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PROGRAM ON EARTH OBSERVATION DATA MANAGEMENT SYSTEMS (EODMS)

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16. Abstract

The purpose of this report is to investigate a group of potential users of satellite remotely sensed data -- state, regional, and local agencies involved in natural resources management. We assess this group's needs in five states, (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) and outline alternative data management systems to satisfy these needs. The major contributions of this work are: i) A comprehensive data needs analysis of state and local users. ii) The design of remote sensing-derivable information products that serve priority state and local data needs. iii) A cost and performance analysis of alternative processing centers for producing these products. iv) An assessment of the impacts of policy, regulation and government structure on implementing large-scale use of remote sensing technology in this community of users. v) the elaboration of alternative institutional arrangements for operational Earth Observation Data Management Systems (EODMS).

We conclude that an operational EODMS will be of most use to state, regional, and local agencies if it provides a full range of information services -- from raw data acquisition to interpretation and dissemination of final information products. Our major focus is to analyze alternative systems for providing these services.

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PREFACE

This volume contains the Appendices to the EODMS Final Report. A major segment of this project involved information gathering and compilation. It was necessary to make wide-ranging background studies, via literature review and interviews, of the current situation vis a vis state-level remote sensing data use. Some of these studies were:

1) The current data needs and data management practices in state agencies (e.g. data acquired, reason for frequency of acquisition, level of detail, format, task and subtask, etc.)

2) Current experiments and operational programs producing information products from remote sensing (costs, accuracy, timeliness, steps taken, etc.)

3) Methods for estimating image processing costs and times.

4) Previous system analyses.

5) Legal constraints on remote sensing data use.

6) Current computerized geographic information systems.

The results of these data-gathering studies are presented in these Appendices. They form the foundation for the analyses of the project.

The appendices also have their own set of references which appear at the end of the appendix volume. With this section the Appendices constitute a supplement to the major text of the report.

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LIST OF ACRONYMS

A/C	Aircraft
AC	Agricultural Conservation Program
ACS	Automated Cantographic System
APFO	Aerial Photography Field Office
APSRS	Aerial Photo Summary Record System
ARS	Agricultural Research Service
ASCS	Agricultural Stabilization and Conservation Service
B&W	Black and White
B&W IR	Black and White Infrared
BD	Board
BLM	Bureau of Land Management
BLS	Bureau of Labor Statistics
C	Color
CAP	Citizens Advisory Panel
CCT	Computer Compatible Tape
CFM	Cooperative Forest Management Program
COMSAT	Communication Satellite
CPU	Central Processing Unit
CRIP	Critical Resource Inventory Program
CRT	Cathode Ray Tube
dbms	data base management system
DMA	Defense Mapping Agency
DOI	Department of the Interior
EODMS	Earth Observation Data Management System
EPA	Environmental Protection Agency
ERISTAR	Earth Resource Information, Storage, Transformation, Analysis and Retrieval

EROS	Earth Resources Observation System
ERS	Earth Resources Survey
ESSA	Environmental Science Services Administration
FAGR	Floating Arm Graphic Recorder
FEDNET	Federal Information Network
FIC	Federal Information Center
FOIA	Freedom of Information Act
GIC	Geographic Information Center
GS	Geological Survey
GSA	General Service Administration
GSFC	Goddard Space Flight Center
H/A	High Altitude
HDDT	High Density Digital Tape
HEW	Department of Health, Education, and Welfare
HUD	Department of Housing and Urban Development
GCP	Ground Control Point
ILLIMAP	Illinois Mapping Program
INFOSAT	Information Satellite
I/O	Input/Output
IR	Infrared
IRIS	Illinois Resource Information System
L/A	Low Altitude
LACIE	Large Area Crop Inventory Experiment
LANDSAT (formerly ERTS)	Earth Resources Technology Satellite
LARS	Laboratory for Application of Remote Sensing

LARSYS	Laboratory for Applications of Remote Sensing System
LUNR	Land Use and Natural Resources Information System
M/A	Medium Altitude
MLMIS	Minnesota Land Management Information System
MO	Missouri
MSS	Multispectral Scanner
NARIS	Natural Resource Information System
NASA	National Aeronautics and Space Administration
NCIC	National Castographic Information Center
NCSL	National Council of State Legislatures
NDPF	National Data Processing Facility
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NTIS	National Technical Information Service
OMB	Office of Management and Budget
PDC	Printing and Dissemination Center
PI	Photo Interpretation
P.I.	Prinicipal Investigators
PNA	Preliminary Needs Analysis
PSU	Primary Sampling Unit
RADAR	Radio Detection and Ranging
RADC	Rome Air Development Center
RALI	Resource and Land Investigation
RBU	Return Beam Vidicon
R&D	Research and Development
RPC	Regional Planning Commission
RMC	Regional Multidisciplinary Center

RS	Remote Sensing
SAB	Space Application Board
S&D	Scanned and Digitized
SCS	Soil Conservation Service
SRS	Statistical Reporting Service
SUNY	State University of New York
TAC	Technology Application Center
TERSSE	Total Earth Resource System for the Shuttle Era
UDDCER	User Data Dissemination Concepts for Earth Resources
U.S.	United States
USBM	United States Bureau of Mines
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
UTM	Universal Tranverse Mercator

APPENDIX A. DATA BASE OF USER NEEDS IN THE FIVE STATE REGION

A.1 THE DATA NEEDS SURVEY

As a prelude to conceptualizing alternative EODMS systems which might effectively meet the needs of state and local agencies in the five state study region, we developed a data base of information on agencies' current operations. We gathered information on the tasks agencies perform, the roles of these tasks in decision-making, the frequency with which tasks are performed, and the priorities among tasks. We identified those data used in performing specific tasks, their characteristics, how they were processed and from what sources they were derived. Thus, our data base represents actual needs according to agencies' current practices. It is not what is often referred to as a "wish list", since we have included only data items actually used or required to meet current responsibilities, whether actually used or not. The EODMS team worked closely with representatives from agencies in the five state study region responsible for the management and development of the states' renewable and nonrenewable resources, for transportation planning and development, for state and regional planning and for environmental protection. The full list of agencies involved in this process is included in Table A-1. A list of all the visits between agency officials and EODMS staff can be found in Appendix 1 of our Preliminary Needs Analysis Report. (A-1) Activities of agencies were organized into categories of task and subtask wherever possible. For each task, information was sought on the items listed in Table A-2. This was done through an interactive process of searching the

Table A-1: State, Regional and Local Agencies Visited

<u>Illinois</u>

Dept. of Agriculture

Dept. of Conservation
    Division of Forestry

Environmental Protection Agency
    Division of Water Pollution Control
    Division of Air Pollution Control

Dept. of Local Governmental Affairs
    Office of Research and Planning

Dept. of Mines and Minerals
    Division of Land Reclamation

Dept. of Transportation

Southwestern Illinois Metropolitan Planning Commission

<u>Iowa</u>

Iowa Conservation Commission
    Forestry Section

Dept. of Environmental Quality
    Division of Air Quality Management
    Division of Water Quality Management
    Solid Waste Division

Geological Survey
    Remote Sensing Laboratory

<u>Minnesota</u>

Dept. of Natural Resources
    Division of Land and Forestry

State Planning Agency
    Division of Environmental Planning

Geological Survey

Twin Cities Metropolitan Council

<u>Missouri</u>

Office of Administration
    Division of State Planning and Budget

Dept. of Agriculture

<u>Missouri (continued)</u>

Dept. of Conservation
    Division of Fisheries
    Division of Forestry
    Division of Wildlife

East-West Gateway Coordinating Council (St. Louis Region)

Highway Department

Mid-America Regional Council (Kansas City Region)

Dept. of Natural Resources
    Division of Environmental Quality
        Air Conservation Commission
        Solid Waste Management Program
        Water Quality Program
        Soil and Water Conservation Program
        Land Reclamation Program
    Division of Parks and Recreation
    Division of Policy Planning and Development
    Geological Survey

St. Louis County Air Pollution Control Division

St. Louis County Planning Department

South-East Missouri Regional Planning Commission

Dept. of Transportation

Dept. of Consumers Affairs, Registration, and Licensing
    Division of Commerce and Industrial Development

<u>Wisconsin</u>

Dept. of Natural Resources
    Division of Environmental Protection
        Bureau of Air Pollution and Solid Waste Management
        Bureau of Water Quality
    Division of Forestry, Wildlife and Recreation

Table A-2: Information Sought
From Agencies

I. Task Statement

II. Task Description:

a. Frequency of occurrence

b. Agency initiating

c. Reasons for initiating

d. Agency performing

e. Process and methodology for performing task

i. data used

ii. data sources

iii. data format

iv. data processing

v. time constraints

vi. final product(s)

vii. dissemination process

viii. accuracy achieved (data quality)

f. Priority assigned or imputed by agency(s)

III. Role, or Relative Importance, of Task Outputs in Decision Making:

a. Final Users

b. Decisions to be made

c. Accuracy required for decision purposes

d. Timeliness required for decision purposes literature and agency documents, interviewing agency representatives, drafting visit reports for review and comment by agency personnel, and revising these reports accordingly.

The major difficulties encountered in assessing the tasks and data needs of agencies were in specifying acceptable delay times between requests for data and their receipt, and data accuracies required. These are important considerations in designing data management systems. Thus, when agency representatives could not provide the detailed responses sought, we developed our own estimates based on our understanding of their needs.

Although we studied the data needs of agencies in all five states of the study region, Missouri agencies were studied in greatest detail. Early in 1975, the Missouri Inter-Departmental Council on Natural Resources Information facilitated our work by encouraging agency cooperation and by identifying and introducing us to agency representatives. This cooperative effort with Missouri agencies culminated in the preparation of an EODMS project report, Natural Resources Data Requirements Inventory: Missouri, (A-2) which was completed in October, 1975. That report represents the most comprehensive data base developed for any of the five states in the study region. It was subsequently used as a point of departure for discussion with some agencies in the other four states.

The data information needs of agencies in the five state study region are portrayed in the tables of the next section. Data needs of agricultural agencies are presented first, followed by environmental protection, fisheries, forestry, geology, mineral resources, land reclamation, land use, transportation, water resources, and wildlife agencies. Occasionally, as in land reclamation, there are so many data items per task that we had to use successive pages to list them all.

As an example of how to read the tables, consider the data item "stand composition" on page 21. This data item is used by state divisions or departments of forestry in the performance of nine subtasks of the major activity of forest management. These subtasks are: perform forest inventory, monitor reforestation, improve private forests, determine the need for timber stand improvement, monitor forest conversions, disease and pest detection, determine fire potential, fire detection and fighting, and fire damage survey. These data are produced in cooperation with the U.S. Forest Service; both agencies contribute manpower and finances. Formats are maps and statistical tables. The most commonly used or preferred map scale is 1:24000 although other scales are not uncommon, as noted. The different scales are used by various agencies at different times, depending on availability and other factors.

This data base is a refined and corrected version of the data bases displayed in two previous project reports: Natural Resources Data Requirements Inventory: Missouri, September 1972, (A-2) and Preliminary Needs Analysis Report, December 1975, (A-1). It represents the foundation for the analysis in Chapter 3 of this report wherein we screened each data item for the applicability of remote sensing to its production, aggregated the data needs across application areas, identified important information products for conveying these data to agencies and analyzed the implications of these products for EODMS system design.

This data base was developed to provide a foundation for conceptualizing alternative earth observation data management systems designs. However, state and regional agencies concerned with designing natural resources data base management systems as well as agencies concerned with natural resources management and planning will likely find it a useful product. In fact, for the Interdepartmental Council on Natural Resources Information in Missouri it has proven to be a very valuable foundation document.

A.2 AGRICULTURE

Some data items in the tables are not self-explanatory. For the readers' convenience, these are defined here:

1. <u>Relative Location</u> - the location of one field in relation to other fields.
2. <u>Single or Double Crop</u> - refers to whether only one crop or two crops, e.g., corn and soybeans are grown in the same field in the same year.
3. <u>Physiological Tolerance</u> - denotes the type and intensity of weather, pests, and chemical damage a specific crop variety can withstand.

Table A-3: Data Needs in Agriculture by Subtasks and Data Characteristics

Subtask and Characteristics / Data Items	ACREAGE	GEOGRAPHIC LOCATION	RELATIVE LOCATION	LOCATION BY COUNTY	CROP VARIETY	CROP SPECIES	SINGLE OR DOUBLE CROP	GROWING SEASON	ROTATION SCHEME
Distinguish Irrigated/Non-Irrigated Lands	X	X							
Distinguish Agricultural/Non-Agricultural Lands	X	X							
Distinguish Cultivated/Forested and Grazing Lands	X	X							
Distinguish Fallow/Producing Lands	X	X					X	X	X
Identify Field Crops	X	X						X	X
Identify Tree Crops	X	X						X	
Determine Stage of Maturity	X	X	X			X			
Determine Planting Date		X			X	X			
Determine Harvest Date		X			X	X			
Determine Moisture Status		X				X			
Estimate Flood Damage	X	X			X	X			
Estimate Hail Damage	X	X				X			
Estimate Wind Damage	X	X			X	X			
Estimate Drought/Frost Damage	X	X			X	X			
Estimate Disease and Pest Damage	X	X			X	X			
Estimate Chemical Damage	X	X	X			X			
Perform Livestock Inventory				X					
Identify Grassland Vegetation	X			X					
Determine Grassland Vigor	X			X					
Perform Grassland Wildlife Inventory				X					
Current Source	SRS Survey; in-house	SRS Survey; in-house	SRS; in-house	SRS; in-house	SRS Survey; in-house	SRS Survey; in-house	SRS Survey; in-house	in-house	in-house
Format	table; map	table; map	table	table	table	table	table	text	text
Scale	1:125,000	1:125,000	---	---	---	---	---	---	---
Resolution	---	---	---	---	---	---	---	---	---
Frequency of Update	seasonally	seasonally	seasonally	Semi-annual	seasonally	several times a season	seasonal	once	seasonal
Time Constraint	2-3 days	2-3 days	2-3 days	1 month	1-2 days	2-3 days	1 month	1 week	1 month
Comments	Other scales: 1:24,000		Wildlife data is obtained from Div. of Wild-life						

Table A-3: Data Needs in Agriculture by Subtasks and Data Characteristics (continued)

Subtask and Characteristics / Data Items	ONTOGENY	VEGETATION TYPE	DEGREE OF DAMAGE	PHYSIOLOGICAL TOLERANCE	SOIL DRAINAGE	SLOPE	ASPECT	WEATHER	LIVESTOCK POPULATION
Distinguish Irrigated/ Non-Irrigated Lands					X				
Distinguish Culti-vated/Non-Agricultu-ral Lands									
Distinguish Cultiva-ted Forested and Grazing Lands									
Distinguish Fallow/ Producing Lands									
Identify Field Crops									
Identify Tree Crops									
Determine Stage of Maturity									
Determine Planting Date							X	X	
Determine Harvest Date								X	
Determine Moisture Status	X			X	X	X	X	X	
Estimate Flood Damage			X		X	X		X	
Estimate Hail Damage	X		X					X	
Estimate Wind Damage			X					X	
Estimate Drought/Frost Damage			X	X		X	X		
Estimate Disease and Pest Damage	X		X	X				X	
Estimate Chemical Damage			X	X				X	
Perform Livestock Inventory									X
Identify Grassland Vegetation.		X							
Determine Grassland Vigor		X							
Perform Grassland Wildlife Inventory									
Current Source	in-house	SRS; in-house	in-house	ARS; in-house	SCS	USGS	USGS	NOAA	SRS; in-house
Format	text	text; table	text; table	text	map; text	map	map	text	table
Scale	---	---	---	---	1:9,600	1:24,000	1:24,000	---	---
Resolution	---	---	---	---	---	2m	2m	---	---
Frequency of Update	biweekly	annual	on demand	on demand	once	once	once	daily	semi-annually
Time Constraint	1 day	1 month	1 day	1 week	1 day	1 day	1-2 days	1 day	1 month
Comments	---	---	---	---	---	---	---	---	---

Table A-3: Data Needs in Agriculture by Subtasks and Data Characteristics (continued)

Subtask and Characteristics / Data Items	AGE	SEX	ANIMAL GENUS	WILDLIFE POPULATION						
Distinguish Irrigated/Non-Irrigated Lands										
Distinguish Agricultural/Non-Agricultural Lands										
Distinguish Cultivated/Forested and Grazing Lands										
Distinguish Fallow/Producing Lands										
Identify Field Crops										
Identify Tree Crops										
Determine Stage of Maturity										
Determine Planting Date										
Determine Harvest Date										
Determine Moisture Status										
Estimate Flood Damage										
Estimate Hail Damage										
Estimate Wind Damage										
Estimate Drought/Frost Damage										
Estimate Disease and Pest Damage										
Esimtate Chemical Damage										
Perform Livestock Inventory	X	X	X							
Identify Grassland Vegetation										
Determine Grassland Vigor										
Perform Grassland Wildlife Inventory	X	X	X	X						
Current Source	SRS; in-house	SRS; in-house	SRS; in-house	Div. of Wildlife						
Format	table	table	table	table						
Scale	---	---	---	---						
Resolution	---	---	---	---						
Frequency of Update	semi-annually	semi-annually	semi-annually	semi-annual						
Time Constraint	1 month	1 month	1 month	6 weeks						
Comments	---	---	---	---						

Table A-3: Data Needs in Agriculture by Subtasks and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	LOCATION OF CROP DAMAGE	KIND OF CROP	SEVERITY OF DAMAGE	TYPE OF DAMAGE	EXTENT OF DAMAGE	$ VALUE OF DAMAGE	WEATHER PATTERNS CAUSING DAMAGE		
Crop Damage by Hail	X	X	X	X	X	X	X		
Current Source	USDA in-house USGS	USDA in-house	USDA in-house	USDA in-house	USDA in-house USGS	USDA in-house farmers	NOAA		
Format	aerial photos on site visits topographic maps	aerial photos on site visits	aerial photos on site visits	aerial photos on site visits	aerial photos topographic map overlay	reports text	---		
Scale	1:2,000 1:6,000	1:2,000 1:6,000	1:2,000 1:6,000	1:2,000	1:2,000 1:6,000	1:2,000 1:6,000	1:5,000,000 some larger		
Resolution	< 1m 2m	< 1m	< 1m	< 1m	< 1m	---	variable 1 km		
Frequency of Update	as needed	as needed	as needed	as needed	as needed	as needed	daily		
Time Constraint	< 1 week	< 1 week	< 1 week	< 1 week	< 1 week	< 1 week	< 24 hrs.		
Comments	---	---	---	---	---	---	---		

A.3 ENVIRONMENTAL PROTECTION

In this study, environmental protection agencies are defined as operational state and local government agencies with responsibilities for environmental protection in three areas: air pollution, water pollution, and solid waste management. Solid waste management problems are limited to landfills and salvage yards. Industrial waste on-site disposal on the land as well as agricultural and mining waste problems were not considered. Other activities include overseeing state environmental impact statement programs in Minnesota and Wisconsin, and overseeing public water supply quality in several states. Some agencies are responsible for performing basic and applied environmental research programs.

Each of the states is organized somewhat differently for the purposes of environmental protection. The grouping of responsibilities for the different media (air, water, land) and for different functions is different in each state, but the ultimate functions to be performed and the data required to perform them are nearly the same. This fact reflects the heavy influence of recent federal legislation on state activities in this area.

Table A-4 summarizes the tasks, data needs, and data characteristics for environmental protection agencies in the five state region, as generalized for all the states. The focus of this table is on the environmental quality data needs. Other data needed to carry out the tasks listed, such as land use, transportation activity and population density, are not included. Many of these allied data needs are similar to those required by land use planning agencies. Data needs for the preparation of Environmental Assessments and Environmental Impact Statements under NEPA appear under the needs of agencies in each area and are not included here. Considerable additional detail on environmental protection data deeds is available in the PNA (A-1) and in the EODMS project report by Osner.(A-3)

Table A-4: Tasks, Data Needs and Data Characteristics
Environmental Protection Agencies

Tasks	Data Needs	Frequency	Resolution Parameters	Time Lag to Management Product	Format
A. Air Quality Management	1. Ambient Air Quality in Rural Areas (Aerosol)	once each 6 days	less than 100 point samples for an entire state	1-4 weeks	tabular listing of concentration of each location
	2. Ambient Air Quality in Rural Areas (gaseous pollutants)	once each 6 days	less than 50 point samples for an entire state	1-4 weeks	tabular listing of concentration of each location
	3. Ambient Air Quality in Urban Areas	once each 3 min. or less frequent	few (~12) point samples for metropolitan region	few minutes to few days	tabular listing of concentration of each location
	4. Meteorological Parameters	daily to once each 3 min.	few sites in metropolitan region	same day	weather map, tabular listing of parameters at each location
	5. State-wide Point Source Inventory	yearly or less often		1 + month	tabular listing of location, identity, discharge rate.
	6. Emissions by Point Sources	as needed		1 week or less	documentation of quality and quantity of discharge
	7. Local concentrations and emissions of exotic pollutants	as needed		1-4 weeks	do., documentation of local air quality
	8. Illegal Intermittent Emissions	random		few minutes	report of location and nature of violation
B. Solid Waste Management	1. Inventory of Waste Disposal Sites	yearly or less frequent	Identify sites 1-2 acres in extent	1 month	thematic map
	2. Inspect Sanitary Landfill Operations	semi-annual to annual		1 month	site imagery
	3. Effects of landfill operation on ground water	quarterly to semi-annual	done by sampling 3 or 4 wells located around perimeter of site	1 month	
	4. Landfill site selection and prepermit investigations	as needed		1 month	site imagery
C. Water Quality Management	1. Ambient and source-oriented water quality				

Table A-4 Tasks, Data Needs and Data Characteristics
Environmental Protection Agencies
(continued)

Tasks	Data Needs	Frequency	Resolution Parameters	Time Lag To Management Product	Format
Water Quality Management (continued)	a. Water Quality Trends in remote areas	semi-annual to annual	streams 50 m wide and up	one month + acceptable	tabular listing
	b. Monitor siting of facilities	as needed	few meters	one month +	currently done ad hoc
	c. Thermal Sources	(weekly to monthly)		one month +	tabular listing and/or isotherm maps
	d. Radioactivity in water	quarterly		one month +	tabular listing
	2. Outfall detection and Inventory	yearly update	outfall from 6-8 inch pipe is of importance		tabular listing
	3. Effluent Levels	monthly		4 weeks	tabular listing
	4. Lake Trophic Level Classification	yearly update	10-100 acre minimum lake size	one month +	tabular listing
	5. Areal Source Inventory	yearly update	Identify areal sources 5 acres in extent	one month +	tabular listing and thematic map may be useful
	6. Oil Spills and Seeps	as needed	locate slicks 10-50 m. wide	few hours	report of location and nature of spill
	7. Basin Plans	yearly or longer update			thematic maps of land use, data from above activities
	a. Stream flow volume	seasonal			tabular listing

A.4 FISHERIES

Data items which need explanation are defined here for the readers' convenience:

1. Cause of Change in Condition - refers to pollutants, dredging activities, and other phenomena which affect aquatic habitat quality.
2. Runoff Quality - refers to the nutrient (pollutants, silt) content of water runoff.

Table A-5: Data Needs in Fisheries by Subtask and Data Characteristics

Subtasks and Characteristics / Data Items	LOCATION	ACREAGE	CONDITION	MEASURE WATER TEMPERATURE	CAUSE OF CHANGE IN CONDITION	INTENSITY OF POLLUTING AGENT	RUNOFF RATE	RUNOFF QUALTIY	LENGTH OF CHANNELIZATION
Aquatic Habitat Inventory and Assessment	X	X	X	X	X			X	X
Aquatic Population Inventory	X		X						
Monitor Terrestrial Cover Type Conversion	X	X							X
Locate Barriers to Fish Movement	X	X			X				
Determine and Monitor Effects of Pollution	X	X	X	X	X	X			
Determine and Monitor Recreation Types	X	X	X						
Determine and Monitor Impact of Recreation	X	X	X		X				
Determine and Monitor Physical Alteration of Water Bodies	X	X	X	X	X				X
Identify Drainage Patterns	X	X					X	X	
Identify Flood Plain Constriction	X	X	X				X	X	
Current Source	in-house	in-house	in-house	in-house	in-house	in-house; Dept. of Environmental Quality	in-house; SCS	in-house; SCS	---
Format	map	map	text	table	text	table	table; text	table; text	---
Scale	1:24,000	1:24,000	---	---	---	---	---	---	---
Resolution	2m	2m	---	---	---	---	---	---	---
Frequency of Update	none	none	seasonal	on demand	annual	on demand	annual	annual	---
Time Constraint	1 week	1 week	1 day	1 day	1 month	1 day - week	1 month	1 month	
Comments	scale may vary	scale may vary							This data item is not presently available

Table A-5: Data Needs in Fisheries by Subtask and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	COVER TYPE IDENTIFICATION	SIZE OF FISH	SPECIES IDENTIFICATION	POPULATION SIZE	SEX					
Aquatic Habitat Inventory and Assessment	X									
Aquatic Population Inventory		X	X	X	X					
Monitor Terrestrial Cover Type Conversion	X									
Locate Barriers to Fish Movement			X	X						
Determine and Monitor Effects of Pollution										
Determine and Monitor Recreation Types			X	X						
Determine and Monitor Impact of Recreation		X	X	X						
Determine and Monitor Physical Alteration of Water Bodies			X	X						
Identify Drainage Patterns										
Identify Flood Plain Constriction										
Current Source	in-house	in-house	in-house	in-house	in-house					
Format	map	table	table	table	table					
Scale	1:4,800	---	---	---	---					
Resolution	---	---	---	---	---					
Frequency of Update	seasonal	seasonal	seasonal	seasonal	seasonal					
Time Constraint	1 day	1 day	1 day	1 day	1 day					
Comments	scale may be larger	based on field data	based on field data	based on field data	based on field data					

A. 5 FORESTRY

The following are definitions of those data needs of forestry agencies that are not self-explanatory.

1. Stand Size - refers to the merchantibility of the stand. It is based on the average diameter at breast height (DBH). Trees are classed as seedlings, saplings, poletimber, small sawtimber, or large sawtimber.
2. Site Index - a measure of productivity based on the projected growth rate of dominant trees on an individual site.
3. Seed Source - refers to the genetic parents of a seedling group.
4. Regeneration Potential - the probability that a stand will reforest itself after a harvest or natural disaster.
5. Practice Required - refers to activities such as pruning and thinning that are an integral part of timber stand improvement.
6. Site Preparation Needs - the practices necessary to employ to ready a site for reforestation.
7. Conversion Method - refers to the use to which forest land has been converted. Agriculture and housing are two examples.
8. Porosity - includes both permeability (how many inches water can seep in an hour) and infiltration rate (the speed at which water enters the surface soil).
9. A-horizon Thickness - the depth to subsoil, that is, the thickness of the surface soil.

