

**A Guide to Land Cover and Land Use Information
in the MAIA Region**

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INTRODUCTION

The Mid-Atlantic Integrated Assessment (MAIA) is a research, monitoring, and assessment initiative created to develop high-quality scientific information on the condition of natural resources within the Mid-Atlantic region of the United States. Scientific activities conducted in the MAIA region focus on assessment issues that are of critical importance to resource managers and environmental decision-makers. In its three years, the MAIA program has helped forge alliances between federal and state agencies. An array of reports on estuaries, groundwater, streams, land use, landscape attributes, and other related topics have been produced through the MAIA initiative.

The purpose of this guide is to provide researchers and scientists whose work encompasses the Mid-Atlantic Integrated Assessment (MAIA) region, a comprehensive guide to land cover and land use. In addition to being a guide to the federal, state, regional and university based organizations in the area, this document also provides information on standards to consider for data development, as well as quality assurance and quality control techniques that should be implemented.

The role of landscape studies

Landscape studies play an integral role in the MAIA program as they allow for a broad scale approach to information gathering and assessment. Landscape studies take into account spatial arrangements of environmental elements and also include humans and their activities within assessments.

The role of land cover mapping for change detection

Land cover maps display information on the vegetation of an area as well as political units, hydrologic units, census county subdivisions, and in some cases, federal land ownership. Mapping land cover will provide a visual statement of conditions at any given point in time. When compared to other maps from different time periods, the resulting change over time can be seen. Mapping information from years past and comparing it to the present can give land use and resource management professionals a valuable tool to help define land use and cover as well as the resulting changes, thus aiding them in future planning.

The need for coordination and standardization

Coordination and standardization will help the environmental community by offering a framework to which to adhere. A framework can greatly reduce time, effort, and expense in using geographic data. It gives data users ready, reliable data in a consistent form as well as providing reference sources, standards, and guidance for creating geographic data. A framework also makes it possible to combine data from many sources and areas across the country.

Terminology

Land cover

Land cover describes vegetation, water, natural surface, and artificial constructions at the land surface.

Land use

Land use describes any application of the land by humans. Timber production is an example of land use.

Landscape

A conceptual unit for the study of spatial patterns in the physical environment and the influences of these patterns on important environmental resources.

RESEARCH ACTIVITIES BY RESOURCE ASSESSMENT EFFORTS

This section lists projects and organizations that are key contributors to Land Use and Land Cover research in the MAIA region by resource category. The designated categories are ecological or functional. Whenever possible we have listed the website URL for the organization responsible for the information.

Agricultural Lands

Monitoring Land Treatment in Agricultural Non-point Source Pollution Control Projects. The Rural Clean Water Program Experience. Osmond, Spooner and Line. North Carolina State University. 1995. <http://h2osparc.wq.ncsu.edu/brochures/nine.html>

Forests

National Forest Health Monitoring Program. U.S. Forest Service, Department of Agriculture. http://willow.ncfes.umn.edu/fhm/fhm_hp.htm

Landscapes

Bara, Thaddeus J. GIS-Based Regionalization of Natural Landscapes Using Derived Land Cover Occurrence Probabilities. ManTech Environmental Technology, Inc. Research Triangle Park, NC 27709. 1994. <http://www.sgi.ursus.maine.edu/gisweb/spatdb/gis-lis/gi94005.html>

Committee on the Environment and Natural Resources. National Environmental Monitoring Initiative. 1997. <http://www.epa.gov/monitor>

An Ecological Assessment of the United States Mid-Atlantic Region: A Landscape Atlas, 1997. <http://www.epa.gov/maia/html/maia-atlas.html>

Eve, Marlen D. and Merchant, James W. A National Survey of Land Cover Mapping Protocols Used in the Gap Analysis Program. Center for Advanced Land Management Information Technologies (CALMIT, University of Nebraska - Lincoln). 1998. <http://www.calmit.unl.edu/gapmap/report.html>

Global Land Cover Characterization. 1992-1993. <http://edcwww.cr.usgs.gov/landdaac/glcc/glcc.html>

Gurda, Robert F. Linking and Building Institutions for A Statewide Land cover Mapping Program. Wisconsin State Cartographer's Office. Madison, WI 53706-1404. 1994. <http://www.sgi.ursus.maine.edu/gisweb/spatdb/gis-lis/gi94049.html>

Lambin, E. F. and Strahler, A. H., 1994. Indicators of land-cover change for change-vector analysis in multi temporal space at coarser spatial scales. International Journal of Remote Sensing, **15**(10), 2099-2119. <http://modarch.gsfc.nasa.gov/MODIS/ABSTRACTS/MST-A0029.html>

Land Characterization and Data Management. U.S. Department of Interior. http://www.gcrio.org/ocp96/progsum/DOI_07.html

North American Landscape Characterization (NALC) Project/Campaign Document. NASA 1998.
http://eosims.cr.usgs.gov:5725/CAMPAIGN_DOCS/nalc_proj_camp.html

Statewide Land cover and Trees Study. Department of Natural Resources Queensland On-line.
1998. <http://www.dnr.qld.gov.au/resourcenet/veg/slots.html>

Third International Conference/Workshop on Integrating GIS and Environmental Modeling CD-ROM. January 21-25, 1996. Santa Fe, New Mexico, USA. 1996.
http://www.sbg.ac.at/geo/idrisi/GIS_Environmental_Modeling/program.html

Turner, Moss and Skole. *Relating land use and global land-cover change: A proposal for an IGBP-HDP core project. Report from the IGBP-HDP Working Group on Land-Use/Land-Cover Change.* Joint publication of the International Geosphere-Biosphere Program (Report No. 24) and the Human Dimensions of Global Environmental Change Program (Report No. 5). Stockholm: Royal Swedish Academy of Sciences. 1993. <http://www.ciesin.org/docs/002-105/002-105.html>

U.S. EPA. North American Landscape Characterization Project Research Summary. 1998.
<http://www.epa.gov/crdlvweb/land-sci/north-am.htm>

U.S. EPA Office of Water. Land Cover Digital Data Directory for the United States. 1997.
<http://www.epa.gov/OWOW/watershed/landcover>

Van Driel, Nick and Loveland, Tom. The U.S. Geological Survey's Land Cover Characterization Program. EROS Data Center. Sioux Falls South Dakota, 57198.
http://www.sbg.ac.at/geo/idrisi/GIS_Environmental_Modeling/sf_papers/vandriel_nick/sf.html

Streams

Hunsaker, Carolyn T., Jackson, Barbara L. and Schwartz, Paul M. *Landscape Characterization for Watershed Management.* Oak Ridge National Laboratory, Oak Ridge, TN. 1996.
<http://www.epa.gov/owowwtr1/watershed/Proceed/hunsaker.htm>

Leffler, Merrill. Land Use and Water Quality: Connecting Ecology and Economics. Maryland Sea Grant. 1995. <http://www.mdsg.umd.edu/MDSG/Communications/MarineNotes/F-M-A95/>

Maryland Department of Natural Resources, State of the Streams: 1995–1997 Maryland Biological Stream Survey Results, Contact No. PR–96–055–001, in press

Mid-Atlantic Highlands Coordinating Council. Upper Potomac River–Physical Data. 1996.
<http://aegis.lsc.nbs.gov/potomac/upg-phys.htm>
United States Geological Survey. National Water Quality Assessment (NAWQA) Program. 1999.
<http://www.rvares.er.usgs.gov/nawqa/>

United States Geological Survey. Stream-Gaging Program of the U.S. Geological Survey.
<http://waterdata.usgs.gov/nwis-w/US/>

Urban Areas

Clark, Susan C., Starr, John, Foresman, Timothy, Acevedo, William and Solomon, Carol.
Development of the Temporal Transportation Database for the Analysis of Urban Development in the Baltimore-Washington Region. U.S. Geological Survey & University of Maryland.
http://edcwww2.cr.usgs.gov/umap/pubs/asprs_sc.html

Foresman, Timothy W., Wiggins, Helen V., Porter Dana L., Masuoka, Penny and Acevedo, William. *Design and Documentation of a Baltimore-Washington Regional Spatial Database Testbed for Environmental Model Calibration and Verification.* University of Maryland and U.S. Geological Survey. http://www.ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/foresman_timothy/foresman.html

Time Scales of Land Use Change and Export of N and P from Coastal Plain Basins. University of Maryland. 1998. <http://people.hpl.umces.edu/~klee/timescale1.html>

Wetlands

Landscape Level Habitat Modeling for Amphibians and Reptiles in West Virginia. Rowe and Yuill. West Virginia University. <http://www.caf.wvu.edu/mikewww/jackie/gaposter/wyposter.html>

NASA–GlobalOceanColorMonitoringMission(SeaWIFS). <http://seawifs.gsfc.nasa.gov/SEAWIFS.html>

NOAA Coastal Change Analysis Program. <http://www.csc.noaa.gov/ccap/>

INVENTORY OF FEDERAL DATA (SATELLITE, AERIAL, MAPPED)

This section lists sources of Land Use/Land Cover data categorized by the federal agencies responsible for the work in Land Cover data creation and production. A web site reference/URL has been provided for more extensive information and data downloads where available. Please refer to the appendices for specific contact information.

United States Department of Agriculture (USDA)

- Natural Resources Conservation Service State of the Land
- State Soil Geographic (STATSGO) Data Base

Natural Resources Conservation Service State of the Land

The National Land Cover site provides information in map and tabular format about land cover in each state. Particular areas of interest show the percentage of state land area that each broad land cover/use occupies. Margins of error are included with the tables.

Organization	USDA
Scope	National
Scale	Varies
Date of Project	1992
Status	Complete
Data Sources	National Resources Inventory. The 1992 NRI covers 800,000 sample points representing 1.5 billion acres of non-federal land. At each sample point, information is available for three years—1982, 1987, and 1992. Data is currently being collected for 1997.
Standards and Protocols	
Distribution Format	Arc/Info Export; ASCII text (tables)
Website	<i>http://www.nhq.nrcs.usda.gov/land/index/intro.html</i>

State Soil Geographic (STATSGO) Data Base

The State Soil Geographic (STATSGO) Database provides information about soil features on or near the surface of the Earth. It is designed primarily for regional, multi-state, river basin, and multi-county resource planning, management, and monitoring as data are not detailed enough to make interpretations at a county level. The STATSGO soil survey product is not designed for use as a primary decision-making tool, but may be used as a reference source.

Organization	USDA
Scope	National
Scale	1:250,000
Date of Project	1994
Status	Complete
Data Sources	Soil Conservation Service soil survey maps
Standards and Protocols	Compiled by generalizing more detailed soil survey maps
Distribution Format	Spatial line data are in DLG-3 optional or ARC cover formats. Digital line graph files contain major and minor code pairs in area and line records. Map unit IDs are available in a companion ASCII attribute file. The Map Unit Interpretations Record attribute soil data are available in variable length, tab delimited, ASCII, INFO, or dBASE files.
Website	http://www.ftw.nrcs.usda.gov/stat_data.html http://edcwww.cr.usgs.gov/Webglis/glisbin/guide.pl/glis/hyper/guide/statsgo

United States Environmental Protection Agency (U.S. EPA)

- An Ecological Assessment of the United States Mid-Atlantic Region:
A Landscape Atlas
- GIRAS Spatial Data in the Conterminous United States
1:250,000 Scale Quadrangles of Land Use/Land cover
- LANDSAT Fly Over Land Use Data for the Chesapeake Basin
- Multi-Resolution Land Characteristics Consortium (MRLC) Federal Regional Land
Cover
- MAIA Geographic Reference Database
- Omernik's Ecoregion Boundaries for EPA Region III

An Ecological Assessment of the United States Mid-Atlantic Region: A Landscape Atlas

The Landscape Atlas assesses relative ecological conditions by identifying land cover and land use across the mid-Atlantic region of the United States. This enables the user to visualize and understand environmental conditions across the region as well as understand the way in which these conditions can be applied to community-based environmental decision making. The Atlas represents one of the first regional-scale ecological assessments of the Environmental Monitoring and Assessment Program (EMAP) and will contribute to comprehensive ecological assessments being conducted by EPA Region III. It is useful to states, local communities, and others.

