper, Oak
- 109 Ponderosa Pine, Lodgepole Pine
- 110 Douglas Fir, Pacific Silver Fir, Western Hemlock
- 111 Ponderosa Pine, Lodgepole Pine, Juniper
- 112 Douglas Fir, Sitka Spruce, Western Hemlock
- 113 Lodgepole Pine, Ponderosa Pine, Western White Pine
- 114 Ponderosa Pine, Pinyon Pine, Douglas Fir, Juniper, Aspen
- 115 Ponderosa Pine, Lodgepole Pine, Douglas Fir, Oak
- 116 Ponderosa Pine, Lodgepole Pine, Western White Pine, Douglas Fir
- 117 Ponderosa Pine, Lodgepole Pine, Western White Pine, Douglas Fir, Aspen
- 118 Ponderosa Pine, Douglas Fir
- 119 Douglas Fir, Ponderosa Pine, Sugar Pine, Oak
- 120 Ponderosa Pine, Douglas Fir, Oak
- 121 Ponderosa Pine, Sugar Pine, Douglas Fir, Oak
- 122 Douglas Fir, Western Hemlock, Western Red Cedar, Sitka Spruce
- 123 Western Hemlock, Western Red Cedar, Douglas Fir, Sitka Spruce, Pasture
- 124 Ponderosa Pine, Sugar Pine, Douglas Fir, Redwood, Oak
- 125 Ponderosa Pine, Western Hemlock, Redwood, Western Red Cedar, Douglas Fir, Oak

* Three hues of increasing intensity were used to represent the group's increasing primary production.

Western Woodlands

- 126 Grasses, Ponderosa Pine, Lodgepole Pine
- 127 Sage, Annual Grasses, Oak, Pine
- 128 Ponderosa Pine, Lodgepole Pine, Wheatgrass, Sage
- 129 Ponderosa Pine, Pinyon Pine, Juniper
- 130 Pinyon Pine, Juniper, Grasses, Ponderosa Pine
- 131 Ponderosa Pine, Western White Pine, Grasses
- 132 Pinyon Pine, Juniper, Ponderosa Pine, Douglas Fir, Grasses, Sage

Western Mixed Forest

- 142 Lodgepole Pine, Douglas Fir, Aspen, Mountain Shrubs
- 143 Lodgepole Pine, Western White Pine, Ponderosa Pine, Aspen, Mountain Shrubs
- 144 Lodgepole Pine, Western White Pine, Ponderosa Pine, Aspen, Mountain Shrubs
- 145 Lodgepole Pine, Western White Pine, Ponderosa Pine, Aspen, Mountain Shrubs
- 146 Lodgepole Pine, Douglas Fir, Aspen
- 147 Ponderosa Pine, Lodgepole Pine, Aspen
- 148 Ponderosa Pine, Lodgepole Pine, Aspen

Western Deciduous Forest

- 96 Aspen, Mountain Shrubs, Grasses
- 97 Aspen, Mountain Shrubs

Alpine Tundra

- 156 Lodgepole Pine, Douglas Fir, Aspen, Alpine Tundra
- 157 Alpine Tundra
- 158 Alpine Tundra
- 159 Alpine Tundra

Barren

- 155 Barren or Sparsely Vegetated

Seasonal Land Cover Regions

This map represents seasonal regions of the conterminous United States and was developed through the analysis of March-October 1990 1-km Advanced Very High Resolution Radiometer (AVHRR) imagery, digital elevation, ecoregions, and climate data. The seasonal land cover regions have unique combinations of vegetation mosaics, seasonal properties (onset, peak, and length of green period), and annual primary production. The regions are grouped into general land cover types; increasing color intensity within each group corresponds to increasing primary production. The vegetation types listed above represent species commonly found in each region. For each seasonal land cover region, there are corresponding sets of attributes of land characteristics (vegetation components, seasonal properties, spectral measures, elevation, soils, and climate).