Table A-6: Data Needs in Forestry by Data Source and Data Characteristics

Data Needs / Subtasks and Characteristics	STAND MATURITY	TIMBER VOLUME ESTIMATE	SUCCESSIONAL STAGES	LOCATION OF HARVEST	AMOUNT HARVESTED	SEED SOURCE	# SEEDLINGS PLANTED	REGENERATION POTENTIAL	USE OF TREE
Perform Forest Inventory	X	X	X	X	X				
Monitor Reforestation					X	X	X	X	X
Improve Private Forestry	X	X							
Determine Harvest Schedule & Method	X	X			X				
Determine Need for Timber Stand Improvement	X	X			X				
Monitor Forest Conversion		X		X	X				
Disease & Pest Detection	X	X	X						
Determine Fire Potential	X		X						
Determine Land Capacity									
Plan Erosion Protection									
Determine Water Storage Capacity									
Determine Soil Moisture Availability									
Determine Potential Cropping Scheme									
Assess Soil Fertility									
Distinguish Forest Industry		X		X					X
Run Nursery Program						X	X		X
Fire Detection/ Fighting	X								
Fire Damage Survey	X		X					X	
Current Source	in-house	USFS/ in-house	in-house	in-house	in-house	in-house	in-house	in-house	in-house
Format	table	table	text	text	table	table	table	text	table
Scale	---	---	---	---	---	---	---	---	---
Resolution	---	---	---	---	---	---	---	---	---
Frequency of Update	10 years	10 years	once	on demand	on demand	continual	annual	on demand	continual
Time Constraint	1 year	1 year	1 year	1 week	1 week	---	1 month	1 month	---
Comments						refers to genetic parents of seedlings	based on records		based on records

Table A-6: Data Needs in Forestry by Data Source and Data Characteristics (continued)

Subtask and Characteristics / Data Needs	FOREST LOCATION	OWNERSHIP CLASS	STAND COMPOSITION	STAND AREA	COVER TYPE IDENTIFICATION	STAND CONDITION	STAND SIZE	STAND DENSITY	SITE INDEX
Perform Forest Inventory	X	X	X	X	X	X	X	X	X
Monitor Reforestation	X	X	X	X	X	X	X		
Improve Private Foretry	X	X	X	X	X	X	X	X	X
Determine Harvest Schedule & Method	X			X	X		X		X
Determine Need for Timber Stand Improvement	X	X	X	X	X	X	X	X	X
Monitor Forest Conversion	X		X		X	X			
Disease & Pest Detection	X		X	X	X	X		X	X
Determine Fire Potential	X		X	X	X	X		X	
Determine Land Capacity									
Plan Erosion Protection									
Determine Water Storage Capacity									
Determine Soil Moisture Availability									
Determine Potential Cropping Scheme									
Assess Soil Fertility									
Distinguish Forest Industry					X				
Run Nursery Program	X	X			X				
Fire Detection/Fighting			X	X	X			X	
Fire Damage Survey			X	X	X	X	X	X	X
Current Source	USFS/ in-house	USFS/ in-house	USFS/ in-house	USFS/ in-house	USFS/ in-house	USFS/ in-house	USFS/ in-house	USFS/ in-house	USFS/ in-house
Format	map table	county plats	map table	map table	map table	text photo	table	table	table
Scale	1:24,000	---	1:24,000	1:24,000	1:125,000	1:4,800	---	---	---
Resolution	30m	---	30m	30m	30m	5m	---	---	---
Frequency of Update	10 years	10 years	10 years	10 years	10 years	annual	on demand	10 years	10 years
Time Constraint	1 year	1 year	1 year	1 year	1 year	1 week	2 months	1 year	1 year
Comments	other scales: 1:125,000 1:100,000 1:9,600 1:4,800		other scales: 1:125,000 1:100,000 1:9,600 1:4,800	other scales: 1:125,000 1:100,000 1:9,600 1:4,800	other scales: 1:24,000 1:100,000	scale may vary			field measurement

Table A-6: Data Needs in Forestry by Data Source and Data Characteristics (continued)

Subtasks and Characteristics / Data Needs	SOIL SERIES NAME OR NUMBER	POROSITY	BULK DENSITY	TEXTURE PROFILE	STRUCTURE PROFILE	CONSISTENCE PROFILE	A-HORIZON THICKNESS	DEPTH TO BEDROCK	SOIL LOCATION
Perform Forest Inventory									
Monitor Reforestation									
Improve Private Foretry									
Determine Harvest Schedule & Method									
Determine Need for Timber Stand Improvement									
Monitor Forest Conversion									
Disease & Pest Detection									
Determine Fire Potential									
Determine Land Capacity	X	X	X	X	X	X	X	X	X
Plan Erosion Protection	X	X	X	X	X		X	X	X
Determine Water Storage Capacity		X	X	X				X	X
Determine Soil Moisture Availability		X	X	X		X			X
Determine Potential Cropping Scheme				X	X	X	X		X
Assess Soil Fertility	X		X	X	X		X		X
Distinguish Forest Industry									
Run Nursery Program									
Fire Detection/ Fighting									
Fire Damage Survey									
Current Source	SCS	SCS	SCS	SCS	SCS	SCS	SCS	SCS	SCS
Format	map text	map text	map text	map text	map text	map text	map text	map text	map text
Scale	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600
Resolution									
Frequency of Update	20 years	20 years	20 years	20 years	20 years	20 years	20 years	20 years	20 years
Time Constraint	1 week	1 week	1 week	1 week	1 week	1 week	1 week	1 week	1 week
Comments	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas

Table A-6: Data Needs in Forestry by Data Source and Data Characteristics (continued)

Subtasks and Characteristics / Data Needs	RATE OF EROSION	TYPE OF EROSION	MACRO-NUTRIENT STATUS	MICRO-NUTRIENT STATUS	CATION EXCHANGE CAPACITY	PH OF SOIL	SALT CONTENT	DEPTH TO WATER	ORGANIC MATTER CONTENT
Perform Forest Inventory									
Monitor Reforestation									
Improve Private Forestry									
Determine Harvest Schedule & Method									
Determine Need for Timber Stand Improvement									
Monitor Forest Conversion									
Disease & Pest Detection									
Determine Fire Potential									
Determine Land Capacity	X	X	X	X	X	X	X	X	X
Plan Erosion Protection	X	X							
Determine Water Storage Capacity								X	
Determine Soil Moisture Availability								X	
Determine Potential Cropping Scheme	X	X	X	X	X		X		
Assess Soil Fertility			X	X	X	X	X		
Distinguish Forest Industry									
Run Nursery Program									
Fire Detection/ Fighting									
Fire Damage Survey									
Current Source	SCS	SCS	SCS	SCS	SCS	SCS	SCS	SCS	SCS
Format	map text	map text	map text	map text	map text	map text	map text	map text	map text
Scale	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600	1:9,600
Resolution									
Frequency of Update	on demand	on demand	20 years	20 years	20 years	20 years	20 years	20 years	20 years
Time Constraint	1 week	1 week	1 week	1 week	1 week	1 week	1 week	1 week	1 week
Comments	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas	map not available for all areas

Table A-6: Data Needs in Forestry by Data Source and Data Characteristics (continued)

Subtasks and Characteristics / Data Needs	SUBSOIL COLOR	SURFACE COLOR	LOCATION OF INDUSTRY	SIZE OF INDUSTRY	# PERSONS EMPLOYED	PRESENCE OF AIR ON WATER POLLUTION	TYPE OF INDUSTRY	WIND DIRECTION	LOCATION OF FIRE
Perform Forest Inventory									
Monitor Reforestation									
Improve Private Forestry									
Determine Harvest Schedule & Method									
Determine Need for Timber Stand Improvement									
Monitor Forest Conversion									
Disease & Pest Detection									
Determine Fire Potential									
Determine Land Capacity									
Plan Erosion Protection	X								
Determine Water Storage Capacity									
Determine Soil Moisture Availability									
Determine Potential Cropping Scheme									
Assess Soil Fertility		X							
Distinguish Forest Industry			X	X	X	X	X		
Run Nursery Program									
Fire Detection/ Fighting								X	X
Fire Damage Survey									X
Current Source	SCS	SCS	permit	permit	permit	permit	permit	in-house	in-house
Format	text map	text map	text	text	text	text	text	text map	table
Scale	1:9,600	1:9,600	---	---	---	---	---	1:100,000	---
Resolution	:	:	---	---	---	---	---	50m	---
Frequency of Update	20 years	20 years	annual	annual	annual	annual	annual	daily in season	daily in season
Time Constraint	1 week	1 week	1 month	1 month	1 month	1 month	1 month	1 hour	1 hour
Comments	map not available for all areas	map not available for all areas	Illinois desires these data but does not have them	Illinois desires these data but does not have them	Illinois desires these data but does not have them	Illinois desires these data but does not have them	Illinois desires these data but does not have them	scale may be larger	Project Fire Scan provides some of these data.

Table A-6: Data Needs in Forestry by Data Source and Data Characteristics (continued)

Subtasks and Characteristics / Data Needs	WIND SPEED	HUMIDITY	LOCATION OF FIREFIGHTERS	SIZE OF FIRE	LOCATION OF RURAL FIRE PROTECTION DISTRICTS AND AGREEMENTS	TIME AND CAUSE OF FIRE	DEGREE OF DAMAGE	AMOUNT OF FUEL BUILD-UP	TRAVEL TIMES
Perform Forest Inventory									
Monitor Reforestation									
Improve Private Forestry									
Determine Harvest Schedule & Method									X
Determine Need for Timber Stand Improvement									
Monitor Forest Conversion									
Disease & Pest Detection									
Determine Fire Potential								X	X
Determine Land Capacity									
Plan Erosion Protection									
Determine Water Storage Capacity									
Determine Soil Moisture Availability									
Determine Potential Cropping Scheme									
Assess Soil Fertility									
Distinguish Forest Industry									
Run Nursery Program									
Fire Detection/ Fighting	X	X	X	X	X	X		X	
Fire Damage Survey							X	X	
Current Source	in-house	in-house	in-house	in-house	in-house	in-house	in-house	in-house	in-house
Format	table map	table	table text	map table	map table	text table	table text	table	map
Scale	1:100,000	---	---	1:4,800	1:24,000	---	---	---	1:24,000
Resolution	[illegible]0m	---	---	5m	30m	---	---	---	2m
Frequency of Update	daily in season	daily in season	daily in season	on demand	annual	on demand	annual/on demand	daily in season	on demand
Time Constraint	1 hour	1 hour	1 hour	1 hour	1 hour	1 hour	2 weeks	1 hour	1 week
Comments		ground measurement		scale may vary	scale may vary				

Table A-6: Data Needs in Forestry by Data Source and Data Characteristics (continued)

Subtasks and Characteristics / Data Needs	LAND USE TRENDS	ACTIVITY SPECTRUM	RECREATIONAL USE INTENSITY	PRACTICE REQUIRED	SITE PREPARATION NEEDS	CONVERSION METHOD	SLOPE	ASPECT	ELEVATION
Perform Forest Inventory									
Monitor Reforestation									
Improve Private Forestry	X	X							
Determine Harvest Schedule & Method	X		X						
Determine Need for Timber Stand Improvement			X	X	X				
Monitor Forest Conversion						X			
Disease & Pest Detection							X	X	
Determine Fire Potential							X	X	X
Determine Land Capacity							X		
Plan Erosion Protection							X		
Determine Water Storage Capacity							X		
Determine Soil Moisture Availability							X		
Determine Potential Cropping Scheme									
Assess Soil Fertility									
Distinguish Forest Industry									
Run Nursery Program									
Fire Detection/ Fighting									
Fire Damage Survey									
Current Source	in-house	in-house	in-house	in-house	in-house	in-house	USGS	USGS	USGS
Format	table text	table	table	table	table	table	map	map	map
Scale	---	---	---	---	---	---	1:24,000	1:24,000	1:24,000
Resolution	---	---	---	---	---	---	2m	2m	2m
Frequency of Update	on demand	annual	annual	annual	annual	annual	once	once	once
Time Constraint	1 week	1 month	1 month	1 month	1 month	1 month	on demand	on demand	on demand
Comments				based on field studies and models	based on field studies				

A.6 GEOLOGY

Data items which are not self explanatory are explained here for the convenience of the reader:

1. Geologic Unit - a single formation or association of rock layers which are thought to have originated at the same time and in the same environment.

2. Soil Type - the nature and identity of soils present in a given area, such as clay, sandy loam, and so forth.

3. Description of Surficial Materials - description of the types and characteristics of soils and unconsolidated earth materials present in an area, such as soil and rock type.

4. Rock Type - nature and identity of rocks present in an area, such as limestone, sandstone, granite, etc.

5. Water Quality - the physical, chemical and biological properties of subsurface water, such as dissolved solid content, conductivity, pH, B.O.D., and heavy metal content.

5. Well Logs - records of what rock types and geologic units have been drilled through at various depths below the ground.

6. Well Core Data - records of the materials recovered from wells which have been drilled.

6. Correlative Units - geologic units which are similar in age (and origin to units in other areas).

7. Aeromagnetic data - data on the magnetic field intensities at a given point.

8. Gravitometric data - data on the variations in gravitational intensity at a given point.

9. <u>Feature</u> - a structure or land form; for example faults, morraines or mountains.

12. <u>Physical Properties of Aquifers</u> - all the physical properties of a rock unit which act as a water conduit, includes flow rate, porosity and permeability.

Table A-7: Data Needs in Geology by Task and Data Characteristics

Subtasks and Characteristics / Data Items	GEOGRAPHIC LOCATION	STRUCTURE AND ORIENTATION OF GEOLOGIC UNIT OR FEATURE	AREAL EXTENT	SOIL TYPE	DESCRIPTION OF SURFICIAL MATERIALS	SOIL THICKNESS	ROCK TYPE	SUBSURFACE WELL LOGS AND CORE DATA	UNIT THICKNESS
Stratigraphic Studies	X	X	X	X	X	X	X	X	X
Surficial Geologic Mapping	X	X	X		X		X	X	X
Geomorphic Feature Mapping	X	X	X	X	X	X	X		X
Subsurface Geologic Logging	X	X			X	X	X		X
Geologic Mapping	X		X		X	X	X	X	X
Structural Geologic Analyses	X	X					X		
Geologic Features Inventory	X	X	X				X		
Geologic Constraints on Urban Development		X		X			X		
Mine Roof Fall Studies		X					X		
Karst Area Subsidence Potential Evaluation		X		X			X		
Earthquake Advisement		X		X			X		
Slope Stability - Landslide Studies		X		X			X		
Water Impoundment Site Suitability Studies/ and Liquid		X		X		X	X		
Solid Waste Disposal Site Suitability Studies		X		X		X	X		
Foundation Construction Suitability		X		X			X		
Engineering Geologic Mapping	X	X	X	X		X	X		
Engineering Soils Mapping	X	X	X	X		X	X		
Current Source	USGS	USGS in-house	in-house USGS	USGS in-house SCS	in-house USGS SCS	USGS in-house SCS	USGS in-house	in-house	USGS in-house
Format	topographic map	text geologic map	geologic maps engineering geology maps	soils maps	soils and geologic maps	soils and surficial materials maps	geologic maps	well logs well core data	geologic maps text
Scale	1:24,000	1:24,000 1:62,500	1:24,000	1:24,000 1: 9,600	1:24,000 1: 9,600	1:24,000 1: 9,600	1:24,000 1:62,500	---	1:24,000 1:62,500
Resolution	2m	2m - 4m	2m	2m - < 1m	2m - < 1m	2m - < 1m	2m - < 1m	---	2m - 4m
Frequency of Update	5-10 yrs.	20 years	5-10 yrs.	10 years	10 years	10 years	20 years	as needed	20 years
Time Constraint	none	none	none	none	none	none	none	4-6 weeks	none
Comments	---	some field work necessary	---	---	---	---	---	---	---

Table A-7: Data Needs in Geology by Task and Data Characteristics (continued)

Subtask and Characteristics / Data Items	WATER QUALITY DATA	COLOR OF EARTH MATERIALS	COMPOSITION OF EARTH MATERIALS	TEXTURE OF EARTH MATERIALS	TRACE ELEMENT CONTENT	CONTAINED FOSSILS	AGE	CORRELATIVE UNITS	AEROMAGNETIC GRAVITOMETRIC AND OTHER GEOPHYSICAL DATA
Stratigraphic Studies	X	X	X	X	X	X	X	X	X
Surficial Geologic Mapping	X				X		X		
Geomorphic Features Mapping							X		X
Subsurface Geologic Logging		X	X	X		X		X	
Geologic Mapping									X
Structural Geologic Analyses									X
Geologic Features Inventory									
Geologic Constraints on Urban Development									
Mine Roof Fall Studies									
Karst Area Subsidence Potential Evaluation									
Earthquake Advisement									
Slope Stability-Landslide Studies									
Water Impoundment Site Suitability Studies/ and Liquid									
Solid Waste Disposal Site Suitability Studies									
Foundation Construction Suitability									
Engineering Geologic Mapping									
Engineering Soils Mapping									
Current Sourse	in-house reports	in-house reports based on samples	in-house reports	in-house reports	in-house reports	in-house reports	in-house reports	in-house reports	in-house contractor reports
Format	text tabular summaries	text	text laboratory analyses	text laboratory analyses	text tabular summaries	text	text	text geologic maps	text charts
Scale	---	---	---	---	---	---	---	1:24,000 1:62,500 1:250,000	1:62,500 1:250,000
Resolution	---	---	---	---	---	---	---	2m - 1m	---
Frequency of Update	as needed	as needed	as needed	as needed	as needed	as needed	as needed	as needed	as needed
Time Constraint	1-2 weeks	1-2 weeks	1-2 weeks	1-2 weeks	1-2 weeks	1-2 weeks	1-2 weeks	none	8-12 weeks
Comments	---	---	---	---	---	---	---	---	---

Table A-7: Data Needs in Geology by Task and Data Characteristics (continued)

Subtask and Characteristics / Data Needs	SLOPE	HEIGHT OF FEATURE	INSOLUBLE RESIDUE TYPE	GEOLOGIC UNIT PRESENT	DEPTH OF UNITS	MINERALS PRESENT	LAND COVER/USE TYPE	SIZE OF FEATURE	SHAPE OF FEATURE
Stratigraphic Studies									
Surficial Geologic Mapping									
Geomorphic Features Mapping	X	X							
Subsurface Geologic Logging			X	X	X	X			
Geologic Mapping									
Structural Geologic Analyses				X			X	X	X
Geologic Features Inventory	X			X			X		X
Geologic Constraints on Urban Development	X								
Mine Roof Fall Studies	X								
Karst Area Subsidence Potential Evaluation	X								
Earthquake Advisement	X								
Slope Stability - Landslide Studies	X								
Water Impoundment Site Suitability Studies and Liquid	X				X				
Solid Waste Disposal Site Suitability Studies	X				X				
Foundation Construction Suitability	X				X				
Engineering Geologic Mapping	X								
Engineering Soils Mapping	X								
Current Source	USGS	NASA, USGS SCS, ASCS in-house	in-house laboratory analysis	USGS in-house	USGS in-house drill logs	in-house laboratory analysis	USGS in-house	USGS in-house	USGS in-house
Format	topographic or slope map	aerial photos topographic maps	text and insoluble residue logs	texts geologic maps	text	text tabular summaries	land use/cover map map	topographic and maps	topogra-map
Scale	1:24,000	1:24,000 & larger some some at 1:1,000,000	---	1:24,000 1:62,500	---	---	1:24,000 1:250,000	1:24,000 1:62,500	1:24,000
Resolution	2m on base 10m on slope zone	2m - 10m a/c s/c 80m	---	20 years	---	---	2m - 30m	2m - 10m	2m
Frequency of Update	20 years	as needed	as needed	20 years	as needed	as needed	5 years	20 years	5 years
Time Constraint	none	4-6 weeks	4-6 weeks	none	none	4-6 weeks	4-6 weeks	none	none
Comments	10-12 slope zones needed							interpretation needed	

Table A-7: Data Needs in Geology by Task and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	SURFACE DRAINAGE	GEOLOGIC HISTORY DATA	TYPE OF FEATURE	SUBSURFACE DRAINAGE	ROCK PERMEABILITY	SOIL PERMABILITY	BEARING STRENGTH OF SOILS	GROUND WATER USE IN AREA	PHYSICAL PROPERTIES OF AQUITERS
Stratigraphic Studies									
Surficial Geologic Mapping									
Geomorphic Features Mapping									
Subsurface Geologic Logging									
Geologic Mapping									
Structural Geologic Analyses	X	X							
Geologic Features Inventory	X		X	X					
Geologic Constraints and Urban Development	X			X	X	X	X	X	X
Mine Roof Fall Studies				X	X			X	X
Karst Area Subsidence Potential Evaluation	X			X	X	X	X	X	X
Earthquake Advisement							X		
Slope Stability - Landslide Studies	X			X	X	X			
Water Impoundment Site Suitability Studies/ and Liquid	X				X	X	X	X	
Solid Waste Disposal Site Suitability Studies	X				X	X		X	
Foundation Construction Suitability					X	X		X	
Engineering Geologic Mapping	X				X	X	X		
Engineering Soils Mapping	X					X	X	X	
Current Source	USGS	USGS in-house	USGS in-house reports	USGS in-house reports maps	in-house laboratory analyses	in-house laboratory analyses	in-house laboratory analyses	USGS in-house reports	in-house
Format	topographic maps	text	text	text geologic maps	text tabular summaries	text tabular summaries	text tabular summaries	text	field and analyses text
Scale	1:24,000	---	---	---	---	---	---	---	---
Resolution	2m	---	---	---	---	---	---	---	---
Frequency of Update	20 years	as needed	as needed	20 years	as needed	as needed	as needed	annual	as needed
Time Constraint	4-6 weeks	none	none	4-6 weeks	1-2 weeks	1-2 weeks	1-2 weeks	4-6 weeks	1-2 weeks
Comments			interpretation required						

Table A-7: Data Needs in Geology by Task and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	GROUND WATER LEVEL	GROUND WATER FLOW	TECTRONIC STABILITY	BEARING STRENGTH OF ROCK	PHYSICAL PROPERTIES OF ROCK	ACCESS TO CONSTRUCTION MATERIAL	STREAM DISCHARGE	PHYSICAL PROPERTIES OF ROCK	SOIL SHEARING STRENGTH
Stratigraphic Studies									
Surficial Geologic Mapping									
Geomorphic Features Mapping									
Subsurface Geologic Logging									
Geologic Mapping									
Structural Geologic Analyses									
Geologic Features Inventory									
Geologic Constraints an Urban Development	X	X	X	X					
Mine Roof Fall Studies	X	X		X					
Karst Area Subsidence Potential Evaluation	X	X		X					
Earthquake Advisement	X		X	X					
Slope Stability - Landslide Studies	X		X	X					
Water Impoundment Site Suitability Studics/ and Liquid	X	X		X	X	X	X	X	
Solid Work Disposal Site Suitability Studies	X	X			X	X	X	X	
Foundation Construction Suitability	X	X		X	X	X		X	
Engineering Geologic Mapping	X	X		X	X	X		X	X
Engineering Soils Mapping									
Current Source	in-house field tests	in-house field tests	USGS USBM in-house reports	in-house	in-house	in-house consultants	USGS Corps of Eng. in-house NOAA	in-house laboratory analyses	in-house laboratory analyses
Format	text	text	text	laboratory analyses	laboratory analysis	topographic maps materials overlay	text tabular summaries	text tabular summaries	text tabular summaries
Scale	---	---	---	---	---	1:24,000	---	---	---
Resolution	---	---	---	---	---	2m	---	---	---
Frequency of Update	annual	annual	as needed	as needed	as needed	as needed	weekly	as needed	as needed
Time Constraint	4-6 weeks	4-6 weeks	archive only	1-2 weeks	1-2 weeks	8-12 weeks	24-48 hrs	1-2 weeks	1-2 weeks
Comments						faster turn around may be required in some cases			

Table A-7: Data Needs in Geology by Task and Data Characteristics (continued)

Subtask and Characteristics / Data Needs	SOIL COMPOSITION	TOPOGRAPHY							
Stratigraphic Studies									
Surficial Geologic Mapping									
Subsurface Geologic Logging									
Geologic Mapping									
Structural Geologic Analyses									
Geologic Features Inventory									
Geologic Constraints on Urban Development									
Mine Roof Fall Studies									
Karst Area Subsidence Potential Evaluation									
Earthquake Advisement									
Slope Stability - Landslide Studies									
Water Impoundment Site Suitability Studies/ and Liquid									
Solid Waste Disposal Site Suitability Studies									
Foundation Construction Suitability									
Engineering Geologic Mapping	X	X							
Engineering Soils Mapping	X								
Current Source	in-house laboratory analysis	USGS							
Format	text tabular analyses	topographic maps							
Scale	---	1:24,000 1:62,500							
Resolution	---	2m - 4m							
Frequency of Update	as needed	20 years							
Time Constraint	1-2 weeks	none							
Comments	---	---							

A.7 MINERAL RESOURCES

Data items needing further explanation are:

1. Grade of Deposits - the relative quality of a mineral deposit. Based on the amount of desired mineral present in the ore.

2. Stratigraphic Relationships - the connections and juxtapositions of geologic units which occur in the same area.

Table A-8: Data Needs in Mineral Resource Geology by Task and Data Characteristics

Subtasks and Characteristics / Data Items	LOCATION OF MINES, PITS AND QUARRIES	VOLUME AND AMOUNT PRODUCED	MATERIALS MINED	METHOD OF MINING	LOCATION OF RESERVES	GEOLOGY OF MINERAL RESOURCES	$ VALUE OF MATERAILS MINED	MINED LAND OWNERSHIP	LAND USE/COVER
Mineral Resource Studies	X	X	X	X	X	X	X	X	X
Annual Reports on State Mineral Resources and Production	X	X	X	X	X	X	X	X	X
Coal Gasification Potential						X			
Coal Utilization Potential						X			
Strippable Coal Reserves						X			
Potential Coal Resources and Resource Depletion						X			
Coal Resource Studies						X			
Oil and Gas Resource Studies		X				X			
Reports on Oil and Gas Reserves									
Chemical Analysis of Soils									
Chemical Analysis of Rocks									
Chemical Analysis of Minerals									
Chemical Analysis of Water									
Current Source	USGS mining county offices	mining companies	mining companies	mining companies	mining companies in-house	mining companies in-house USGS	mining companies in-house	county offices	USGS in-house
Format	topographic maps land plats	texts	texts	texts	texts maps	texts geologic maps	texts	land plats	land cover maps
Scale	1:24,000 1: 1,000 1: 100	---	---	---	1:24,000	1:24,000 1:62,500	---	1:1,000 - 1: 100	1:24,000 1:250,000
Resolution	2m - .3m	---	---	---	2m	2m - 10m on geologic data	---	.3m	2m - 10m
Frequency of Update	annual	annual	annual	annual	as needed	20 years	annual	annual	5 years
Time Constraint	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks
Comments	---	---	---	---	---	---	---	---	---

Table A-8: Data Needs in Mineral Resource Geology by Task and Data Characteristics (continued)

Subtask and Characteristics / Data Items	GRADE OF DEPOSITS	DEPTHS AT WHICH MINERALS OCCUR	STRUCTURE AND ORIENTATION OF GEOLOGIC UNITS PRESENT	ROCK TYPE	STRATIGRAPHIC RELATIONSHIP	MAJOR ELEMENT CONTENT	MINOR ELEMENT CONTENT	TRACE ELEMENT CONTENT	ORIGIN OF ORES
Mineral Resource Studies	X	X	X	X	X	X	X	X	X
Annual Reports on State Mineral Resources and Production									
Coal Gasification Potential									
Coal Utilization Potential									
Strippable Coal Reserves									
Potential Coal Reserves and Resource Depletion									
Coal Resource Studies									
Oil and Gas Resource Studies			X			X	X	X	
Reports on Oil and Gas Reserves			X			X	X	X	
Chemical Analysis of Soils						X	X	X	
Chemical Analysis of Rocks						X	X	X	
Chemical Analysis of Minerals						X	X	X	
Chemical Analysis of Water						X	X	X	
Current Source	USGS in-house mining companies	USGS in-house mining companies	USGS in-house mining companies	USGS in-house mining companies	USGS in-house mining companies	in-house laboratory analysis	in-house laboratory analysis	in-house laboratory analysis	in-house USGS mining companies
Format	text	text charts	text maps	text charts	text	text tabular summaries	text tabular summaries	text tabular summaries	text
Scale	---	---	1:24,000	1:24,000 1: 1,000	---	---	---	---	---
Resolution	---	---	2m	< 1m 2m	---	---	---	---	---
Frequency of Update	annual	annual	20 years	as needed	once	as needed	as needed	as needed	once
Time Constraint	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-5 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks
Comments	---	---	---	---	---	---	---	---	---

Table A-8: Data Needs in Mineral Resource Geology by Task and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	EXTENT OF ORE BODIES	AREA OF COAL OCCURRENCE	AREAL EXTENT OF INDIVIDUAL COAL SEAMS	AVERAGE SEAM THICKNESS	AVERAGE ARRANGEMENT OF OVERBURDEN THICKNESS	TONNAGE ESTIMATES OF COAL	QUALITY AND GEOCHEMISTRY OF COAL	PROXIMITY TO MARKETS AND AVAILABLE TRANSPORTATION	POTENTIAL MINING METHODS
Mineral Resource Studies	X								
Annual Reports on State Mineral Resources and Production		X	X	X	X	X	X	X	X
Coal Gasification Potential		X	X	X	X	X	X	X	X
Coal Utilization Potential		X	X	X	X	X	X	X	X
Strippable Coal Reserves		X	X	X	X	X	X	X	X
Potential Coal Reserves and Resource Depletion		X	X	X	X	X	X	X	X
Coal Resource Studies		X	X	X	X	X	X	X	X
Oil and Gas Resource Studies								X	
Reports on Oil and Gas Reserves								X	
Chemical Analysis of Soils									
Chemical Analysis of Rocks									
Chemical Analysis of Minerals									
Chemical Analysis of Water									
Current Source	in-house USGS companies	in-house USGS companies	in-house USGS companies	in-house mining companies	in-house mining companies	in-house mining companies	in-house mining companies	in-house reports	in-house reports
Format	text map	maps	maps	text	text	text	laboratory analysis text	text	text
Scale	1:24,000	1:24,000	1:24,000	---	---	---	---	---	---
Resolution	2m	2m	2m	---	---	---	---	---	---
Frequency of Update	once	as needed	as needed	as needed	as needed	as needed	as needed	as needed	as needed
Time Constraint	4-6 weeks	none	none	none	none	none	none	none	none
Comments	---	---	---	---	---	---	---	---	---

Table A-8: Data Needs in Mineral Resource Geology by Task and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	ENVIRONMENTAL FACTORS RECLAMATION AND CONTROL	WATER REQUIRED AND AVAILABLE	ESTIMATED COSTS PER TON OF COAL F.O.B. MINE	ESTIMATED COSTS OF PLANT CONSTRUCTION	PROFITABILITY OF MINE AND PLANT CONSTRUCTION	LOCATION OF WELLS	NUMBER OF WELLS	METHOD OF RECOVERY	DEPTH OF WELLS
Mineral Resource Studies									
Annual Reports on State Mineral Resources and Production									
Coal Gasification Potential	X	X	X	X	X				
Coal Utilization Potential	X	X	X	X	X				
Strippable Coal Reserves	X		X	X	X				
Potential Coal Reserves and Resource Depletion	X	X	X						
Coal Resource Studies	X	X	X	X	X				
Oil and Gas Resource Studies						X	X	X	X
Reports on Oil and Gas Reserves									
Chemical Analysis of Soils									
Chemical Analysis of Rocks									
Chemical Analysis of Minerals									
Chemical Analysis of Water									
Current Source	in-house reports	in-house reports	mining companies reports	mining companies in-house reports	mining companies reports	producers USGS reports	producers reports	producers reports	producers reports
Format	text	text	text	text	text	text maps	text	text	text drill logs
Scale	---	---	---	---	---	1:24,000	---	---	---
Resolution	---	---	---	---	---	2m	---	---	---
Frequency of Update	as needed	as needed	annual	once	annual	annual	annual	annual	annual
Time Constraint	4-6 weeks	none	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks
Comments	---	---	---	---	---	---	---	---	---

Table A-8: Data Needs in Mineral Resource Geology by Task and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	GEOLOGIC UNITS PENETRATED	PHYSICAL PROPERTIES OF OIL AND GAS	LOCATION OF RESERVES	PROJECTED RECOVERY COSTS	WELL AND LEASE OWNER	RESERVES ESTIMATED	RESERVOIRS PENETRATED		
Mineral Resource Studies									
Annual Reports on State Mineral Resources and Production									
Coal Gasification Potential									
Coal Utilization Potential									
Strippable Coal Reserves									
Potential Coal Reserves and Resource Depletion									
Coal Resource Studies	X	X	X	X	X	X	X		
Reports on Oil and Gas Reserves		X		X					
Chemical Analysis of Soils									
Chemical Analysis of Rocks									
Chemical Analysis of Minerals									
Chemical Analysis of Water									
Current Source	producers reports	in-house laboratory analysis	producers in-house reports	producers reports	producers county records	producers in-house reports	procuders reports		
Format	text drill logs	text tabular summaries	text maps	text	plat books	text	text drill logs		
Scale	---	---	1:24,000	---	1:1,000 1: 100	---	---		
Resolution	---	---	2m	---	< 1m				
Frequency of Update	annual	as needed	annual	annual	annual	annual	annual		
Time Constraint	4-6 weeks	4 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks	4-6 weeks		
Comments	---	---	---	---	---	---	---		

A.8 LAND RECLAMATION

Data items in Table A.9 are considered self-explanatory.