Organization	U.S. EPA
Scope	Mid-Atlantic region of the United States
Scale	varies from 30 meters to 1 kilometer
Date of Project	November 1997
Status	Complete
Data Sources	Satellite imagery and spatial databases on biophysical features such as soils, elevation, and human population patterns.
Standards and Protocols	Not provided
Distribution Format	The atlas is offered as ZIPed (compressed) PDF (Portable Document Format) files (except Chapter 1 which is in PDF only). Or readable online in HTML. Either the entire file or individual chapters can be downloaded or viewed.
Website	<i>http://www.epa.gov/maia/html/maia-atlas.html</i>

GIRAS Spatial Data in the Conterminous United States 1:250,000 Scale Quadrangles of Land Use/Land Cover

This land use/land cover digital data collected by USGS is converted to ARC/INFO by the EPA. The data are useful for environmental assessment of land use patterns but may be limited due to the dates involved in the study (mid 1970s to early 1980s). Data are meant to be used by quadrangle or among adjacent quadrangles and can be used in any geographic application where intermediate scale land use data are appropriate and the dates are representative. When joined together, these quadrangles will not likely match along edges due to differences in interpretation and time coverage.

Organization	U.S. EPA
Scope	National (by State)
Scale	1:250,000 and 1:100,000 (map); 1:24,000 to 1:100,000 (photo)
Date of Project	1970s
Status	Complete
Data Sources	Multiple sources (e.g., NASA high-altitude aerial photos)
Standards and Protocols	Anderson Level 2
Distribution Format	Arc/Info export, GIRAS, CTG, vector, raster. No cost through anonymous FTP account; available at cost of reproduction on magnetic tape.
Website	http://nsdi.epa.gov/nsdi/projects/giras.htm http://www.epa.gov/OWOW/watershed/landcover/lulcusa.html#USA
Anonymous FTP	http://edcwww.cr.usgs.gov/glis/hyper/guide/1_250_lulc

LANDSAT Fly Over Land Use Data for the Chesapeake Basin

In order to create a model to estimate nutrient loadings, the Chesapeake Bay Program obtained LANDSAT images to map land use of the Chesapeake Basin. The data was aggregated into sub-basin units and divided into nine categories of land use: forest, cropland with winter cover (low till), cropland without winter cover (high till), pasture, low density residential, medium density residential, high density residential, commercial industrial, and idle land. Photographs were taken in April, May and June 1977–1979 to determine differences in agricultural use.

Organization	U.S. EPA; Chesapeake Bay Program
Scope	Chesapeake Bay
Scale	Not provided
Date of Project	April, May and June of 1977–1979
Status	Complete
Data Sources	LANDSAT
Standards and Protocols	USGS Level I Land Cover Classification
Distribution Format	Not provided
Website	<i>http://www.neonet.nl/ceos-idn/datasets/004017.html</i>

MAIA Geographic Reference Database

The MAIA Geographic Reference Database (GRD) ensures constant data infrastructures for resource groups, partner agencies, federal and scientific communities. The GRD is a program-wide database which contains spatial data sets and descriptions of available data, its quality and ownership. The GRD references spatial data for a variety of physical, biological, and cultural themes including: land cover, ecoregions, physiographic regions, soils, watershed boundaries and political boundaries.

Organization	U.S. EPA
Scope	EPA Region III
Scale	1:7,500,000
Date of Project	1991-1992
Status	Complete
Data Sources	Forest Cover Types of the United States and Canada (1:7,500,000 scale) (F.H. Eyre, Society of American Foresters, 5400 Grosvenor Lane, Bethesda, MD 20814); Digitized Forest Cover Types of the United States at a scale of 1:3,750,000 (S.H. Azevedo, Forest Ozone Team, U.S. EPA Environmental Research Lab, Corvallis, OR); Digital Line Graph State Boundaries for the conterminous U.S. at a scale of 1:2,000,000 (USGS); Digital Line Graph County Boundaries for the U.S. at a scale of 1:2,000,000 (USGS)
Standards and Protocols	See http://www.epa.gov/docs/grd/forest/forest_vol1.html
Distribution Format	One compressed Arc/Info export file
Website	http://www.epa.gov/docs/grd/

Multi-Resolution Land Characteristics Consortium (MRLC) Federal Regional Land Cover

Six Federal environmental monitoring programs, EMAP (U.S. EPA), GAP (USGS), NAWQA (USGS), C-CAP (NOAA), NALC (U.S. EPA/USGS), and the RSA Center (USFS) have formed a consortium with the EROS Data Center (USGS) to facilitate the development of comprehensive land characteristics information. This partnership, entitled the Multi-Resolution Land Characteristics Interagency Consortium (MRLC) provides databases which serve as archives for the 1992 (+/- 1) year. The data will be used in the development of the MRLC National Land Cover Database (NLCD) and when complete, will contain land cover data for the continental U.S. This will include satellite image data, processed data, regional land cover data sets, final products and associated derivative data. Users are able to obtain comprehensive land cover information for their areas of interest.

Organization	MRLC
Scope	EPA Region III (30 million hectares)
Scale	30-m by 30-m resolution, map scale 1,100:000
Date of Project	Spring 1991 to Summer 1993 satellite images
Status	EPA Region III available (national coverage expected to be completed by mid 2000)
Data Sources	LANDSAT TM, DLG, DEM, vector, raster,
Standards and Protocols	Anderson land cover classification
Distribution Format	Unrestricted access to all users in ARC/INFO (GRID) or Generic Binary format on CD-ROM or 8-mm tape; also hard copy maps and peer-reviewed publications. FTP sites are most practical for data distribution.
Website	http://www.epa.gov/mrlc/ http://www.epa.gov/reg3giss/libraryp.htm http://www.epa.gov:6706/nemidcd/owa/monitor.program?id=8 http://www.epa.gov/OWOW/watershed/landcover/lulcde.html#mrlc

Omernik's Ecoregion Boundaries for EPA Region III

Digitized from Omernik's map entitled *Ecoregions of the Conterminous United States* (1987), the map consists of 3,733 polygons grouped into 76 regions. An additional attribute indicates whether the polygons are most typical or generally typical of a particular region. Omernik's map contains regions defined by common soils, land use, potential natural vegetation and land forms.

Organization	U.S. EPA
Scope	EPA Region III
Scale	1:2,500,000
Date of Project	1987
Status	Complete
Data Sources	Based on USGS 1:2,000,000 Digital Line Graph (DLG) County boundaries
Standards and Protocols	Omernik methodology, as published in: Omernik, J.M., 1987, "Ecoregions of the conterminous United States", <i>Annals of the Association of American Geographers</i> , v. 77, no. 1, p. 188-125. Omernik, J.M., and Gallant, A.L., 1988, <i>Ecoregions of the upper Midwest States: Corvallis, Oregon</i> , U.S. Environmental Protection Agency, 56 p., folded map in pocket. [Part of a Publication Series.]
Distribution Format	From U.S. EPA (GRD): Arc/Info export format From USGS (EDC): Map in two versions: 1. ecoregions, 2. most typical portions of each ecoregion). Available in raster and vector formats on the Conterminous U.S. AVHRR Companion Disc
Website	http://www.epa.gov/docs/grd/eco/eco_vol1.html http://edcwww.cr.usgs.gov/eros-home.html

United States Fish and Wildlife Service (USFS)

- Division of Habitat Conservation – National Wetlands Inventory (NWI)

Division of Habitat Conservation – National Wetlands Inventory (NWI)

The National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service provides information on the characteristics, extent and status of the nation's wetlands and deepwater habitats. This information is used by federal, state, and local agencies, academia and the private sector. The NWI has produced over 130 publications, including manuals, plant and hydric soils lists, field guides, posters, wall size resource maps, atlases, and state reports, and has had numerous articles published in professional journals. The NWI has mapped 89% of the lower 48 states, and 31% of Alaska.

Organization	USFWS
Scope	National
Scale	1:250,000 (minimum mapping unit is from 1 to 3 acres depending on the wetland type and the scale and emulsion of the source aerial photography)
Date of Project	Ranges from 1971 to 1992 (varies for each 7.5' quad)
Status	Complete digital maps for MAIA region except for two areas of Virginia that have final paper maps
Data Sources	USGS 7.5' quads, field mapping, National Aerial Photography Program (NAPP), National High Altitude Photography (NHAP), Agricultural and Stabilization Conservation Service (ASCS), NASA or special project photography
Standards and Protocols	NWI wetland classification (Cowardin, L.M., V. Carter, F. Golet, and E. LaRoe. 1979. <i>Classification of Wetlands and Deepwater Habitats of the United States</i> . U.S. Fish Wildlife Service. 103 pp.
Distribution Format	Hardcopy, DLG3 (FTP download)
Website	http://www.nwi.fws.gov/

United States Geological Survey (USGS)

- Conterminous U.S. Land Cover Characteristics Data Set
- Gap Analysis Program (GAP)
- USGS Land Use Land Cover (LULC) Data, GIRAS
- USGS-NPS Vegetation Mapping Program

Conterminous U.S. Land Cover Characteristics Data Set (1990 prototype)

The Conterminous U.S. Land Cover Characteristics Data Set 1990 Prototype is a classification of seasonal land cover types at 1 km resolution. It was created from a combination of multi-temporal satellite data with earth science data sets including climate, elevation, and ecoregions. This data set is intended to complement, rather than replace, other land cover classifications including those derived from higher-resolution satellite imagery such as LANDSAT or SPOT. The concept of the seasonally distinct land cover region as used in this data set is fundamentally different than that used in most spectral classifications of remotely sensed data. It was developed by the USGS EROS Data Center and the Center for Advanced Land Management Information Technologies University of Nebraska-Lincoln.

Organization	USGS
Scope	Seasonal land cover types; national
Scale	1-km resolution
Date of Project	1990 growing season
Status	Complete
Data Sources	National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) High Resolution Picture Transmission (HRPT) satellite imagery
Standards and Protocols	Normalized Difference Vegetation Index (NDVI) compositing
Distribution Format	CD-ROM, raster data type
Website	http://edcwww.cr.usgs.gov/Webglis/glisbin/guide.pl/glis/hyper/guide/landchar http://www.epa.gov/OWOW/watershed/landcover/lulcusa.html#three http://www.calmit.unl.edu/calmit/research.html

Digital Orthophoto Quadrangles

Organization	USGS
Scope	National
Scale	1:12,000 scale for 3.75-minute quadrangles and at 1:24,000-scale for 7.5-minute quadrangles.
Date of Project	Varies with data set
Status	Complete
Data Sources	USGS standard digital orthophotos in black-and-white, or color infrared, 1-meter ground resolution quarter quadrangle image.
Standards and Protocols	National Map Accuracy Standards
Distribution Format	DOQ's are available on CD and through File Transfer Protocol (FTP) over the Internet, as well as on 8-mm and 3480-cartridge tapes.
Website	<i>http://nsdi.usgs.gov/products/doq.html</i>

Gap Analysis Program

The mission of the Gap Analysis Program (GAP) is to provide regional assessments of the conservation status of native vertebrate species and natural land cover types and to facilitate the application of this information to land management activities. The Gap Analysis Program is a collaboration of regional, state, and federal agencies, and private groups as well as the USGS Biological Resources Division (BRD).

Organization	USGS
Scope	National
Scale	1:100,000 scale, 30-m x 30-m resolution
Date of Project	Varies by state, see below
Status	Varies by state
Data Sources	LANDSAT-TM, DLG, DEM and other sources (varies by state)
Standards and Protocols	GAP standards: http://www.gap.uidaho.edu/GAP/AboutGAP/Handbook/S.htm
Distribution Format	Varies by state (ARC/INFO, vector and raster)
Website	http://www.gap.uidaho.edu/gap/index.htm http://www.epa.gov/OWOW/watershed/landcover/lulcusa.html#gap

Delaware, Maryland, New Jersey

Status	MD and DE complete; no plans for New Jersey completion
Website	http://www.gap.uidaho.edu/Projects/States/Detail.asp?state=de http://www.gap.uidaho.edu/Projects/States/Detail.asp?state=md http://www.gap.uidaho.edu/Projects/States/Detail.asp?state=nj

North Carolina (USGS-BRD and NC Cooperative Fish and Wildlife Unit, NCSU)

Status	In progress
Website	http://www.gap.uidaho.edu/Projects/States/Detail.asp?state=nc

Pennsylvania

Status	In progress
Website	http://www.gap.uidaho.edu/Projects/States/Detail.asp?state=pa

Virginia

	(USGS-BRD and Virginia Tech)
Status	Two-thirds complete
Website	http://www.gap.uidaho.edu/Projects/States/Detail.asp?state=va

West Virginia

Status	Ongoing
Website	http://www.gap.uidaho.edu/Projects/States/Detail.asp?state=vv http://www.caf.wvu.edu/mikewww/jackie/gapposter/wvposter.html

USGS Land Use Land Cover (LULC) Data, GIRAS

The United States Geological Survey provides these data sets and associated maps as a part of its National Mapping Program. The Land Use and Land Cover (LULC) data files show vegetation, water, natural surface, and cultural features on the land surface. The LULC mapping program is designed so that standard topographic maps of a scale of 1:250,000 can be used for compilation and organization of the land use and land cover data. In some cases, such as Hawaii, 1:100,000 scale maps are also used.