The complete land characteristics data base, available on CD-ROM from the following address, can be tailored into classification legends or parameters required for specific applications:

Customer Services
USGS, EROS Data Center
Sioux Falls, SD 57198
605-594-6507

Shrublands

Desert Shrubland

- 66 Bur Sage, Saltbush, Greasewood, Shadscale
- 67 Greasewood, Sage
- 68 Creosote, Mesquite, Saltbush, Sand Sage
- 69 Creosote, Saltbush, Sand Sage
- 70 Dropseed, Sand Sage, Creosote
- 71 Saltbush, Greasewood, Big Sage

Shrubland/Grassland

- 72 Greasewood, Sage, Rabbitbrush, Needlegrass
- 73 Sand Sage, Creosote, Ricegrass, Blue Grama, Dropseed
- 74 Big Sage, Rabbitbrush, Wheatgrass, Fescue
- 75 Greasewood, Sage, Wheatgrass, Needleandthread
- 76 Sand Sage, Blue Grama, Wheatgrass, Buffalograss
- 77 Creosote, Sand Sage, Grama, Wheatgrass
- 78 Big Sage, Rabbitbrush, Wheatgrass, Fescue
- 79 Sand Sage, Creosote, Dropseed, Blue Grama
- 80 Blue Grama, Buffalograss, Big Sage, Saltbush
- 81 Sand Sage, Oak, Blue Grama, Buffalograss
- 82 Grama, Buffalograss, Wheatgrass, Creosote, Mesquite
- 83 Grama, Buffalograss, Wheatgrass, Creosote, Mesquite

Grasslands

Chaparral

- 84 Annual Grasses, Manzanita, Oak, Pine
- 85 Annual Grasses, Manzanita, Oak, Pinyon Pine, Juniper

Savanna

- 86 Bluestem, Sand Sage, Blue Grama, Oak, Juniper
- 87 Oak, Juniper, Bluestem, Indiangrass, Switchgrass
- 88 Oak, Bluestem, Indiangrass, Mesquite, Juniper
- 89 Oak, Bluestem, Indiangrass, Switchgrass, Juniper

Grassland

- 55 Wheatgrass, Needlegrass, Needleandthread
- 56 Wheatgrass, Needlegrass, Needleandthread
- 57 Bluestem, Blue Grama
- 58 Blue Grama, Wheatgrass, Buffalograss
- 59 Wheatgrass, Blue Grama, Needleandthread
- 60 Wheatgrass, Fescue, Big Sage
- 61 Wheatgrass, Blue Grama, Needleandthread, Big Sage
- 62 Annual Grasses, Manzanita, Oak
- 63 Wheatgrass, Needlegrass
- 64 Wheatgrass, Needlegrass, Needleandthread
- 65 Bluestem, Indiangrass, Switchgrass

Arctic Land Processes

Alaska Field Office (AFO) staff continue development of data sets for the northern circumpolar regions. Most recently, the June 1992 biweekly global 1-km AVHRR NDVI greenness composite for regions north of the 50th parallel was reprojected from the Goode's interrupted map projection into a Lambert Azimuthal Conformal projection. This data set, and others, will be the foundation for the USGS/EPA/Environmental Canada circumpolar ecoregions mapping project and for the USGS/USFWS Conservation of Arctic Flora and Fauna initiative. A draft report, map, and digital data base for the Alaska Ecoregions project was completed. The map and report were circulated to over 40 agency and academic personnel in Alaska for professional and scientific review. Comments on the draft will be incorporated into the final Alaska Ecoregions report and color map to be published in FY 1994 as a USGS professional paper.

EDC and the Office of Production Operations are collaborating with the USFWS and Utah State University to create maps for the Utah GAP Analysis Project. There are three maps planned for production by the end of calendar year 1993, all of Utah at 1:750,000: a TM image map; a habitat land cover map; and a land ownership map. Risk assessment maps of species or groups of species may be done if time permits.

Utah GAP Analysis Project

Data from the State Soil Geographic (STATSGO) data base has been used to map the distribution of potential native plant communities in the Great Plains. Plots of dominant grass species within each state, as well as maps of the distribution of plants with C3 and C4 photosynthesis types have been made for states from North Dakota to Texas. The maps are being evaluated by ecologists, as part of a study of soil carbon isotopes and their relationship to past climates.

Soils Data Base Development and Analysis

A set of maps showing the individual attributes of the Fertility Capability Classification have been made for North and South America, based on a reclassification of the Food and Agricultural Organization (FAO) of the United Nations Soil Map of the World. A teacher-intern worked on this aspect of the project, and it is expected that this experience will result in additional understanding of geographic information systems (GIS) by teachers in area schools.

A paper has been prepared for the Second International Conference on Integrating GIS and Environmental Modeling. The STATSGO data are used to produce maps of available water capacity and soil depth. These parameters are being requested by researchers that are modeling land surface processes, such as evapotranspiration, for use in climate models.