Table A-9: Data Needs in Land Reclamation by Tasks and Data Characteristics

Subtasks and Characteristics / Data Items	LOCATION OF MINES	OWNERSHIP OF MINES	AREAL EXTENT	STAGE OF RECLAMATION	SURFACE DRAINAGE	SLOPE	LAND COVER	VEGETATION COVER	MINE HISTORICAL DATA
Mined Land Reclamation Monitoring	X	X	X	X	X	X	X	X	X
Current Source	USGS ASCS SCS in-house	County land plats	USGS ASCS SCS in-house	ASCS SCS in-house	USGS	USGS	SCS, USGS ASCS USFS in-house	SCS ASCS USFS in-house	SCS ASCS USGS in-house
Format	1:24,000 maps aerial photos	maps	aerial photos	aerial photos	topographic map	slope or topographic map	aerial photos or land use maps	aerial photos land cover maps	aerial photos maps
Scale	1:24,000 or larger	large scale maps maps <1:24,000	1:24,000 1:12,000 1: 6,000	1:12,000 1: 6,000	1:24,000	1:24,000	1:24,000	1:24,000	1:24,000
Resolution	2m	< 1m	2m and < 2m	< 2m	2m	2m and 10m on slope zone	2m	2m	2m
Frequency of Update	annual (seasonal)	irregular	annual (seasonal)	annual (seasonal)	20 years	20 years	annual	annual	archive only
Time Constraint	4 weeks (max)	---	4 weeks (max)	4 weeks (max)	---	---	---	---	---
Comments	---	---	---	---	---	if slope map unavailable requires inference from contour of topographic map	maps require field work		

Table A-9: Data Needs in Land Reclamation by Tasks and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	WATER PRESENT	SUBSURFACE GEOLOGY	GROUND WATER CHARACTERISTICS					
Mined Land Reclamation Monitoring	X	X	X					
Current Source	USGS SCS ASCS in-house	USGS State GS	USGS State GS State Water Survey					
Format	aerial photos field investigations	geological maps	maps text					
Scale	1:24,000	1:24,000	1:24,000					
Resolution	2m	2m on base 10m on geology	2m					
Frequency of Update	annual (seasonal)	20 years	20 years					
Time Constraint	4 weeks (max)	available as archive	4 weeks					
Comments	---	---	---					

A.9 PLANNING AGENCIES

Tables A-10 and A-11 list the data needs of state and regional/ local planning agencies respectively along with the characteristics of those data where available. Data items are arranged in broad groups according to data type rather than task. This approach was adapted because the tasks and projects of planning agencies tend to differ widely among the states and over time, as discussed in some detail in (A-1). Thus, the data items listed here are typical needs of agencies in the five state region as reflected in their recent activities. In general, "time constraint" is not specified.

Planning agencies generate relatively little of the data used, depending upon inputs from other state agencies, local and federal governments, and the private sector. Thus under the heading Current Source, "State" means that the data item is obtained from cooperating state agencies. More details on the specific sources are available in the Missouri Report (A-2) and in the Preliminary Needs Analysis (A-1).

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE
PLANNING: STATE LEVEL

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Agriculture	estimated annual production of energy in form of harvestable vegetable growth	Universities	table	---	---	annual	---	
	estimated total annual production of organic matter from all categories of vegetation	Universities	table	---	---	annual	---	
	annual yield-frequency curve for all crops	Universities	table	---	---	annual	---	
	irrigated land	Universities	table	---	---	annual	---	
	livestock prices	State	table	---	---	annual	---	
	grain prices	---	table	---	---	annual	---	
	market trends	---	table	---	---	annual	---	
	livestock receipts	---	table	---	---	annual	---	
	degree of crop damage	---	table	---	---	annual	---	
	pasture acreage	USDA SRS	table	---	---	annual	---	
	crop acreage and location	USDA SRS	table	---	---	annual	---	
	crop production	USDA SRS	table	---	---	annual	---	
	average crop yield by soil type	Universities	table	---	---	annual	---	
Vegetation	vegetative cover type, area, location	USDA USCS	maps	1:250,000 and 1:24,000	40m	3 years	---	
	native vegatation	---	maps	1:250,000 and 1:24,000	40m	once	---	
	cultural vegetation	---	maps	1:250,000 and 1:24,000	40m	3 years	---	
	wetlands inventory	---	maps	1:250,000 and 1:24,000	40m	3 years	---	
	soil productivity ratings	Universities	table	---	---	annual	---	

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE PLANNING: STATE LEVEL (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Soils	soil locational patterns	SCS	map	---	---	as needed with land-use change	---	
	slope	SCS	map	---	---	as needed with land-use change	---	
	generalized soil limitations to construction activities	---	table	---	---	as needed	---	
	generalized soil productivity	---	table	---	---	as needed	---	
	soil family groupings	---	table	---	---	as needed	---	
	soil reconnaissance	---	map	---	---	as needed	---	
	soil assocations	---	map	---	---	once	---	
	land capability	---	map	---	---	as needed	---	
	engineering groupings of soils	---	tabular	---	---	once	---	
Forestry	forest location	State	map	1:250,000	40m	once	---	
	forest conversion	State	map	1:250,000	40m	annual	---	
	reforestation	State	map	1:250,000	40m	annual	---	
	tree stand size	State	table	---	---	annual	---	
	tree stand composition	State	table	---	---	annual	---	
	amount of tree harvest	State	table	---	---	annual	---	
	use of tree harvest	State	table	---	---	annual	---	
	timber volume estimates	State	table	---	---	annual	---	
	forest inventory	State	map	1:250,000	40m	annual	---	
Wildlife	habitat characteristics	State	table	---	---	5 years	---	
	wildlife type and population	State	table	---	---	5 years	---	

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE PLANNING: STATE LEVEL (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Water Resources and Quality								
	intensity of pollution on aquatic habitat	State	table	---	---	annual	---	
	aquatic population	State	table	---	---	annual	---	
	impact of recreation type on aquatic habitat	State	---	---	---	annual	---	
	impact of floodplain construction on aquatic habitat	State	---	---	---	annual	---	
	physical alteration of water bodies	State	---	---	---	annual	---	
	surface water	Universities	table map	1:250,000	40m	5 years	---	
	stream flow	---	table	---	---	monthly	---	
	ground water availability	---	table	---	---	annual	---	
	lake volumes	---	table	---	---	annual	---	
	reservoir location	---	map	---	---	5 years	---	
	potential reservoir sites	---	map	---	---	5 years	---	
	winter fish-kill	---	table	---	---	annual	---	
	wild rivers	---	map	---	---	5 years	---	
	fishery resource types	---	table	---	---	2 years	---	
	eutrophication classes	---	table	---	---	annual	---	
	submerged aquatic macrophyte communities	---	table	---	---	5 years	---	
	aquatic invertebrate communities	---	table	---	---	5 years	---	
	groundwater recharge regions	---	map	1:250,000	---	once	---	
	groundwater discharge regions	---	map	1:250,000	---	once	---	
	estimated volumes of groundwater discharge	---	table	---	---	annual	---	
	miles of shoreline	---	table	---	---	once	---	

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE PLANNING: STATE LEVEL (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	sedimentation rates	---	table	---	---	annual	---	
	major point pollution sources by type	---	table	---	---	annual	---	
	mean annual lake level fluctuation	---	table	---	---	annual	---	
	intermittent streams	---	map table	---	---	once	---	
	permanent streams	---	map table	1:250,000	---	once	---	
	phreatic water surface	---	map	1:250,000	---	once	---	
	potentiometric maps of major bedrock aquifer systems	---	map	1:250,000	---	once	---	
	depth to water table	---	map	1:250,000	---	once	---	
	estimated total aquifer water storage volume	---	map	---	---	once	---	
	floodplain location	U.S. Army Corps of Engineers	map	1:250,000 and 1:2,400	---	once only	---	
	floodprone area location	U.S. Army Corps of Engineers	map	1:250,000 and 1:2,400	---	once only	---	
	surface water and ground water quality	---	table	---	---	annual	---	
Air Quality	location of point source	State	map table	---	20m	annual	---	
	size of point source	State	tabular	---	---	once	---	
	area source location	State	map table	---	40m	annual	---	
	ambient air sampling	State	table	---	---	monthly	---	
Climate/ Meteorology	weather records: precipitation temperature humidity tornado frequency	---	table	---	---	yearly (annual records)	---	
	atmospheric inversion probability	---	map	---	---	yearly	---	

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE PLANNING: STATE LEVEL (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Solid Waste	sanitary landfill sites	State	map	---	10m	2 years	---	
	solid waste facility processing sites	State	map	---	10m	2 years	---	
	solid waste management plans	State	map	---	---	2 years	---	
	solid waste generation data	State	table	---	---	annual	---	
Geology	precambrian surface	---	map	1:250,000	---	once	---	
	overburden thickness	---	map	---	---	once	---	
	glacial deposits	---	map	---	---	once	---	
	unique geologic features	---	map	---	---	once	---	
	surface drainage	State	map	---	---	once	---	
	slope	USGS	map	---	---	once	---	
	generalized geology	State	map	---	---	once	---	
	physiographic regions	State	map	---	---	once	---	
	subsurface drainage	State	map	---	---	once	---	
	topography	USGS	map	---	---	once	---	
	local relief	USGS	map	---	---	once	---	
	seismic risk zone	USGS	map	---	---	once	---	
	surface geology	---	map	---	---	once	---	
	bedrock geology	---	map	---	---	once	---	
	bedrock surface contour	---	map	---	---	once	---	
Minerals Resources	number of wells	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	reservoirs penetrated	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	amount produced	Mining, Gas, and Oil Comapnies	table	---	---	annual	---	
	recovery cost	Mining, Gas, and Oil Companies	table	---	---	annual	---	

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE PLANNING: STATE LEVEL (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESOLUTION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	reserve estimates	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	extent of mining	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	material extracted	Mining, Gas, and oil Companies	table	---	---	annual	---	
	historical mining	State	---	---	---	once	---	
	types of minerals	State	map	1:250,000	---	once	---	
	mineral grade	State	table	---	---	once	---	
	mineral origin	State	table	---	---	once	---	
	estimated reserves	State	table	---	---	5 years	---	
	$ value of minerals	State	table	---	---	5 years	---	
	access to market	State	table	---	---	5 years	---	
	profitability to mine	State	table	---	---	5 years	---	
	coal and mineral quality	State	table	---	---	once	---	
	strip mine loca-location and inventory	U.S. Council on Environmental Quality	map	1:24,000	10m	2 years	---	
	strip mine acreage	U.S. Council on Environmental Quality	table	---	---	2 years	---	
	strip mine condition	U.S. Council on Environmental Quality	table	---	---	2 years	---	
Energy	inventory of fuel oil consumers	State	table	---	---	annual	---	
	inventory of L.P. gas consumers	State	table	---	---	annual	---	
	inventory of interruptable natural gas consumers	State	table	---	---	annual	---	
	fuel consumption estimates	State	table	---	---	annual	---	
	service station inventory	State	table	---	---	annual	---	

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE PLANNING: STATE LEVEL (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Recreation	water-related recreational activities	State	table	---	---	3 years	---	
	state forests visitors per year	State	table	---	---	annual	---	
	recreational activity spectrum in state forests	State	table	---	---	annual	---	
	travel times to state forests	State	table	---	---	once	---	
	state park attendance	State	table	---	---	annual	---	
	camping areas by type and density	---	table map	---	20m	annual	---	
	historical sites	State	map	1:250,000	---	once	---	
	prehistoric sites	State	map	---	---	once	---	
	size of parks	State	table	---	---	5 years	---	
	length of trails	State	table	---	---	5 years	---	
	location of existing parks	State	map	1:250,000 and 1:24,000	40m	5 years	---	
	location of potential parks	State	map	1:250,000 and 1:24,000	---	5 years	---	
	location of natural and scenic parks	State	map	1:250,000 and 1:24,000	---	5 years	---	
	camping permits sold	State	table	---	---	annual	---	
	inventory of public and private recreational facilities	State	table	---	---	5 years	---	
	recreation demand estimates	State	table	---	---	annual	---	
	inventory of natural areas	State	map	1:250,000 and 1:24,000	40m	5 years	---	
Transportation	road inventory	State	map	---	---	5 years	---	
	traffic data	State	tabular	---	---	annual	---	
	general county and city road location	State	map	1:24,000	---	---	---	
	highways	Universities	map	---	---	---	---	
	motor freight	Universities	map	---	---	---	---	

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE PLANNING: STATE LEVEL (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESOLUTION	FREQUENCY OF UPDATE	TIME CONSTRAINTS	COMMENTS
	state population by age	Census	table	---	---	10 years	---	
	years of education	Census	table	---	---	10 years	---	
Services	urban services	Census	table	---	---	5 years	---	
	regional services	Census	table	---	---	5 years	---	
	drinking water availability	U.S. Army Corps of Engineers	table	---	---	5 years	---	
	health care facilities	RPC's	table	---	---	5 years	---	
	emergency medical service	RPC's	table	---	---	5 years	---	
	generalized soil limitations for use of septic tanks	---	table	---	---	5 years	---	
Socio-Economic-General	number of welfare recipients	Dept. of Social Services in MO.	table	---	---	annual	---	
	number of welfare payments	Dept. of Social Services in MO.	table	---	---	annual	---	
	poverty guidelines	HEW Economic Development Administration	table	---	---	2 years	---	
	value of land	Census	table	---	---	annual	---	
	value of buildings	Census	table	---	---	annual	---	
	value of machinery	Census	table	---	---	annual	---	
	value of equipment	Census	table	---	---	annual	---	
	earnings by industrial sector	Census	table	---	---	annual	---	
	hourly wage rates	Census	table	---	---	annual	---	
	gross regional product	Census	table	---	---	annual	---	
	gross county product	Census	table	---	---	annual	---	
	total regional employment by occupation	Census	table	---	---	10 years	---	

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE PLANNING: STATE LEVEL (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	pipelines	Universities	map	---	---	---	---	
	railroads	Universities	map	---	---	---	---	
	airports	Universities	map	---	---	---	---	
	waterways	Universities	map	---	---	---	---	
Land Use	land ownership	County Abstract Records Office	map	---	40m	annual	---	
	land boundaries	County Abstract Records Office	map	---	---	annual	---	
	land plats	County Courts	map	---	---	---	---	
	current land use	Regional Planning Commission	map	1:250,000 and 1:24,000	40m	annual	---	
	housing estimate	Private Air Photo Firms	image	---	---	annual	---	
	urban base	Regional Planning Commission	map	1:9,600	---	5 years	---	
	land use change	---	map	1:250,000 and 1:24,000	40m	annual	---	
	major public open space	---	map	1:24,000	40m	5 years	---	
	lands of special public policy designation	---	map	1:24,000	---	annual	---	
Socio-Economic-Population	density rural/urban	Census	table	---	---	annual	---	
	locational patterns	Census	table	---	---	annual	---	
	number of families /household	Census	table	---	---	10 years	---	
	projections of population	Census	table	---	---	3 years	---	
	percent of families by income level	Census	table	---	---	10 years	---	
	median family income	Census	table	---	---	10 years	---	
	current population estimates	Private Air Photo Firm	image	---	---	annual	---	

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE PLANNING: STATE LEVEL (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	total regional employment by industry	Census	table	---	---	10 years	---	
	men and women in civilian work force	Census	table	---	---	10 years	---	
	economic factors influencing urban development	Regional Planning Commission	table	---	---	annual	---	
	financial resources of urban areas	Regional Planning Commission	table	---	---	annual	---	
	employment trends	Dept. of Labor and Industrial Relations in MO.	table	---	---	annual	---	
	average annual employment	Division of Employment Security	table	---	---	annual	---	
	total employment (by county)	Division of Employment Security	table	---	---	annual	---	
	percent employment (by county)	Division of Employment Security	table	---	---	annual	---	
	total percent unemployment	Division of Employment Security	table	---	---	annual	---	
	starting wage for selected occupations	Division of Employment Security	table	---	---	annual	---	
	estimates of agricultural labor	USDA SRS	table	---	---	annual	---	
	per capita income	Census	table	---	---	10 years	---	
	median earnings for selected occupations	Census	table	---	---	10 years	---	
	sales tax receipts	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	tourist expenditures	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	bank deposits	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	new jobs	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	manufacturing investment	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.

Table A-10:

DATA NEEDS AND CHARACTERISTICS - LAND USE
PLANNING: STATE LEVEL
(continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	square feet of industry	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	industrial products	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	location of industry	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	industrial payroll	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	railroad accessibility to industry	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	labor force characteristics	---	table	---	---	annual	---	Dept. of Consumer Affairs in MO.

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Agriculture	livestock prices	State	table	---	---	annual	---	listing from MO; assumed for other states
	grain prices	State	table	---	---	annual	---	
	market trends	State	table	---	---	annual	---	
	livestock receipts	State	table	---	---	annual	---	
	square feet of glass per green-house	State	table	---	---	once	---	
	degree of crop damage	State	table	---	---	annual	---	
	livestock acreage	USDA SRS	table	---	---	annual	---	
	crop acreage	USDA SRS	table	---	---	annual	---	
	crop location	USDA SRS	table	---	---	annual	---	
	crop production	USDA SRS	table	---	---	annual	---	
	total farms	Census	graph	---	---	annual	---	
Vegetation	type of vegeta-tion cover	USDA USCS	map	1:250,000	40m	5 years	---	
	type of vegeta-tion acreage	USDA USCS	table	1:250,000	---	5 years	---	
	locational pattern of vege-tation cover	USDA USCS	map	1:250,000	40m	5 years	---	
Soils	soil locational patterns	SCS	map	1:24,000	500'-1000'	once	---	
	slope	SCS	map	1:24,000	---	once	---	
	permeability	State	table	---	---	once	---	
	bearing strength	State	table	---	---	once	---	
	shearing strength	State	table	---	---	once	---	
	composition	State	table	---	---	once	---	
	soil type	SCS	table	---	---	once	---	
	soil series name or number	SCS	table	---	---	once	---	
	soil fertility	SCS	table	---	---	once	---	
	physical proper-ties	SCS	table	---	---	once	---	

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	subsurface drainage	State	map	1:250,000	500' or better	once, as needed	---	
	topography	USGS	map	1:500,000	500'	once, as needed	---	10' contours
	local relief	USGS	map	1:24,000	---	once, as needed	---	
	seismic risk zone	E.S.S.A. Coast and Geodetic Survey USGS	map	1:24,000	---	once, as needed	---	
	terrain type	E.S.S.A. Coast and Geodetic Survey USGS	map	1:24,000	---	once, as needed	---	
	geochemical properties	USGS	table	---	---	once, as needed	---	
	rock type	USGS	table	---	---	once, as needed	---	
	geologic units							
	structure of unit	USGS	table	---	---	once, as needed	---	
	orientation of unit	USGS	table	---	---	once, as needed	---	
	depth to bedrock	USGS	table	---	---	once, as needed	---	
	thickness of bedrock	USGS	table	---	---	once, as needed	---	
	geomorphic feature type	USGS	table	---	---	once, as needed	---	
	geomorphic feature orientation	USGS	table	---	---	once, as needed	---	
	geologic history	USGS	table	---	---	once, as needed	---	
	tectonic data	USGS	table	---	---	once, as needed	---	
	areal extent	USGS	table	---	---	once	---	
	age	USGS	table	---	---	once	---	
	correlative units	USGS	table	---	---	once	---	
	topographic cross-section	State	diagram	---	---	once	---	
	foundation depth requirements	State	text	---	---	once	---	
	engineering geology	State	map	1:500,000	---	once	---	

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESOLUTION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	thickness	SCS	table	---	---	once	---	
	erosion	SCS	table	---	---	once	---	
	engineering properties	SCS	table	---	---	once	---	
Forestry	forest cover location	State	map	1:250,000	500'-1000'	once	---	Division of Forestry in MO.
	forest conversion	State	map	1:250,000	---	annual	---	Division of Forestry in MO.
	reforestation	State	map	1:250,000	---	annual	---	Division of Forestry in MO.
	recreational opportunities	State	table	---	---	annual	---	Division of Forestry in MO.
	tree stand size	State	table	---	---	annual	---	Division of Forestry in MO.
	amount of tree harvest	State	table	---	---	annual	---	
	use of tree harvest	State	table	---	---	annual	---	
	timber volume estimates	State	table	---	---	annual	---	
Wildlife	habitat characteristics	State	table	---	---	5 years	---	Division of Wildlife in MO.
	wildlife (existing)	State	table	---	---	annual	---	Division of Wildlife in MO.
Water	intensity of polluting agent	State	table	---	---	6 months	---	
	effects of pollution on aquatic habitat	State	table	---	---	6 months	---	
	aquatic population	State	table	---	---	annual	---	
	impact of recreation type on aquatic habitat	State	table	---	---	annual	---	
	impact of floodplain construction on aquatic habitat	State	table	---	---	annual	---	
	physical alterations of water bodies	State	table	---	---	annual	---	
	surface water	Universities	map	1:24,000	10m	once, or as needed	---	

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (Continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	stream flow	---	table	---	---	monthly	---	
	ground water availability	---	table	---	---	once, or as needed	---	
	floodplain location	U.S. Army Corps of Engineers	map	1:250,000	10'	once, as needed	---	
	floodprone area location	U.S. Army Corps of Engineers	map	1:250,000	10'	once, as needed	---	
	major floods	U.S. Army Corps of Engineers	---	---	---	as needed	---	
	surface water quality	---	---	---	---	annual	---	
	ground water quality	---	---	---	---	annual	---	
	run-off rate	---	---	---	---	annual	---	
	dam location	State	map	1:250,000	40m	once	---	
	dam type	State	table	---	---	annual	---	
	dam condition	State	table	---	---	---	---	
	volume of dam impoundment	State	table	---	---	once	---	
	dam height	State	table	---	---	once	---	
	stream flow characteristics (gaining vs. losing)	Regional Planning Commission, with MO. Geological Survey	map	1:250,000	500-1000	---	---	
	stream discharge	U.S. Army Corps of Engineers	table	---	---	monthly	---	
	ground water level	State	table	---	---	2 years	---	
	ground water flow	State	table	---	---	once	---	
	ground water use	State	table	---	---	2 years	---	
	ground water availability	State	table	---	---	2 years	---	
	recharge area	State	map	---	---	once	---	
	water well location	State	map	1:50,000	500'-1000	5 years	---	
	major streams and water sheds	USGS	map	1:50,000	10'	once	---	
	water shed characteristics	USGS	table	---	---	5 years	---	

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	water-bearing limestone formations	State	map	1:250,000	---	once	---	
	well depths and yields	State	graph	---	---	---	---	
Air Quality	location of point source	State	map	1:24,000	10m	annual	---	
	size of point source	State	table	---	---	annual	---	
	area source	State	map	1:24,000	10m	annual	---	
	ambient air sampling	State	table	---	---	monthly	---	
	gaseous and particulate air pollution	Universities	table	---	---	monthly	---	
	radioactivity	Universities	table	---	---	monthly	---	
	air turbidity	Universities	table	---	---	monthly	---	
Climate/ Meteorology	weather records: temperature wind precipitation inversion probability	---	table	---	---	monthly	---	
	earthquake history	NOAA	---	---	---	---	---	
Solid Waste	sanitary landfill sites	State	map	1:24,000	10'	2 years	---	
	solid waste processing facility sites	State	map	1:24,000	10'	2 years	---	
	solid waste management plans	State	text	---	---	2 years	---	
	solid waste generation data	State	table	---	---	annual	---	
Geology	surface drainage	State	map	1:24,000	10m	2 years	---	
	slope	USGS	map	1:24,000	10m	once, as needed	---	
	generalized geology	State	map	1:250,000	40m	once, as needed	---	
	physiographic regions	State	map	1:250,000	500' or better	once, as needed		

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Minerals Resources	number of wells	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	reservoirs penetrated	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	amount produced	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	recovery cost	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	reserve estimates	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	extent of mining	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	material extracted	Mining, Gas, and Oil Companies	table	---	---	annual	---	
	historical mining	State	table	---	---	once	---	
	types of minerals	State	table	---	---	once	---	
	mineral grade	State	table	---	---	once	---	
	mineral origin	State	table	---	---	once	---	
	estimated reserves	State	table	---	---	annual	---	
	dollar value of minerals	State	table	---	---	annual	---	
	access to market	State	table	---	---	annual	---	
	profitability to mine	State	table	---	---	annual	---	
	overburden thickness	State	table	---	---	annual	---	
	coal and mineral quality	State	table	---	---	once	---	
	strip mine location and inventory	U.S. Council on Environmental Quality	map table	1:24,000	10'	annual	---	
	strip mine acreage	U.S. Council on Environmental Quality	map table	---	---	annual	---	
	mineral resources	State	map	1:500,000	500'-1000	---	---	

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Table A.11

Data Needs and Characteristics - Land Use
Planning: Regional and Local Level
(continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESOLUTION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Energy	inventory of fuel oil consumers	State	table	---	---	annual	---	
	inventory of L.P. gas consumers	State	table	---	---	annual	---	
	inventory of interruptable natural gas consumers	State	table	---	---	annual	---	
	fuel consumption estimates	State	table	---	---	annual	---	
	service station inventory	State	table	---	---	annual	---	
Recreation	historic sites	State	map	1:24,000	10m	once	---	
	prehistoric sites	State	map	1;24,000	10m	once	---	
	size of parks	State	table	---	---	as needed	---	
	length of trails	State	table	---	---	as needed	---	
	location of existing parks	State	map	1:24,000	10m	as needed	---	
	location of potential parks	State	map	---	---	as needed	---	
	location of natural and scenic areas	State	map	1:24,000	10m	as needed	---	
	camping permits sold	State	table	---	---	annual	---	
	inventory of public and private recreational facilities	State	table	---	---	as needed	---	
	recreation demand estimates	State	table	---	---	annual	---	
	inventory of natural areas	State	map	---	---	as needed	---	Division of Fisheries in MO.
	water-related recreational activities	State	table	---	---	annual	---	Division of Fisheries in Mo.
	travel times to state forests	State	table	---	---	once	---	Division of Fisheries in Mo.
	recreational activity spectrum in state forests	State	table	---	---	annual	---	Division of Fisheries in MO.