Organization	USGS
Scope	National (by State)
Scale	1:250,000
Date of Project	1970's
Status	Complete
Data Sources	Multiple sources (e.g., NASA high-altitude aerial photos, etc.)
Standards and Protocols	Anderson land cover classification
Distribution Format	GIRAS or CTG on CD-ROM
Website	<i>http://edcwww.cr.usgs.gov/glis/hyper/guide/1_250_lulc</i>

USGS-NPS Vegetation Mapping Program

This project is a long-term vegetation monitoring program to map vegetation of 235 National Parks (only Assateague Island National Seashore in MAIA region). Another goal is to develop a standard national vegetation classification, develop and use effective inventory and mapping protocols, produce digital (GIS-compatible) vegetation maps of parks and environs, develop databases for field vegetation documentation.

Organization	USGS
Scope	National
Scale	1:6720
Date of Project	photos flown in September 1995
Status	Complete
Data Sources	Color-infrared (CIR) stereo-paired diapositives, average scale 1:6720
Standards and Protocols	follows FGDC National Vegetation Classification System (October 1995)
Distribution Format	Map in several formats (gif, rtl, E00, SDTS , GRASS vector and raster)
Website	http://biology.usgs.gov/npsveg/ http://biology.usgs.gov/npsveg/TUZI/tuzimeta.html

National Oceanic and Atmospheric Administration (NOAA)

- Coastal Change Analysis Project (C-CAP) for Chesapeake Bay
- Coastal Change Analysis Project (C-CAP) for MAIA Coastal Areas

Coastal Change Analysis Project (C-CAP) for Chesapeake Bay

The Coastal-Change Analysis Program (C-CAP) is developing tools to monitor and understand changes in wetlands and adjacent uplands and to relate these impacts to living marine resources. C-CAP has developed a standard, nationally accepted protocol for mapping these areas which involves using LANDSAT satellite imagery and aerial photography. The prototype Chesapeake Bay data set constitutes one of the largest change detection efforts ever attempted. NOAA's National Oceanographic Data Center archives and manages C-CAP data and is developing C-CAP CD-ROM products.

Organization	NOAA / NOS / CSC
Scope	Chesapeake Bay (30,000 square miles)
Scale	30-meters by 30-meters
Date of Project	1984-1989
Status	Complete
Data Sources	LANDSAT imagery
Standards and Protocols	C-CAP
Distribution Format	CD-ROM
Website	http://www.csc.noaa.gov/ccap/text/chesapeake.html http://www.esdim.noaa.gov/story/nodc_diccap.html

Coastal Change Analysis Project (C-CAP) for MAIA Coastal Areas

The Coastal Change Analysis Program is designed to monitor change in terrestrial land cover and nearshore benthic resources within coastal environments of the United States including the Atlantic, Pacific, and Gulf of Mexico, the Great Lakes, Alaska, Hawaii, and all U.S. territories and possessions. C-CAP classifies types of land cover, analyzes and monitors changes in coastal submerged habitats, wetland habitats, and adjacent uplands using remote sensing techniques (satellite imagery and aerial photography). Through this analysis, scientists can correlate the changes in terrestrial regions with those in coastal aquatic habitats, and with changes in the distribution, abundance, and health of living marine resources. The program is managed through the NOAA Coastal Services Center, in Charleston, South Carolina in coordination with the National Marine Fisheries Service Laboratory in Beaufort, North Carolina and with technical support from the Oak Ridge National Laboratory in Oak Ridge, Tennessee.

Organization	NOAA
Scope	MAIA coastal areas
Scale	Varies with data set
Date of Project	Not provided
Status	On going
Data Sources	LANDSAT imagery
Standards and Protocols	C-CAP
Distribution Format	Varied with data set
Website	<i>http://www.csc.noaa.gov/ccap</i>

INVENTORY OF STATE DATA (SATELLITE, AERIAL, MAPPED)

This section provides detailed records for the primary State agencies that are engaged in Land Cover data creation and production. Typically it is appropriate to visit each State's GIS data center as a comprehensive provider of spatial data including land cover information. It is also helpful to note that the EPA Office of Wetlands, Oceans and Watersheds has a land use land cover study guide for each state accessible through their web site <http://www.epa.gov/OWOW/watershed/landcover.html>.

The references provided in this section are standardized in content to provide a quick synopsis of the available land cover information from the specific organization. A web site reference/URL has been provided so that the user of this guide can refer to the site directly for more extensive information and data downloads where available. Please refer to the appendices for specific contact information.

Delaware

Delaware Land-Use/Land Cover Transitions

This study summarizes land-use/land cover (LULC) changes occurring in Delaware between 1984 and 1992. It is considered a follow-up to "Land Use Transitions in Delaware, 1974–1984" (AES Bulletin 483, September, 1989). A graphical frequency analysis of LULC categories in the two series was performed for each county, as well as for the northern and southern halves of New Castle County.

Organization	University of Delaware Spatial Analysis Lab
Scope	Delaware
Scale	30-meter resolution
Date of Project	1984 – 1992
Status	Complete
Data Sources	1984 LULC series (EarthSat Corp. under contract with the Delaware Dept. of Agriculture) at LANDSAT MSS satellite imagery resolution (79-meter pixel size). The 1992 LULC series (PhotoScience Inc. under contract with the Delaware Dept. of Natural Resources & Environmental Control) polygons were digitized on 1-meter resolution digital orthophotos using a different modification of the Anderson LULC classification scheme, with a 4-acre minimum mapping unit.
Standards and Protocols	A modified 2-digit Anderson LULC classification scheme using a 15-acre minimum mapping unit
Distribution Format	Arc/Info Export (.E00) files can be downloaded from this site by county
Website	http://bluehen.ag.s.udel.edu/spatlab/lulc/

Gross Land Use Changes In Delaware, 1992 to 1997

Digital orthophotography from 1992–1997 was used to derive land use and land cover data for the state of Delaware. This data provides an opportunity to take a snapshot of the land use and land cover of the state in those years and can be used to study changes in land use in Delaware over time.

Organization	Delaware Office of State Planning Coordination, Au
Scope	Delaware
Scale	Not provided
Date of Project	1992 - 1997
Status	Complete
Data Sources	Aerial and digital orthophotography funded by a consortium of state agencies.
Standards and Protocols	Anderson et al., Land Use Classification System
Distribution Format	Not provided
Website	http://www.state.de.us/planning/info/lulcdata/change/lulcchng.htm http://www.state.de.us/planning/info/lulcdata/lulc.htm

Delaware Spatial Data Clearinghouse

This clearinghouse includes a searchable database of metadata compliant with Federal Geographic Data Committee (FGDC) standards. Metadata entries provide detailed descriptions of the content and sources of the data, and often includes direct hypertext links to the data sets. From this site, you can search the Delaware Clearinghouse node along with the many others that make up the National Spatial Data Infrastructure (NSDI). The Clearinghouse also maintains direct links to other sites having valuable Delaware spatial data collections and resources. This website was developed by the Research Data Management Services at the University of Delaware and the Center for Applied Demography and Survey Research at UDE. This site is now maintained in partnership with the Delaware Office of State Planning Coordination and the Institute for Public Administration, University of Delaware.

Organization	Research Data Management Services, University of Delaware
Scope	Land use data for 50 USGS quads in Delaware
Scale	Source scale 1:12,000; finished product has 4-acre resolution
Date of Project	Spring 1992
Status	Complete
Data Sources	Orthophotography by PhotoScience
Standards and Protocols	Anderson Land Use Classification System
Distribution Format	FTP of quarter-quads in Arc/Info export (.E00) files (.ZIP format)
Website	<i>http://gis.smith.udel.edu/fgdc/gateway</i>

Delaware Land Cover by Aerial Photograph

These aerial images for the state were produced by VARGIS LLC. VARGIS is a commercial organization which specializes in providing imagery for geographic and environmental analysis. The type of aerial imagery available through the VARGIS inventory for each state includes black & white, color and color infrared photography.

Organization	DE Department of Natural Resources and Environmental Control
Scope	Delaware
Scale	1:63,360 (map scale)
Date of Project	January 1, 1984 (image date), December 31, 1985 (map date)
Status	Complete
Data Sources	Aerial photograph, Vector data type
Standards and Protocols	Anderson Modified (22 classes)
Distribution Format	ARC/INFO. Data available for purchase.
Website	http://www.epa.gov/OWOW/watershed/landcover/lulcde.html#DE

Infrared Aerial Photography of Delaware

Organization	VARGIS
Scope	Delaware
Scale	1:1,000 ft, 1 meter resolution
Date of Project	1992 (photo)
Status	Complete
Data Sources	Infrared aerial photograph from Department of Transportation, digital format
Standards and Protocols	Not provided
Distribution Format	GeoTIFF and MrSID available in ft or meters with overlay options. Data available for a fee for each quarter quad.
Website	<i>http://www.vargis.com</i>

Maryland

Maryland's Coastal Bays, An Electronic Atlas

This CD-ROM contains an atlas of Maryland's Atlantic coast. The data cover the coastal bay regions and include three basic levels: 1 SPOT satellite image from 1995; 11 adjacent 7.5' topographic map quadrangles from USGS; 36 adjacent 3.75' color-infrared orthophoto quadrangles. In addition, 27 GIS theme coverages are available for overlay on these data levels. These include wetlands, streams, watersheds, flood plains, submerged aquatic vegetation, roads, land use, land parcel boundaries, historical sites, archaeological sites, protected land areas, and poultry farms. Metadata on the source of each coverage is also available. The information can be obtained through the Global Change Master Directory Website (URL found below).

Organization	Maryland Department of Natural Resources
Scope	Maryland
Scale	Not provided
Date of Project	1981–1997
Status	Complete
Data Sources	SPOT imagery, USGS 7.5' quadrangles, 3.75' color-infrared orthophoto quadrangles, 27 GIS theme coverages
Standards and Protocols	Not provided
Distribution Format	CD-ROM
Website	<i>http://gcmd.nasa.gov/cgi-bin/md</i>

Maryland Land Use/Land Cover

This program provides digital data, maps and custom products and services for land use/land cover, natural soils groups, streams and watersheds. It provides parcel data summarized by assessment district and computerized parcel mapping as well as LANDSAT images. Real Property parcel data file including x.y. coordinates is based on North American Datum (USGS) 1983, Real Property parcel map file theme layer (GIS).

Organization	Maryland Office of Planning, Planning Data Services
Scope	Maryland
Scale	1:63,360
Date of Project	1990 and 1994 data
Status	Available for purchase
Data Sources	Not provided
Standards and Protocols	USGS
Distribution Format	Not provided
Website	<i>http://www.inform.umd.edu:8080/UMS+State/MD_Resources/MSDC/.www/MSGIC/guide/mop_pds.htm</i>

Maryland Land Cover by High Altitude Aerial Photography

Information about these land cover data can be accessed through the EPA Office of Water and Watershed (OWOW) web site. The Land Cover Data Directory at this site is a comprehensive set of land cover data for each state. The data can vary from state to state for map scale and type of photography. The OWOW Directory for each state contains any state initiated land cover mapping, MRLC generated land cover, US EPA land cover and USGS land cover.

Organization	MD Department of Environmental Management, Division of Information Systems
Scope	Entire state by county and city
Scale	1:62,500 (map and photo)
Date of Project	January 1, 1989 (image), April 1, 1991 (map)
Status	Complete
Data Sources	High altitude aerial photograph
Standards and Protocols	Anderson 2 Modified (25 classes)
Distribution Format	ARC/INFO, Vector. Data can be purchased by county.
Website	http://www.epa.gov/OWOW/watershed/landcover/lulcmd.html#MD

Infrared Aerial Photography of Maryland

These aerial images for the state were produced by VARGIS LLC. VARGIS is a commercial organization which specializes in providing imagery for geographic and environmental analysis. The type of aerial imagery available through the VARGIS inventory for each state includes black & white, color and color infrared photography.