A set of routines were developed to correct Thematic Mapper-P (TM-P) terrain data in the oblique mercator projection. Comparisons to an EOSAT terrain corrected product were excellent, with differences under 0.2 pixel. Image-to-map registrations yielded root mean squared error (RMSE) of less than 1 pixel for two test cases over highly variable terrain. Techniques were developed to use the Landsat MSS and TM Ground Control Point Libraries to partially automate control point selection. This

Satellite Image Registration Research and Development

algorithm development will support the Multi-Resolution Land Characteristics Project. In addition, a paper entitled "Mapping Raster Imagery to the Interrupted Goode Homolosine Projection" was written and submitted to the International Journal of Remote Sensing for publication.

Geographic and Spatial Information Analysis

Multi-dimensional Applications and Gigabit Internetwork Consortium (MAGIC)

EDC continues its participation in the Multi-dimensional Applications and Gigabit Internetwork Consortium (MAGIC) network research and development project. The MAGIC project, a partnership between the DoD, the DoI, the academic community, and private industry, combines advanced technologies in networking, mass storage, supercomputing, and terrain visualization. The consortium is building a fiber optic gigabit network testbed using supercomputer technology and sophisticated mass storage systems to combine high volume, high resolution digital imagery with digital elevation data from geographically distributed archives.

National Biological Survey (NBS)

EDC staff participated on the Technical Review Board for the NPS in support of their contract for Vegetation Mapping of all National Park Units in the conterminous United States. Over 25 private firms submitted proposals. The contract, when awarded, will provide for the development of a National Vegetation Classification System. The digital vegetation maps will be integrated into GIS's being developed for over 235 park units nationwide, excluding Alaska. This program will migrate to the National Biological Survey(NBS) in FY 1994, and be administered by the NBS Inventory and Monitoring Division.

Japanese Earth Resources Satellite-1 (JERS-1) Investigations

The Framework for Cooperation formalizing the participation by EROS Data Center scientists in the JERS-1 System Verification Program was signed by National Space Development Agency (NASDA) (Japan) and the NMD. SAR data acquired last summer over the Drum Mountains, Utah field site were received from Japan and will be processed in the near future. Quick-look images from optical sensor data acquired over the Utah field site also were received. NASDA will process those data pending final assessment of limitations on analysis imposed by the substantial cloud cover present in the scene.

Infobase

The Infobase project was established as a collaborative research activity between EDC, the David Sarnoff Research Center, and the USFS, Intermountain Fire Sciences Laboratory. The project involves the development of advanced land characterization analysis and exploration tools. Meetings held at EDC with project cooperators resulted in completion of two planning documents (Concept of Operations and System Requirements) that identified the philosophy, requirements, and responsibilities of project participants. The initial Infobase toolset was delivered to EDC and the Intermountain Fire Sciences Laboratory in mid-August 1993. A software evaluation exercise to be performed at EDC has been outlined and approved by the Infobase project team. This exercise was executed during September and October and feedback on the software will be given to the David Sarnoff Research Center for the final software delivery in November 1993.

Work continues on the Landsat TM and SPOT land cover classifications of the Chugach National Forest. Ancillary data were applied to two of the Landsat TM scenes to improve the land cover classifications. Also, four hard copy plots of the preliminary land cover classification were produced and given to the USFS for review and comment. Chugach GIS data base development has included mosaicking of the individual 1:63,360 DEM's covering the Chugach into a seamless product. A number of map products were generated demonstrating the integration of the DEM data with other thematic layers of information.

*Chugach National
Forest*

INTERNATIONAL PROGRAM

The EROS Data Center supported several international projects during FY 1993 that support a wide range of interdisciplinary earth science to advance and develop knowledge, data and analysis tools to better understand global resources and change. These projects are conducted largely through reimbursable funding from sponsoring organizations for the purpose of testing and, subsequently, transferring earth science technologies to developing countries for effective resource assessment, development, and monitoring.

Long-Term Monitoring and Change Prediction of Natural Resources. Project activities were completed under this first phase of U.S. Agency for International Development (USAID)/USGS support. A 5-year time-series 1-km AVHRR data base over West Africa was completed. The time-series data were evaluated for targeting areas of short- and long-term environmental change in West African landscapes. NDVI-based land productivity anomaly image maps were prepared. The anomalies were investigated during an extensive field trip through rural Senegal from July 15, 1993, to August 11, 1993. Research results show that several types of anomalies in NDVI correspond with degraded landscapes, particularly those with intense human and livestock activity. Results were presented at the Pecora 12 Symposium and at USAID/Washington.