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESOLUTION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	state park attendance	State	table	---	---	annual	---	
Transportation	road inventory	State	map	---	---	once, or as needed	---	
	traffic data	State	tabular	---	---	annual	---	
	general county and city road locations	State	map	---	---	as needed	---	
	highways	Universities	map	---	---	---	---	
	motor freights	Universities	map	---	---	---	---	
	pipelines	Universities	map	---	---	---	---	
	railroads	Universities	map	---	---	---	---	
	airports	Universities and local airports	map	---	---	---	---	
	waterways	Universities	map	---	---	---	---	
	address range	---	---	---	---	---	---	
	registered aircraft	State	table	---	---	---	---	
	travel distance to work	survey	table	---	---	as needed	---	
Land Use	land ownership	County Abstract Records Offices	map	1:24,000	---	annual	---	on parcel basis in urban areas
	land boundaries	County Abstract Records Offices	map	1:24,000	---	as needed	---	
	land plats	County Courts	map	---	---	as needed	---	
	current land use	Private Air Photo Firms	image	1:24,000 1:9600 in urban areas	---	annual	---	levels I, II, III, and IV in urban areas
	housing estimate	Private Air Photo Firms	image	---	---	once, as needed	---	
	urban base	Regional Planning Commissions	map	1:9,600	---	annual	---	
	condition of structures	Field survey	---	---	---	---	---	
	undeveloped land	County Planning Dept.	graph	---	---	annual	---	

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UDPATE	TIME CONSTRAINT	COMMENTS
	existing sidewalks and curbs	lot-by-lot field survey	map	1:2,400	10'	annual	---	
	neighborhood boundaries	County Planning Dept.	map	1:4,800	1/2 A.	annual	---	
Land Survey Data	original government survey documents	State	map	---	---	---	---	
	county survey or land documents	State	map	---	---	---	---	
	land subdivision plats	State	map	---	---	---	---	
	private land surveys	State	map	---	---	---	---	
	state boundary surveys	State	map	---	---	---	---	
Population	population characteristics	Census	table	---	---	10 years	---	
	percent renter occupied units as proportion of total stock	Census	table	---	---	10 years	---	
	school age population	Supt. of Public Schools	table	---	---	annual	---	
	public school enrollment	Supt. of Public Schools	table	---	---	annual	---	
	average household size	Census	graph	---	---	10 years	---	
	density rural/urban	Census	table	---	---	10 years	---	
	locational patterns	Census	table	---	---	10 years	---	
	number families/household	Census	table	---	---	10 years	---	
	projections and trends	Census	table	---	---	10 years	---	
	percent of families by income level	Census	table	---	---	10 years	---	
	median family income	Census	table	---	---	10 years	---	
	current population estimates	Private Air Photo Firms	image	---	---	2 years	---	

Table A.11

Data Needs and Characteristics - Land Use
Planning: Regional and Local Level
(continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	net migration	Census	table	---	---	10 years	---	
	place of work	Census	table	---	---	10 years	---	
	census tracts with population loss	Census	map	---	---	10 years	---	
Services	public drinking water	State	table	---	---	annual	---	
	areas supplied	State	table	---	---	annual	---	
	population served	State	table	---	---	annual	---	
	type of ownership	State	table	---	---	annual	---	
	number of services	State	table	---	---	annual	---	
	source of supply	State	table	---	---	as needed	---	
	treatment capacity	State	table	---	---	as needed	---	
	average water consumption	State	table	---	---	as needed	---	
	treatment process used	State	table	---	---	as needed	---	
	finished water storage	State	table	---	---	as needed	---	
	chemical quality	State	table	---	---	as needed	---	
	bacteriological quality	State	table	---	---	as needed	---	
	urban services	Census and local jurisdictions	table	---	---	10 years	---	
	regional services	Census and local jurisdictions	table	---	---	10 years	---	
	public sewage services	Local treatment companies	table	---	---	as needed	---	
	drinking water availability	U.S. Army Corps of Engineers	table	---	---	as needed	---	
	emergency medical service	Regional Planning Commissions	table	---	---	as needed	---	
	natural gas services	State	table	---	---	as needed	---	

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	electric services	State	table	---	---	as needed	---	
	motor carrier routes	State	table	---	---	as needed	---	
	barge lines	State	table	---	---	as needed	---	
	normal truck delivery	State	table	---	---	as needed	---	
	railroads	State	table	---	---	as needed	---	
	college and vocational technical educational facilities	State	map	1:250,000	---	5 years	---	
	percent dwelling without plumbing facilities or overcrowded	Census	graph	---	---	10 years	---	
	school system bonded indebtness	County School Reports	graph	---	---	annual	---	
	total school system operating expenses	Supt. County Schools	graph	---	---	annual	---	
	total school districts	County Government	table	---	---	annual	---	
	existing storm water sewers	Local sewer district	map	1:4,800	1/4 acre	annual	---	
	higher education opportunities per capita	County Planning Dept.	graph	---	---	annual	---	
	county library volumes per capita	County Library Annual Report	graph	---	---	annual	---	
	police officers per 1,000 population	County Police	graph	---	---	annual	---	
	major fires	County Fire Marshall	table	---	---	annual	---	
Socio-Economic-General	major crimes	County Police	graph	---	---	annual	---	
	autos registered	County Government	graph	---	---	annual	---	
	building permits	County Public Works Dept.	graph	---	---	annual	---	

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENT
	total local government expenditures	County Government and Census of Government	graph	---	---	annual (Census-10 years)	---	
	county government operating expenses	County Government	graph	---	---	annual	---	
	bonded indebtness	County Government	graph	---	---	annual	---	
	number of welfare recipients	Dept. of Social Services in MO.	table	---	---	annual	---	
	number of welfare payments	Dept. of Social Services in Mo.	table	---	---	annual	---	
	poverty guidelines	HEW Economic Development Administration	---	---	---	---	---	
	percent elderly families below poverty level	Census	table	---	---	10 years	---	
	percent low rent housing units and low valued owner occupied units	Census	graph	---	---	10 years	---	
	value of land	Census	table	---	---	10 years	---	
	value of buildings	Census	table	---	---	10 years	---	
	value of machinery	Census	table	---	---	10 years	---	
	value of equipment	Census	table	---	---	10 years	---	
	earnings by industrial sector	Census	table	---	---	10 years	---	
	hourly wage rates	Census	table	---	---	10 years	---	
	gross regional product	Census	table	---	---	10 years	---	
	gross county product	Census	table	---	---	10 years	---	
	housing values	Census	table	---	---	10 years	---	
	subsidized housing	Census	table	---	---	10 years	---	

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	new construction	Field survey/ building permits issued by local government	table	---	---	monthly	---	
	total regional employment by occupation	Census	table	---	---	10 years	---	
	total regional employment by industry	Census	table	---	---	10 years	---	
	men and women in civilian work force	Census	table	---	---	10 years	---	
	economic factors influencing urban development	Regional Planning Commissions	table	---	---	annual	---	
	financial resources of urban areas	Regional Planning Commissions	table	---	---	annual	---	
	employment trends	State	graph	---	---	annual	---	
	family income by type	Census	table	---	---	10 years	---	
	non-agricultural employment	Bureau of Labor Statistics	graph	---	---	monthly	---	
	employment trends	State	table	---	---	monthly	---	
	average annual employment	State	table	---	---	annual	---	
	total employment (by county)	State	table	---	---	annual	---	
	percent employment (by county)	State	table	---	---	annual	---	
	total percent unemployment	State	table	---	---	annual	---	
	starting wage for selected occupations	State	table	---	---	annual	---	
	estimates of agricultural labor	USDA SRS	---	---	---	10 years	---	
	per capita income	Census	---	---	---	10 years	---	
	median earnings for selected occupations	Census	---	---	---	10 years	---	

Table A.11

Data Needs and Characteristics - Land Use Planning: Regional and Local Level (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	sales tax receipts	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	tourist expenditures	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	bank deposits	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	new jobs	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	manufacturing investment	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	square feet of industry	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	industrial products	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	location of industry	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	industrial payroll	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	railroad accessibility to industry	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	labor force characteristics	State	table	---	---	annual	---	Dept. of Consumer Affairs in MO.
	employment growth	Bureau of Labor Statistics & Census	graph	---	---	5-10 years	---	
	manufacturing data	State	table	---	---	annual	---	
	firm identification : address spokesman products employment location	State	table	---	---	annual	---	
	wholesale trade	Census	table	---	---	10 years	---	
	retail trade	Census	table	---	---	10 years	---	
	economic activity centers	Regional Planning Commission	map	1:500,000	---	2 years	---	
	land boundaries	Local community government	maps or CCT's	1:2,400	10'	as needed	---	
	zoning	Local community government	maps or CCT's	1:2,400	10'	as needed	---	

Table A.11

Data Needs and Characteristics - Land Use
Planning: Regional and Local Level
(continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESOLUTION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	political subdivisions	Local community government	maps or CCT's	---	---	as needed	---	
	school districts	Local community government	maps or CCT's	---	---	as needed	---	
	fire districts	Local community government	maps or CCT's	---	---	as needed	---	
	comprehensive plan	Local community government	maps or CCT's	---	---	as needed	---	
	incorporated cities	Census	table	---	---	10 years	---	
	unincorporated areas	Census	table	---	---	10 years	---	
	proposed rezoning	Petitioner, his architect and lawyer	text	1:2,400	---	with each new proposal (approximately 200 each year per agency)	---	

A.10 TRANSPORTATION

The data needs of transportation agencies at the state level are shown in Table A-12, based principally on analyses of needs in Illinois and Missouri. A limited amount of information was available for Iowa, Minnesota, and Wisconsin. For Wisconsin, we used the report of Miller and Nieman (A-4) as a basis. The data needs are organied according to data type rather than by task.

Data are required for the broad functions of modal selection; corridor and route location; and design, construction, and maintenance of facilities such as highways and airports. The National Environmental Policy Act and the concept of integrated, inter-modal transportation planning have combined to expand greatly the range of data needs of transportation agencies, including highway departments. These new needs make up a large number of the items which appear in this table.

Table A.12 Data Needs and Characteristics Transportation

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Transportation Activities	automobile trips origin/destination		tapes, files, maps, tables		county or township	5-10 years		
	traffic forecasts		tapes, files, maps, tables			5-10 years		
	vehicle weight/ passenger	U.S. Urbanized Area Transportation Census Studies and State Depts. of Transportation	tapes, files, maps, tables			annual		
	truck weights	"	tapes, files, maps, tables			bi-annual		
	commodities hauled	"	tapes, files, maps, tables			5 years		
	county highway maps	aerial photo	maps	1:63340		annual		
	location of waterways	consultants	maps	1:633400		annual		
	city maps	field inspection	maps	1:9600 1:14400		annual		
	utilities	consultants	maps	1:633440		annual		
	pipelines	consultants	maps			annual		
	electrical transmission lines	consultants	maps			annual		
	barge lines	consultants	maps			annual		
	motor carrier routes	consultants	maps			annual		
	airports	consultants	maps			annual		
	number of aircraft and location base		maps and tapes, tables			annual		
	highway jurisdiction	regional offices	magnetic tapes			annual		
	pavement width	regional offices	magnetic tapes			annual		
	roadside features	regional offices	magnetic tapes			annual		
	surface conditions	regional offices	magnetic tapes					
	bridge conditions	regional offices	magnetic tapes					

Table A.12 Data Needs and Characteristics Transportation
(continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	accidents	regional offices	magnetic tapes					
	production and transportation of hazardous substances near water supply	State Water Survey						
Highway Design Information	aerial imagery for highway location	in-house air-photo prints	9"x9" prints			by projects		
	aerial imagery for highway design	in-house air-photo facilities	9"x9" prints			by projects		
	topographic maps derived from aerial imagery	aerial photos	maps	urban areas 1:600 rural areas 1:1200		by projects		
	microfilm records of structure design					by projects		
Political Subdivision and Land Survey Data	fire districts	Districts	maps		township or census tract	1-2 years		
	comprehensive plan	Plan Commission	maps			1-2 years		
	zoning	---	---			1-2 years		
	school districts	Districts	maps			1-2 years		
	original government survey documents							
	land subdivision plans							
	benchmark locations							
	triangulation and transit station locations							
	state coordinate system location	maps	cards/ tape		1 foot	not applicable		
Geologic Information	mineral resource maps	USGS	maps	1:24,000				
	mineral grade							
	historical mining	USGS	maps	1:24000				
	earthquake history							
	seismic risk zones							
	stratigraphic relations	USGS State GS						
	geological maps	USGS	maps	1:24000		not applicable		
	local relief							

Table A.12 Data Needs and Characteristics Transportation (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	topographic cross-section							
	slopes							
Soils	type	Bureau of Soils, USDA	maps	1:62500		not applicable		
	series name or #	Bureau of Soils, USDA	maps	1:62500		not applicable		
	fertility	Bureau of Soils, USDA	maps	1:62500		not applicable		
	location	Bureau of Soils, USDA	maps	1:62500		not applicable		
	physical properties	Bureau of Soils USDA	maps	1:62500		not applicable		
	soil moisture	State Water Survey						
Environmental Quality	observed air quality measures of CO, HC, and NO_x for all transportation facilities	U.S. EPA and DOT	maps and tables	1:9600		annual		
	point sources of air pollution	U.S. EPA and DOT	maps and tables	1:9600		annual		
	area sources of air pollution	State EPA and DOT	maps and tables	1:9600		annual		
	highways	State EPA and DOT	maps and tables	1:9600		annual		
	airports	State EPA and DOT	maps and tables	1:9600		annual		
	forests							
	sanitary landfill sites							
	demolition landfill sites							
	strip mine location	State Geological Survey	maps	1:9600		annual		
	water run-off quality	State Water Survey						
	flood plain location	State Water Survey	maps	1:24000				
	flood prone area location	State Water Survey	maps	1:24000				
	flood plain area	State Water Survey	maps	1:24000				
	weather records	Weather Bureau						

Table A.12 Data Needs and Characteristics Transportation
(continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
Water Resources	dam location/ condition	State Water Survey						
	location of lakes streams and rivers	State Water Survey						
	stream discharge	State Water Survey						
	ground water use	State Water Survey						
Recreation, Parks, and Conservation	boundary description of parks	State Park Service	maps	1:9600				
	attendance at parks	State Park Service	tables			annual		
	potential park sites	State Park Service	maps	1:9600		1-2 years		
	natural and scenic areas	State Park Service	maps	1:9600		1-2 years		
	historic and archaeological sites	Natural History Survey	maps and tables	1:9600		1-2 years		
	recreation areas: ownership and jurisdiction	Regional Planning or Park Service	maps	1:10500				
	major uses (camping, hiking, etc)	Regional Planning or Park Service	maps	1:10500				
	vegetation location		maps and tables	1:15840				
	protected plants		maps and tables					
	wildlife species, location, and population	environmental inventory	maps and tables					
	rare and endangered species	environmental inventory	maps and tables					
Commercial Activity	retail trade	Regional Planning Agencies, cities, others	maps		township or census tract	1-2 years		
	wholesale trade	Regional Planning Agencies, cities, others	maps			1-2 years		
	value of land	Regional Planning Agencies, cities, others	maps			1-2 years		
	value of buildings	Regional Planning Agencies, cities, others	maps			1-2 years		

Table A.12 Data Needs and Characteristics Transportation (continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESO-LU-TION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	location of energy facilities	Public utilities State Public Service Commission	maps photos		township or census tract	1-2 years		
	crop production	State Dept. of Agriculture USDA	maps			1-2 years		
	livestock	environmental inventory	maps and tables					
	recreational activities	State Dept. of Conservation	maps			1-2 years		
	commercial services	---	---			1-2 years		
	sales tax receipts		tables			one year or less		
	new jobs		tables			one year or less		
	investment		tables			one year or less		
	sq. feet		tables			one year or less		
	products		tables			one year or less		
	location		tables			one year or less		
	payroll		tables			one year or less		
	location of public service facilities	Regional Planning Agencies, cities, others	maps photos			1-2 years		
Industrial Facilities	specifications	Commerce or Industrial Development Commission	maps, tables					
	available financing	Commerce or Industrial Development Commission	maps, tables					
	utilities	Commerce or Industrial Development Commission	maps, tables					
	land	Commerce or Industrial Development Commission	maps, tables					
	special features	Commerce or Industrial Development Commission	maps, tables					

Table A.12 Data Needs and Characteristics Transportation
(Continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESOLUTION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	transportation alternatives	Commerce or Industrial Development Commission	maps, tables					
	acreage of industrial sites	State Commerce and Industrial Development Commission	files					
	utilities on industrial sites	Public Service Commission or Utility Companies	files					
	railroad accessibility	companies						
	zoning	local authorities	maps					
Labor Force	age	State Dept. of Labor	tables			one year or less		
	sex	State Dept. of Labor	tables			one year or less		
	skills	State Dept. of Labor	tables			one year or less		
	% unemployment	State Dept. of Labor	tables			one year or less		
Population	location	census tapes, regional agencies	magnetic tapes, tables		township or census tract	1 year or less		
	place of employment	census tapes, regional agencies	magnetic tapes, tables			1 year or less		
	projections	census tapes, regional agencies	magnetic tapes, tables			1 year or less		
	number families per household	census tapes, regional agencies	magnetic tapes, tables			1 year or less		
	dwelling type	census tapes, regional agencies	magnetic tapes, tables			1 year or less		
	income levels	census tapes, regional agencies	magnetic tapes, tables			1 year or less		
	number welfare recipients	census tapes, regional agencies	magnetic tapes, tables			1 year or less		
	percentage of families by income level	census tapes, regional agencies	magnetic tapes, tables			1 year or less		

Table A.12 Data Needs and Characteristics Transportation (Continued)

DATA TYPE	DATA NEED	CURRENT SOURCE	FORMAT	SCALE	RESOLUTION	FREQUENCY OF UPDATE	TIME CONSTRAINT	COMMENTS
	median family income	census tapes, regional agencies	magnetic tape, tables		township or census tract	1 year or less		
	density	census tapes, regional agencies	magnetic tape, tables		township or census tract	1 year or less		
	ethnic and religious distribution		magnetic tape, tables		township or census tract			not fully available
	location of illiterate persons		magnetic tape, tables		township or census tract			not fully available
	location of non-drivers		magnetic tape, tables		township or census tract			not fully available
	location of handicapped persons		magnetic tape, tables		township or census tract			not fully available

A.11 WATER RESOURCES

Terms needing explanation are:

1. Rate of Recharge - the rate at which a water source is being resupplied.

2. Demand Schedule - the times of demand and amounts of water needed from a reservoir.

3. Constrictive Works - the types of structures which constrain water in a stream to flow in a well-defined channel.

4. Hydraulic Head - Pressure of water upon a unit area due to the height at which the surface of the water stands above the point where the pressure is measured.

4. Piezometric Surface - an imaginary surface that everywhere coincides with the static level of water in an aquifer.

5. Structure of Aquifer - the physical orientation and shape of a water-bearing rock unit.

Table A-13: Data Needs in Water Resources by Task and Data Characteristics

Subtasks and Characteristics / Data Items	DAM TYPE	SURFACE DRAINAGE	WATERSHEDS FEEDING WATER BODIES	SLOPE	LAND COVER/USE VEGETATION COVER	TURBIDITY	WATER QUALITY	RATE OF RECHARGE	DEMAND SCHEDULE
Public Inquiries on Ground Water									
Water Resource Studies									
Aquifer Water Yield Information									
Inventory Surface Water Bodies	X	X	X	X	X				
Surface Water Resource Studies		X	X	X	X	X	X	X	X
Flood Plain Management Studies					X				
Logging of Observation Well Network									
Current Source	in-house on site investigation	USGS	USGS	USGS	USGS, SCS ASCS, NASA USFS, in-house	in-house on site investigation	in-house on site investigation	in-house on site measurement	in-house and measurement
Format	aerial photos text	topographic map	topographic map	topographic and slope maps	aerial and spacecraft imager land cover maps	text aerial photos	text	text	text
Scale	1:24,000 or larger	1:24,000	1:24,000	1:24,000	1:24,000 1:250,000	1:24,000	---	---	---
Resolution	2m or less	2m	2m	2m - 10m on slope zones	2m - 80m	< 2m	---	---	---
Frequency of Update	5 - 10 yrs	20 years	20 years	20 years	annual - 10 years	daily if needed	daily if needed	daily if needed	daily if needed
Time Constraint	6-8 weeks	6-8 weeks	6-8 weeks	6-8 weeks	12-16 weeks	< 24 hrs.	< 24 hrs.	< 24 hrs.	< 24 hrs.
Comments	---	---	---	---	---	---	---	---	---

Table A-13: Data Needs in Water Resources by Task and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	LOCATION AND EXTENT OF FLOOD PLAIN	EXTENT OF FLOODING	MAXIMUM FLOODING	MAXIMUM AND MINIMUM FLOODING	DURATION OF FLOODING	FLOOD DAMAGE	CONSTRICTIVE WORKS PRESENT
Public Inquiries on Ground Water							
Water Resource Studies							
Aquifer Water Yield Information							
Inventory Surface Water Bodies							
Surface Water Resource Studies							
Flood Plain Management Studies	X	X	X	X	X	X	X
Logging of Observation Well Network							
Current Source	USGS, ASCS, SCS in-house	USGS NASA in-house	USGS in-house	USGS Corps of Engineers	USGS in-house	USGS in-house Dept. of Commerce	Corps of Engineers USGS
Format	aerial and satellite imagery topographic maps	aerial and satellite imagery topographic maps	text aerial imagery	flood and stream flow data	text aerial imagery	text	topographic maps and civil works maps
Scale	1:24,000 1:125,000 1:250,000 1:1,000,000	1:24,000 1:125,000 1:250,000 1:1,000,000	1:2,000	---	---	---	1;24,000
Resolution	A/C 2-10m S/C 80m	A/C 2-10m S/C 80m	A/C < 1m	---	---	---	2m
Frequency of Update	as needed	as needed	daily	several times daily	daily	daily	5-10 yrs.
Time Constraint	48 hours	48 hours	< 6 hrs	< 6 hours	< 24 hrs.	< 24 hrs	6 weeks
Comments	---	---	---	---	---	---	---

Table A-13: Data Needs in Water Resources by Task and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	PHYSICAL PROPERTIES OF AQUIFERS	AQUIFER ROCK TYPE	GEOLOGIC UNITS PRESENT	CHEMICAL PROPERTIES OF WATER	POLLUTANTS IN WATER	LOCATION AND AREAL EXTENT OF WATER BODIES	TYPE OF WATER BODY	DEPTH AND VOLUME OF WATER BODY	CONDITION OF DAM AND IMPOUNDMENT
Public Inquiries on Ground Water	X	X	X	X	X				
Water Resource Studies	X	X	X	X	X				
Aquifer Water Yield Information	X	X	X	X	X				
Inventory Surface Water Bodies						X	X	X	X
Surface Water Resource Studies						X	X	X	
Flood Plain Management Studies									
Logging Observation Well Network			X		X				
Current Source	(rock sample) in-house	(Well logs) in-house	in-house	in-house laboratory analyses	in-house laboratory analyses	USGS, SDS, ASCS, NASA in-house	USGS, ASCS, SCS, NASA in-house	USGS ASCS, SCS in-house	USGS ASCS, SCS in-house
Format	text	text well logs	text well logs geologic map	tabular summaries text	tabular summaries text	aerial and satellite photos topographic maps	aerial and satellite imagery	aerial imagery	aerial imagery
Scale	---	---	1:24,000	---	---	1:24,000 1:125,000 1:250,000 1:1,000,000	1:24,000 1:125,000 1:250,000 1:1,000,000	1:24,000 or more	1:24,000
Resolution	---	---	---	---	---	A/C - 2m - 10m S/C 80m	A/C - 2m - 10m S/C 80m	A/C - 2m	A/C 2m
Frequency of Update	once only	once only	20 years	on demand	on demand	5-10 yrs.	once only	annual	annual
Time Constraints	6 weeks	6 weeks	6 weeks	1 week	1 week	6-8 weeks	2-8 weeks	1 week	1 week
Comments								inference and interpretation required	

Table A-13: Data Needs in Water Resources by Task and Data Characteristics (continued)

Subtasks and Characteristics / Data Items	WATER LEVEL	FLOW RATE (DISCHARGE)	HYDRAULIC HEAD	DRAW DOWN RATE	PIEZOMETRIC SURFACE	ROCK POROSITY	ROCK PERMEABILITY	STRUCTURE OF AQUIFER	DEPTH OF AQUIFER
Public Inquiries on Ground Water	X	X	X	X	X	X	X	X	X
Water Resource Studies	X	X	X	X	X	X	X	X	X
Aquifer Water Yield Information	X	X	X	X	X	X	X	X	X
Inventory Surface Water Bodies									
Surface Water Resource Studies		X							
Flood Plain Management Studies									
Logging Observation Well Network	X	X		X	X			X	
Current Source	observation well data	observation well data	observation well data	observation well data	observation well data	rock sample analysis	rock sample analysis	USGS state GS well log data	well logs
Scale	---	---	---	---	---	---	---	1:24,000	---
Resolution	---	---	---	---	---	---	---	2m on base 10m on geologic data	---
Frequency of Update	variable annual or semiannual	variable annual or semiannual	variable annual or semiannual	variable annual or semiannual	variable annual or semiannual	on demand	on deamdn	20 years	once only
Time Constraint	6 weeks	6 weeks	6 weeks	6 weeks	6 weeks	6 weeks	6 weeks	archive	archive
Comments	---	---	---	---	---	---	---	---	---

A.12 WILDLIFE

Data items in Table A.14 are self-explanatory.

Table A-14: Data Needs in Wildlife by Task and Data Characteristics

Data Items / Subtasks and Characteristics	LOCATION	ACREAGE	COVER TYPE IDENTIFICATION	SPECIES IDENTIFICATION	POPULATION SIZE	SEX	HABITAT CONDITION	WILDLIFE CONDITION
Wildlife Habitat Assessment	X	X	X				X	
Wildlife Habitat Inventory	X	X	X					
Wildlife Inventory	X			X	X	X		X
Monitor Cover Type Conversion	X	X	X					
Determine and Monitor Effects of Toxic Substances on Wildlife	X			X				X
Current Source	in-house	in-house	in-house	in-house	in-house	in-house	in-house	in-house
Format	map	map	map	text	table	text	text; map	text
Scale	1:24,000	1:24,000	1:125,000	---	---	---	1:24,000	---
Resolution	---	---	---	---	---	---	---	---
Frequency of Update	annual	annual	annual	annual	annual	annual	annual	on demand
Time Constraint	1 week	1 week	1 week	6 weeks	6 weeks	6 weeks	1 week	1 week
Comments	scale may vary	scale may vary	scale may vary				scale may vary	

A.13 DATA NEEDS JUDGED TO BE NOT FEASIBLE OR NOT PLAUSIBLE FOR PRODUCTION BY REMOTE SENSING

In Section 3.2 we discuss a procedure by which the data needs listed in this Appendix were screened with respect to the feasiblity and plausibility of their production using remote sensing technology. Table A-15 is a list of those data items which can not be produced by any of the six remote sensing technologies; i.e., they are not feasible for technical reasons. Table A-16 is a list of those data items which were judged to be not plausible for production by remote sensing, for the reasons indicated in Section 3.2.