Organization	VARGIS
Scope	Maryland
Scale	1:12,000 (1"=1000') (map), 1.2m (4') resolution
Date of Project	1989 – 1994 (images)
Status	Complete, updates available
Data Sources	CIR (Color Infrared) photographs
Standards and Protocols	Not provided
Distribution Format	24 bit TIFF, CD available for fee
Website	http://www.vargis.com/vardog.html

New Jersey

Mapping Land Use/Land Cover for the New Jersey Council on Affordable Housing

The Center for Remote Sensing and Spatial Analysis (CRSSA), Rutgers University was asked to map vacant and developed land in the summer of 1991 for the New Jersey Council on Affordable Housing (COAH). The CRSSA combined three LANDSAT images along with housing unit density information derived from the US Census Bureau's TIGER system. A Level I land use/land cover map was generated.

Organization	Center for Remote Sensing and Spatial Analysis, Rutgers University
Scope	Statewide vacant and developed land
Scale	Not provided
Date of Project	Post summer, 1991
Status	Complete
Data Sources	Three LANDSAT TM scenes, U.S. Census housing unit density information, PL94-171 redistricting data
Standards and Protocols	Level I land use/land cover map was generated and combined with housing unit density information and redistricting data to improve the detection of residential land use
Distribution Format	Not provided
Website	http://deathstar.rutgers.edu/projects/coah/coah.html

New Jersey DEP Land Use Data

The LULC layers are Land Use and Land Cover polygon shape files for New Jersey counties as of 1986. The LULC shape files were created by combining two separate data sets, the land use/land cover layer from the county Integrated Terrain Unit Maps (ITUM) and the freshwater wetlands (FWW) layer generated under the New Jersey Freshwater Wetlands Mapping Program

Organization	NJ Department of Environmental Protection and Energy, Office of Information Resources Management, Bureau of Geographic Information and Analysis
Scope	Entire state
Scale	1:58,000 (photo), 1:24,000 (map)
Date of Project	January 1, 1986 (image), January 1, 1995 (map)
Status	Complete
Data Sources	Aerial photograph
Standards and Protocols	Anderson 2
Distribution Format	Available on 3 CD-ROMs for purchase. Data in ARC/INFO export format for DOS.
Website	http://www.princeton.edu/~geolib/gis/njluse.html

New Jersey Land Cover by High Altitude Aerial Photography

The information about this land cover data can be accessed through the EPA Office of Water and Watershed (OWOW) web site. The Land Cover Data Directory at this site is a comprehensive set of land cover data for each state. The data can vary from state to state for map scale and type of photography. The OWOW Directory for each state contains any state initiated land cover mapping, MRLC generated land cover, US EPA land cover and USGS land cover.

Organization	NJ Department of Environmental Protection and Energy, Office of Information Resources Management, Bureau of Geographic Information and Analysis
Scope	Entire state
Scale	1:58,000 (photo), 1:24,000 (map)
Date of Project	January 1, 1986 (image), January 1, 1995 (map)
Status	Complete
Data Sources	Aerial photograph
Standards and Protocols	Anderson 2
Distribution Format	Available on 3 CD ROMs for purchase. Data in ARC/INFO export format for DOS.
Website	http://www.epa.gov/OWOW/watershed/landcover/lulcnj.html#NJ http://www.state.nj.us/dep/gis

New York

Adirondack Park Land Cover from LANDSAT MSS

This land cover was produced with Landsat Satellite imagery for a significant portion of Northeastern up state New York. The reference information for this data along with other land cover data can be accessed through the EPA Office of Water and Watershed web site.

Organization	Adirondack Park Agency
Scope	Northeast New York within Adirondack Park, 6 million acres
Scale	1:100,000 (photo), 1:24,000 (map)
Date of Project	July 1, 1983 (image), July 1, 1989 (map)
Status	Complete
Data Sources	LANDSAT MSS
Standards and Protocols	Anderson Modified
Distribution Format	ERDAS, Raster. Available for purchase for costs of reproduction and media
Website	http://www.epa.gov/OWOW/watershed/landcover/lulcny.html#two

New York Partial State Land Cover from Property Assessment Maps

This data set developed by the NY Division of Equalization and Assessment provides a high resolution land cover data set. The reference information for these land cover data can be accessed through the EPA Office of Water and Watershed (OWOW) web site. The Land Cover Data Directory at this site is a comprehensive set of land cover data for each state. The data can vary from state to state for map scale and type of photography. The OWOW Directory for each state contains any state initiated land cover mapping, MRLC generated land cover, US EPA land cover and USGS land cover.

Organization	NY Division of Equalization and Assessment
Scope	52 of 57 counties
Scale	1:4800 (Average)
Date of Project	Not provided
Status	Complete
Data Sources	Data from property assessment maps. Digital data available for every parcel centroid. Boundary information not available for all counties.
Standards and Protocols	Property Type Classification Code (similar to Anderson)
Distribution Format	Data is available in standard format for the cost of reproduction only. (Standard format: 9 track tape, in ARC/INFO EXPORT format) Files can be customized for your system at additional cost. Costs of reproduction will be agreed on prior to creation of files.
Website	http://www.epa.gov/OWOW/watershed/landcover/lulcny.html#NY

North Carolina

Land Use/Land Cover - TM (Albemarle-Pamlico & Coastal NC)

EOSAT (now Space Imaging) and the Computer Graphics Center at North Carolina State University with the cooperation of the NC Center for Geographic Information and Analysis, developed the Land Use/Land Cover digital data set. This will enhance planning, siting and impact analysis in the Albemarle-Pamlico Estuarine Study area and the rest of Eastern North Carolina. The data layer enables the user to identify areas depicting human uses of the land, vegetation, water, natural surface, and construction in this area.

Organization	North Carolina Center for Geographic Information and Analysis
Scope	North Carolina
Scale	Imagery pixel size is 30 x 30 meters with a satellite altitude of approximately 438 miles.
Date of Project	Reflects conditions in 1987-1989. 1987 (image), 1989 (map)
Status	Complete
Data Sources	The data are from LANDSAT 5 Thematic Mapper (TM). Contributors to this data include Earth Observation Satellite Corporation; and NC State University, Computer Graphics Center.
Standards and Protocols	Raster imagery ground-truthed, classified, run through a 5 x 5 pixel filter, vectorized and tiled to U.S. Geological Survey 1:100,000-scale map extent (Anderson II modified).
Distribution Format	Available for eastern North Carolina and southeastern Virginia tiled by USGS 1:100,000-scale map extent, vector data. Must be purchased.
Website	http://www.cgia.state.nc.us/cgdb/datalist.html http://www.cgia.state.nc.us/cgdb/lulc87.html http://www.cgia.state.nc.us/cgdb/refdocs/lc96 http://www.cgia.state.nc.us/ncgdc http://www.epa.gov/OWOW/watershed/landcover/lulcnc.html

North Carolina Land Cover 1996

The North Carolina Center for Geographic Information and Analysis (CGIA), in cooperation with the NC Department of Transportation and United States Environmental Protection Agency Region IV Wetland Division, contracted Earth Satellite Corporation (EarthSat) of Rockville, Maryland to generate comprehensive land cover data for the entire state of North Carolina. These data were created to assist governmental agencies and others in making resource management decisions through the use of a geographic information system (GIS).

Organization	North Carolina Center for Geographic Information and Analysis
Scope	North Carolina
Scale	Image pixel size is 28.5 x 28.5 meters
Date of Project	Based on imagery dated from 3/5/93 through 5/20/95 and ground condition data collected in 1996
Status	Complete
Data Sources	LANDSAT TM
Standards and Protocols	The raster imagery was ground-truthed, classified, run through various pixel filters, vectorized and tiled to U.S. Geological Survey 1:100,000-scale map extent.
Distribution Format	Available in a statewide ERDAS Imagine raster file, tiled vectorized files for North Carolina, ARC/INFO GIS.
Website	http://www.cgia.state.nc.us/cgdb/datalist.html http://www.cgia.state.nc.us/cgdb/refdocs/lc96 http://www.cgia.state.nc.us/cgdb/lulc87.html http://www.epa.gov/OWOW/watershed/landcover/lulcnc.html#NC

Pennsylvania

Pennsylvania Partial State Land Cover from Aerial Photographs and Digital Orthophotos

The information about these land cover data can be accessed through the EPA Office of Water and Watershed (OWOW) web site. The Land Cover Data Directory at this site is a comprehensive set of land cover data for each state. The data can vary from state to state for map scale and type of photography. The OWOW Directory for each state included state initiated land cover mapping, MRLC generated land cover, US EPA land cover and USGS land cover.

Organization	PA Department of Environmental Resources, Bureau of Information Services
Scope	Partial State
Scale	1:12,500 (photo), 1:24,000 (map)
Date of Project	January 1, 1995 (map)
Status	Ongoing
Data Sources	Aerial photographs, digital orthophotos
Standards and Protocols	Not provided
Distribution Format	ARC/INFO, Vector. Some digital data available. Also topographical maps and aerial photographs available. For metadata or data, contact the Maps room of Pattee Library, Pennsylvania State University.
Website	http://www.epa.gov/OWOW/watershed/landcover/lulcpa.html#PA

Pennsylvania Spatial Data Access Web Site

PASDA supports search, display, and retrieval of FGDC (Federal Geographic Data Committee) standard metadata, geographic information systems (GIS) data, and imagery related to Pennsylvania's environment. The search engine on the site is dynamic to allow users to find land use and land cover data by keyword, topic, data type or provider.

Organization	Pennsylvania State University
Scope	Pennsylvania
Scale	Varies with data set
Date of Project	Varies with data set
Status	Varies with data set
Data Sources	Varies with data set
Standards and Protocols	Varies with data set
Distribution Format	ArcInfo export files, Digital Image Files are found as .tif images
Website	<i>http://www.pasda.psu.edu</i>

Virginia

Distributions of Land Cover Types at the Eastern Shore of Virginia

A TM satellite image from 28 July 1993 was used to define the distributions of different land cover types on the eastern shore of Virginia. Both supervised and unsupervised classification methods were applied to separate major land cover types. In total, 6 land cover types including forest/shrub, beach, cropland, dune grassland, marsh and tidal flat were recognized using the TM image. The verification of the classification results was completed at several study sites.

Organization	Department of Environmental Sciences, University of Virginia
Scope	Report on a study by researchers
Scale	Based on Landsat TM
Date of Project	July 28, 1993 image
Status	Complete
Data Sources	TM satellite image
Standards and Protocols	Supervised and unsupervised classification
Distribution Format	Not provided
Website	http://atlantic.evsc.virginia.edu/davedocs/VCRASC95/shaocov.html

Infrared Aerial Photography of Northern Virginia

These aerial images for the state were produced by VARGIS LLC. VARGIS is a commercial organization which specializes in providing imagery for geographic and environmental analysis. The type of aerial imagery available through the VARGIS inventory for each state includes black & white, color and color infrared photography.

Organization	VARGIS
Scope	Six counties in Northern Virginia (Fairfax, Arlington, Prince William, Loudoun, Fauquier and Stafford including the cities of Alexandria, Falls Church, Fairfax, Mannassas and Fredericksburg
Scale	1:12,000 (10=1,000M) 1.0 meter resolution
Date of Project	March 1995 (image)
Status	Complete
Data Sources	CIR (Color Infrared) photography
Standards and Protocols	Not provided
Distribution Format	Available for purchase on CD-ROM in 24 bit TIFF format
Website	<i>http://www.vargis.com</i>

Monochrome photographs of Tidewater Virginia

These aerial images for the state were produced by VARGIS LLC. VARGIS is a commercial organization which specializes in providing imagery for geographic and environmental analysis. The type of aerial imagery available through the VARGIS inventory for each state includes black & white, color and color infrared photography.

Organization	VARGIS
Scope	York County
Scale	1:1,200 (10=100M) (map), 0.5' (0.2m) resolution
Date of Project	March 1996 (image)
Status	Complete
Data Sources	Monochrome (B&W) photography
Standards and Protocols	Not provided
Distribution Format	Available for purchase on CD in 8 bit TIFF format
Website	<i>http://www.vargis.com</i>

Natural Color Aerial Photography of Northern Virginia

These aerial images for the state were produced by VARGIS LLC. VARGIS is a commercial organization which specializes in providing imagery for geographic and environmental analysis. The type of aerial imagery available through the VARGIS inventory for each state includes black & white, color and color infrared photography.