*Monitoring Land
Responses*

Long-Term Ecological Monitoring Framework of Senegal's Natural Resources. In contrast to the regionally-focused project described above, this activity is establishing a multi-level framework for monitoring natural and cultural landscapes at local to national levels in Senegal using Landsat and SPOT image data, airborne videography, and extensive field work. Much progress was made in co-registering historical and recent Landsat MSS data over Senegal. An approach for revisiting and collecting field data at numerous historical ground sites in Senegal was tested during the July 15 to August 11, 1993, field trip to rural Senegal. Plans are being made for a major field mission to Senegal in late 1993. A Participating Agency Service Agreement (PASA) is being established between USGS and USAID/Senegal to support this activity.

*Famine Early
Warning System
(FEWS) Operations
(USAID)*

Several USAID Missions requested USGS consultation in the design of program monitoring information systems (MIS) which incorporate geographic information systems. Travel in support of the MIS designs was conducted in tandem with data collection efforts in Ethiopia, Madagascar, and Zimbabwe. While in Zimbabwe, FY 1994 work plans for the Famine Early Warning System (FEWS) Southern Africa Regional Office were defined. Two desk top data management software packages were delivered to the FEWS field representatives and their African counterparts in ten countries. The packages included RAINMAN, for managing rainfall data, and AGMAN, for managing agricultural production data. Newly recruited FEWS field representatives received GIS training at EDC before assuming their responsibilities at posts in Kenya, Mauritania, Malawi, and Ethiopia.

*Agricultural-
Hydrological-
Meteorological
(AGRHYMET) Data
Center (USAID)*

Training in GIS was provided under the Agricultural-Hydrological-Meteorological (AGRHYMET), FEWS and Intergovernmental Authority for Drought and Development (IGADD) projects. National AGRHYMET Centers in Senegal, Gambia, Mali, and Guinea Bissau each had computers, peripherals, software, and basic data sets installed. Introductory instruction was provided on-site to scientists from natural resource management agencies in each country. CLIMBASE 2.0, a desk top data management software package for management of daily climate data, was delivered to users at a training workshop at the AGRHYMET Regional Center in Niamey, Niger, for scientists from nine West African countries. (Figure 8)

*Intergovernmental
Authority for Drought
and Development
(IGADD)*

All project activities were completed bringing the IGADD project to a close on March 31, 1993. EDC staff conducted a workshop jointly with the FAO/IGADD Project on "Advanced Applications of Satellite Data for Environmental Monitoring and Early Warning in the IGADD Region," in Nairobi, February 22 to March 5, 1993. The workshop was attended by 15 representatives of all six IGADD member countries (Ethiopia, Sudan, Djibouti, Somalia, Kenya, and Uganda).

*United Nations
Environmental
Programme/Global
Resources
Information Database
(UNEP/GRID) Support*

GRID-Sioux Falls continues to facilitate access to and assist in validating geographic data sets of developing countries for the North American research community. A workshop was organized to develop large environmental data bases for sustainable development. The workshop was held in Nairobi, Kenya, and was attended by about 90 participants from over 20 countries. The DCW was repackaged at GRID-Sioux Falls into regional/continental data sets and redistributed to the other GRID centers. A consultant was recruited to assist in the development of the 30-arc second global DEM from DCW data. A visiting scientist from the Geography Institute at the National Autonomous University of Mexico has joined the staff to assist in the global land characterization project. During the 6-month visit, efforts will be concentrated on obtaining, developing, and incorporating ancillary data sets for Latin American countries in the land cover characteristics data base.

China Protocol

In November 1992 two EDC scientists traveled to Beijing, China as part of the ongoing exchange of technology and personnel under the protocol between the National



Figure 8

Bureau of Surveying and Mapping of China and the USGS. While in China they worked on finalizing the Landsat change detection activities that were started during the scientific exchange of a year ago, and they discussed cartographic applications and processing of AVHRR data. EDC scientists also spent time at the Satellite Meteorology Centre (SMC) discussing the SMC's participation in the global 1-km data set project and AVHRR reception, processing, and applications activities performed at the EDC.