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Table A-15:

DATA ITEMS WHICH ARE NOT FEASIBLE FOR PRODUCTION BY ANY OF THE SIX REMOTE SENSING SYSTEMS

SOCIO-ECONOMIC DATA

LANDS OF SPECIAL PUBLIC POLICY DESIGNATION
URBAN SERVICES - POLICE, FIRE, MEDICAL, ETC
ZONING
VALUE OF LAND AND BUILDINGS
UTILITY FACILITIES
SALES TAX RECEIPTS
TRAFFIC ORIGIN/DESTINATION DATA
COMMODITIES TRANSPORTED
ACCIDENTS
BRIDGE CONDITION
HAZARDOUS MATERIALS PRODUCTION SITES
UTILITY SERVICES
SCHOOL SYSTEM DATA
CRIME DATA
GOVERNMENT EXPENDITURES
AUTO REGISTRATIONS
COMMERCIAL ACTIVITY, BANK DEPOSITS, ETC.
FIRM LOCATION, ADDRESS, OWNERSHIP, ETC.
LAND SURVEYS - PRIVATE, PUBLIC, HISTORICAL
LAND OWNERSHIP OR OWNERSHIP CLASS
FACILITY OWNERSHIP
EMPLOYMENT BY INDUSTRY, AGE, SEX, RACE, OCCUPATION
PARK OWNERSHIP
PARK FACILITIES AVAILABLE
MINE OWNERSHIP
MINERAL PRODUCTION BY TYPE, LOCATION, YEAR
MINERAL RESERVES BY TYPE, LOCATION, DEPTH, VALUE INCLUDING COAL, METALS, ETC.
ECONOMIC VALUE OF DAMAGE BY NATURAL CAUSES
POLLUTION CONTROL COSTS
CONSTRUCTION COST ESTIMATES
MINERAL LEASE OWNERSHIP
FLOOD PLAIN CONSTRUCTION
INVENTORY OF MAJOR ENERGY CONSUMERS BY FUEL AND INDUSTRY
TRAFFIC VOLUME
A WIDE VARIETY OF CENSUS OF POPULATION AND INDUSTRY DATA
LIVESTOCK AND GRAIN PRICES
FIRE PROTECTION DISTRICTS
SCHOOL DISTRICTS
SUBDIVISION PLANS
PARK BOUNDARIES
NEIGHBORHOOD BOUNDARIES
CITIES, TOWNS, UNINCORPORATED AREA BOUNDARIES

DATA REQUIRING CHEMICAL OR MINERAL IDENTIFICATION OR OTHER LABORATORY ANALYSES

SOIL SERIES NAME OR NUMBER, POROSITY, BULK DENSITY, TEXTURE PROFILE, STRUCTURE PROFILE, CONSISTENCE PROFILE, DEPTH TO WATER, A-HORIZON THICKNESS, DEPTH TO BEDROCK, DEPTH TO SUBSOIL, MACRO- AND MICRO NUTRIENT STATUS, ORGANIC MATTER, CATION CAPACITY, pH, SALT CONTENT, SUBSOIL COLOR, BEARING STRENGTH, ENGINEERING PROPERTIES, PRODUCTIVITY RATINGS
RUNOFF WATER QUALITY
TRACE ELEMENTS IN WATER, SOILS, MINERALS
X-RAY DIFFRACTION IN MINERALS
AIR AND WATER EFFLUENTS INVENTORY, COMPOSITION, FLOW RATE
AIR QUALITY PARAMETERS

GENERAL DATA

CROP GROWING SEASON
CROP MATURITY
CROP ONTOGENY
LIVESTOCK AND WILDLIFE POPULATION, AGE, SEX, SPECIES, CONDITION
TREE STAND SIZE (DIAMETER AT BREAST HEIGHT)
FOREST SITE INDEX
FOREST SITE PREPARATION NEEDS
FOREST SUCCESSIONAL STAGES
SEED SOURCES
NUMBER OF SEEDLINGS PLANTED, USES
FOREST REGENERATION POTENTIAL
USE OF TREES
RECREATIONAL ACTIVITY SPECTRUM
RECREATIONAL USE INTENSITY, VISITORS PER YEAR
FOREST FUEL BUILD-UP
WIND DIRECTION AND SPEED
HUMIDITY
LOCATION OF FIRE FIGHTERS
CAUSES AND TIMES OF FOREST FIRES
FISH SIZE, SPECIES, CONDITION, POPULATION, SEX
TRAIL LENGTH
SUBSURFACE GEOLOGY, STRATIGRAPHY, UNITS
GROUND WATER VOLUME, QUALITY, SOURCE, FLOW, DEPTH
AQUIFER TYPE AND STRUCTURE
GROUND WATER EXTRACTION RATE, DEMAND SCHEDULE, USE
ROCK COLOR, POROSITY, PERMEABILITY
PIEZOMETRIC SURFACE

Table A-15:

DATA ITEMS WHICH ARE NOT FEASIBLE FOR PRODUCTION BY ANY OF THE SIX REMOTE SENSING SYSTEMS (CONTINUED)

GENERAL DATA (CONTINUED)

PHREATIC WATER SURFACE
ROCK TYPE, MINERAL IDENTIFICATION
FORMATION THICKNESS, COMPOSITION, TEXTURE, FOSSIL CONTENT, AGE, CORRELATIVE UNIT, GEOLOGIC HISTORY
SOIL THICKNESS
WATER BODY MIXING PATTERNS
HEALTH IMPACT OF WATER AND AIR POLLUTION
BEDROCK STRUCTURE, ORIENTATION, DEPTH
TECTONIC STABILITY, EARTHQUAKE HISTORY, SEISMIC RECORDS
ORIGIN OF MINERAL ORES
SURFACE WATER AVAILABILITY
STREAM DISCHARGE RATE
WATER WELL LOCATION, DEPTH, WATER ANALYSIS
WATER BEARING LIMESTONE FORMATIONS
TOPOGRAPHIC CROSS SECTION
WINTER FISH KILL
DEPTH TO WATER TABLE
WEATHER RECORDS
ATMOSPHERIC INVERSION PROBABILITY
LAND CAPABILITY
SOLID WASTE GENERATION RATE
PRE-CAMBRIAN ROCK SURFACE, BEDROCK GEOLOGY AND SURFACE CONTOUR
BENCHMARK LOCATION
PROTECTED PLANTS
ENDANGERED SPECIES LOCATION AND POPULATION
ROADWAY CONDITION
PUBLIC WATER SUPPLY - SOURCE, QUALITY, OWNERSHIP, SERVICES, AREA SERVED, TREATMENT CAPACITY, PROCESS USED
SEWAGE FACILITIES

Table A-16:

DATA ITEMS WHICH ARE FEASIBLE BUT NOT PLAUSIBLE FOR PRODUCTION BY REMOTE SENSING

LIVESTOCK POPULATION ESTIMATES
FOREST STAND DATA FOR DETERMINATION OF NEED FOR STAND IMPROVEMENT
FOREST STAND DATA FOR DETERMINATION OF FOREST FIRE POTENTIAL
AREA OF BARRIERS TO FISH MOVEMENT
WILDLIFE SPECIES INVENTORY
DISTANCE FROM PARKS TO POPULATION CENTERS
PARK LOCATION, AREA, FACILITIES AVAILABLE, ROAD WIDTH
AIR AND WATER POLLUTION POINT SOURCE LOCATION AND COMPOSITION
STREET AND HIGHWAY LOCATION FOR AREAL AIR POLLUTION SOURCE DETERMINATION
URBAN PARTICULATE AIR POLLUTION MONITORING
METEOROLOGICAL PARAMETERS FOR AIR POLLUTION MANAGEMENT
GEOLOGIC FEATURE SIZE
MINING METHOD
DISTANCE BETWEEN MARKET AND POTENTIAL COAL GASIFICATION SITE
DAM HEIGHT
PHYSIOGRAPHIC REGIONS
GEOMORPHIC FEATURE TYPE
LOCATION AND ACCESSIBILITY OF RAILROADS
LOCATION OF AIRPORTS AND WATERWAYS
NUMBER OF AIRCRAFT
POTENTIAL RESERVOIR SITES
WILD RIVERS
GROUND WATER DISCHARGE AND RECHARGE REGIONS
LAKE LEVEL FLUCTUATION
SURFACE WATER QUALITY
SOLID WASTE PROCESSING FACILITY SITE LOCATION
WATER RELATED RECREATIONAL ACTIVITIES
CAMPING AREAS
INVENTORY OF PUBLIC AND PRIVATE RECREATIONAL FACILITIES
ANNUAL ENERGY PRODUCTION AS BIOMASS
ANNUAL BIOMASS PRODUCTION

APPENDIX B: OBSERVED COSTS, PERFORMANCE, AND PRODUCTION METHODS OF SYSTEMS PRODUCING THE PRIORITY PRODUCTS

B.1 PRODUCTION COSTS

This appendix lays out and evaluates two alternative production schemes for each of seven of the twenty-eight priority products described in Chapter Three: timber volume estimate tables, Level II land use/land cover maps, soil maps, vegatative cover type maps, surface-mined land maps, topographic maps, and slope maps. Discussion of each product begins with a list of the characteristics of the products repeated from Table B.1. Product production steps are next listed and described, first for an operational or traditional method based on manual interpretation of aircraft data and then for an alternative scheme employing digital processing and satellite data. Next a detailed comparison of costs and performance (timeliness, accuracy) of the two product production systems appear. When possible, a review of both production and capital costs for each system is included. Production costs may include charges for personnel time, supplies, remote sensing data, aerial photos, computer processing, and printing costs. Capital costs include equipment, software development and facility costs.

B.2 TIMBER VOLUME ESTIMATE TABLE

Many types of information are collected in the process of performing a forest inventory. A timber volume estimate is produced in tabular form every 5-10 years for all the forested regions of the United States.(B-1)

B.2.1 Product Characteristics

Table B-1 highlights the requirements for this product in the five states; (More detail is presented in Table 3-4).

B.2.2 Production Steps: Operational Method

Steps for producing timber volume estimates by the operational method used by the U.S. Forest Service are listed below:

Table B-1:

Product Characteristics of a Timber
Volume Estimate Table

Input Resolution	All area covered with 80m and 10m resolution imagery
Area Covered	Forested land - 12.5% of total area
Categories per product	5 strata are sampled
Update Frequency	5 - 10 years
No. of products for 5-state region	as needed
Product scale	---

1. Determine number of forest plots needed to yield the precision necessary for the volume estimate by employing the standard statistical formula.

2. Obtain imagery (B-1)*

   A. Obtain current (3 years old) stereo aerial photos from ASCS and the U.S. Forest Service.

   B. Mosaic photos by township.

3. Choose sample points and classify.

   A. Select the required number of photointerpretation (P I) dots** on a township-by-township basis.

   B. Classify the P I dots on the township mosaic as forest, non-forest, water, or questionable. Record separately for each township.

   C. As each township is compiled, summarize the points by class and by county.

4. Stereoclassify selected points.

   A. Systematically select 1/3 of the forest dots and 1/3 of the questionable dots for stereoclassification (B-2).

   B. Use a stereoscope to classify the sample's forest cover type and stand size.

5. Choose points to be field checked.

   A. Select 1/17 of the stereoclassified forest and questionable points and 1/51*** of the non-forest water dots for field checking.

6. Make field measurements (B-3, B-4).

   A. Determine photo scale by comparing ground and photo measurements of the horizontal distance between two landmarks visible on photo.

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*The steps presented here are compiled from various documents. The references are those documents in which the steps are described more fully.

**Photointerpretation dots are sample areas on the photo which are viewed and interpreted by the analyst. They are chosen and located by use of a template. 214,000 P I dots are used in Missouri.

***These fractions are determined by statisticians from specifications for allowable sampling error.

B. Select a landmark which is readily identifiable on the ground and on the photo, and as close as possible to the sample location. Mark it on the photo and on the ground.

C. Stake a 10-point cluster design* using the landmark as a reference.

D. Using the basal area factor for the region in question, determine the area to be sampled around each of the ten points.

E. Estimate the merchantible bole length of each tree with a diameter at breast height (d.b.h.) (B-5) that falls within the areas.

F. Using a table, estimate the gross board foot tree volume based on the d.b.h. and merchantible bole length.

7. Use a computer program to make volume estimate for state.

A. The data gathered for each sample is fed into a computer program, which is a general program for sorting and regression analysis, to make a volume estimate for the entire state.

B. Detail records are computed and summarized on a USFS computer.

B.2.3 Production Steps: Alternative Method

The following is a more automatic system for making timber volume estimates. There are three stages: LANDSAT, low altitude, and field measurements. The steps listed below are based on reference (B-5):

1. Obtain and interpret high altitude coverage of ranger district.

A. Obtain high altitude color IR images of area at a scale of 1:120,000.

B. Interpret images and choose 33 training cells which fall into four timber volume classes** based on crown closure and average crown diameter.

2. Obtain and classify LANDSAT CCT's

A. Locate training cells on LANDSAT tapes.

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*The design consists of ten contiguous equilateral triangles with seventy-foot sides.

**The volume classes are: a) non-forested; b) forest sites with 10,000 Bd ft/acre; c) sites with 10,000 -20,000 Bd ft/acre; and d) sites with 720,000 Bd ft/acre.

B. Train classifier to recognize 4 timber classes using the 33 training cells.

C. Determine boundaries of area to be surveyed in order to save processing time (only pixels within boundaries are classified).

D. Locate boundary coordinates on tapes.

E. Classify areas within the boundaries on CCT's into four timber classes using an interactive computer system.

3. Divide the classified area into primary sampling units (psu) and make a volume estimate for each psu.

A. Divide classified areas into 892.48 psu's measuring 1325 ft. by 1 1/2 miles long.*

B. For use in statistical analysis, compute for each psu:

a) number of points/volume class within unit
b) weighted total volume for each volume class**
c) sum of weighted totals for all classes

C. For use in statistical analysis, compute over all psu's:

a) cumulative sum of weighted totals
b) mean volume or the first stage volume estimate
c) variance

4. Choose four psu's for further sampling

A. Choose 4 units (with probability of selection proportional to estimated first stage volume) for further sampling.

B. Transfer location of selected psu's from LANDSAT classified images to color IR high altitude 1:120,000 photos to facilitate locating them accurately from the air when photographed at low altitude.

5. Obtain low altitude wide angle and stereo coverage of the selected p.s.u.'s.

A. Plan low altitude flight line.

B. Use a 35 mm camera with the following characteristics to get low altitude photos of psu's:

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*Based on a practical area which could be photographed in a single flight line in a light plane with a 35 mm camera, the ability of a ground crew to do the ground work for a flight line in 1 day, and the variations between sampling units.

**Non timber = 0; 10,000 Bd ft = 1; 10,000 - 20,000 Bd ft = 2; 20,000 Bd ft = 3.

1) 24 mm focal length wide angle lens at a scale of 1:7500 (10/psu).
2) 200 mm focal length large scale stereo triplicate in color at a scale of 1:1000 (10/psu) to make precise photo estimates of timber volume.

C. Make mosaic of wide angle photos for each psu to show full area.

6. Make volume estimate based on low altitude photos.

A. Use center of middle photo of each stereo triplicate as a plot center, locate and mark on mosaic and on topographic map, and determine scale of photo near each plat center from topotraphic map.

B. Draw 0.4 acre circular plot about each photo plot center.

C. Estimate timber volume in each 0.4 area plot using photo volume tables (based on interpretation of % crown closure and measurements of average stand height using parallax.) Call this volume the second stage volume estimate.

7. Make direct measurements on the photo of selected trees and estimate volume.

A. Within each psu, choose 2 out of 10 possible photo plots (with probability of selection proportional to estimated second stage volume).

B. Pin prick and number all trees of merchantible size within selected photo plots.

C. Determine average crown diameter of selected trees (based on longest and shortest crown dimensions).

D. Use the average crown diameter for a third stage volume estimate.

8. Select trees from the previous sample to measure on the ground.

A. Select trees from the population of merchantible trees within each photo plot based on estimated third stage volume; use low altitude photos to locate photo plot centers and the trees to be measured.

B. Measure selected trees on the ground using a dendrometer (an optical device somewhat similar to a range finder used to measure precise tree bole diameters and vertical heights).

9. Based on the above data, use variable probability technique to estimate volume for entire area.

B.2.4 Cost and Performance Comparisons Between Operational and Alternative Production Methods

B.2.4.1 Cost Comparisons: Personnel, Equipment

It was not possible to isolate the cost of making a timber volume estimate by the operational method. Cost figures available were for the entire Forest Inventory of Missouri of which a timber volume estimate is only a part. The 1972 Forest Inventory for Missouri cost a total of $930,000. This cost includes salaries, equipment costs, fieldwork, data compilation costs, and system overhead. Medium altitude (1:15840 scale IR, B & W) imagery was borrowed from the ASCS at no cost to the Forest Service. The cost of this survey was approximately $\$18.00/km^2$. Of this cost approximately 45 per cent was associated with fieldwork.

Using this figure and based on estimates of aerial photography costs, we present the following table, Table B-2, which shows the expected costs of performing a timber volume estimate with imagery being charged at full cost.

The cost for timber volume estimate is $\$15.41/km^2$. Appropriate imagery costs $\$5.29/km^2$. If this imagery charge is added to the Forest Inventory charges above, the total cost of performing the Forest Inventory would be $\$23.29/km^2$. The 1970 inventory of Plumas National Forest in California covered 1.2 million acres ($4800\ km^2$) and cost $300.00 or $\$62.50/km^2$ much of which is associated with the timber volume estimate. Both inventories took nearly two years to complete.

The variation in cost may be due to differences in the accessibility of the area for field measurements, the age and type of forest, the cost of obtaining aerial photography or any number of other factors. The Missouri Inventory also used data gathered at the county level without cost when sufficiently good data were available.(B-6)

Table B-2:

Cost Estimate for Timber Volume Estimate Table

(Operational Method)

Step	Time+	Hour Costs	Total Cost	Cost/km^2*
1. Acquire Imagery (med A/C, B&W IR)			$273,000	5.29
2. Field Work (45% total inventory costs) includes expenses	8 mn-yrs	$25	$410,000	7,95
3. Compilation and** Related Processing	4 mn-yrs	$15+	$112,000	2.17
TOTAL (exclusive of printing)	12 mn-7rs		$795,000	15.41

*Total are based on 1972 Forest Inventory of Missouri covering 51,700 km^2.

+Time and hour costs are our own estimates. Actual times and hour costs not available.

**Assumed at 1/3 of costs (40%) not attributable to field work (45%) or estimated administration (15%).

Table B-3:

Cost of Timber Volume Estimate Tables
Alternative Methodology

Step	Time	Hours Costs	Total Cost	Cost/km^2
1. Obtain data				
a) high altitude photo			$ 200	.05
b) LANDSAT CCT's			800	.20
2. Interpret data				
a) photos			825	.20
b) classify CCT's			1,207	.30
3. Sample selected areas with ground truth				
a) low altitude a/c photos			300	.07
b) ground sampling			400	.10
c) laboratory measurements			1,240	.30
4. Estimate timber volume by statistical analysis			1,650	.41
			$6,590	1.63

Table B-3 breaks out the cost, by category, of making a timber volume estimate using the alternative multistage sampling method for the Quincy Ranger District of the Plumas National Forest on an experimental basis in 1973. The cost to do the entire forest by multistage sampling (over one million acres) was estimated by Nichols(B-5) to be $15,000 or about $1.63/km^2 per acre). The costs per acre showed a decrease as acreage increases. Nichols predicts that it would cost .175¢ per acre ($0.44/km^2) to make a volume estimate for the whole of California.

A cost comparison between the operational and alternative methods is difficult to make since only a portion of the above costs for the operational forest survey system is concerned with making volume estimates. However, the experimental multi-stage system cost 0.6¢ per acre ($1.63/km^2) to make only a volume estimate for the California forest mentioned above. This is an order of magnitude less expensive than the forest inventory done by the operational method and, as stated above, further decreases in cost are predicted by the California experimenter for a operationalized version of his experimental system.

B.2.4.2 Performance Comparison: Accuracy, Timeliness

Accuracy achieved in estimating the timber volume in Quincy Ranger District by the multistage system, which results in a sampling error of 8.6%, is superior to the operational system, which results in a 20% sampling error (B-5).

The alternative multistage method also takes about one-sixth of the time that the operational (10-factor) system requires for the same amount of acreage. For example, to make a timber volume estimate for a million acres using the alternative method would take 5 months. The standard system would take two years with more manpower (B-5).

B.3 LEVEL II LAND USE/LAND COVER MAP

Level II land use maps facilitate land use planning and management of urban development. Land use types are mapped at 1:24,000 and smaller scales corresponding to USGS topographic maps. Only 5% of the area needs detailed 1:24,000 scale maps. For the remaining areas 1:250,000 scale maps would be adequate. As many as 37 different classes of land use can be delineated and marked on the map.

B.3.1 Product Characteristics

Table B-4 defines the product's characteristics for states in the five-state region.

B.3.2 Production Steps: Operational Method

Listed below are the steps for the manual, operational production of Level II Land Use/Land Cover Maps, condensed from a description by Fitzpatrick (B-7):

1. Determine area to be mapped.
2. Establish scale of map and type of land use classification to be used.
3. Plan flight line and times.
4. Establish field control.
5. Acquire color IR, high altitude aircraft imagery.
6. Check image quality.
7. Scribe map base with planmetric features.
8. Register imagery on map base.
9. View imagery in stereo and outline agricultural areas (5 acre cells).
10. Delineate residential areas (use neighborhood features as guides).
11. Delineate commercial-industrial sites, (based on building type and some guideline features such as parking lots and loading areas.)

Table B-4:

Product Characteristics of a Level II
Land Use/Land Cover Map

Input Resolution	10 - 30m
Area Covered	155 km^2
Required Coverage	urban areas (5% of total) 1:24,000, rural areas (1:250,000)
Categories per product	28 or fewer
Update Frequency	5 years
Platforms	high altitude A/C LANDSAT Follow-On LANDSAT 1, 2, and C
No. of Products for Five-State Region	5400 at 1:24,000 43 at 1:250,000
Product Scale	1:24,000 1:250,000

12. Delineate forested and park areas.
13. Delineate water bodies.
14. Complete the delineation of the 28 Level II Land Use categories relevant in the five state region*.
15. Check for accuracy.
16. Produce separation sheets of land use data and planimetric base.
17. Produce working copies of map.
18. Edit and letter.
19. Print.
20. Check for desired map quality.

B.3.3 Production Steps: Alternative Method

The alternative production strategy involves computer classification of LANDSAT CCT's to derive Level II Land Use maps for an area equivalent to the size of 1 LANDSAT frame (35,225 km^2). This production scenario involves clustering analyses and maximum likelihood classification techniques. The production steps are listed below:

1. Read and reformat CCT data.
2. Geometrically correct LANDSAT frame data.
3. Overlay.
4. Classify by maximum likelihood ratio technique, 4 bands and 30 categories.
5. Refine classification through iteration.
6. Cluster analyze the ratioed data.
7. Output the land use classifications.

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*The categories are listed and described in USGS Circular #964. (B-8)

8. Produce a copy of the map on a map base.

9. Check, edit, and print as in operational method.

B.3.4 Cost and Performance Comparisons Between Operational and Alternative Production Methods

B.3.4.1 Cost Comparison: Personnel, Equipment

For the operational (manual) production system, the USGS quotes a production cost of $11.93/km^2 for 1:24,000 scale maps and $0.88/km^2 for 1:250,000 maps. Tables B-5 and B-6 present the breakdown of costs for Level II Land Use Maps as presented in Fitzpatrick.(B-7) We have made explicit her estimates of time to produce these products for consistency with the other products presented in this Appendix.

For the automated system, costs on LARSYS were obtained from conversation with Leonard Gaydos of the USGS.(B-9) These costs assume a CPU charge of $6.00/CPU-minute. Tables B-7 and B-8 presents our estimates for producing Level II Land use maps at 1:250,000 scale and 1:24,000 scale. Printing costs are $0.07/km^2 for 1:25,000 scale maps and $3.10/km^2 for 1:24,000 scale maps.

As the tables show, Level II Land Use Maps at 1:250,000 scale cost more to produce in the alternative system than in the operational (manual) system. The majority of the cost is associated with computer processing. In Chapter 4, we show that an operational system can save significantly on computer processing costs. Level II Land Use Maps at 1:24,000 scale cost approximately the same in both systems. This reflects the high cost of printing maps at large scale. In addition, since current LANDSAT 80 M. imagery is not particularly useful at 1:24,000 scale, only slight savings are realized in imagery acquisition costs.

Table B-5:

Costs of Level II Land Use Maps (Operational Method)
@ 1:250,000 Scale

Steps	Time	Hour Rate	Cost	Cost/km^2
1. Acquire Data H/A Coverage			$ 975	.05
2. Mosaicing			$ 3,120	.16
3. Interpretation	488	$20	$ 9,760	.50
4. Cartographic	156	$12	$ 2,150	.11
5. Reproduction and Printing			$ 1,365	.07
Total Cost: (per $19,500 km^2 sheet)			$17,370	.88

*Costs in this table are taken from costs cited in reference (B-7).

Table B-6:

Costs of Level II Land Use Maps (Operational Method)
@ 1:24,000 Scale

Steps	Time	Hour Rate	Cost	Cost/km^2
1. Acquire Data			$ 22	.14
2. Mosaicing	6		930	6.00
3. Interpretation	9.3	$20	186	1.20
4. Cartographic	3.1	$12	38	.24
a) marginalia			194	1.25
5. Reproduction and Printing			480	3.10
TOTAL (per 155 km^2 sheet)			$ 1,850	11.93

*Estimate in this table are taken from costs cited in reference (B-7)

Table B-7:

Cost of Level-II Land Use Maps (Alternative Method)

1:250,000 Scale, 19,500 km^2/Map Sheet

Step	Time	Cost/Hr.	Cost	Cost/km^2*
1. Collect data				
a) LANDSAT CCT's			$ 480**	.02
b) ground truth	40	$16	$ 640	.03
2. Preprocess data				
a) reformat			$ 100	
b) geometrically correct			$ 2,475	
c) overlay			$ 7,375	
SUBTOTAL			$ 9,950	.51
3. Process data				
a) classify by max. likelihood ratio: assume 3 iterations			$11,700	.60
b) cluster classified data: assume 3 iterations			$ 750	.04
c) computer programmer	12	$20	$ 240	.01
4. Output and Print Data			$ 1,360	.07
TOTAL			$25,120	1.28

*Based on 19,500 km^2/map sheet.

**One 1:250,000 scale map sheet covers approximately 60 percent of one LANDSAT frame. The cost of one LANDSAT frame has been reduced proportionately under the assumption that an alternative system could utilize the remaining portion of the frame for additional products.

Table B-8 :

Cost of Level II Land Use Maps (Alternative Method)
1: 24,000 Scale 155 km^2/map sheet

Step	Time	Cost/Hr.	Cost	Cost/km^2
1. Acquire Level II Land-use Maps enlarged to 1:24000 scale			$ 198	1.28*
2. Acquire additional Groundtruth	40	$16	$ 640	4.13
3. Overlay and Register G-T Data	10	$20	$ 200	1.29
4. Print Map			$ 465	3.10
TOTAL	50		$ 1,503	9.80

*Assuming that digital enlargements of 1:250,000 scale Level-II land use maps cost approximately the same as the maps themselves. The area to be mapped at 1:24,000 scale is roughly 4% of the 5-state region.

B.3.4.2 Performance Comparison: Accuracy and Production Time

Positional or geographic accuracy standards for 1:24,000 scale Level II Land Use maps are the same as for normal 1:24,000 scale topographic maps. This is, 90% of all well-defined points must be located to with 40 ft. of their actual geographic position.

A recent USGS/NASA study(B-7) established the accuracy of identification of Level II land use classes using the operational method at 1:24,000 scale to be 84.9 per cent, while using the alternative brought the identification accuracy to 80-85%.

600 person/hours were required to do interpretation and editing of one Level II 1:24,000 scale map by the operational method of which 200 person hours were required for cartographic compilation and production (B-7) With the alternative system we estimate (see Sect. 4.3. of this report) a maximum likelihood processing technique would require .3 - 7.7 hours of computer time (depending upon computer used) to process one image of LANDSAT data into a Level II Land Use map of the type described. Additional time for plotting of the product might raise the times to 18 - 22 hours.

B.4 SOIL MAPS

Since the 1930's aerial photography has provided data for the production of soil maps. Much of the U.S. is still not mapped in detail. Present effort is concentrated on mapping agricultural lands.

B.4.1 Product Characteristics

The desired characteristics of soil maps are listed in Table B-9.

B.4.2 Production Steps: Operational Method (B-10, B-11, B-12) (SCS, USDA)

1. Plan two years ahead for procurement of aerial photos. Decide if a new aerial survey is needed. (Photo scale 1:20,000 or 1:24,000).

2. Collect existing maps and reports of survey area: Photo index, topographic, geologic, and forest-type maps, old soil maps and reports, planning board maps and reports.

Table B-9:
Soil Map Product Characteristics

Input Resolution	30 - 80m
Area Covered	155 km^2 (1:24,000 scale)
Required Coverage	Selected Areas
Update Frequency	20 years
Platform	LANDSAT I, II, C, and Follow-On Extensive Groundtruth
No. of products for five-state region	as needed
Product Scale	1:24,000 and smaller

3. On the aerial photos draw soil lines bounding the area to be mapped (match lines).

4. Choose area to be mapped and outline on photo.

5. Make stereoscopic reviews of area.

   A. Delineate major drains, smaller drains, intermittent streams, drainage head and ponds.

   B. If soil surveys have been made on adjacent photos, all soils and mapped features should be transferred stereoscopically to the outside edge of the match lines.

   C. Ink and classify roads on basis of knowledge of area and latest county highway maps.

   D. Ink on photo, dwellings and other prominent buildings outside of built up areas. In built up areas, only ink public buildings important to farmers or farm buildings (e.g., schools, courthouses).

   E. In pencil, tentatively delineate flood deposits and bottom land, gravel and borrow pits, ridge lines, sinkholes and wet spots, stream terrace, swamp and marsh boundaries, other significant land forms (e.g. rock outcrop).

   F. Delineate all slopes that are clearly seen and appear to correspond with the slope phases in the legend. Estimate slope group.

   G. Delineate gullies and severely eroded areas and place estimated-erosion symbol in delineation.

   H. Tentatively delineate soil series or types that can be differentiated and indicate by symbols.

   I. Plan route for transversing the area most efficiently.

6. Make field measurements on cultivated areas.

   A. Take sample cores.

   B. Dig pits and observe horizons.

7. Map vegetation in area.

8. Perform chemical analysis of soil sample.

9. Classify soil.

10. Make a controlled aerial mosaic base from the photos to produce scale uniformity, provide a close match of images.

11. Complete the map manuscript "greencote" by scribing main drainage roads, soil boundaries, and other field data on the base map.

12. Scribe in soil symbols.

13. Edit the soil map by using the field sheets and correlation legend to check the accuracy.

14. Print two plastic "yellowcotes".

15. Print cultural and drainage features on one in black, and soil boundaries, erosion symbols and other symbols on the other in red.

16. Make contact prints of the yellowcotes and add lettering (for names of roads, alphabetical soil symbols, etc.).

17. Make a negative for each of the above contacts and a composite color proof from the negatives.

18. Edit the proof and make corrections.

19. Make press plates and print.

B.4.3 Production Steps: Alternative Method

The alternative production method is based upon a series of studies carried out by the Soil Conservation Service at Columbia, Missouri (B-13). The studies involve the use of LANDSAT digital tapes to prepare soil maps for Chariton County, Missouri. The project was initiated in order to establish the true value of satellite data for vegetation, soil and water mapping. The production steps for soils mapping may be outlined as follows:

1. Establish what area is to be mapped and what soil and soil-vegetation classes are to be delineated.

2. Acquire LANDSAT CCT's for the study area.

3. Geometrically correct, reformat and overlay LANDSAT CCT data.

4. Train the computer to recognize soil and soil-vegetation classes by spectral signature recognition.

5. Cluster the points into soil classes of mappable units.

6. Computer classify the CCT on a pixel-by-pixel (point-by-point) basis based on known spectral signatures.

7. Use a preliminary output of the data and perform ground truth soils mapping and sampling to verify accuracy of identification of soil units.