Organization	VARGIS
Scope	Northern Virginia (Arlington and Fairfax Counties, Alexandria, Falls Church and Fairfax Cities)
Scale	1:1,000 (10=83M), 0.2m (7") meter resolution
Date of Project	March 1995 (image)
Status	Complete
Data Sources	Natural Color photography
Standards and Protocols	Not provided
Distribution Format	Available for purchase on CD-ROM in 24 bit TIFF format
Website	<i>http://www.vargis.com</i>

Natural Color Photographs of James City County, Virginia

Organization	VARGIS
Scope	James City County, Virginia
Scale	1:2,400 (10=200M), 1.0 foot resolution
Date of Project	March 1996 (image)
Status	Complete
Data Sources	Natural Color photography
Standards and Protocols	Not provided
Distribution Format	Available for purchase on CD-ROM in 24 bit TIFF format
Website	<i>http://www.vargis.com</i>

Virginia Partial State Land Cover from LANDSAT TM

The information about these land cover data can be accessed through the EPA Office of Water and Watershed (OWOW) web site. The Land Cover Data Directory at this site is a comprehensive set of land cover data for each state. The data can vary from state to state for map scale and type of photography. The OWOW Directory for each state includes state initiated land cover mapping, MRLC generated land cover, US EPA land cover and USGS land cover.

Organization	National Oceanographic Data Center
Scope	20 counties east of Interstate 95 in Virginia
Scale	1:24,000 (map)
Date of Project	January 1, 1988 (image), January 1, 1992
Status	NOAA updates this every four years
Data Sources	LANDSAT TM
Standards and Protocols	Not provided
Distribution Format	ARC/INFO, Raster. Available on CD ROM for sale
Website	http://www.epa.gov/OWOW/watershed/landcover/lulcva.html#VA

West Virginia

West Virginia Division of Environmental Protection Watershed Atlas Project

On the West Virginia DEP's Website noted below a map and land cover table for each map provide a very good on line means of drilling into each watershed for land cover information. Maps can be generated by state for land cover themes or by watershed for comprehensive land cover by watershed.

Organization	West Virginia Division of Environmental Protection
Scope	By state / watershed
Scale	Varies with data set
Date of Project	Varies with data set
Status	Complete
Data Sources	West Virginia DEP
Standards and Protocols	Varies with data set
Distribution Form	Varies with data set
Website	http://www.dep.state.wv.us/watershed

West Virginia Division of Environmental Protection Interactive Mapping & Query Interface

The interface provides access to several important datasets, including the Toxic Release Inventory, the STORET water quality database, wetlands, and abandoned mine lands. You can choose from three background images, including SPOT satellite imagery.

Organization	West Virginia Division of Environmental Protection
Scope	By state / county / watershed
Scale	Varies with data set
Date of Project	Varies with data set
Status	Complete
Data Sources	West Virginia DEP
Standards and Protocols	Varies with data set
Distribution Form	Arc/Info
Website	http://www.dep.state.wv.us/imap/

West Virginia Land Cover Data Sets

The land cover data directory contains reference information about data coverages within West Virginia. Various land use/land cover data sets are provided including LANDSAT TM and MSS, GIRAS USGS Data.

Organization	West Virginia University
Scope	West Virginia, entire state
Scale	Varies with data set
Date of Project	Varies with data set
Status	Complete
Data Sources	LANDSAT TM and MSS, DLG, DEM, aerial photographs, SPOT
Standards and Protocols	Varies with data set
Distribution Format	Varies with data set
Website	<i>http://www.epa.gov/OWOW/watershed/landcover/lulcwv.html</i>

West Virginia Middle Fork Watershed Land Cover, Data Set #5 from SPOT, NAPP Photograph

These land cover data for the Middle Fork Watershed were derived from SPOT and NAPP photographs. The information about the land cover data can be accessed through the EPA Office of Water and Watersheds Web Site noted below.

Organization	West Virginia University
Scope	Middle Fork Watershed, 140 square miles
Scale	1:50,000 (photo), 1:24,000 (map)
Date of Project	January 1, 1989 (image), January 1, 1994 (map)
Status	Complete
Data Sources	SPOT, NAPP photograph
Standards and Protocols	Anderson Level 2
Distribution Format	ARC/INFO, Vector, Raster
Website	<i>http://www.epa.gov/OWOW/watershed/landcover/lulcwv.html#five</i>

CLASSIFICATION SYSTEMS

This section documents the federal standards for environmental resource data types and standards for the data. The primary classification systems which are utilized for land use land cover analysis are provided below. Please see Appendix I for full information regarding the classification systems.

A Land Use and Land Cover Classification System for Use with Remote Sensor Data. James R. Anderson, Ernest E. Hardy, John T. Roach, and Richard E. Witmer. Geological Survey Professional Paper 964. A revision of the land use classification system as presented in U.S. Geological Survey Circular 671 United States Government Printing Office, Washington: 1976

<http://mapping.usgs.gov/pub/ti/LULC/lulcpp964/lulcpp964.txt>

The C-CAP Coastal Land Cover Classification System.

<http://www.csc.noaa.gov/ccap/protocol/protocoltxt.html#c2>

GAP Modified UNESCO Natural Terrestrial Cover. Mike Jennings. National Biological Survey.

<http://www.gap.uidaho.edu/gap/AboutGAP/Handbook/misc/UNESCO/unesco.htm>

The Multi-Resolution Land Characteristics Interagency Consortium (MRLC) Classification System..

http://www.epa.gov/mrlc/Implmnt_plan.htm#Def

The U.S. Fish & Wildlife Service

<http://www.fws.gov/stand/>

FEDERAL CONTENT STANDARDS

Federal Geographic Data Committee

Introduction

Organized in 1990 under OMB Circular A-16, the Federal Geographic Data Committee (FGDC) is an interagency committee that promotes the coordinated use, sharing, and dissemination of geospatial data nationally. The FGDC develops geospatial data standards for implementing the NSDI, in consultation with state, local, and tribal governments, the private sector and academic community.

Members

The FGDC is composed of representatives from sixteen Cabinet level and independent federal agencies including the Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, Interior, State, Transportation, the Environmental Protection Agency, Federal Emergency Management Agency, Library of Congress, National Archives and Records Administration, National Science Foundation, Tennessee Valley Authority. The Chair is Bruce Babbitt, Secretary of the Interior.

Standards

A variety of standards are in development while many others have been endorsed by the FGDC. This report provides a summary of the following:

- Notes on the FGDC Standards Development Process
- National Vegetation Classification Standard
- Soil Geographic Data Standard
- Earth Cover Classification System
- Content Standard for Digital Geospatial Metadata
- Classification of Wetlands and Deepwater Habitat of the United States
- Geospatial Positioning Accuracy Standards (Part 1)
- Content Standard for Remote Sensing Swath Data
- Spatial Data Transfer Standard
- Content Standards for Digital Gridded Land Elevation Data
- Content Standard for Digital Orthoimagery

Web Site *<http://www.fgdc.gov/>*

Notes on the FGDC Standards Development Process

The FGDC has developed a 12 step program by which a standard is created. The steps have been adopted for use by the FGDC from those used in ANSI and ISO processes.

Proposal Stage

- Step 1. Develop Proposal
- Step 2. Review Proposal - The Standards Working Group reviews and evaluates the standard proposal and sends it for public comment.

Project Stage

- Step 3. Project Set Up - The FGDC Subcommittee or Working Group establishes the project and activates the development of the standard.

Draft Stage

- Step 4. Working Draft - The Standards Development Group develops a working draft of the standard.
- Step 5. Review Working Draft - The Standards Development Group submits the draft for pre-public review. The Group also prepares a committee draft for public review.

Review Stage

- Step 6. Review and Evaluation - The Standards Working Group evaluates the draft makes a recommendation for public review to the Coordination Group.
- Step 7. Approve Standard for Public Review - The Coordination Group reviews the recommendation of the Standards Working Group and approves standard for public review.
- Step 8. Coordinate Public Review - The FGDC Secretariat announces and coordinates a public review of the proposed standard. Testing and validation of the standard take place at this time.
- Step 9. Respond to Public Comments - The Standards Development Group reviews comments and produces a revised standard as well as a comment response document. Results from testing and validation of the standard are documented.
- Step 10. Evaluate Responsiveness to Public Comments - The proposed standard and response document are reviewed by the Standards Working Group.
- Step 11. Approve Standard for Endorsement - The Coordination Group reviews the recommendation of the Standards Working Group and approves the proposed standard for FGDC endorsement.

Final Stage

- Step 12. Endorsement - The FGDC Steering Committee reviews the recommendation of the FGDC Coordination Group and endorses the standard.

Classification of Wetlands and Deepwater Habitat of the United States

Developed by

National Wetlands Inventory; U.S. Geological Survey; University of Rhode Island, Department of Natural Resources Science; National Oceanic and Atmospheric Administration , US Fish & Wildlife Service.

Maintenance

National Wetlands Inventory (USFWS)

Development Step

Endorsed (12)

Type

Data classification standard

Scope

The purpose of the standard is to provide a system that allows communication about wetlands and their features in a national context. Hierarchical in structure, progressing from Systems and Subsystems at the most general levels, to Classes, Subclasses, and Dominance Types. Modifiers for water regime, water chemistry, and soils are applied to Classes, Subclasses, and Dominance Types. Special modifiers describe wetlands and deepwater habitats that have been either created or highly modified by man or beavers. This is a comprehensive work on wetlands.

Web Site Reference

<http://www.nwi.fws.gov/classifman/classman9.html>

Content Standard for Digital Geospatial Metadata

Developed by

Metadata Ad Hoc Working Group: Federal Geographic Data Committee, National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers; National Imagery and Mapping Agency; U.S. Geological Survey, U.S. Department of Agriculture; National Archives and Records Administration; U.S. Bureau of Census

Maintenance

FGDC Secretariat

Development Step

Endorsed (12). Version 2.0

Type

Data content standard

Scope

This standard establishes a common set of terms and their definitions for documenting digital geospatial data. It provides the names of data elements and compound elements, their definitions and information about their values. The standard is hierarchically organized by data elements and compound elements and certain mandatory elements must be included in all metadata that adheres to this standard.

Web Site Reference

<http://www.fgdc.gov/metadata/contstan.html>

Content Standards for Framework Land Elevation Data

Developed by

Subcommittee on Base Cartographic Data: Natural Resources Conservation Service; U. S. Forest Service; Bureau of the Census; Coast & Geodetic Survey; Department of Defense; Department of Energy; Bureau of Indian Affairs; Bureau of Land Management; Bureau of Mines; Bureau of Reclamation; Fish & Wildlife Service; Minerals Management Service ; National Park Service; U.S. Geological Survey; Department of Transportation; Environmental Protection Agency; Federal Emergency Management Agency; National Aeronautics and Space Administration; National Archives and Records Administration; National Capitol Planning Commission; National Association of Counties; Tennessee Valley Authority

Maintenance

United States Geological Survey

Development Step

Review (10)

Type

Data content standard

Scope

This standard is meant to provide a basis by which to collect, register and integrate digital elevation data. It describes considerations for processing, accuracy, reporting, and applications for land surface elevation data

Web Site Reference

http://www.fgdc.gov/standards/status/sub2_6.html

Content Standard for Digital Orthoimagery

Developed by

Subcommittee on Base Cartographic Data: Natural Resources Conservation Service; U. S. Forest Service; Bureau of the Census; Coast & Geodetic Survey; Department of Defense; Department of Energy; Bureau of Indian Affairs; Bureau of Land Management; Bureau of Mines; Bureau of Reclamation; Fish & Wildlife Service; Minerals Management Service ; National Park Service; U.S. Geological Survey; Department of Transportation; Environmental Protection Agency; Federal Emergency Management Agency; National Aeronautics and Space Administration; National Archives and Records Administration; National Capitol Planning Commission; National Association of Counties; Tennessee Valley Authority

Maintenance

United States Geological Survey

Development Step

Review (12)

Scope

This standard is intended to facilitate the interchange and use of digital orthoimagery data. It covers a range of specification issues, some in general terms as the technology associated with geospatial sciences is rapidly evolving.