As a part of the scientific exchange, Mr. Zhicheng Qiu and Mr. Yutong Liu, Research Bureau of Surveying and Mapping, Beijing, People's Republic of China (PRC) visited EDC from April 10 through May 1, 1993, under the USGS/PRC Protocol. The emphasis of their work while at the EDC was the development of an AVHRR temporal data set for a selected region in central China. These data are then being used to prototype a land cover characterization data set of the study site.

*University of Georgia
Technical Support*

Development of baseline data for the Philippines Sustainable Agriculture and Natural Resource Management (SANREM) site continues, and work is beginning at the site in Burkina Faso. Site selections in Ecuador and Morocco are taking place, and the suitability of the sites from a GIS/remote sensing perspective is being studied. Travel has included visits to AID and State Department offices to discuss the role of GIS in natural resource management, and to the Georgia Experiment Station to install three Sun SPARC 10 workstations and GIS software and to present a poster on GIS to the Global Technical Committee of the Cooperative Research Support Program (CRSP).

ADVANCED CARTOGRAPHIC SYSTEMS

The EROS Data Center actively supports the National Mapping Division's mapping modernization program to develop the next generation of technologically advanced, computer-assisted, cartographic production and management systems. The Data Center's support contributes largely to the development of computer software required by users of a wide range of cartographic and geographic information systems applications.

Major accomplishments during FY 1993 included requirements analysis, systems design, and software development of version 1 of the DLG-E Production System, and the initiation of requirements analysis and systems design for Version 2. Work on Version 2 included developing specifications of the analysis and design methodology, training both developers and users on the methodology, and using the methodology in the analysis and design of Version 2. This work is done at EDC and at the mapping centers for extensive user interaction and feedback. Version 2 software will be implemented in late 1994.

*DLG-E Production
Development*

NATIONAL MAP & DIGITAL DATA PRODUCTION

One of the National Mapping Division's objectives is to produce current and accurate cartographic data and maps that meet consistent standards in primary, intermediate, and small scales for the United States and outlying territories. In support of this objective, the EROS Data Center provides a variety of services that contribute to national map and digital data production activities.

Two-hundred and sixty-four (264) flight line delineation maps required in contracting of FY 1994 National Aerial Photography Program (NAPP) coverage were produced for Florida, Nevada, Louisiana, Virginia, Wyoming, and Ohio. The remaining flight maps of California, New York, South Carolina, and Arkansas are in work.

*National Aerial
Photography Program
(NAPP)*

The NAPP data base was converted from UNIFY 3.2 to UNIFY 5.0 to facilitate data transfer and data base reconciliation. Data base updates from Reston are now provided electronically rather than being shipped on 9-track tapes. This data is then transmitted to the Aerial Photography Field Office in Salt Lake on a weekly basis.

In the February 1993 meeting of the NAPP Steering Committee a decision was made to split the archive location of B/W NAPP original rolls and the production of duplicate B/W rolls between the Aerial Photography Field Office (APFO) and the EROS Data Center. The decision facilitates the handling of a large increase in B/W photography and the need to provide increased diapositive production capacity by utilizing the APFO facility in support of a growing Digital Orthophoto Quadrangle (DOQ) program. EDC

provided APFO training on printing specifications, workflow and printer certification using EDC's Image Preproduction Analysis System (IRAS) program.

Over 79,000 diapositives and associated paper products have been produced during fiscal year 1993. This represents an increase of about 60 percent in diapositives production over the previous year. In response to increase production changes were made to workflow procedures, equipment, and product specifications.

*SLAR Conversion
Project*

EDC completed a special project to convert 334 SLAR digital image files from 9-track tapes to 19 CD-ROM discs for distribution. All problem flightline image data and header files were corrected as part of the conversion process. In addition, index maps (where available) were scanned for inclusion on the CD-ROM disc as a visual guide to the relative positioning of the image within each 1:250,000 scale quadrangle map. SLAR documentation text was prepared for each quadrangle and included on the SLAR CD-ROM.

*Map Production
Support*

Nine 1:250,000 scale image map quadrangles from 17 MSS scenes were produced this year in support of the Office of International Activities. In addition, 10 other image maps were produced including: a 13 scene MSS mosaic of the Central Arctic Management Area (CAMA), which was joined to the existing mosaic covering the Arctic National Wildlife Refuge (ANWR) (The two joined data sets produce a full digital product covering the entire north slope of Alaska.); and a 3 scene TM mosaic resulting in nine 1:50,000 scale quadrangles of the US/Mexican border near Nogales, Arizona.