8. After completing groundtruth, output the map at the desired scale. Output or print may be produced as an overlay for a topographic map at the appropriate scale.

B.4.4 Cost and Performance Comparison

To produce a 1:24,000 scale soil map by the operational method for areas 200,000 acres in size (1 county) would require approximately 9 person-years. In a typical Missouri county (Chariton County, it cost $108,000 to prepare soil maps, approximately $72,000 for cultivated regions, the rest for other vegetated areas. Six person-years of labor were required for the cultivated region and 3 person-years for the other vegetated areas. The USDA Soil Conservation Service reports that an average cost for this mapping is $166/km^2.

Using LARSYS technique SCS produced soils maps by the satellite-based method at a total cost of $52,000.(B-13) However, only $4,000 of this expenditure was for computer processing. Preprocessing costs were approximately $1700 and data classification and processing cost almost $2000. $275 was expended on outputting data and another $130 for data gathering and preliminary analysis. The balance of the cost, some $48,000 or $60/km^2 was incurred for performing 4 person-years of ground truth for the soil map (See Table B-10).

B.4.4.1 Performance Comparison: Accuracy, Timeliness

The accuracy achieved by the operational soils mapping methodology approaches 99%.(B-13) The accuracy discussed here refers to the number of mappable soil units (areas 1 acre in area) which are correctly identified as to soil type. The alternative methodology can only distinguish approximately 90% of mappable soil units in cultivated or bare soil areas but substantial field mapping is necessary for detailed soil identification. A much lower accuracy (60%) is achieved in vegetated areas because cover types need to be correlated with soil types.(B-13)

The alternative system offers substantial improvements in production time: 5 person years over the operational methodology. By use of the

Table B-10:

Soil Map: Alternative Method

1: 24,000 Scale

Step	Time	Hr-Cost	Cost	Cost/km^2*
1. Preliminary Work	8 hr	$15	$ 120	.15
2. Acquire Data				
a) LANDSAT CCT's			$ 10$^+$	.01
3. Preprocess Data				
a) Reformat tape			$ 90	
b) Geometric correction			$ 260	
c) Register image			$ 1,310	
SUBTOTAL			$ 1,660	2.08
4. Process Data				
a) classify imagery by M-L b) clustering			$ 1,940	2.43
5. Output on line printer			$ 275	.34
6. Ground truth	4 mn-yrs		$48,000	$60.00
TOTAL			$52,005	$65.01

*Based on a study of 800 km^2.

$^+$Cost of LANDSAT frame is reduced proportional to area.

alternative methodology, map production time is reduced to a few hours and total ground truth to 4 person-years. (B-13) Therefore, an accuracy-time tradeoff exists.

The SCS hopes to demonstrate by further analysis that the 90% accuracy and more rapid turnaround time will be acceptable, however this work has not yet been completed.

B.5 VEGETATIVE COVER TYPE MAP

The vegetation in an area is both a reflection and an expression of its topography, soils, climate and land use practices. The type of vegetative cover may indicate the potential usefulness of the land or its previous and current use. Cataloging and mapping vegetative cover type provides information for decisions involving land use practice.

The estimates shown below assume that 10% of the five-state region would be mapped at 1:24,000 scale for wildlife habitat management and environmental studies. The remainder could be mapped at 1:250,000 scale to show crop land and major forest types.

B.5.1 Product Characteristics

Table B-11 lists the characteristics of this product.

B.5.2 Production Steps: Operational Method (B-14)

1. Perform background work.
   - A. Select area to be mapped.
   - B. Define the purpose of map and estimate mapping intensity required.
   - C. Gather relevant materials: topographic maps, soil maps, existing vegetation maps, etc.
   - D. Become acquainted with vegetation occuring in mapping area.
   - E. Refine estimate of required detail.
   - F. Choose mapping scale to meet detail requirements.
   - G. Select appropriate base map.

Table B-11:

Product Characteristics of Vegetative Cover Type Maps

Input Resolution	2 - 80m
Area Covered	155 km^2 at 1:24,000 19,500 km^2 at 1:250,000
Required Coverage	vegetative, non-urban areas (85% of total)
Categories per product	10 - 20
Update Frequency	annual
Platform	medium and high altitude A/C ground survey LANDSAT Follow-on
No. of products for five state region	1:250,000 54 1:24,000 540 (10% area)
Product Scale	1:250,000 1:24,000

H. Set-up controlled mapping units on base map.

2. Acquire, interpret and register imagery.

A. Obtain aerial imagery at 1:10,000 -1,20,000 scale either by contracting for imagery or acquiring existing imagery, e.g. ASCS photography.

B. Prepare imagery for interpretation.

C. Reference imagery to base map.

D. Delineate major vegetation boundaries and identify where possible on imagery.

E. Perform roadside field survey by car (optional).

F. Register information on base map.

3. Perform field survey.

A. Do intensive field survey to obtain vegetation inventory.*

B. Check boundary lines between vegetation classes in field and record positions.

C. Record field survey data on imagery and base map.

D. Reinterpret imagery if necessary.

4. Construct final map.

A. Correct information on base map where necessary.

B. Define mapping classification scheme: colors, symbols.

C. Prepare final map and overlays (if any)

D. Check consistency of map.

5. Print map.

B.5.3 Production Steps: Alternative Method (B-15)

1. Perform background work.

A. Select area and define purpose of map.

B. Perform literature search. Gather relevant materials.

C. Design classification scheme and decide mapping intensity and repeatability.

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*The aerial imagery or a conveniently referenced field map can be used in the survey.

2. Perform initial stratification.

   A. Acquire satellite imagery and CCT's.

   B. Visually interpret imagery with regard to chosen classification scheme and detail. Attempt broad classification.

   C. Obtain sufficient ground truth.

   D. Outline areas of interest on imagery and select training sites.

3. Do first subsampling of data.

   A. Perform digital enhancement.

   B. Perform digital analysis and classification of MSS data over selected areas of interest.

4. Select support system and staging.

   A. Incorporate other space acquired data (e.g. Skylab) if applicable or available (optional)

   B. Utilize aerial underflight photography.

   C. Acquire additional ground truth.

5. Perform refined interpretation.

   A. Extend digital analysis over entire area.

   B. Determine accuracy of map.

   C. Acquire additional ground truth to improve accuracy.

   D. Redo analysis to achieve required accuracy.

6. Print final map product.

B.5.4 Cost and Performance Comparisons Between Operational and Alternative Production Methods

B.5.4.1 Cost Comparison: Personnel, Equipment

Tables B-12A and B-12B present the estimated production costs for the operational method for producing vegetative cover type maps at 1:250,000 scale and 1:24,000 scale, respectively.

The principal expenditures for the operational system center on the acquisition and interpretation of aerial imagery and the production of the final map prior to printing. To calculate the cost of acquiring imagery we

Table B12-A:

Costs of Vegetative Cover Type Mapping:
Operational System

1:250,000 Scale

Step	Time	Rate/Hr.	Cost	$Cost/km^2$
1. Perform Background Work	-		$ 980	.05
2. Acquire, interpret and Register Imagery				
a) H/A CIR (stereo			$49,000	2.51
b) Mosaicing	300	$20	$ 4,800	.25
c) Interpreting	300	$20	$ 4,800	.25
3. Perform Field Survey	160	$20	$ 3,200	.16
4. Construct Final Map	100	$12	$ 1,200	.06
5. Print Map			$ 1,305	.07
TOTAL	860		$65,345	3.35

Table B-12B:

Costs of Vegetative Cover Type Mapping: Operational Method at 1:24,000 Scale

Step	Time (Man-Hours)	Rate/Hr.	Total Cost	Cost/km^2**
1. Perform background work			$ 8.00	$ .05
a) Acquire imagery CIR stereo at 1:20000 scale			$ 840.00	$ 5.42
2. Interpret and register imagery	24 hrs.	$16+	$ 385.00	$ 2.48
3. Perform field survey (includes cost of auto survey)	96	$20*	$1920.00	$ 12.39
4. Construct final map	80	$12++	$ 960.00	$ 6.19
5. Print final map product			$ 480.00	$ 3.10
TOTAL	200		$4593.00	$ 29.63

+K. A. Fitzpatrick, as an average of the hour rates of compilers and cartographers. (B-7)

++K. A. Fitzpatrick, hour rate for cartographers only.

*Our estimate.

**Based on 155 km^2/quadrangle.

assumed one mission per map sheet at a cost of \$30/linear mile for H/A photography and \$7.50/linear mile for L/A photography. We estimate interpretation times at 150 hrs./$10^4 km^2$ for H/A and 300 hrs./$10^4 km^2$ for M/A. Time for rectifying and mosaicing imagery is equal to interpretation time for H/A imagery and equal to 5 times the interpretation time for Med-L/A imagery. Ground truth was estimated at 4 person-weeks per 19,500 km^2 and 2.4 person weeks per 155 km^2. This difference is representative of the detail and increased mapping intensity at the larger scale.

The estimated cost for producing vegetative cover maps at 1:250,000 scale from H/A CIR imagery is \$3.35/km^2 and at 1:24,000 scale from Med/A imagery is \$25.63.

Capital costs associated with these products would include one or more BAUSCH & LOMB Zoom Transferscopes at approximately \$7000 each and miscellaneous cartographic supplies costing approximately \$1000. It is assumed that the operational system could make use of equipment for rectifying and mosaicing the imagery at small marginal costs.

The operational method is very labor-intensive, requiring 860 man-hours to map 19,500 km^2 at 1:250,000 scale and 184 man-hours to map 155km^2 at 1:24,000 scale, exclusive of preliminary work. The intensity of mapping, the diversity of species in the mapping area, and analyst familiarity can vary widely from mapping area to mapping area. This makes time spent on preliminary background work much harder to estimate.

For illustrative purposes we assumed that vegetative cover type mapping was roughly equivalent to Level-II land-use mapping in cost and complexity. The USGS is currently compiling land-use maps for Missouri at 1:100,000 scale from NASA RB-57/U-2 high altitude color-infrared imagery. In preparation for this mapping, the USGS contacted the 20 regional planning agencies in Missouri, the Missouri Department of Conservation, the Soil Conservation

Service, the University of Missouri and other state agencies and urban planning commissions across Missouri for information concerning land-use practices in the state. This was estimated to have taken 1 1/2 - 2 weeks excluding lag time. In addition, field crews were sent out to obtain low altitude hand-held photography of selected areas and to collect ground-level photography. Data from three two-men crews was used to cover the approximately 180,000 km^2 of Missouri (B-17)In all, ten person weeks of preliminary work was done to aid the compilers and interpreters before mapping was begun. If we assume a cost of $25/hr for each person in the field crew and office (including the cost of the airplane rental, travel expenses, etc.) this results in $10,000 being spent on preliminary work for the state of Missouri. This is roughly $0.05/$km^2$ for preliminary work. Since this work is done independently of the scale or number of classes used in the final mapping, this estimate can be used for both the operational and alternative methods.

Table B-13 presents the estimated production costs for an alternative method using high-altitude aircraft and satellite imagery and mapping at a scale of 1:250,000. The capital expenditures for such an alternative system would include equipment comparable to that described above and a major capital commitment to digital processing equipment.

As an example of the digital processing equipment which might be used, a G.E. Image 100 system costs approximately $500,000 including installation. (B-17)For an agency already owning or having access to a computer with 512 K core memory, the LARSYS software system of Purdue University is available for $1000. This cost does not include adapting the program to run on the agency's computer, which could cost nearly $10,000. (B-18) A remote terminal and peripherals linked to the LARSYS system would cost approximately

\$55,000/year. (B-18) All these costs are for equipment or access and do not include the time charges for using the computer, which are considerable. Our estimate for computer time charges for determining 17 classes over 19,500 km^2 at 80 m resolution is \$12,850 based on \$6.00/CPU minute. Of this cost, \$10,000 is associated with preprocessing and overlaying two bands each of spring and summer imagery. Roughly \$3000 is associated with clustering and classifying the imagery. Personnel cost for the alternative system are considerably lower than the operational method, again exclusive of preliminary work gathering background materials. We estimate 152 man-hours to map 19,500 km^2. This is approximately 6 times faster than the operational method.

The alternative method thus costs \$1.17/km^2 to produce a vegetative cover map at 1:250,000 scale.

B.5.4.2 Performance Comparison: Accuracy, Timeliness

The operational system working at 1:250,000 scale or 1:24,000 scale with an implied resolution of 2-10 m. provides for more intensive mapping, greater detail, and more classification. It is not unreasonable to assume an accuracy figure of 95% for these products.

An alternative system using present 80m. resolution LANDSAT MSS data does not appear to be particularly effective at scales above 1:100,000 although some work has been done at scales up to 1:24,000. The necessary reduction in scale for an alternative system also reduces the mapping intensity and detail possible on the map product. An alternative system mapping at 1:250,000 to 1:100,000 scale could achieve 85% accuracy.

The operational system would map 19,500 km^2 at 1:250,000 scale in 21.5 person weeks. These maps would be drawn exclusively from High and Medium altitude CIR imagery. Acquring H/A imagery over 19,500 km^2 would cost approximately \$49,000 based on a delivered imagery price of \$30/linear mile.

Table B-13:

Cost of Vegetative Cover Type Mapping
Alternative Methods at 1:250,000

Step	Time	Cost/Hr	Total Cost	Cost/km^2
1. Perform Background Work	65.3 hrs	$15	$ 980	$ .05
2. Perform Initial Stratification				
a) LANDSAT Imagery	--	--	$ 40	<.01
b) LANDSAT CCT's	--	--	$ 800	.04
c) Visual Interpretation	78 hrs	$16	$ 1,250	.06
d) Ground Truthing	40 hrs	$16	$ 640	.02
3. First subsampling of Data				
a) Preprocessing of CCT's	--	--	$10,000	.51
b) Do 16 class clustering on training cells for 13% of area 3 iterations	--	--	$ 750	.04
c) Computer programmer	12 hrs	$20	$ 240	.01
4. Select Support System and Staging				
a) Aerial imagery				
2% of area H/A CIR			$ 2,200	.11
2% of area M/A CIR			$ 2,150	.11
b) Additional ground truth	10 hrs	$16	$ 160	<.01
5. Perform Refined Interpretation				
a) Classification over map area 19,500 km^2 3 iterations			$ 2,100	.11
b) Computer programmer	12 hrs	$20	$ 240	.01
6. Print Map	--	--	$ 1,360	.07
TOTAL			$22,910	1.17

Medium altitude imagery over 155 km^2 would cost approximately \$850 based on a delivered imagery price of \$7.50/linear mile. Updating these maps would require aerial imagery reflights and selected ground check surveys. In addition, there is a lag of several months to a year between the contracting and acquiring of imagery. Updating most probably would not be done more often than every 5-10 years.

The alternative system could map 19,500 km^2 in 3 1/4 person weeks. Updating these maps would require the latest LANDSAT imagery and CCT's; only minimal ground checking need be done. A map update could be done almost entirely by computer.

The small-scale vegetative cover type maps produced by the alternative system have potential usefulness in updating products obtained by the operational method. Digitally-derived overlays at 1:24,000 scale would cost approximately the same per km^2 as the vegetative cover type map at 1:250,000 scale if taken from the small-scale product. Over one hundred such overlays could be obtained from a 1:250,000 map product at a cost \$1.17/km^2. The frequent repetitive coverage of the satellite coupled with the speed of digital processing would allow such products to be produced semi-annually, seasonally or perhaps monthly, if required over small areas. The digitally-derived products should have sufficient accuracy to allow detection of gross changes in the vegetative cover, even at 1:24,000 scale. This would insure that accurate and current vegetative cover type maps are available for decisions regarding land use practice.

B.6 SURFACE MINED LAND EXTENT AND CONDITION MAPS

In the five-state study region, surface mining constitutes the bulk of current mining activities. The states have enacted laws regulating the reclamation and extension of surface mines within their boundaries. These laws mandate that surety bonds and various fees be collected to ensure that the companies which mine land also reclaim them. These laws also require that accurate maps and records of the extent and condition of surface mined lands be made and maintained on an annual basis.

B.6.1 Product Characteristics

Table B-14 lists desired product parameters for surface mined land maps. These large scale maps are an input to the smaller scale industrial maps we list as a priority product. Product parameters for the industrial map (a priority product) are presented in Table B-14.

B.6.2 Production Steps: Operational Methodology

Missouri agencies used U-2 high altitude aircraft color infrared and black-and-white photography to identify, locate and measure the extent of surface mined lands for 70% of the state. The mapper employed low altitude aircraft photos for the remaining 30% of the state (B-19). The production steps listed below are drawn from this work.

1. Determine the area to be studied.
2. Determine the scale to be used and type of map presentation (usually overlay on 1:24,000 scale topographic map).
3. Obtain imagery (either use existing high or low altitude aircraft photos or contract for new overflight).
4. Locate mined areas by visual inspection of aircraft photos.
5. Outline affected areas on photo.
6. Measure extent of affected lands with a planimeter.
7. Field check some areas to verify the interpreted imagery.
8. Transfer data to 1:24,000 scale topographic map with a zoom transferscope from aircraft photos.
9. Prepare overlays of affected areas on light table.
10. Distribute maps.

Table B-14:

Product Characteristics of Surface Mined Land Extent and Condition Maps and Industrial Maps

	Surface Mined Land Map	Industrial Map
Input Resolution	2-10m	30m
Area Covered	155 km^2	11,620 km^2
Required Coverage	Selected Areas (1% of total)	entire region
Categories per Product	3-5	10-30
Update Frequency	annual	annual
Platform	Low Altitude A/C High Altitude A/C	LANDSAT Follow-On High Altitude A/C
No. of Products for 5-State Region	150-200	45-50
Product Scale	1:24,000	1:125,000

B.6.3 Production Steps: Alternative Method

The alternative system for producing surface mined land mapping and detection is discussed in a report on the delineation and mapping of surface mines in the Maryland-West Virginia area (B-20). Both analog and digital LANDSAT imagery were classified in this study; in this section we will discuss only the digital production system.

Two distinct digital analysis methods were used according to the report. The first is a point-by-point table look-up classification of pixels into three cover classes (stripped, open, and vegetated). The spectral signatures used were based upon the International Biological Program (IBP) vegetation classification system . The second digital analysis method was LARSYS 2, a clustering algorithm classifier which used LANDSAT bands 5 and 7 reflectance values to assess ground condition. Field checking and ground truth verified classification results. The production steps which follow pertain to the second digital analysis method:

1) Determine area to be studied.

2) Obtain CCT of LANDSAT image of appropriate data and area.

3) Locate the mined areas by classifying the CCT on a pixel-by-pixel basis using table look-up based on IBP spectral signatures.

4) Select sample areas including the mined regions on the data tapes.

5) Select reflectance values from training sites in Bands 5 and 7.

6) Analyze selected portion of the image with the selected reflectance values with a clustering algorithm.

7) Compare by visual inspection the results of pixel-by-pixel and clustering analyses.

8) Output a map product on a line printer.

9) Field check with aerial photos and ground truth.

B.6.4. Cost and Performance Comparisons Between Operational and Alternative Production Methods

B.6.4.1 Cost Comparison: Personnel, Equipment

The map products being described here are comparable. Both the alternative satellite-based system and the operational aircraft-based Missouri project were designed to locate and measure the extent of surface mined lands. No attempt to determine land condition in a quantitative way is made for either of the products, but this can be performed from low altitude aircraft data if desired.

Production costs for the operational method used in the Missouri surface mined land mapping project are not published; therefore, all costs are EODMS staff estimates (B-19) Major costs are as listed below:

Data Acquisition	\$6,800 - 970 frames at \$7.00/frame
Salary	\$1,500 - 3 months at \$500/month
Equipment	\$5,000 - cost of zoom transferscope
Supplies	\$ 250

The cost of purchasing the zoom transferscope is the major capital cost. The remaining expenditures are marginal costs of production. Defraying capital costs over 10 years, production costs per annum would be \$9,050.00 for Missouri, of which \$8,550.00 is the marginal production cost. We estimate costs for the five-state region, based on area covered by surface mines, to be in the range of \$50-60,000. For the Illinois project, low altitude aircraft data are used exclusively. The project requires 24 person-months to complete and uses approximately \$3,000 for data acquisition for a total estimated cost of \$27,000.

Cost estimates for the alternative method are based on required personnel and data processing time for the method described in reference (B-20). The costs are presented in Table B-15.

Table B-15:

Surface Mined Land Extent and Condition*
Alternative Method
1:24,000 Scale 155 km^2/map sheet

Steps	Time	Cost/Hr.	Cost	Cost/km^2
1. Preliminary Work	8	$ 15	$ 120	.04
2. Acquire data a) LANDSAT CCT's 2-bands			$ 35$^+$	.01
3. Preprocess Data a) Reformat b) Geometrically Correct c) Rectify	8	$330	$2640	.86
4. Process Data a) Classify by M-L b) Cluster				
5. Output on line printer				
6. Field Check	20	$ 10	$2000	.66
TOTAL	36		$4196	1.57

Cost of one 1:24000 scale sheet $1.57 x 155 km^2 = $243.

*Based on a study of 3050 km^2.

$^+$Costs of data are reduced proportionately with area under the assumption that an alternative system could utilize the remaining portion of the frame for additional products.

We can make a comparison of costs per square kilometer for this product. With the alternative method used in the Maryland-West Virginia case, 3045 km^2 were mapped at a cost estimated at $4796. When cost calculations on a km^2 basis are made, a cost of $1.57 per km^2 is indicated. With the Missouri projects operational method approximately 5,000 km^2 were inventoried at a cost of $9050. This yields a per km^2 cost of $1.81.

B.6.4.2 Performance Comparison: Accuracy, Timeliness

Accuracy. Conversation with agency personnel revealed that 95%+ accuracy was achieved by the operational method. In addition, mines were located to within 100 feet of their true location in 90% of the cases(B-19). Accuracies of identification achieved by the alternative NASA study of surface mined lands were in the vicinity of 80-85%. No mapping accuracy standards were quoted. The mapping format was line printer output which could be overlayed on topographic maps.

Thus, the operational method identifies mined areas more accurately and can identify small areas. This is due to the greater detail available on the aircraft imagery than on the digital tapes. The data will also be more reliable and better suited to the necessary legal tests it will have to face. However, the automated methodology can provide more rapid identification of any changes in the extent of surface mining in a particular area. In addition it could provide a continual updating of the progress of such mining if this type of information was required.

Timeliness. The Missouri surface mined regions were mapped in three person months. Seventy per cent of the state was covered by U-2 photos and was mapped; the rest was covered using lower altitude photos (B-19).

With the alternative method, the time required to perform the analysis of data totaled 8 hours of computer time and 2 person-months of preparation and verification time. Total time involved in the actual data processing is minimal and once such a system had been set up and tested the verification and preparation time could be cut substantially.

As an aside, we note that to use low-altitude imagery exclusively for a state with active strip-mining (such as Illinois), requires 24 person-months annually. This includes all map preparation and field checking (B-21). Low altitude aircraft data is not used to identify and locate strip mines but to map changes in extent and condition in mines whose location is known. Thus this activity is not comparable to the one we discuss here.

B.7 TOPOGRAPHIC MAPS

Topographic maps are among the highest priority data and information needs of many state natural resource agencies. Much of the work and planning these agencies do depend upon the existence of accurate and up-to-date 1:24,000 scale topographic maps. These maps are graphic representations of the surficial features of the Earth. They include elevation contours, cultural and natural features, and planimetric data.

B.7.1 Product Characteristics

Topographic maps are prepared in a variety of formats in the U.S. However, the most common and widely used type is the USGS 7 1/2' quadrangle, 1:24,000 scale line maps. Characteristics of this map as stated in chapter 2 are presented in Table B-16.

B.7.2 Production Steps: Operational Method

Steps for producing topographic maps by the operational method are listed below (B-22).

1. Plan mapping site and data acquisition.
   A) Select and specify scale and contour interval.
   B) Product base maps from county maps.

Table B-16:

Topographic Map Product Characteristics

Input Resolution	2 - 3.3m (B-23)
Area covered	155 km^2 in 1:24,000 scale map
Required coverage	Entire 5-state region 835,530 km^2, coverage 70% complete with current program. But a continual update program is desired.
Categories per product	5-6 per product: Forest, Water, Urban, Contour and name, Base map
Update Frequency	5 years (cultural features) 20 years (topography)
Platform	Low and medium altitude aircraft
No. of products for 5-state region	5400
Product scale	1:24,000

C) Design flight lines on base maps.

D) Plan flight times (depends on season, sun angle, etc.)

E) Mark existing ground control points (GCP's) on base map.

F) Make additional field measurement as required.

2. Obtain and check imagery.

A) Contract for and obtain stereo B&W imagery from contractor.

B) Check image quality.

C) Check imagery for deviation from flight path and correct over- and side-lap.

3. Prepare imagery and map base for the stereoplotter.

A) Produce diapositive plates.

B) Drill GCP's on diapositive plates.

C) Measure imagery scale and tilt.

D) Calculate by computer the projected positon of GCP's on the map base.

E) Generate and plot by computer the projected position of

GCP's on the map base.

F) Generate and plot by computer the UTM map grid on the mylar map base.

G) Align diapositive plates with GCP's in Kelsh plotter.

4. Produce original copy of base map.

A) Pencil topographic contours on map base.

B) Pencil cultural feature, forestry, water, etc. on other map bases.

C) Check mapping accuracy.

D) Scribe mylar sheets.

5. Produce final copies.

A) Produce plastic copies of each base map.

B) Edit and mark words on overlay.

C) Print map,

D) Check results.

TOPOGRAPHIC MAP UPDATE PRODUCTION STEPS

1. Plan imagery acquisition.

   A) Design flight lines on base maps.

   B) Plan flight times.

   C) Mark existing ground control points (GCP's) on base map.

   D) Mark GCP's in field.

2. Acquire and check imagery.

   A) Acquire high altitude stereo imagery.

   B) Check image quality.

   C) Check imagery for deviations from flight path and correct over- and side-lap.

3. Produce inputs to update procedure.

   A) Produce diapositive plates.

   B) Drill GCP's on diapositive plates.

   C) Measure imagery scale and tilt.

   D) Calculate the projected position of GCP's on map base by computer.

4. Update original topographic map.

   A) Pencil areas of change on map base.

   B) Check accuracy.

   C) Scribe the mylar map base.

   D) Produce copies of map base.

5. Edit and print updated map.

   A) Edit and check for accuracy.

   B) Print map.

   C) Check results.

B.7.3 Production Steps: Alternative Method

An experimental manual-interactive automated mapping sytem called the Automated Cartographic System (ACS) has been developed by the Rome Air Development Center at Rome Air Force Base. This alternative system will not be able to incorporate satellite data from LANDSAT-like satellites, which provide little topographic data. The ACS was developed with custom-built and hard-wired equipment. Litle detailed information is available on automated cartographic systems since most have been developed by DOD agencies. The information presented in this discussion of the ACS was gathered by a review of a paper by D. Hall and personal communications (B-24, B-25).

The ACS was designed to compile or construct a complete map or chart from aerial photographs and/or a series of large scale graphic source materials. The development goal is to automate, as much as possible, the map-making process. The sytem as it is envisioned will proceed as indicated by the production steps listed below:

1) Acquire imagery.
2) Rectify and geometrically correct imagery.
3) Input to analog or graphic to digital conversion system and convert imagery to digital format.
4) Manipulate data to change scale, projection, or resolution as desired.
5) Mark planimetric and cultural features.
6) Develop stereo model of terrain on image.
7) Construct topographic contours.
8) Check for accuracy.
9) Final edit.
10) Produce output map.

B.7.4 Cost and Performance Comparisons Between Operational and Alternative Production Methods

B.7.4.1 Cost Comparison: Personnel, Equipment

We were not able to obtain specific cost information on capital costs but major equipment which is used to produced topographic maps includes Kelsh Plotters (these devices may cost from \$50K to \$100K), machines for drilling and recording GCP positions, and for updating cultural features, orthophoto machines for correcting scale and tilt of aerial photographs. A large scale computer would be required for the recording, translating and manipulation of GCP coordinates onto a digital tape. The tape is then used on a minicomputer and is translated into directions for driving an automatic line plotting device. This equipment is extremely expensive and results in a high overhead for the operation.

Table B-17 shows that the cost estimates derived from manual production of a typical 1:24,000 scale topographic map indicate a total cost per map of \$11.8K. This figure compares with the figures quoted by USGS of \$12K for a typical Missouri quadrangle (B-26). The cost estimates given are the marginal costs per map for personnel and supplies; capital costs are excluded. Equipment, personnel and facility costs for an active mapping facility are substantial--on the order of several millions of dollars per year. The equipment necessary to produce one map probably costs from \$200-500 K.

In order to establish the alternative system, significant investments in trained personnel and specialized equipment would be needed. Major capital costs of this automated system can be described as lying in three areas: (1) software development; (2) personnel training and costs and; (3) hardware costs. These costs are not currently specifiable, but hardware types can be listed and the system configuration specified as in Figure B-1. The hardware of such a system may be described as in the following paragraph.