Web Site Reference

http://www.fgdc.gov/standards/status/sub3_6.html

Content Standard for Remote Sensing Swath Data

Developed by

Standards Working Group: Natural Resources Conservation Service; U.S. Forest Service, Department of Commerce, Department of Defense, Bureau of Land Management, U.S. Geological Survey, National Institute of Standards and Technology, National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, National Aviation and Space Administration, Library of Congress, Bureau of the Census, U.S. Department of Transportation

Maintenance

TBD

Development Step

Development (8)

Type

Data content standard

Scope

The primary objective of this proposed standard is to define the content of remote sensing swath data and develop interoperable swath data formats. This standard will define the minimal content requirements for a swath and the relationship between individual components. It also aims to discuss the treatment of optional supporting information within the swath model. The standard will be based on the NASA EOSDIS' data model for remote sensing swath data. NASA/GSFC's EOSDIS Project is funding the development of this standard.

Web Site Reference

http://www.fgdc.gov/standards/status/sub4_4.html

http://spsosun.gsfc.nasa.gov/New_EOSDIS.html

Earth Cover Classification System

Developed by

Earth Cover Working Group: Natural Resources Conservation Service; United States Geological Survey; U.S. Army Corp of Engineers, Bureau of Land Management; U.S. Department of Energy; National Oceanic Atmospheric Administration; Tri-Service CADD/GIS Technology Center; National Aeronautics and Space Administration; Bureau of the Census; U.S. Environmental Protection Agency; U.S. Fish and Wildlife Service

Maintenance

to be determined

Development Step

Proposal (1)

Type

Intended to be a data classification standard

Scope

This standard is intended to be an integrated approach to the identification, classification, and mapping of surficial features of the United States. The guiding principles of the team developing this standard include classification categories that are mutually exclusive and additive to 100% of earth cover surfaces. Vegetation, water, snow, ice, human constructions, bare soil, sand, and exposed rocks will qualify as cover surfaces while land use classifications and terminology will be disregarded. This system will be independent of scale and applicable over extensive areas. When instituted, the system will complement other earth and land cover classification systems but will not replace them. The Working Group is requesting information from all federal and state agencies and private institutions collecting and/or using land cover data such that it can be used in the development of a standard.

Web Site Reference

To be determined

Geospatial Positioning Accuracy Standards (Part 1)

Developed by

Federal Geodetic Control Subcommittee: Department of Agriculture; Department of Commerce; Department of Defense; Department of the Interior; Department of State; Department of Transportation; Environmental Protection Agency; Federal Communications Commission; National Aeronautics and Space Administration; National Capital Planning Commission; National Science Foundation; Tennessee Valley Authority

Maintenance

Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, National Geodetic Survey

Development Step

Endorsed (12)

Type

Data usability standard

Scope

This standard provides a common procedure for reporting the accuracy of horizontal and vertical coordinate values for features represented by a single point coordinate such as survey monuments, church spires, radio towers, mountain peaks, and targeted photogrammetric control points. In addition to reporting accuracy, it provides users with the ability to directly compare the accuracy of coordinate values for a given point from one method with that of another (e.g., map vs. GPS). The accuracy within this standard is that of a 95% confidence level. This standard has been developed in multiple parts in order to better address various activities. By doing so, the standard addresses the differences in these data collection methods (e.g., geodetic surveys, navigation charts) while having them adhere to one set standard for accuracy.

Web Site Reference

http://www.fgdc.gov/standards/status/sub1_3.html

National Vegetation Classification Standard

Developed by

Vegetation Subcommittee: Department of Agriculture; Department of Commerce (NOAA, NMFS), Department of Defense; Department of Interior, U.S. Geological Survey, Environmental Protection Agency, National Aeronautics and Space Administration, The Nature Conservancy, Ecological Society of America.

Maintenance

USDA Forest Service

Development Step

Endorsed (12)

Type

Data classification standard

Scope

The National Vegetation Classification Standard provides a framework for classifying natural, semi-natural, planted and cultivated vegetation types. All areas having equal to or more than 1% live vegetation surface area are classified by this standard. Hierarchical in nature, its most general levels concentrate on physiognomic qualities and broad ecological modifiers while the more specific levels concentrate on floristic characteristics. Physiognomic classification levels are based on factors that are apparent from imagery or ground verification. The floristic levels are determined by field data. Since it is more difficult to assign floristic levels than physiognomic, a process to help users classify vegetation within the floristic levels will be developed in the future.

Web Site Reference

<http://biology.usgs.gov/npsveg/classification/toc.html>

Soil Geographic Data Standard

Developed by

Soil Data Subcommittee, Soil Working Group: Natural Resources Conservation Service, U.S. Forest Service, Louisiana State University, Bureau of Land Management; U.S. Department of Agriculture; U.S. Department of Defense; U.S. Environmental Protection Agency

Maintenance

Natural Resources Conservation Service

Development Step

Endorsed (12)

Type

Data content standard

Scope

This standard attempts to categorize the names, definitions, ranges of values, and other characteristics of soil survey map attribute data developed by the National Cooperative Soil Survey (NCSS). It contains a listing of data elements for physical, chemical and interpretive soil data associated with soil surveys. The standard applies to data associated with soil survey maps developed by the NCSS at scales of 1:12,000 to 1:30,000. While it contains data about soil map units and components it does not cover descriptions of land forms and landscapes or vegetation related to soil map units.

Web Site Reference

<http://www.nhq.nrcs.usda.gov/SDS/stds.htm>

Spatial Data Transfer Standard

Developed by

Standards Working Group: Natural Resources Conservation Service; U.S. Forest Service, Department of Commerce, Department of Defense, Bureau of Land Management, U.S. Geological Survey, National Institute of Standards and Technology, National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, National Aviation and Space Administration, Library of Congress, Bureau of the Census, U.S. Department of Transportation

Maintenance

United States Geological Survey

Development Step

Endorsed (12)

Type

Data transfer standard

Scope

This standard specifies a structure for packaging vector or raster spatial data with attributes, metadata, a data quality report and usually a data dictionary. It allows for the standardization of data such that transfers between different spatial database systems is possible. By using this standard, the data will be non-proprietary and cross platform—the user need only use software to convert data and transfer file sets. The standard does not specify requirements for the processing of data into or out of SDTS format. Any data must be accompanied by a separate data quality report which includes factors such as lineage, positional accuracy, attribute accuracy, logical consistency and completeness.

Whether or not one of three recommended reference systems (Geographics, UTM/UPS, State Plane) has been used must also be implicit as must the level of conformance to the list of standard terms. Users include the USGS, NOAA, and the U.S. Census Bureau (Tiger data only).

Web Site Reference

<http://mcmcweb.er.usgs.gov/sdts/>

QUALITY ASSURANCE CONTROL AND ASSESSMENT TECHNIQUES

This section lists the primary sources of Quality Assurance, Quality Control (QA/QC) and assessment techniques in relation to landscape and land cover analysis. Links to web sites for further information on technical guides for QA/QC techniques are provided below;

An Overview of Three Levels of QA/QC

QA/QC for land cover analyses breaks into three parts: common sense, fitness for use, and accuracy assessment. The *NOAA Coastal Change Analysis Program: Guidance for Regional Implementation* (cited below as reference number eight) is a very good source for a description of this breakdown.

Common sense is the most basic form of QA/QC, and is dealt with in documentation. Usually this documentation constitutes metadata. The questions answered here are:

- Were georeferencing, enhancement, radiometric calibration, and noise reduction, etc. performed according to logical methodologies and procedures?
- What is the lineage of the data?
- Were logical procedures followed to accomplish a good product?

Fitness-for-use is second measure of QA/QC. This is a somewhat abstract and nebulous term. It is decided by the user, not the producer. Questions that are answered at this level are

- Do the data meet your needs?
- Are they adequate for use in your application?

The fitness-for-use measures dramatically improve the data product, but rarely make significant differences in the GIS accuracy from a stratified random sample.

Accuracy Assessment is the most difficult of the three measures to quantify due to the relationship of statistical rigor for large databases and the cost of ground-truthing procedures. First, the sheer number of observations in a typical data set precludes the collection of valid samples under current statistical procedures. A standard Landsat Thematic Mapper digital satellite image contains approximately 6000 x 6000 spatially organized spectral observations. This means that a single TM scene has 36,000,000 landscape based observations, therefore a .5% sample would require 180,000 field observations. The cost of this is far beyond the means of most producers of land cover databases. The natural and anthropogenic landscapes also suffer from inaccurate statistical assumptions of randomness. The landscape displays strong patterns of auto-correlation and therefore, all analyses based upon a random distribution are invalid. The hope for valid statistical accuracy assessment lies in adaptive sampling methodologies (Thompson, 1990, 1991, 1996).

Second, there is still debate on the proper source for ground truth information. The standard practice is to base the accuracy of any remotely sensed data set on a data set of higher spatial resolution (finer pixel size or larger scale). Many practitioners argue that in-situ fieldwork is the only valid data set,

while others prefer aerial photography. Both groups have important points. In-situ fieldwork is expensive and heavily dependant on local conditions (wet season vs. dry season, etc.). Aerial photography is rarely coincidental with image collection, and suffers from the logical problems of basing the accuracy of one remotely sensed data set on another remotely sensed data set.

A good example of an organization that has employed these techniques are The Coastal Change Analysis Program (C-CAP). For example, C-CAP uses computer based real-time differential GPS interlinked field assessment tools to judge both accuracy and fitness-for-use. A team of C-CAP personnel take geo-referenced imagery and GIS databases on laptop computers to the field and record observations in real-time on the conditions and species of the environment. The tools to view the image derived GIS information simultaneously with the landscape and record ground truth information provide the ability to evaluate the data beyond any statistical analysis. If there are trends of error (spatial or thematic) or systematic patterns, the analyst can record these and use them to correct the data. This process can be performed from cars, planes, boats, and helicopters.

The subject of QA/QC is far from resolved in the arena of GIS and remote sensing. However, many studies have been and continue to be devoted to the accuracy assessment facet of QA/QC.

The following resources provide detailed descriptions of QA/QC processes.

1) *Quantitative assessment of landscape and land cover change using remote sensing and GIS*
<http://climate.konza.ksu.edu/general/nasalandcover/sld006.html>

2) *Development and Testing of a Habitat Map for Maine – A Status Report*. (Chapter 7.0 Accuracy Assessment).
<http://wlm13.umenfa.maine.edu/progs/unit/gap/layers/veg/Classification-report.html#aa>

3) *Stratification of Landsat Thematic Mapper Data, Based on Regional Landscape Patterns, to Improve Land-Cover Classification Accuracy of Large Study Areas*. Jana S. Stewart, Geographer, U.S. Geological Survey-WRD, 6417 Normandy Lane, Madison, WI 53719
Thomas M. Lillesand, Director, Environmental Remote Sensing Center, University of Wisconsin-Madison, 1225 W. Dayton Street, Madison, WI 53706.
<http://www.dwdm.dn.er.usgs.gov/nawqa/pubs/jana.asprs.html>

4) *Assessing Vegetation/Land Cover Map Accuracy for Gap Analysis*. David Stoms, Frank Davis, Chris Cogan, Kelly Cassidy. 1994.
http://www.epa.gov/mrlcpage/sect8_2.html

5) *Assessing Land Cover Map Accuracy*. Patrick Crist and Robert Deitner. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, ID. Cooperative Fish and Wildlife Research Unit, New Mexico State University, Las Cruces, NM. 1998. From GAP site.
http://www.gap.uidaho.edu/GAP/AboutGAP/Handbook/LCA_PDF.html

6) *Land Use and Land cover Databases for Verification*.
http://ice.cor.epa.gov/~jeff/workz/agr_dist/landuse/

7) *Evaluation of North and South America AVHRR 1-km Data for global environmental modeling*. Limin Yang, Zhi-Liang Zhu, Jorge A Izaurralde, James W. Merchant.
http://bbq.ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/yang_limin/my_paper.html

8) *Accuracy Assessment of Land Cover Change Detection*, CGC Report No. 101, Prepared for NOAA Coastal Change Analysis Program. Khorram, S., G.S. Biging, N.R. Chrisman, D.R. Colby, R.G. Congalton, J.E. Dobson, R.L. Ferguson, M.F. Goodchild, J.R. Jensen, T. H. Mace, 1994. *This document is expected to be accessible as a white paper on the ASPRS web site in early 2000* (<http://www.asprs.org/publications.html>)

9.) *The Second International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences*. May 21-23, 1996. Colorado State University. Fort Collins, Colorado.
<http://www.uni-koeln.de/themen/Statistik/conferences/spatial.txt>

Additional Resources

Congalton, R.G., 1991 "A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data" *Remote Sensing of Environment*, Vol. 37, 1991, p. 35-46.