INFORMATION & DATA SYSTEMS

The EROS Data Center supports the National Mapping Division's commitment to provide cartographic and earth science information and technical assistance to a wide range of data requestors involved with domestic and international interests. During FY 1993 technical assistance was provided to the Central Intelligence Agency (CIA) and to the Department of Defense.

*CIA Technical
Assistance*

Four 15-day composite periods (March 15 - May 15) were produced using 1993 data for a study area covering the Middle East, including two years of historical coverage. Deliverable products include digital composites, paper plots, film transparencies, and digital statistics. Six 10-day composite periods were produced covering June - July 1993. Image maps at 1:50,000-scale of the Dubrovnic areas in the Newly Independent States of the USSR also were produced.

*Army Technical
Assistance*

A 2-scene Spot HRV-P mosaic of the Sarajevo and Mostar, Bosnia Hercegovina, area was produced for the U.S Army Intelligence and Threat Analysis Center (USAITAC). The data were registered to 1:50,000-scale topographic maps. Two overlapping sheets were produced to cover a 30 kilometer radius of Sarajevo at a final

product scale of 1:50,000-scale. Map collars with 1000-meter UTM grids, latitude and longitude ticks, scene information, and titling were combined with the image data in the final products.

In addition, an 11-scene MSS image mosaic of the southern portion of the country of Somalia was produced for the Office of Imagery Analysis (OIA) and USAITAC. The MSS data were registered to the DCW. A map collar containing annotated city names and DCW road network was combined with the image data in the final product. Color film positives were supplied at 1:3,750,000-scale and 1:1,000,000-scale color prints were produced.

Two 2-scene Landsat TM data sets also were produced for USAITAC. The data show wet season vs. dry season conditions for Ft. Polk, Louisiana. Both 1:250,000-scale and 1:100,000-scale collared map sheets were produced for each data set.

OTHER ACTIVITIES

The 12th William T. Pecora Memorial Remote Sensing Symposium was held on August 24-26, at Sioux Falls, South Dakota. The theme for the symposium was "Land Information from Space-based Systems." The conference was designed to explore the needs for land information, to determine the status of current technologies for providing land information, and to look at possibilities for enhancing these technologies in the future. Co-sponsors for Pecora 12 included the USGS, NASA, NOAA, and the EPA.

*Pecora Remote
Sensing Symposium*

The program consisted of 65 oral presentations, 30 poster papers and provided opportunities for tours of the EDC. The American Society for Photogrammetry and Remote Sensing will print and distribute the Pecora 12 Symposium Proceedings.

At the annual NASA/South Dakota Space Grant Consortium meeting, held in November 1992, the consortium decided to support a high altitude balloon project for Space Grant Scholarship and Fellowship students. The project will fly remote sensors across South Dakota at altitudes exceeding 100,000 feet and will fly west to east. Initial planning is complete and students are in the design/purchase phase. The final goal is to launch the balloon from the Stratobowl in the Black Hills of South Dakota next spring, complete with remote sensing and biological experiments. Graduate, undergraduate, and middle high students are involved with the project. Raven Industries of Sioux Falls, South Dakota is donating the zero pressure gravity balloon. EDC participates as a full partner in the Consortium, although no exchange of funds are involved.

*South Dakota Space
Grant Consortium*

Two mass storage systems were integrated into the Center's computing environment to provide automation and streamlining of its operations and extension of on-line disk storage for supporting research and production programs. The first system consists

*Computer Operations
Support Service*

of a host computer controlling a (STK ACS4400) tape robot offering over one terrabyte of storage to the users within the local-area-network. The second system, based upon optical disk technologies and a media changer, provides over 300 gigabytes of storage for electronic data transfer of digital products and GLIS browse imagery applications.

STATISTICAL DATA

This section summarizes EDC sales and distribution of products and services provided in fiscal year 1993. It also provides information about customer profiles, historical trends, and the contents of the EDC archives and data bases.

Products and Services

In FY 1993, EDC produced and distributed over \$5.6 million worth of products and services. Of this total, \$2.7 million were direct repay sales and \$1.7 million were for products and services provided through EDC cooperative repay projects totaling \$4.4 million. The remaining \$1.2 million were for products and services distributed to users within the U.S. Geological Survey, including EDC users, other National Mapping Division facilities, and other divisions of the USGS.