Table B-17:

Topgraphic Map Production Steps, Costs of Production and Time Estimates: Operational System

Step	Cost Estimate $	Time Person Hr.
Plan imagery to be acquired	$ .2 K	28-36
Establish field control	1.5 K	100-150
Acquire imagery	4.0 K	NA
Check image quality	.2 K	16-40
Produce diapositives and drill GCP's	.5 K	48-56
Derive and plot contours and other map data	2.4 K	80-160
Check map accuracy	.5 K	24-40
Scribe mylar sheets	1.0 K	24-72
Produce feature separate (map pulls)	.2 K	2-4
Edit and check for accuracy	.4 K	24-36
Printing Cost	.5 K	
TOTAL	$11.8 K	

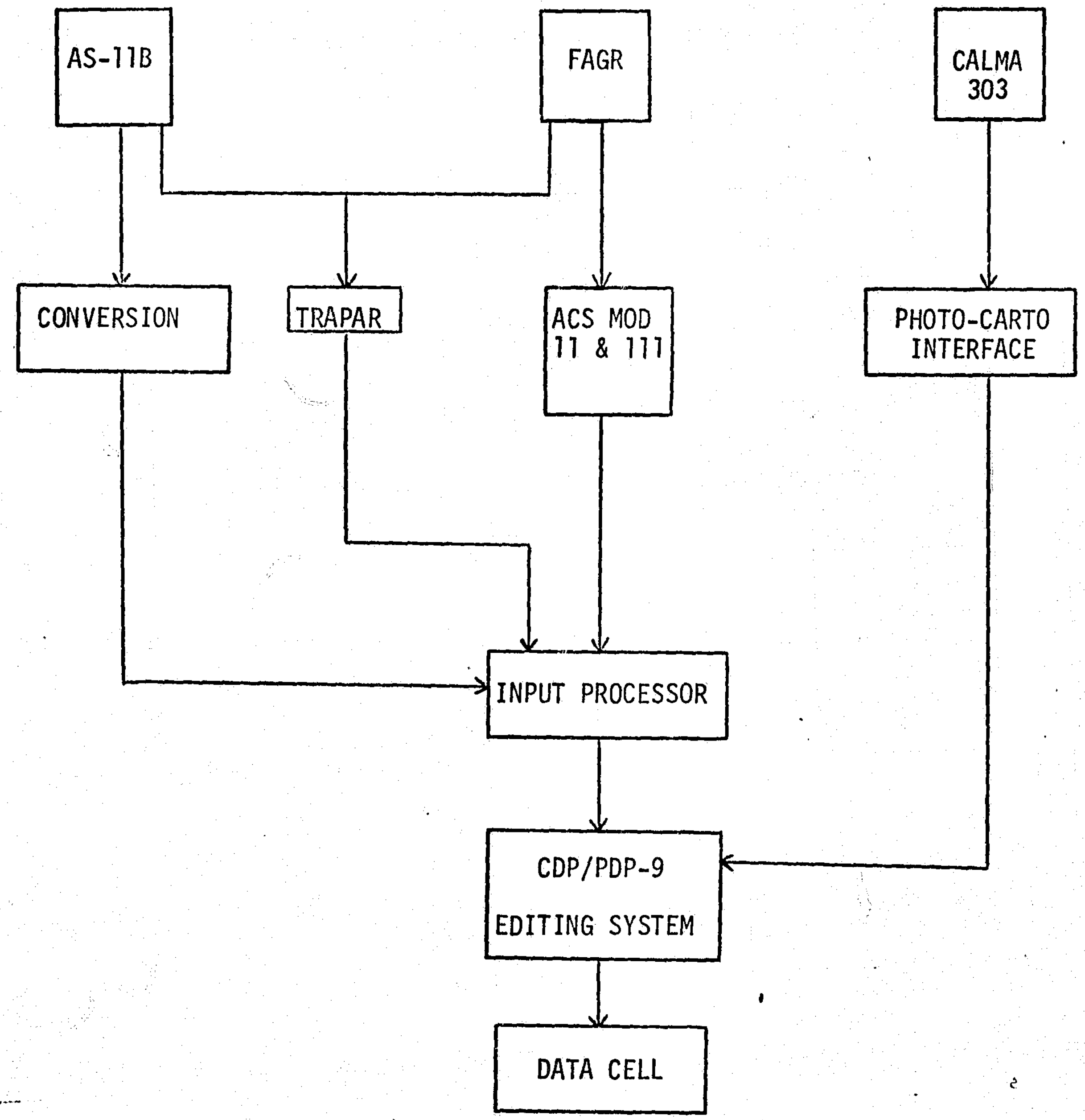

Figure B-1:

Alternative Automated Cartographic System Configuration

The AS-11B (Unit 20) system is an analytical stereoplotter system based on the solving of the photogrammetric equations relating to stereo models by a computer. This system is composed of a Calma 303 digitizer, a PDP-9/CDP mini-computer, and Calcomp 563 Plotter. It also includes a Floating Arm Graphic Recorded (FAGR)/PDP-7, which is a manual linear digitizer. The PDP-9 is used as a cartographic Digitizer/Plotter for output plotting. The line printer is used as an additional output printing device.

The cost for the hardware described is in the range of \$300,000 - \$500,000 for equipment purchase and rental. Costs of map production vary with the amount of processing time required to develop the map and the personnel time to supervise and interact with the system. The system designer estimates the cost of making one map to be \$4,000 - \$6,000.

B.7.4.2 Performance Comparisons: Accuracy, Timeliness

The standard (operational system) specifications for topographic map accuracy may be briefly summarized by saying that 90% of all well-defined points on the ground must be located to within 40 feet of their actual geographic position. Similarly all such points must have an accuracy of elevation equivalent to one-half the contour interval (in most cases this would be 5 - 10 feet). The literature which reports on the capabilities of the RADC/ACS system states that the accuracies achieved by the system seem to be within the standards set for national map accuracy. If the same preparation standards are maintained, the ACS would be capable of producing usable map products, similar to those currently coming from the various USGS facilities.

The time delays of the current map production system are considerable, ranging from 6-8 months to 5 years. Actual production times make up a relatively small proportion of this delay; the greatest delays are in backlogs of work at government printing offices and in contracting to private firms. In addition to long delays in printing maps, the field surveys and manual compilation processes absorb several hundreds of person-hours. With an automated system, time delays in production could be cut and direct output copy should be available on a short notice basis. However, for multi-copy reproduction, time delays will have to be accepted until better contracting or government production schedules can be worked out.

B.8 SLOPE MAPS

On the current map format, zones of slope values are delineated and colored to differentiate slope values in an area. Such maps are used by many resource and land management agencies and are often prepared at a scale of 1:24,000 for areas corresponding to existing USGS 1:24,000 scale topographic maps.

B.8.1 Product Characteristics

The characteristics of slope maps are listed in Table B-18. Characteristics have been determined from current products and from user specified modifications to current products.

B.8.2 Production Steps: Operational Method

The production of a slope map uses as input a topographic map of the same area and of the same scale. Therefore, the production steps listed in Section B.7 for topographic maps can be considered as preceeding those listed below for slope map production. Steps for the manual operational method of slope map production are:

1) Acquire 1:24,000 scale topographic map for area slope map is required.

2) Determine what ranges of slope zones are to be mapped.

3) Visually inspect and measure spacing of contour lines.

4) Outline areas with equivalent slopes.

5) Check for consistency.

Table B-18:

Product Characteristics of Slope Maps

Input Resolution	Base topographic map with 2-3.5m input resolution.
Area Covered	155 km^2
Required Coverage	Entire area (830,000 km^2)
Categories per Product	4-5 currently 10-12 desired
Update Frequency	20 years
Platform	Low altitude aircraft
No. of products for 5-state region	5400
Product Scale	1:24,000

6) Color or shade the slope zones.

7) Edit, check, and print as in topographic map production.

B.8.3 Production Steps: Alternative Method

Again, the production steps listed below for the alternative method for producing soil maps, necessarily proceed from steps for obtaining topographic maps. The alternative method is that which is currently employed by the USGS on an experimental basis

1) Acquire 1:24,000 scale topographic map for the area it is desired to slope map.

2) Utilize brown contour plate of topographic map in question for photographic processing into slope map.

3) The brown contour plate is photographed using a special camera with a vibrating lens assembly.

4) This wobbling lens causes the contour lines on the map to appear to coallesce or fade into one another when they are in a certain range of spacings.

5) Five to six negatives are made of the various ranges of contour spacing. These negatives represent the various slope zones.

6) The zones are then transferred to a planimetric base for the 1:24,000 scale topographic map on which the slope map is based.

7) Produce copies of this map.

8) Check for accuracy.

9) Edit and letter.

10) Final check

11) Print.

B.8.4. Cost and Performance Comparisons Between Production Systems

B.8.4.1 Cost Comparisons: Personnel, Equipment

Costs of manually producing slope maps by the operational method are directly dependent upon the number of person-hours spent in production. Little equipment or additional supplies are required. Estimates made by federal and state agency personnel indicate that 50 person-hours may be entailed in map production. At $15 per hour this would be $750.00 per map. These costs are less than the alternative method costs but yield substantially less accurate maps. The operational method depends on the very subjective estimates of slope made by the person doing the map using a topo map as a basis. In general, no very detailed measurement of the closeness of adjacent contour lines is made; but rather an overall classification into areas of "steepness" is made. Step-by-step cost estimates are provided in Tables B-19 and B-20.

The cost estimates which we made for the alternative method of slope map production are based upon the time estimates we made for each production step. Where possible we use official USGS hourly cost figures in combination with our time estimates to derive total step-by-step costs for product generation. These estimates appear in Table B-19.

B.8.5 Performance Comparison: Accuracy, Timeliness

Accuracy. Accuracy attained in slope production by the operational method has not been assessed; however, informal estimates by federal personnel suggest that the accuracies achieved by manually classified slope zones rarely exceed 60-65%. Very detailed slope zone mapping is often beyond the capabilities of manual methodologies.

Accuracy standards for the alternative method of producing slope maps are difficult to establish. We have been able to establish that the base map conforms to USGS map accuracy standards. All slope zone boundaries are

Table B-19:

Cost and Time Estimates for the Operational Manual Production of Slope Maps

Steps	Cost	Time
Acquire topographic map and copy	$ 2.50	--
Determine ranges of slope zones	$ 75.00	5 hrs
Inspect and measure spacing of contours	$100.00	6 hrs
Outline areas with equivalent slopes	$475.00	3 hrs
Check (ground truth performed)	$ 50.00	3 hrs
Color or shade areas	$ 50.00	3 hrs
Printing costs	$180.60	--
TOTAL	$933.10	50 hrs

Table B-20:

Cost* and Time Estimates for Alternative Method for Producing Slope Maps

Steps	Time	Hour Costs	Total Cost	Cost/km^2
1. Register topographic map onto mylar overlay	2 hrs.	$25	$ 50.00	$ .24
2. Photographically process to derive slope zone	20 hrs.	$25	$ 500.00	$ 3.72
3. Transfer to planimetric base	20 hrs.	$25	$ 500.00	$ 3.22
4. Produce copies of map	5 hrs.	$10	$ 50.00	$ .32
5. Check for accuracy	5 hrs.	$10	$ 50.00	$ .32
6. Process and Print			$ 750.00	$ 4.84
TOTAL			$1900.00	$12.24

*Costs of producing slope maps do not include those costs incurred when generating the topographic contour data needed in the production process. Those costs would be additional to the cost estimates listed above.

located to within $\pm$ 10 feet of the actual slope zone break. Thus, the semi-automated alternative products are substantially more accurate than those now operationally produced. The slope zones could be delineated in any range of slope zone values desired. The 5-6 zones delineated on current products, however, are not sufficient for many user needs. It may become necessary to erect more slope zones, each with smaller ranges of values in order to overcome user dissatisfaction with current products.

Timeliness. The time required to produce slope maps by the manual methodology described above has been estimated by EODMS staff in conjunction with agency personnel who have actually produced these maps. For slope maps at 1:24,000 scale with 4-5 slope zones, the estimated total time is 242 hours.

For the semi-automatic methodology of the USGS, the EODMS staff has developed estimates for production times of 160-180 hours. This estimate was made in conjunction with USGS personnel.

APPENDIX C: AN ANALYTIC METHOD FOR ESTIMATING COMPUTER IMAGE PROCESSING TIMES AND COSTS

C.1 INTRODUCTION

This appendix provides more detailed information on the analytic method for cost and time estimation which is summarized in Section 4.3.2. The development begins by determining the computational requirements* of image processing algorithms from functional descriptions** of each algorithm. We next specify a per product computational load*** from the mix of algorithms used to produce the information product from raw data. In turn, the computational load determines processing costs and times for a product on any particular computer system for a given menu of products.

Section C.2 evaluates computational requirements of important image processing algorithms. Section C.3 presents estimates of times and costs for individual algorithms run on three different computer systems and also for combinations of algorithms required to produce a typical information product, Level II Land Use/Cover maps.

We also compare our estimates of processing costs on an IBM 360/67 with actual prices charged by LARSYS using the same algorithms, data loads, and computer. The comparison shows that our estimates are somewhat low, because they do not take overhead into account.

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* By an algorithm's "computational requirements", we mean the number of computer operations (add, multiply, etc.) required to perform an algorithm.

** By an algorithm's "functional description", we mean a list of steps which the algorithm takes.

***By a product's "computational load", we mean the total number of operations the computer must perform to produce the product.

C.2 FUNCTIONAL DESCRIPTIONS AND COMPUTATIONAL REQUIREMENTS OF IMAGE PROCESSING ALGORITHMS

We develop functional descriptions for algorithms for reformatting, geometric correction and registration, contrast enhancement, and classification. From these descriptions, we estimate the computational requirements of each algorithm in terms of the number of basic operations (add, multiply, etc.) required. Table C-1 summarizes our results.

To illustrate how the computational requirements of Table C-1 are derived, we generate a functional description of the maximum likelihood algorithm and use the description to determine the algorithm's computational requirements.

The maximum likelihood algorithm computes a measure of the likelihood that an observed pixel value comes from a particular object class. The pixel is assigned to the class for which this measure is greatest.

For Gaussian-distributed data (a common remote-sensing assumption), the likelihood measure that a pixel $\underline{X}$ represents class k is given by

$$L_k(\underline{X}) = \ln(p(k)) - 1/2 \ln|\underline{C}_k| - 1/2(\underline{X} - \underline{M}_k)^T \underline{C}_k^{-1}(\underline{X} - \underline{M}_k) \qquad \text{(C-1)}$$

where p(k) is the probability of object class k, $\underline{M}_k$ is the mean vector (average pixel brightness values) associated with object class k, $\underline{C}_k$ is the kth class' covariance matrix (a measure of the variation of brightness values associated with object class k), and $|\underline{C}_k|$ denotes the determinant of this matrix. $\underline{M}_k$, $\underline{C}_k$, and p(k) must be known before $L_k(\underline{X})$ may be found. "Training the classifier" simply means estimating $\underline{M}_k$, $\underline{C}_k$, and p(k) for each object class of interest.

Equation (C-1) reduces to

$$L_k(\underline{X}) = f(K) - 1/2(\underline{X} - \underline{M}_k)^T \underline{C}_k^{-1}(\underline{X} - \underline{M}_k) \qquad \text{(C-2)}$$

where $f(k) = \ln\ p(k) - 1/2 \ln|\underline{C}_k|$, is a known quantity, for each class k, k = 1, 2, ..., C. (C is the number of possible classes).

Table C-1: Algorithm Computational Requirements

Task	# Moves (1 byte within main memory)	# Disc Accesses (Read/Write M lines' data)	# Adds	# Multiplies	# Compares
Reformat CCT's	$2BN_p$	5460/M	--	--	--
Determine Resample Coordinates a) Linear Transformation	$4N_p$	2340/M	$2N_p$	$4N_p$	--
b) Affine Transformation w/Bilinear Interpolation (30 triangles, 20x20 Interpolation Grid)	$4N_p$	2340/M	$94{,}000 + 18N_p$	$56{,}000 + 10N_p$	19,000
c) Least Squares Fit w/Bilinear Interpolation (Degree = N, 20x20 Interpolation Grid)	$4N_p$	2340/M	$2N^4 + 31N^3 + 3292N^2 + 9799N + 4828 + 18N_p$	$2N^4 + 15N^3 + 1849N^2 + 5489N + 3623 + 10N_p$	--
Resample a) Nearest Neighbor	$2BN_p$	4680/M	$4N_p$	--	$2N_p$
b) Bilinear Interpolation	BN_p	4680/M	$(6 + 3B)N_p$	$(1 + 4B)N_p$	--
c) Cubic Convolution	BN_p	4680/M	$(28 + 15B)N_p$	$(20 + 20B)N_p$	--
Contrast Enhancement	$2BN_p$	4680/M	128B	128B	14,161B
Classification: a) Gaussian Maximum likelihood (C classes)	CN_p	2925/M	$[C(B^2 + B + 3)-1]N_p$	$(B^2 + B + 1)CN_p$	$(C-1)N_p$
b) Clustering (C classes, I iterations)	ICN_p	2925I/M	$BI[(C + 3)N_p + 3C + 1] + \frac{C(C-1)}{2}(4B^3 + 3)$	$BI[5C + (C + 1)N_p + 1] + \frac{C(C-1)}{2}[4B^3 + 2B^2 + 1]$	$(C-1)N_pI$

Notes: a) B = # of bands (4 for current LANDSAT)

b) N_p = # of pixels (7.6×10^6 for one LANDSAT image)

c) $M = \frac{\text{main memory size (bits)}}{1.05B \times 10^5}$

d) 4M = # of imagery lines able to be stored in main memory

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Given the observed brightness values $\underline{X}$, the maximum likelihood algorithm computes $L_k(\underline{X})$ for each of the C object classes and assigns the pixel to the class having the largest value of $L_k(\underline{X})$. A flowchart illustrating this procedure appears in Figure C-1.

Specifying the computations required to perform this algorithm permits us to determine the number of computer operations of various types required to run the algorithm on a given set of data, i.e., the algorithm's "computational requirements". For example, one of the steps in the flowchart of Figure C-1 is $\underline{X}_2(k) = \underline{C}_k^{-1} \underline{X}_1(k)$. $\underline{C}_k^{-1}$ is a BxB element matrix, where B is the number of data bands used; $\underline{X}_1(k)$ is a B element vector, each of whose elements is the dot product of a row of $\underline{C}_k^{-1}$ with $\underline{X}_1(k)$. Thus, for B band data, calculating $\underline{X}_2(k)$ requires B^2 multiplies and B(B-1) additions. The number of computer operations required for each of the algorithm's other steps can be similarly determined by inspection.

We then find the algorithm's total computational requirements by multiplying each step's requirements by the number of times the step is executed, and totaling the results for every step. For example, the step $\underline{X}_2(k) = \underline{C}_k^{-1}\underline{X}_1(k)$ is executed C times for each pixel, where C is the number of object classes of interest. Therefore, when classifying N_p pixels into one of C classes, the step $\underline{X}_2(k) = \underline{C}_k^{-1}\underline{X}_1(k)$ contributes CN_pB^2 multiplies and $CN_pB(B-1)$ additions. The maximum likelihood algorithm's total computational requirements, found by summing each step's total computational requirements, are given in Table C-1.

C.3 PROCESSING TIMES AND MARGINAL PROCESSING COSTS FOR IMAGE PROCESSING ALGORITHMS ON SELECTED COMPUTER SYSTEMS

C.3.1 CPU Time Required

The computational requirements determined above allow us to estimate the CPU time required to perform each algorithm on any serial computer. As

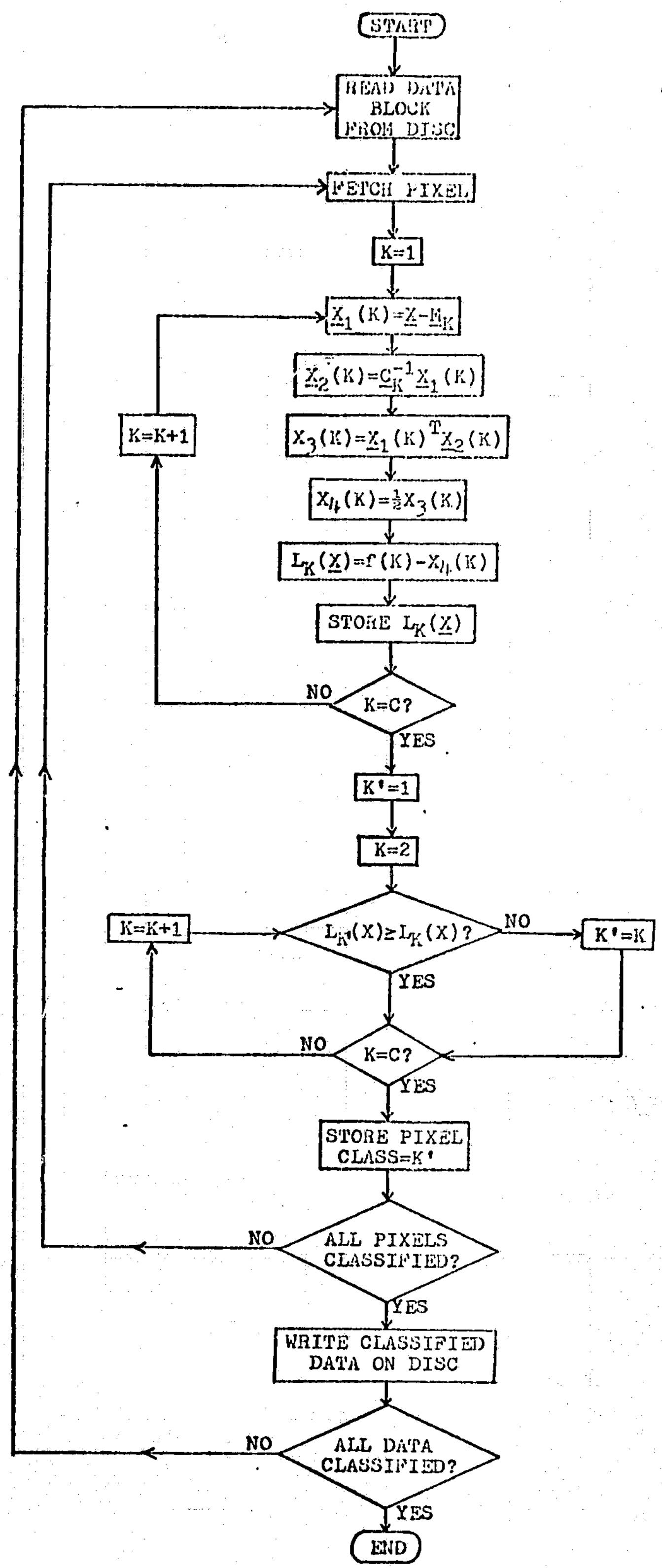

Figure C-1: Maximum Likelihood Algorithm Flowchart

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examples, we chose three systems with different capabilities: the IBM 370/195, the Univac 1108, and the IBM 360/67.* Using published figures (C-1, C-2) listing computer instruction execution times, we first determine the time needed to accomplish the required numbers of each instruction. For example, if an algorithm requires 10^6 add operations to process a given amount of data, a computer which takes 5.4 μsec to fetch data and execute a simple add operation will require 5.4 seconds to perform the adds.

The total estimated CPU time to perform each algorithm is the sum of the times needed to perform the algorithm's required computer operations. A summary of each algorithm's computation time for the selected computers is given in Table C-2. Table C-3 lists the operation execution times from which these figures are derived (C-1, C-2).

C.3.2 CPU Costs

We estimate each computer's cost per CPU minute by assuming that the monthly cost of operating a computing facility is equal to twice the computer's monthly lease cost (a reasonable assumption in costing computing facilities, made to allow for salaries of operating personnel and for maintenance) and that 140 CPU hours of operation are realized monthly. Under these assumptions, the cost per CPU minute is given by

$$\text{Cost per CPU minute} = \frac{2(\text{computer leased cost/mo})}{140 \text{ hrs/mo}} \times \frac{\text{hr}}{60 \text{ min}} \qquad \text{(C-3)}$$

The corresponding costs per CPU minute were \$28.57 for the IBM 370/195, \$10.71 for the Univac 1108, and \$5.48 for the IBM 360/67. Table C-3 lists the cost of performing each algorithm on each of the computers.

C.3.3 Processing Costs for a Level II Land Use/Cover Map

As an example of how the computational estimates can be used to assess the cost of an entire processing sequence, we compute costs of processing

*Computers for illustration only.

Table C-2: Algorithm Processing and Costs for One LANDSAT IMAGE

CPU Time / CPU Cost

Task	Algorithms	IBM 370/195	Univac 1108	IBM 360/67
Reformat CCT's	Reformat	5.72 sec. / 2.72	10.12 sec. / $1.80	5.67 sec. / $0.52
Determine Resample Coordinates	1. Linear Transformation	9.37 sec. / $14.29	112.95 sec. / $20.16	248.48 sec. / $22.69
	2. Affine transformation w/Bilinear Interpolation	30.02 sec. / $14.29	459.92 sec. / $82.10	1,256.30 sec. / $114.74
	3. Least Squares Transformation w/Bilinear Interpolation (N-4)	30.03 sec. / $14.30	459.95 sec. / $82.10	1,256.29 sec. / $114.84
Resample	1. Nearest Neighbor	10.73 sec. / $5.11	95.41 sec. / $17.03	251.32 sec. / $22.95
	2. Bilinear Interpolation	38.50 sec. / $18.33	598.62 sec. / $106.85	1,616.20 sec. / $147.61
	3. Cubic Convolution	197.57 sec. / $94.07	3,242.40 sec. / $578.77	8,761.11 sec. / $800.18
Contrast Enhancement	Enhance	5.73 sec. / $2.73	10.23 sec. / $1.82	5.99 sec. / $0.55
Classification (37 classes)	1. Maximum Likelihood	1,707.94 sec. / $785.09	28,075.87 sec. / $5,011.54	76,257.86 sec. / $6974.02
	2. Clustering (15 iterations)	5,615.34 sec. / $2,673.83	87,785.32 sec. / $15,669.68	238,307.45 sec. / $21,765.41

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Table C-3: Execution Times for Operations on Typical Computers*

Computer	Execution Times (microseconds)			
	for Move	for Add	for Multiply	for Compare
1. IBM 370/195	0.0945	0.11	0.16	0.11
2. Univac 1108	0.1667	1.875	2.62	1.875
3. IBM 360/67	0.0938	5.4	6.8	5.4

*Computers for illustration only. Figures taken from (C-1, C-2)

37-category Level II Land Use/Cover Maps* for the state of Missouri on an IBM 370/195. Level II Land Use/Cover Maps are used in a variety of applications areas; as defined by (C-3), the maps classify land use/land cover into one of thirty-seven classes. The equivalent of 5.3 frames of LANDSAT data must be processed to prepare maps covering the entire state of Missouri.

One algorithm sequence which might be used to process LANDSAT data for Level II Land Use/Cover Maps is illustrated in Figure C-2**. Feedback arrows in Figure C-2 indicate that an algorithm must be performed more than once. For example, two iterations of the linear transformation algorithm are required. The first iteration corrects systematic errors in the data. By comparing the once-transformed data with ground control points, the analyst can achieve better registration during a second transformation.

The CPU costs of the processing sequence of Figure C-2 applied to a full LANDSAT image are summarized in Table C-4. Under our assumptions on number of iterations used, the total CPU cost to process a single image into 37 classes is about $16,000; processing the equivalent of 5.3 images to cover the state of Missouri costs about $85,000. Recall that this cost includes only costs associated with operating the computer center.

Computation times can be determined similarly, using the estimates of required computation given in Table C-1. An IBM 370/195 system requires approximately 560 CPU minutes to process a single LANDSAT image into 37 classes.

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* This calculation is only an excercise. Only 28 of the 37 Level II Land Use classes (as defined in (C-3)) are relevant in Missouri.

**Experiments in which LANDSAT data was processed using algorithmic sequences similar to Figure C-2 (e.g., (C-4)) have not yet achieved Level II accuracy. The sequence does, however, provide an illustrative example of a typical processing technique.