Fenstermaker, Lynn, 1994 *Remote Sensing Thematic Accuracy Assessment*, 420pp

D'Urso, G, and M. Menenti, 1996 "Performance indicators for the statistical evaluation of digital image classifications" *ISPRS Journal of Photogrammetry & Remote Sensing*, Vol. 51, 1996, p. 78-90.

Gond, P, and P.J. Howart, 1990 "An Assessment of Some Factors Influencing Multispectral Land-Cover Classification" *Photogrammetric Engineering and Remote Sensing* Vol. 56, No. 5, May 1990, p. 597-603.

Jensen, John R., 1996 Introductory Digital Image Processing, Second Edition Prentice-Hall, New Jersey.

Snook, P.W., K.C. Wintergerger, N. E. Merritt, 1987 'Comparison between Digital and Manual Interpretation of High Altitude Aerial Photographs', *Photogrammetric Engineering and Remote Sensing* Vol. 53, No. 5, May 1987, pp. 531-534.

Thompson, S.K. 1990 'Adaptive Cluster Sampling,' *Journal of the American Statistical Association*, Vol. 85, No. 412, December 1990, pp. 1050-1059.

Thompson, S.K, 1991 'Stratified Adaptive Cluster Sampling', *Biometrika*, Vol. 78, No. 2, 1991, pp. 389-97.

Thompson, S. K., and G.A.F. Seber, 1996 Adaptive Sampling, New York.

DATA DISTRIBUTION SYSTEMS & DATA ACCESS TOOLS

The intent of this short section is to point the researcher to a set of tools (commercial software, web based access tools etc) that provide a means to working with digital imagery for land cover analysis.

Kansas Land Cover. University of Kansas. 1998.
<http://gisdasc.kgs.ukans.edu/kanview/landcov/landcover.html>

MRSID. LizardTech, Inc. 1520 Bellevue Avenue Seattle, Washington 98122
<http://www.lizardtech.com/>

TerraServer. Microsoft®.
<http://terraserver.microsoft.com/>

The Satellite Active Archive. NOAA. 1998.
<http://www.saa.noaa.gov/>

Tools to Facilitate Access to Digital Orthophotos. MIT. 1998.
<http://ortho.mit.edu/>

Welcome to the EDC DAAC. USGS EDC. 1998.
<http://edcwww.cr.usgs.gov/landdaac/>

SATELLITE SYSTEMS & IMAGERY PRODUCTS FOR ENVIRONMENTAL ANALYSIS

This section lists the government and commercial satellite systems that produce imagery for Land Use/Land Cover analysis. Links to the government agency or commercial provider are included in the references below

Government

USGS/EROS/Landsat

<http://geo.arc.nasa.gov/sge/landsat/landsat.html>, for the USGS EROS Data Center
<http://edcwww.cr.usgs.gov/index.html>

NOAA/GOES

<http://osdaccess.nesdis.noaa.gov/goes.htm>

NOAA/POES

<http://osdaccess.nesdis.noaa.gov/polar.htm>

Commercial

Earthwatch

<http://www.digitalglobe.com/>

Orbimage

<http://www.orbimage.com/products/orb2products/orb2products.html>

Space Imaging

Commercial provider of Carterra Products; which include; Landsat 5, IRS, Radarsat and IKONOS imagery. *<http://www.spaceimaging.com>*

SPOT

<http://www.spot.com/spot-us.htm>

Note

There is a very good on line search tool, provided by Pacific Meridian Resources that assists the user in determining the imagery that meets specific requirements. It is referred to as the Image Advisor. *<http://www.xmission.com/~pmrslc/html/index.html>*

APPENDIX I

Classification Systems

Table I

U.S. Geological Survey Land-Cover Classification Scheme for Remote Sensor Data	
Summary of Level I and Level II elements of the U.S. Geological Survey "Land Use and Land Cover Classification System for Use with Remote Sensor Data" (Anderson et al., 1976; USGS, 1992).	

Level Land-use and land-cover class

- 1 Urban or Built-Up Land*
 - 11 Residential
 - 12 Commercial and Services
 - 13 Industrial
 - 14 Transportation, Communications, and Utilities
 - 15 Industrial and Commercial Complexes
 - 16 Mixed Urban or Built-up
 - 17 Other Urban or Built-up Land
- 18 Agricultural Land*
 - 21 Cropland and Pasture
 - 22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
 - 23 Confined Feeding Operations
 - 24 Other Agricultural Land
- 25 Rangeland*
 - 31 Herbaceous Rangeland
 - 32 Shrub-Brushland Rangeland
 - 33 Mixed Rangeland
- 34 Forest Land*
 - 41 Deciduous Forest Land
 - 42 Evergreen Forest Land
 - 43 Mixed Forest Land
- 44 Water*
 - 51 Streams and Canals
 - 52 Lakes
 - 53 Reservoirs
 - 54 Bays and Estuaries
- 55 Wetland*
 - 61 Forested Wetland
 - 62 Non-forested Wetland

Level Land-use and land-cover class

63 *Barren Land*

- 71 Dry Salt Flats
- 72 Beaches
- 73 Sandy Areas Other than Beaches
- 74 Bare Exposed Rock
- 75 Strip Mines, Quarries, and Gravel Pits
- 76 Transitional Areas
- 77 Mixed Barren Land

78 *Tundra*

- 81 Shrub and Brush Tundra
- 82 Herbaceous Tundra
- 83 Bare Ground Tundra
- 84 Wet Tundra
- 85 Mixed Tundra

86 *Perennial Snow or Ice*

- 91 Perennial Snowfields
- 92 Glaciers

Table II

U.S. Fish and Wildlife Service Wetland Classification Scheme			
Summary of the classification hierarchy of wetlands and deepwater habitats, showing systems, subsystems, and classes of the U.S. Fish and Wildlife Service “Classification of Wetlands and Deepwater Habitats of the United States” (Cowardin et al., 1979).			
System	Subsystem	Class	
Marine	Subtidal	Rock Bottom Unconsolidated Bottom Aquatic Bed Reef	
		Aquatic Bed Reef Rocky Shore Unconsolidated Bottom	
	Intertidal	Rock Bottom Unconsolidated Bottom Aquatic Bed Reef	
		Aquatic Bed Reef Streambed Rocky Shore Unconsolidated Shore Emergent Wetland Scrub-Shrub Wetland Forested Wetland	
Estuarine	Subtidal	Rock Bottom Unconsolidated Bottom Aquatic Bed Reef	
		Aquatic Bed Reef Streambed Rocky Shore Unconsolidated Shore Emergent Wetland Scrub-Shrub Wetland Forested Wetland	
	Intertidal	Rock Bottom Unconsolidated Bottom Aquatic Bed Reef	
		Aquatic Bed Reef Streambed Rocky Shore Unconsolidated Shore Emergent Wetland	
	Tidal	Rock Bottom Unconsolidated Bottom Aquatic Bed Streambed Rocky Shore Unconsolidated Shore Emergent Wetland	
		Rock Bottom Unconsolidated Bottom Aquatic Bed Rocky Shore Unconsolidated Shore Emergent Wetland	
Riverine	Lower Perennial	Rock Bottom Unconsolidated Bottom Aquatic Bed Rocky Shore Unconsolidated Shore Emergent Wetland	
		Rock Bottom Unconsolidated Bottom Aquatic Bed Rocky Shore Unconsolidated Shore	
	Upper Perennial	Rock Bottom Unconsolidated Bottom Aquatic Bed Rocky Shore Unconsolidated Shore	
		Streambed	
	Intermittent	Streambed	
	Limnetic	Rock Bottom Unconsolidated Bottom Aquatic Bed	

<u>System</u>	<u>Subsystem</u>	<u>Class</u>
Lacustrine		
	Littoral	Rock Bottom Unconsolidated Bottom Aquatic Bed Rocky Shore Unconsolidated Shore Emergent Wetland
Palustrine		Rock Bottom Unconsolidated Bottom Aquatic Bed Unconsolidated Shore Moss-Lichen Wetland Emergent Wetland Scrub-Shrub Wetland Forested Wetland

Table III

C-CAP Coastal Land-Cover Classification System

C-CAP Coastal Land-Cover Classification System (Modified from Klemas et al., 1993). C-CAP is committed to include the underlined classes in the land cover change databases.

1.01 Wetland

1.1 Developed Land

- 0.11 High Intensity
- 0.12 Low Intensity

0.13 Cultivated Land

- 0.21 Orchards/Groves/Nurseries
- 0.22 Vines/Bushes
- 0.23 Cropland

0.24 Grassland

- 0.31 Unmanaged
- 0.32 Managed

0.33 Woody Land

- 0.41 Deciduous Forest
 - 0.411 Forest
 - 0.412 Scrub/Shrub
- 0.413 Evergreen
 - 0.421 Forest
 - 0.422 Scrub/Shrub
- 0.423 Mixed Forest
 - 0.431 Forest
 - 0.432 Scrub/Shrub

0.433 Bare Land

0.434 Tundra

0.435 Snow/Ice

- 0.71 Perennial Snow/Ice
- 0.72 Glaciers

1.01 Wetland

1.1 Marine/Estuarine Rocky Shore

- 1.11 Bedrock
- 1.12 Ruble

1.13 Marine/Estuarine Unconsolidated Shore (Beach, Flat, Bar)

- 1.21 Cobble-gravel
- 1.22 Sand
- 1.23 Mud/Organic

1.24 Marine/Estuarine Emergent Wetland

- 1.31 Haline (Salt Marsh)
- 1.32 Mixohaline (Brackish Marsh)

1.33 Estuarine Woody Wetland

- 1.41 Deciduous
 - 1.411 Forest
 - 1.412 Scrub/Shrub
 - 1.413 Dead
- 1.414 Evergreen
 - 1.421 Forest
 - 1.422 Scrub/Shrub
 - 1.423 Dead
- 1.424 Mixed
 - 1.424.1 Forest
 - 1.424.2 Scrub/Shrub
 - 1.424.3 Dead

1.425 Riverine Unconsolidated Shore (Beach, Flat, Bar)

- 1.51 Cobble-Gravel
- 1.52 Sand
- 1.53 Mud/Organic

1.54 Lacustrine Unconsolidated Shore (Beach, Flat, Bar)

- 1.61 Cobble-Gravel
- 1.62 Sand
- 1.63 Mud/Organic

1.64 Palustrine Unconsolidated Shore (Beach, Flat, Bar)

- 1.71 Cobble-Gravel
- 1.72 Sand
- 1.73 Mud/Organic

1.74 Palustrine Emergent Wetland (Persistent)

1.75 Palustrine Woody Wetland

- 1.91 Deciduous
 - 1.911 Forest
 - 1.912 Scrub/Shrub
 - 1.913 Dead
- 1.914 Evergreen
 - 1.921 Forest
 - 1.922 Scrub/Shrub
 - 1.923 Dead
- 1.924 Mixed
 - 1.931 Forest
 - 1.932 Scrub/Shrub
 - 1.933 Dead

1.02 Water and Submerged Land

2.1 Water

- 2.11 Marine/Estuarine
- 2.12 Riverine
- 2.13 Lacustrine (Basin >20 acres)
- 2.14 Palustrine (Basin <20 acres)

2.15 Marine/Estuarine Reef

2.16 Marine/Estuarine Aquatic Bed

- 2.31 Algal (e.g., kelp)
- 2.32 Rooted Vascular (e.g., seagrass)
 - 2.321 (High Salinity (>5 ppt; Mesohaline, Polyhaline, Euhaline, Hyperhaline)
 - 2.322 Low Salinity (<5 ppt; Oligohaline, Fresh)
 - 2.323 Riverine Aquatic Bed
- 2.41 Rooted Vascular/Algal/Aquatic Moss
- 2.42 Floating Vascular
- 2.43 *Lacustrine Aquatic Bed (Basin >20 acres)*
 - 2.51 Rooted Vascular/Algal/Aquatic Moss
 - 2.52 Floating Vascular
- 2.53 *Palustrine Aquatic Bed (Basin >20 acres)*
 - 2.61 Rooted Vascular/Algal/Aquatic Moss
 - 2.62 Floating Vascular

* classification of woody planted/cultivated vegetation subject to availability of sufficient ancillary data to differentiate from natural woody vegetation.