	<u>Items</u>	<u>Dollars</u>
Photographic Products	238,154	3,308,248
Digital Products/Processing	15,369	2,307,633
Reference Aids	N/A	22,051
Miscellaneous	<u>971</u>	<u>21,184</u>
Total	254,494	5,659,116

The following tables show in more detail the level of activity for products and services provided during FY 1993.

Customer Profile
EDC Photographic Products
Fiscal Year 1993

CUSTOMER CATEGORY	ITEMS	DOLLARS
USGS	130,712	\$1,335,138
OTHER FEDERAL	<u>27,961</u>	<u>494,836</u>
TOTAL FED. GOV'T.	158,673	1,829,974
STATE/LOCAL GOV'T.	13,341	127,074
ACADEMIA	9,763	122,654
INDUSTRY	41,282	904,696
INDIVIDUALS	13,570	261,707
NON-U.S.	<u>1,525</u>	<u>17,143</u>
TOTAL	238,154	\$3,308,248

Product Profile
EDC Photographic Products
Fiscal Year 1993

BLACK-AND-WHITE PRODUCTS		
PRODUCT CATEGORY	ITEMS	DOLLARS
10" Film/Paper	90,385	\$ 659,457
10" Diapositives	77,554	556,296
20" Paper	4,414	88,075
30" Paper	1,059	33,430
40" Paper	3,301	137,054
Other	5,723	102,664
TOTAL	182,436	\$1,576,976
COLOR PRODUCTS		
PRODUCT CATEGORY	ITEMS	DOLLARS
10" Film/Paper	35,271	\$ 910,040
10" Diapositives	72	198,868
20" Paper	3,783	99,337
30" Paper	1,655	318,638
40" Paper	4,156	1,452
Other	10,781	202,937
TOTAL	55,718	\$1,731,272
GRAND TOTAL PRODUCTS	238,154	\$3,308,248

Customer Profile
EDC Digital Data Products & Processing
Fiscal Year 1993

Digital Data Products

CUSTOMER CATEGORY	ITEMS	DOLLARS
USGS	7,019	\$1,112,171
OTHER FEDERAL	840	64,627
TOTAL FED. GOV'T.	7,859	1,176,798
STATE/LOCAL GOV'T.	176	5,534
ACADEMIA	1,406	83,817
INDUSTRY	3,701	412,880
INDIVIDUALS	420	25,390
NON-U.S.	591	80,242
TOTAL	14,153	\$1,784,661

Digital Data Processing

CUSTOMER CATEGORY	ITEMS	DOLLARS
USGS	1,207	\$521,947
OTHER FEDERAL	0	0
TOTAL FED. GOV'T.	1,207	521,947
STATE/LOCAL GOV'T.	1	100
ACADEMIA	8	925
INDUSTRY	0	0
INDIVIDUALS	0	0
NON-U.S.	0	0
TOTAL	1,216	\$522,972

EDC Annual Sales Report Fiscal Year 1993

	DIRECT REPAY CUSTOMERS	EDC REPAY PROJECTS	USGS CUST.
PHOTOGRAPHIC DATA			
AERIAL IMAGES			
NAPP	\$1,390,599	\$ 109,021	\$ 621,170
SLAR	9,567	1,019	6,678
Other	465,360	997	21,162
SATELLITE IMAGES			
Landsat MSS/TM	47,042	75,652	1,932
AVHRR	4,935	18,084	5,260
Other	11,080	263	219
Digital Film Recorder Products	3,890	183,415	11,480
Other Photographic Data	40,637	131,457	147,329
TOTAL PHOTOGRAPHIC DATA	\$1,973,110	\$ 519,908	\$ 815,230
DIGITAL DATA PRODUCTS/PROCESSING			
Digital Data Processing	1,025	484,419	37,528
SLAR Images	2,896	96	400
Landsat MSS/TM Image Data	534,488	507,982	210,531
AVHRR Images	82,948	201,169	146,528
NDCDB Data	29,769	11,077	9,424
NURE Data	2,064	0	0
Other Digital Data	20,325	19,180	5,784
TOTAL DIGITAL DATA/PROCESSING	\$ 673,515	\$ 1,223,923	\$ 410,195
MISCELLANEOUS			
Reference Aids	13,616	1,175	7,260
Other Products and Services	14,650	2,499	4,035
TOTAL MISCELLANEOUS	\$ 28,266	\$ 3,674	\$ 11,295
GRAND TOTAL	\$2,674,891	\$1,747,505	\$1,236,720
Satellite Data Brokerage Fees	\$ 107,056	\$ 41,061	\$ 343

This section describes data archives, both digital and photographic, that are maintained by EDC to preserve, reference, and distribute remotely sensed, cartographic, and other earth science data. Several of the data bases reference data held elsewhere that are of interest to EDC customers.