Underlined classes indicate the level of classified data provided by the MRLC. Regional differences do exist and the number of classes will vary by geographic location within the United States. Class definitions are provided on the following pages.

MRLC Class Definitions

Bare Rock/Sand

Includes areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, and other accumulations of rock without vegetative cover, with the exception of such rock exposures in tundra regions.

Bare Soil

Areas within planted or cultivated regions that have been tilled or plowed and do not exhibit any visible cover of vegetation.

Deciduous Shrubland

Shrublands in which 75% or greater of the shrub cover present is characterized by individuals that simultaneously shed their foliage in response to an unfavorable season.

Deciduous Forest

Areas dominated by trees in which 75% or more of the tree cover present is characterized by individuals that shed foliage simultaneously in response to an unfavorable season.

Emergent Herbaceous Wetlands

Non-woody vascular perennial vegetation where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al(1970).

Evergreen Shrubland

Shrublands in which 75% or greater of the shrub cover present is characterized by individuals that maintain their leaves all year. Canopy is never without green foliage.

Evergreen Forest

Areas dominated by trees in which 75% or more of the tree cover present is characterized by individuals that maintain their leaves all year. Canopy is never without green foliage.

Grasslands (Natural/Semi-natural)

Areas comprised of natural upland herbaceous vegetation dominated by graminoids, typically utilized by grazing animals. Examples include the large areas of private and public rangeland of the western half of the United States.

High Intensity Developed

Includes heavily built-up urban centers and large constructed surfaces in suburban and rural areas with a variety of different land uses. Contains areas in which a significant land area is covered by concrete and asphalt or other constructed materials. Vegetation occupies less than 20 percent of the landscape. Examples of such areas include apartment complexes, skyscrapers, shopping centers, factories, industrial complexes, airport runways, and interstate highways.

High Intensity Residential

Includes heavily built-up urban centers where people reside. Examples include apartment complexes and row houses. Vegetation occupies less than 20 percent of the landscape. Constructed materials account for 80-100 percent of the total area.

High Intensity Commercial/Industrial

Includes all highly developed lands not classified as High Intensity Residential. Commercial and Industrial land use may be included but not specifically classified in this category.

Low Intensity Residential

Land includes areas with a mixture of constructed materials and vegetation or other cover. Constructed materials account for 30-80 percent of the total area.

Mixed Shrubland

Areas dominated by shrubland where neither deciduous nor evergreen species represent more than 75% of the cover present.

Mixed Forest

Areas dominated by trees where neither deciduous nor evergreen species represent more than 75% of the cover present.

Open Water

All areas of open water with less than 25% cover of trees, shrubs, persistent emergent plants, emergent mosses, lichens, or other land cover.

Other Grasses

Vegetation planted in developed settings, for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns and golf courses.

Pasture/Hay

Grasses, legumes, or grass-legume mixtures planted or intensely managed for livestock grazing or the production of seed or hay crops.

Perennial Ice/Snow

Areas covered year-round with snow and ice.

Planted/Cultivated Woody

Orchards, vineyards, and tree plantations planted for the production of fruit, nuts, fiber(wood), or ornamental.

Quarries/Strip Mines/Gravel Pits

Areas of extractive mining activities with significant surface expression.

Row Crops

All areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, cotton.

Small Grains

All areas used for the production of graminoid crops such as wheat and rice.

Transitional Bare

Areas dynamically changing from one land cover to another, often because of land use activities. Examples include transition phase between forest and agricultural land, temporary clearing of Woody or Herbaceous vegetation.

Woody Wetlands

Areas of forested and shrubland vegetation where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al. (1970).

Other Pertinent Definitions

Bare

Bare rock, sand silt, gravel or other earthen material with little or no vegetation regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the vegetated categories.

Grasses (Planted/Cultivated)

Areas of herbaceous vegetation planted by humans in developed settings or for livestock grazing or the production of seed or hay crops.

Natural/Semi-natural

Areas dominated by native or naturalized vegetation that has not been cultivated or treated with any annual management or manipulation regime. In cases where it cannot be assessed whether the vegetation was planted or cultivated by humans, the vegetation is considered "Natural/Semi-natural".

Natural/Semi-natural Herbaceous

A class of vegetation dominated by non-woody plants known as herbs (graminoids, forbs, and ferns). Herbs generally form at least 25% cover. Trees, and shrubs generally have less than 25% cover. In rare cases, herbaceous cover is less than 25% but exceeds the combined cover of other life forms present.

Natural Forested

A class of vegetation dominated by trees generally forming >25% canopy cover. (Combination of FGDC Open and Closed Tree Canopy classes).

Natural Shrubland

A class of vegetation defined by areas dominated by shrubs generally less than 6 meters tall with individuals or clumps not touching to interlocking. The species may include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. Shrub canopy cover is generally greater than 25% when tree canopy is less than 25%. Shrub cover may be less than 25% if cases when the cover of each other life form (herbaceous, tree) is less than 25% and shrubs exceed the cover of the other life forms.

Planted/Cultivated Herbaceous

Areas dominated with vegetation which has been planted in its current location by humans, and/or is treated with annual tillage, a modified conservation tillage, or other intensive management or manipulation. The majority of vegetation in these areas is planted and/or maintained for the production of food, feed, fiber, or seed.

Vegetated

Areas having 25% or more of the land or water with live vegetation cover at the peak of the growing season.

Woody Upland Vegetation

Includes any species with an aerial stem that persists for more than one season. Of the vegetation present, woody vegetation comprises >25%. The class is divided into Natural Forested, Natural Shrubland, and Planted/Cultivated subclasses.

Table IV

MRLC Regional Land Cover Classification System

1.0 Water

1.1 Open Water

1.2 Perennial Ice/Snow

2.0 Developed

2.1 High Intensity

2.11 Residential

2.12 Commercial/Industrial

2.2 Low Intensity

2.21 Residential

3.0 Bare

3.1 Transitional

3.2 Quarries/Strip Mines/Gravel Pits

3.3 Bare Rock/Sand

4.0 Vegetated

4.1 Woody Upland Vegetation

4.11 Natural Forested

4.111 Deciduous Forest

4.112 Evergreen Forest

4.113 Mixed Forest

4.12 Natural Shrubland

4.121 Deciduous Shrubland

4.122 Evergreen Shrubland

4.123 Mixed Shrubland

4.13 Planted/Cultivated*(orchards, vineyards, groves)

4.2 Herbaceous Upland Vegetation

4.21 Natural/Semi-natural Herbaceous

4.211 Grasslands

4.22 Planted/Cultivated Herbaceous

4.221 Bare soil

4.222 Small grains

4.223 Row crops

4.224 Grasses

4.224a Pasture/Hay

4.224b Other (parks, lawns, golf courses)

4.3 Wetlands

4.31 Woody wetlands

4.32 Emergent Herbaceous Wetlands

APPENDIX II

Regional Websites of Significant MAIA Partners

Delaware Estuary Program

<http://www.delep.org/>

Chesapeake Bay Program 'Chesapeake Information Management System'

<http://www.chesapeakebay.net/>

<http://cims.chesapeakebay.net/>

EMAP

<http://www.epa.gov/emap>

Mid-Atlantic Highlands Assessment

<http://www.epa.gov/ecoplaces/part1/site14.html>

<http://aegis.er.usgs.gov/potomac/index.html>

U.S. EPA Region III

<http://www.epa.gov/region3/data.htm>

<http://www.epa.gov/reg3giss/libraryp.htm>

U.S. EPA/ORD

<http://www.epa.gov/ORD/BBS.html>

APPENDIX III

Regional Websites of Interest

Land Cover Digital Data Directory

The following is the introduction to the Land Cover Digital Data Directory as taken from the U.S. Environmental Protection Agency's Office of Water Web Site. This is a valuable tool to understanding Land Cover Data and to the Directory that the EPA Office of Water has made available for visitors to the site. The direct link to this website is:

<http://www.epa.gov/OWOW/watershed/landcover/>

What is the Land Cover Digital Data Directory?

Land cover, or the pattern of ecological resources and human activities dominating different areas of the earth's surface, is one of the most important data sources used in watershed analysis and the management of water resources throughout the country. Uses of land cover data in watersheds include modeling and predicting runoff, diagnosis of non-point source pollution sources and characteristics, analyzing habitat, siting appropriate land uses, and analyzing development patterns. Land cover patterns are mapped using aerial photography or satellite imagery. In recent years, land cover data are increasingly available in digital format for use in Geographic Information Systems. Yet, despite the high demand for land cover data, a single source of up-to-date, nationally consistent land cover mapping at moderate to high spatial detail is not available.

In the absence of a single national data source, the U.S. Environmental Protection Agency's Office of Water has researched the availability of single-state and multi-state, moderately detailed land cover data sets across the country and compiled a summary description about each finding. The summaries in this directory include contact information to assist readers who may want to acquire copies of the digital data for their own use. It should be noted, however, that this directory is not a centralized source for ordering and acquiring digital data; to obtain land cover data, readers must contact the reference given for each individual data set in the directory.

In all, 75 different data sets were found, most of covering single states or parts of states. A few national data sets are available, but these are either very coarse in spatial resolution or substantially out of date and thus have limited value in representing current land cover patterns. Some multi-state coverages were found, including two current mapping programs (MRLC and GAP) that may achieve full national coverage in a few years. Where possible, pointers to websites for ongoing mapping programs have also been listed to enable readers to use the most recent internet updates on map coverage and availability.

The EPA Office of Water is interested in updating this directory periodically. Readers who know of a land cover data set that is not yet listed are requested to send the appropriate information to norton.douglas@epamail.epa.gov or fax to 202-260-7024 attn. Douglas Norton.

What is in the Land Cover Digital Data Directory?

The land cover digital data directory contains REFERENCE INFORMATION (i.e., "metadata") on four broad categories of land cover data sets:

- Partial state coverage
- Full state coverage
- Multi-state coverage
- National coverage.

The land cover digital data directory is maintained by the Watershed Branch of EPA's Office of Water. Douglas Norton may be contacted for questions about the directory itself. The contact listed on each data set-description page should be contacted for questions specific to the data set. Questions about the Office of Water web site and other use of Internet should be directed to Karen Klima.

All information in the land cover digital data directory are organized by state. Therefore, you will search for data sets through this web site by state, but will be provided information that is either specific to that state OR that state's portion of a national coverage.

How to Use the Land Cover Digital Data Directory

The selection site provides you with a map from which to select references for downloading and viewing. You will have the choice of retrieving some specific information on-line, or downloading the whole reference document. Complete instructions are given in the selection site.

What is Addressed in the Data Directory?

The information collected for inclusion in this data directory does not provide comprehensive metadata for any of the coverages. It does, however, provide a summary of the structure, content, spatial coverage, and availability of most national and statewide land cover data.

The data directory contains the following data elements:

Coverage

This data element includes information on the spatial extent of the coverage (e.g., national, multi-state, statewide, or partial state).

Comments

This field includes any relevant narrative information related to the coverage.

Resolution

The pixel size of the satellite imagery used for mapping.

Minimum mapping unit

The minimum size area of land cover (e.g., 1 acre) that appears on the maps.

Map date

The date the map or coverage was created from the source data.

Image date

The date the source data was collected.

Image type

The type of image used to create the coverage.

Map scale

Scale of the map or coverage developed.

Photo scale

Scale of the air photos used to create the coverage.

Coordinate system

The specific system used to reference the coverage to a geographic location.

Projection

The specific projection used to display the data coverage.

Classification system

The classification system used in preparing land use/land cover maps.

GIS

The GIS system the data coverage is provided.

Data Type

The data encoding format of the coverage.

Next scheduled update

The date for the next planned update of the data coverage.

Availability

This data field contains relevant information on the type of media, costs, and where available for the data.

Contact name

Information on the state-specific contact.

Contact title

Contact Agency

Address

City, State, ZIP

Phone number

Email address

Related Sites

1:250,000 scale Land Use Land Cover by state (every state but Hawaii)

1:100,000 scale Land Use Land Cover by state (only Arizona, Arkansas, California, Hawaii, Montana, New Mexico, Oklahoma, Oregon, Utah, Washington)

Gap Data Layers for the United States

Geographic Information Retrieval and Analysis System (GIRAS)

Land Use/Land Cover Data (GIRAS format) (gzip compressed)

Land Use/Land Cover Users Guide

Maps on Demand

National Spatial Data Infrastructure (NSDI)

USGS Global Land Information System

APPENDIX IV

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