Ending fiscal year 1993, the Data Center archived over 10.2 million frames of photographic data and over 152,000 digital tapes. This includes over 2.8 million frames of Landsat photographic data and nearly 80,000 Landsat data tapes. The International Landsat Data Base maintained by EDC referenced over 1.0 million scenes archived in the United States, and over 2.2 million scenes of Landsat data held by foreign ground stations.

The following tables show in more detail the status of the EDC archives and data bases.

Data Archive Report As Of October 6, 1993

Summary of Data Archived at EDC

PHOTOGRAPHIC DATA	FRAMES
AERIAL IMAGES	7,157,398
LANDSAT SATELLITE IMAGES	2,852,827
OTHER SATELLITE IMAGES	215,263
TOTAL	10,225,488

DIGITAL DATA	MAGNETIC TAPES
AERIAL IMAGE DATA	3,201
LANDSAT SATELLITE IMAGE DATA	79,806
OTHER SATELLITE IMAGE DATA	68,021
NDCDB DATA	80
EARTH SCIENCE DATA	974
TOTAL	152,082

Data Archive Report As Of October 6, 1993

PHOTOGRAPHIC DATA ARCHIVED AT EDC

AERIAL PHOTOGRAPHY		
SOURCE	ROLLS	FRAMES
US Geological Survey	17,353	2,588,046
NAPP	8,614	1,305,211
Bur. of Land Management	625	124,992
Bur. of Reclamation	303	60,266
National Park Service	85	14,551
Bur. of Indian Affairs	49	9,913
TOTAL DEPT. OF INTERIOR	27,029	4,102,979
Army Map Service	1,681	213,914
US Air Force	3,375	330,832
US Navy	6,323	431,289
Corps of Engineers	86	23,732
TOTAL DEPT. OF DEFENSE	11,465	999,767
Ames Research Center	4,280	552,190
Johnson Space Center	7,632	1,012,642
Other	1,413	125,427
TOTAL NASA	13,325	1,690,259
OTHER SOURCE AGENCIES	2,119	364,393
TOTAL AERIAL PHOTOGRAPHY	53,938	7,157,398

SATELLITE PHOTOGRAPHY		
SOURCE	ROLLS	FRAMES
Landsat MSS 70 mm Film (1/2/3)	7,708	1,342,187
Landsat MSS 9" B&W Film	9,823	1,334,975
Landsat TM 9" B&W Film	2,924	175,665
Skylab	634	44,845
Apollo/Gemini/Appollo- Sojuz	127	18,372
Shuttle (Incl. LFC)	1,821	152,046
TOTAL SATELLITE PHOTOGRAPHY	23,037	3,068,090

Data Archive Report As Of October 6, 1993

Digital Data Archived at EDC

SOURCE	MAGNETIC TAPES
AERIAL IMAGE DATA	
NASA Data	
TMS 8-Channel Data	761
TMS 12-Channel Data	623
TIMS 6-Channel Data	317
M2S 11-Channel Data	76
AOCI 10-Channel Data	44
National Park Service	93
Side-Looking Airborne Radar (SLAR)	<u>1,287</u>
TOTAL	3,201
SATELLITE IMAGE DATA	
Landsat MSS/TM Digital Data	79,806
AVHRR	
EDC-HRPT Data	20,407
LAC Data Received via DOMSAT	31,566
LAC Data Received From Other Sources	13,558
Federally-Owned Landsat Data (FOLD)	1,225
SPOT Data	297
Department of Defense MSI Data	<u>968</u>
TOTAL	147,827
NDCDB DATA	
Digital Elevation Model (DEM)	76
1:2 Million Digital Line Graph (DLG)	<u>4</u>
TOTAL	80
EARTH SCIENCE DATA	
National Uranium Resource Evaluation(NURE)	957
Geophysical Research Program	<u>17</u>
TOTAL	974
TOTAL DIGITAL HOLDINGS	152,082

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