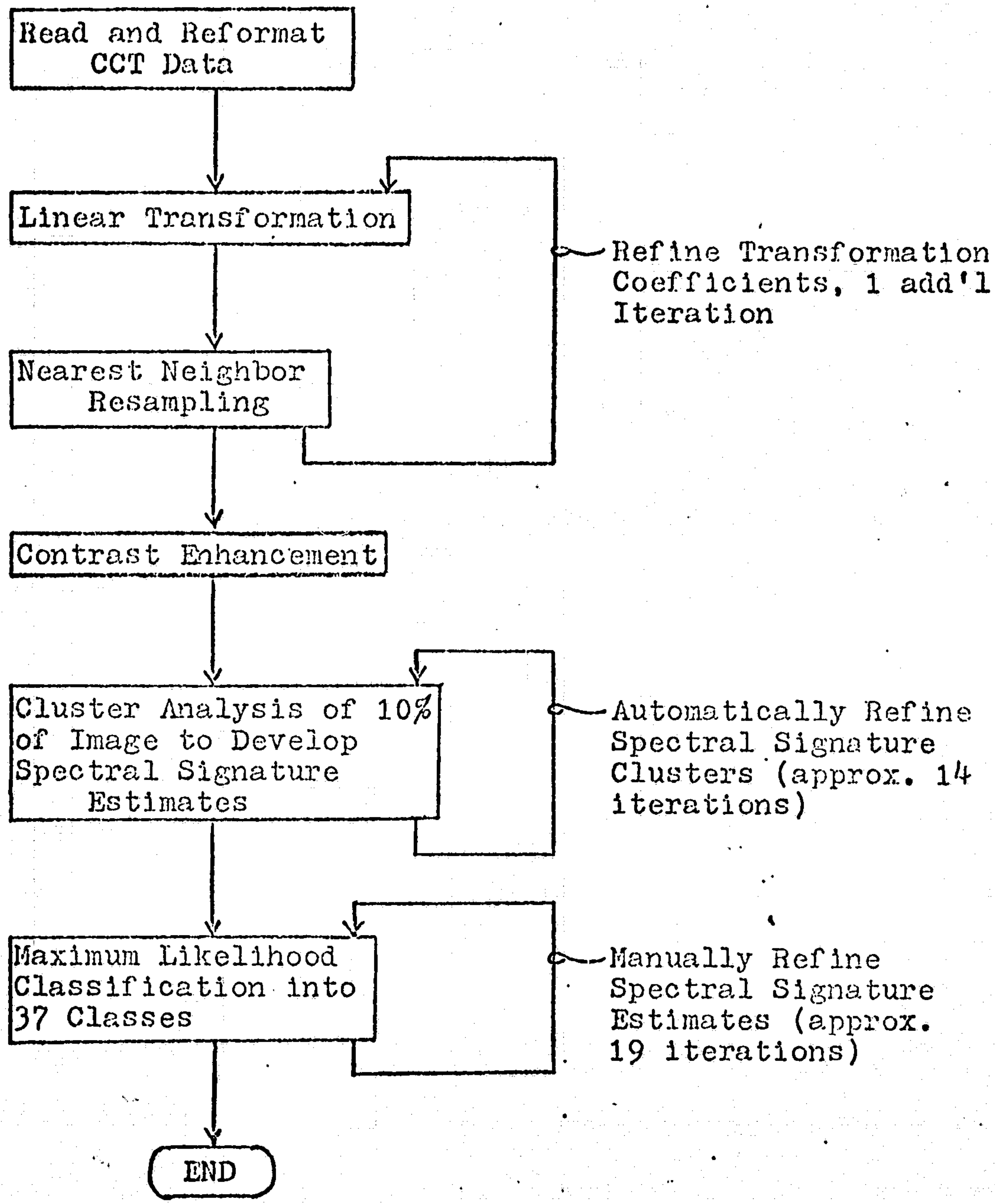

Figure C-2: Processing Sequence for Level II Land Use/Cover Maps

Table C-4: Costs For Processing One LANDSAT Image For Level II Land Use/Cover

Cost per CPU minute = $28.57 for IBM 370/195 system.

Reformatting	$ 2.72
Geometric Correction 2 Iterations	19.14
Contrast Enhancement	2.73
Cluster Analysis of 10% of Image 37 clusters, 15 iterations	267.40
Maximum Likelihood Analysis 37 classes, 20 iterations	15,425.80
	$15,993.79

C.3.4 Cost Variation with Number of Iterations and Number of Classes

Table C-4's cost figures for Level II Land Use/Cover maps assume 20 maximum likelihood iterations and 37 classes. Since the costs are very sensitive to these assumptions, here we briefly discuss how costs vary when these numbers change.

Figure C-3 shows that costs are a linear function of the number of maximum likelihood iterations used. The figure emphasizes the importance of this number to total cost.

The number of classes is also important--not only because it directly influences the cost per iteration of the classifier algorithm, but also because more classes mean more iterations will be required. As more object classes are requested, spectral space is divided into more and smaller decision regions. The number of decision boundaries increases, and because the decision regions themselves are shrinking, boundary placement gets more critical. Therefore, not only will the classifier have to be trained to recognize more object classes, but each class's spectral signature will have to be more closely approximated. Achieving this closer approximation will require more maximum likelihood iterations before a given accuracy can be achieved.

Currently, no one is computer-classifying remotely-sensed data into a large number (20+) of classes on a production basis. As a result, we have had to assume a relationship between the desired number of object classes and the required number of iterations. We estimate that to achieve a given percentage accuracy, the number of iterations required will vary exponentially with the number of object classes, as graphed in Figure C-4.

Processing costs for complex products will be relatively high. Nevertheless, as we saw in Section 4.4., an EODMS providing extensive ground

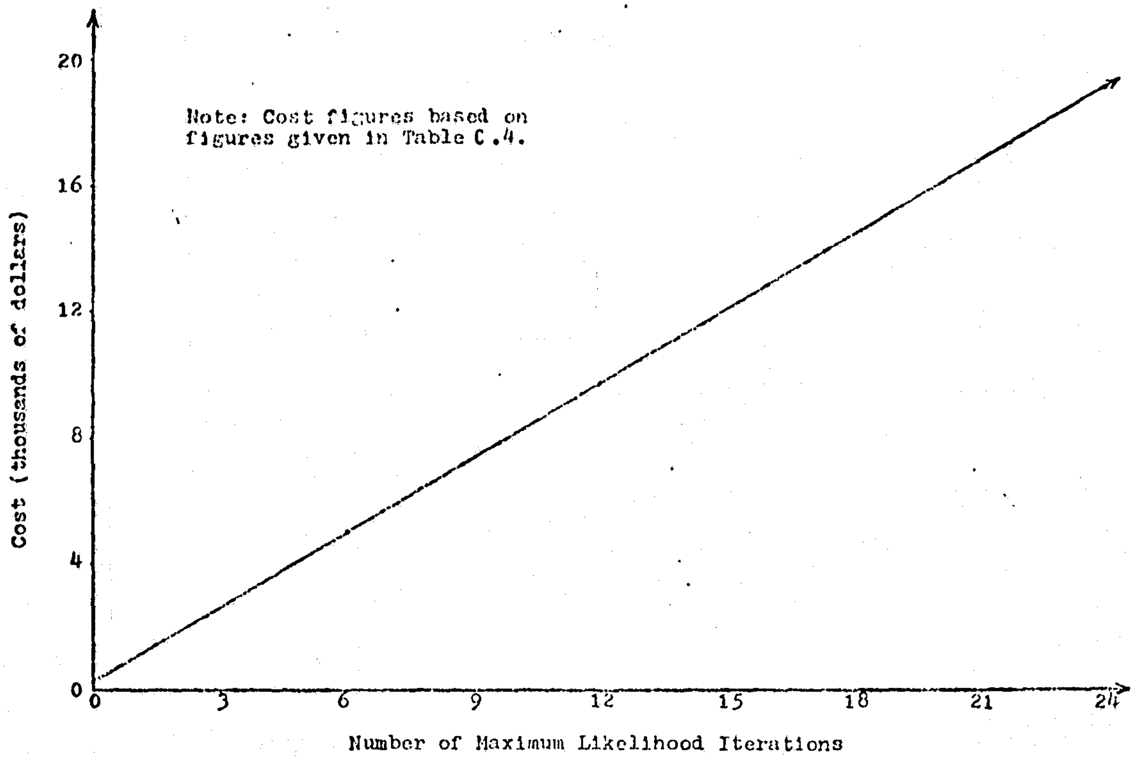

Figure C-3: Interpretation Costs as a Function of The Number of Maximum Likelihood Iterations

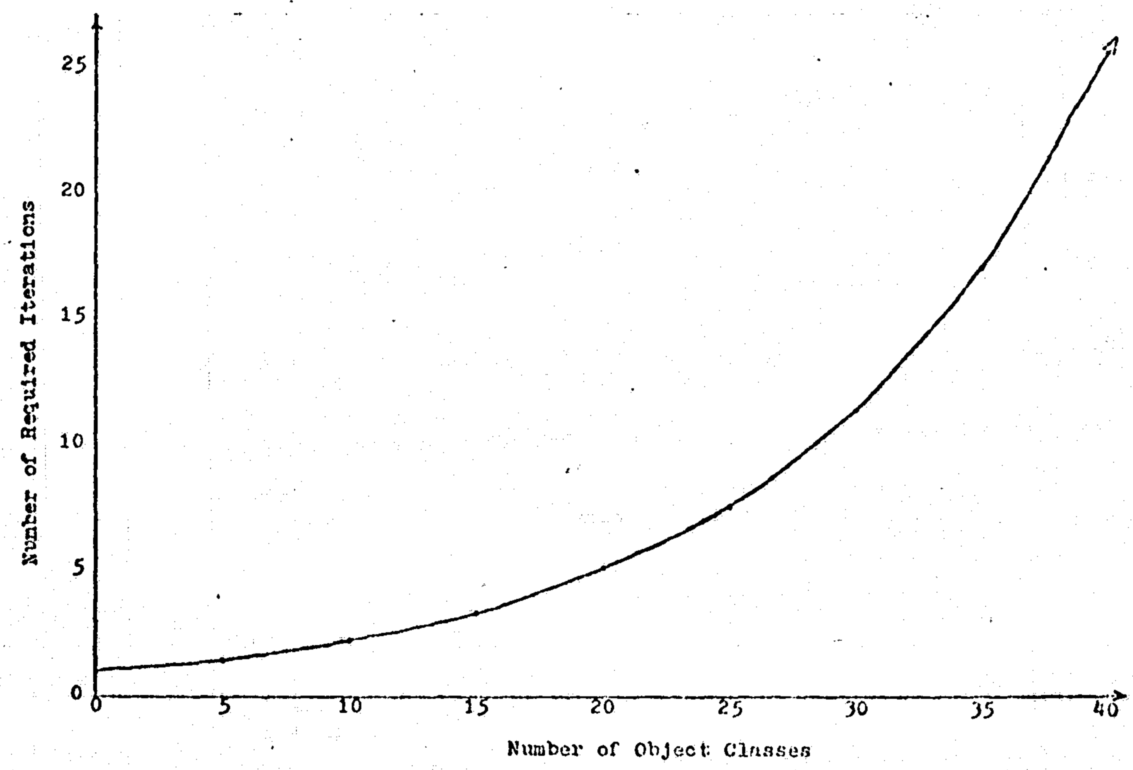

Figure C-4: Number of Maximum Likelihood Iterations Required As A Function of The Number of Classes truth, and cost-sharing through the priority product concept, should allow products to be produced at an acceptable cost.

C.3.5 Table Lookup Classification Algorithms to Speed Classification

The processing costs determined in Table C-4 are very high, and by far the largest contributor to these costs is the 20-iteration, pixel-by-pixel, maximum likelihood algorithm assumed. Table lookup, another means of classification, can speed classification considerably when it is possible to apply this method.

Let us assume for the purposes of this discussion that we must classify a LANDSAT Follow-On image on a CDC-7600 (the situation discussed in Section 4.4). Rather than perform the likelihood calculation for each of the 54,000,000 pixels in the image, the classification can be performed for all possible combinations of values of radiance in the bands under consideration, and stored in a table. The radiance value for each pixel is looked up in the table to find the most likely class, which is far faster than computing the most likely class.

The limitation of this method is that a huge table of data must be stored and quickly accessed. The table size can easily exceed the core size of the computer and much of the speed advantage can be lost. Reducing the number of bands of input data and the range of values within each band used during classification may at times solve this problem. For example, if we have reduced the input to three spectral bands and 64 gray levels (6 bits) in each band, there are $(2^6)^3 = 2^{18} \cong 263{,}000$ possible values. A table of this size will fit in the 650 K byte core of the CDC 7600.

C.3.6 Comparison of Our Estimates to Actual LARSYS Costs

As a check on our cost estimates, we use the method developed here to estimate costs of processing LANDSAT data on LARSYS. We then compare our estimates with the true processing costs realized by a past LARSYS user as shown in Table 4-2.

We estimate using our analytic technique that to process data on an IBM 360/67 would cost \$5.48 per CPU minute. LARS charged \$6.00 per CPU minute as of December 25, 1973 (C-5); currently, LARS charges \$4.83 per CPU minute (C-6). Then we estimate that to classify a full frame of LANDSAT data into 37 classes using the maximum likelihood algorithm would cost \$6975 per iteration. Interpolating in Table 4-2 to find the estimated cost of maximum likelihood classification into 37 classes given by the simple method described in Section 4.3.1, we obtain a figure of \$8100 per iteration.

Comparison of our processing cost estimate with the estimated LARSYS cost thus shows that our cost estimate is low. This is to be expected; our functional descriptions do not completely account for system overhead, etc. In addition, our processing cost does not include salaries for the consultants and other staff required to effectively use a specialized data processing system. The combined estimation method of Section 4.3.3 ameliorates this situation.

APPENDIX D

DATA NEEDS ANALYSES: A BRIEF REVIEW OF RELATED STUDIES

A major element of the EODMS project was to identify in detail the data needs of state, local and regional agencies in a five-state region of Missouri, Illinois, Iowa, Minnesota and Wisconsin. Tn this Appendix, we review briefly several studies which fall broadly within the category of data needs analyses. The first of these reports described below, the TAC Report, was helpful during the formative stages of the project.

The EODMS data needs analysis seems to differ quite significantly from previous work in two critical aspects:

1) In the EODMS project, staff members interviewed, met with and interacted with personnel from many state agencies in the five-state study region over a sustained period of time. The level of interaction was detailed and personal. We returned to agencies to confirm our findings of data needs and to get additional inputs.

2) We defined a set of priority information products to be delivered by an EODMS system through detailed knowledge of agency data needs coupled with an understanding of agency technical and institutional capabilities, and remote sensing technology. The list of priority information products was refined through a continuing process of agency interaction and feedback.

<u>A Study of the Needs and Problems of State Agencies in the Area of Natural Resources and the Environment To Which Remote Sensing Could Contribute.</u> Technology Applications Center, (TAC); University of New Mexico, June 1974.

The Technology Applications Center studied published materials, and a survey team of five members conducted 341 interviews, in order to identify the working level needs of state and local government agencies in the areas of natural resource management, environment, and land-use planning. The first stage output is a list of 520 "problem-statements", some of which are data needs (for example, "determine acreage by crop type", "determine amount of irrigated land"), while others are tasks (for example, "management of grasslands"). After some problem statements are screened out as "not related to remote sensing", (for example, "develop means to study marine fish resources") an attempt is made to match as many as possible of the remainder to technologies currently available or likely to be available in the near future. In assessing the current or likely availability of technologies, project staff relied heavily on published reports of ERTS* principal investigators, and it is emphasized that the P.I.'s conclusions about the feasibility of various technologies are highly tentative. The results of analysis are: 1) "potential near term applications": tasks which may be performed using primarily unaltered ERTS imagery, traditional photo-interpretation equipment, and untrained interpreters, and 2) "potential medium-term applications"; problems for which current research has established the capability of ERTS technology to contribute, but further process development and training are necessary before the technology can become operational in the state environment; precision-processed and/or electronically enhanced imagery, and/or digital data may be required, and hence appropriate equipment and trained personnel.

The TAC study lists the following items as significant areas of concern where remotely sensing can aid in decision making on a national scale:

1) Data to construct inventories of natural and cultural resources.
2) Data to provide national controls on urban encroachment.

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*Now LANDSAT.

3) Data to provide a national basis for protecting water quality.

4) Vegetation mapping.

5) Soils mapping.

6) Data on pest infestations of vegetation.

7) Air pollution detection.

8) Sedimentation in streams and other water bodies.

9) Mineral exploration and mapping of deposits.

10) Flood-plain mapping and flood-effect management

Problems of regional scale which remote sensing might help solve include:

1) Inventory/monitor the marine/freshwater interface.

2) Solid waste disposal.

3) Transportation planning.

4) Water quantity measurement.

5) Saline seep.

6) Acid seep from coal mines.

7) Forest fire mapping.

8) Monitor, control, and eradicate noxious aquatic plants.

9) Maintain navigable channels through ice on waterway.

<u>Information/Data Handling Requirements for Selected State Resource Management Programs</u>. Department of the Interior's Office of Land Use and Water Planning and the U.S.G.S. RALI Program. Technical Supporting Report C (Draft), July, 1975.

The authors attempt to identify data currently used and additional data needed in the administration of four state programs for natural resource protection: wetlands, wild and scenic rivers, coastal zone management, and critical areas.

The authors originally hoped to identify data needs by referring to relevant state and federal statutes requiring resource management programs, but they found this legislation lacking in specificity as to data to be gathered, scale, resolution and format. Consequently they supplemented their analysis of state laws and program materials with consideration of guidelines, permit applications, program evaluations, atlases, applications for federal funds, designation studies, and management plans. Some interviewing of agency personnel was done but the major emphasis of the study was on analyzing needs through the statutory requirements. The result of the study was the production of a handbook to aid states in setting up the information/data handling requirements of resource management programs.

<u>Survey of Users of Earth Resources Remote Sensing Data</u>. Batelle Columbus Laboratories. Columbus, Ohio, March 31, 1976.

This study was performed under NASA User Affairs - Office of Applications sponsorship in response to a request by the Space Applications Board of the National Research Council. It is "a user survey to determine current ERS* data use-user status and recommendations for strengthening use," i.e., the study does not attempt to identify new markets. The survey is limited to users of high-altitude aircraft and satellite (primarily LANDSAT) data, but claims comprehensive coverage of industrial, government, educational, and, to a lesser extent, foreign users. Interview with 389 users were performed and 772 mail surveys were conducted. The study was roughly a one person-year effort over a six-month period.

In the analysis of results, four levels of data use are defined:

<u>Planned/Potential</u> - no or few programs currently using ERS data, but data requirements which ERS can satisfy.

<u>Experimental Use</u> - evaluation of use/application possibilities (involves technical, economic and institutional assessment).

*Earth resources survey.

Quasi-Operational/Demonstrational Use - development and demonstration of a methodology and/or system for routinely using an earth resources survey system.

Routine Operational Use - user financed employment of a methodology and/or system for routinely using satellite data.

The study reached several overall conclusions which the authors state as follows:

1) "An extensive and increasing number of explicit and identifible ERS data users exist.
2) The extent of ERS Data Center* use varies significantly among the user communities.
3) Relative discipline use of ERS data is fairly uniform.
4) The utility of earth resources data varies among users and uses.
5) Significant increase in ERS data users, uses, and value will result from planned and possible improvements in future LANDSAT system capabilities."

The Batelle study also comes to a number of important conclusions concerning state and local users. This sector purchases only one percent of all LANDSAT data. No state was found to use LANDSAT data on a routine operational basis but some found the data to be valuable. "Until LANDSAT data and LANDSAT data products are a routine data base by state user agencies, and until the state users develop confidence in the validity of the data, federal and/or federal regional centers will have to carry the thrust of the research to develop the application systems." The reader is referred to the report, pp. 76-78 for the complete summary and outlook on state and local users.

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*Includes EROS, USDA Data Center in Salt Lake City, NOAA Center in Suitland, Maryland.

Practical Applications of Space Systems. A Study by the Space Applications Board of the Assembly of Engineering, National Research Council. 2101 Constitution Ave., N.W., Washington, D.C. 20410.

NASA was concerned to understand the needs of resource managers and other decision makers as a guide to the development of future space systems for practical applications, and to see how these applications would influence or be influenced by the Space Shuttle System. A "representative group" of users and potential users and academics conducted an intensive two-week study in July 1974 to define user needs that might be met by information or services derived from earth orbiting satellites. This report summarizes the SAB's conclusions upon review of the findings of this two-week study. The report indicates promising future applications, directions for further R&D if certain user needs are to be met, as well as institutional or organizational changes necessary to realize certain socio-economic benefits.

Users were grouped in the following panels: Weather and Climate: Uses of Communications; Land Use Planning; Agriculture, Forest and Range; Inland Water Resources; Extractable Resources; Environmental Quality; Marine and Maritime Uses; and Materials Processing in Space. There were also three non-user panels: Information Services and Information Processing; Costs and Benefits; and Institutional Arrangements. The study concluded that space technology offered significant benefits to users in all of these fields.

As a "needs analysis," the SAB Report relies upon the judgement of users and experts. However, relatively few of the panelists appear to be from state, local and regional government agencies. The agricultural panel appears to have taken the approach of seeing what sensing capability might be available (i.e. 80 meter resolution in 1975 and 30 meter resolution in 1980) rather than start with the perceived needs of individuals working in agencies. A discussion of the SAB's findings on institutional arrangements for a large scale space applications system is included in Appendix E of our EODMS Report.

<u>Recommendations for the Assessment, Inventory and Implementation of A Critical Resource Inventory Program (CRIP) For Wisconsin.</u> February 1, 1974

This study, funded by the Upper Great Lakes Regional Commission and the Department of Administration, State of Wisconsin, was produced by the Environmental Monitoring and Data Acquisition Group, Institute for Environmental Studies, University of Wisconsin, Madison.

The object of the study was to define, inventory and assess Wisconsin's critical resources in order to plan their use. This involved the investigation of existing and potential information sources, and recommendations regarding an information system for the state. "Significant" and "critical" are defined in relation to resources. Procedures for measuring relative criticality are established. During the CRIP investigation, there was extensive communication with planners in Wisconsin and in other states.

Some of the conclusions of this study which are relevant to data needs include the following:

1) Data gathering should be designed to better meet data needs.
2) Additional funds should be allocated for data gathering.
3) There should be a recognition of data needs for all phases of critical area management.
4) Scarce funds should be allocated to essential data.
5) There is a need to define specific program needs.

6) There is a need for combination and coordination of data gathering efforts involving several levels of government.

7) Data gathering priorities need to be established.

8) Some data gathering should be done by land developers.

State Government Activities in Remote Sensing. Ambionics Incorporated, November 1975. (NASA-CR-147927). Prepared under NASA Contract NASW-2756.

The Ambionics report is a survey of state agency activity in remote sensing. The basic method for the survey appears to have been telephone interviews with agency personnel involved in remote sensing activities. The Ambionics group interviewed persons in every state and also performed a literature review for documents relating to state agency remote sensing applications in regional interstate agencies, federal agencies and the private sector. The result of that work was a "Users Reference Manual" on remote sensing applications.

The results of the current work suggest that application of LANDSAT-type data in land resource planning and management will come about through the efforts of state and federal agencies or through a regional approach. It was also suggested that it is unlikely that cities and other localities will ever become major direct users of satellite imagery in the near future, although the reason for this conclusion is not stated.

Natural Resource Data Needs and Recommendations. The Council of State Governments, Lexington, Kentucky, February 1976.

This report is an attempt by a consortium of five groups (The Council of State Governments, Institute for Environmental Studies of the University of Wisconsin, American Society of Planning Officials, Arthur D. Little, Inc. and the U.S. Geological Survey) to identify the users of land resources data and their specific data needs. After lengthy consideration of the needs and problems of land resource agencies, the report presents a list of 18 summary recommendations regarding data needs and agency policy to meet them. Recommendations are grouped into three major categories: i) data users and data needs; ii) data users and formal needs; and iii) accessibility and responsiveness in the provision of data.

The study was designated to support a USGS Resource and Land Investigations (RALI) Program goal of improving the responsiveness of USGS programs to user agency needs.

Some of the recommendations of the report most relevant to data needs are as follows:

1) In urban, urbanizing or other areas confronted with the possibility of near term future developments, soils, geologic, and hydrologic mapping should continue.

2) Production of USGS, 7 1/2 minute topographic maps should continue.

3) Aerial photography and orthophotoquad production should continue.

4) Federal agencies should continue their involvement in flood plain mapping.

5) The provision of detailed maps or data products should become a regularized and readily accessible service to state data users.

On State Use of Satellite Remote Sensing. National Conference of State Legislatures, Denver, Colorado, August 1976.

With support by NASA, the National Conference of State Legislatures (NCSL) appointed a Task Force to review the applications and limitations of the LANDSAT Follow-on Program. The NCSL report evaluates the following five subject areas:

1) The proposed capabilities of LANDSAT Follow-on.

2) Existing satellite applications used by state agencies.

3) Existing state and federal legislation and regulations which mandate state natural resource programs.

4) The inferred data needs of these programs.

5) An analysis of the feasibility of the Follow-On Program to meet those needs.

The Task Force made the following recommendations:

1) Congress should make a firm commitment to insure the operational status of the satellite system.

2) The states should take responsibility of providing some form of support for this system.

3) For an effective technology transfer process, NASA, in its research and development role, should establish or employ an agency or firm of an operational nature to carry out this process.

4) Both the private sector and universities should be encouraged to attempt development of effective, inexpensive data products for state use.

5) It is important to inform and update state legislatures regarding the potentials and limitations of this technology system for their states.

6) Regional user assistance centers should be established.

APPENDIX E

OUTLINING EODMS SYSTEM ALTERNATIVES: A BRIEF REVIEW OF RELATED STUDIES

Several previous studies, to varying degrees, address the problem of outlining EODMS alternatives considered in Chapter 6. In this Appendix, we provide brief summaries of those studies we are aware of which seem most germane to this effort.*

Our analysis of EODMS alternatives represents a step beyond previous analyses because we have made an effort to integrate technical, economic and institutional considerations into the analysis of alternatives, based on carefully examined user needs. Some of these elements are present in previous reports but none appears to have taken a comparable wholistic approach. Other basic differences include the heavy emphasis on state, local and regional requirements in the EODMS study and its end-to-end systems approach, from data acquisition to product delivery.

Report of the Federal Mapping Task Force on Mapping, Charting, Geodesy and Surveying. Office of Management and Budget, July, 1973.

A federal task force was established under the Office of Management and Budget in cooperation with the Departments of Interior, Commerce, Agriculture and Defense to review the status of federal mapping, charting and geodetic programs. Their review was motivated by three major problems:

1) A rapid growth of uncoordinated non-cumulative single purpose surveying and mapping activities which benefit only one user.

2) A growing body of unmet national needs for products and data.

3) An inability on the part of the federal mapping community to deal efficiently and responsively with these needs.

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*Information on computerized geographic information systems is included in Appendix F.

The review prepared by the task force comes to several conclusions regarding mapping efforts which are significant for the EODMS concept. Specifically, the mapping task force recommends that all federal mapping activities be placed under the aegis of a new federal agency.* It also recommends more interaction with the user community, a greater sensitivity to non-federal agency information requirements, and a greater degree of cooperation between defense and civilian mapping agencies which is stated to be needed in order to facilitate transfer of new automated technologies to the civilian sector. An extensive analysis of functions in existing agencies which could be transferred to a new mapping agency is also included.

<u>Food Information Systems: Summary and Analysis</u>. Office of Technology Assessment, United States Congress. August 1, 1976.

This report was produced by the Office of Technology Assessment at the request of the United States Congress. It was designed to answer the following questions about U.S. food information systems:

1) Why had the U.S. food and agriculture information systems failed to give warnings of impending shortages?

2) Are existing food and agriculture information systems adequate?

3) Have appropriate steps been taken to correct the deficiencies that existed in 1972-73?

While the substance of this report may not be directly related to the subject of EODMS design, some of the aspects of the food and agriculture information programs it discusses are relevant. In particular, the OTA report discusses the impacts of the LANDSAT and LACIE (Large Area Crop Inventory Experiment) programs on improving the flow and continuity of information.

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*Some of the ideas developed in this report were used in outlining the System B alternative in Chapter 6.

Three conclusions of interest are:

1) The major problem with use of LANDSAT data in food and agriculture information systems is the inability to use or experiment with the data on a near real-time basis.

2) A centralized multidisciplinary data processing and analysis facility should be established.

3) An early decision to authorize a continuing LANDSAT program would speed the adoption and broaden the use of remotely-sensed data.

Practical Applications of Space Systems. Space Applications Board of the Assembly of Engineering, National Research Council, Washington, D.C. 1975.

This report has been discussed earlier in Appendix D. The SAB work covers both data needs and analysis of possible institutional arrangements to manage satellite-based data gathering. The institutional arrangements section of the report is summarized here. Particular emphasis was placed on those arrangements which would serve in a transition period from the current experimental situation to full operational status.

It was concluded that there "exists at present no institutional mechanism that permits the large body of potential users --- to express their needs and to have a voice in matters leading to the definition of new systems." A mechanism is needed to provide general policy direction, set priorities, establish pricing policy, provide for communication between users and providers, and encourage non-federal investment.

The Board considered four options:

Option I - An Existing Operating Agency

Option II - A New Agency Established for the Purpose

Option III - A Space Applications Corporation Chartered by the Congress.

Option IV - A Congressionally Mandated National Council.

After weighing the advantages and disadvantages, the Board recommended that there be established by statute a National Space Applications Council, charged with responsibility for the functions described above. They also believe that a Congressionally-chartered Space Applications Corporation (or Corporations) will come into being, but not for at least three to five years.

The Role of the State University in Developing Land Use Planning Information Systems in New York State, October 1975.

This study was financed by a small grant from the SUNY Institute for Public Policy Alternatives, to explore "the possibilities of bringing the information needs of public decision makers and the research resources of the university more closely together in the future formulation of land use policy within New York State." Project staff interviewed state planners and produced a list of fourteen "land use categories" (e.g., wildlife habitats, population density, vegetative cover) for which the planners would like to obtain "more, better, or indeed any information....to make better informed policy decisions." Planners reported the need for a sophisticated system of land use information that "has flexibility and can be rapidly updated", is easy to use and highly accessible to the public. This system would replace the existing New York land use information system (LUNR).

ERISTAR, Earth Resource Information, Storage, Transformation, Analysis and Retrieval - Final Report, Auburn University - NASA, Marshall Space Flight Center, September 1972. NASA Grant NGT-01-003-044.

The ERISTAR report presents the results of a 1972 summer systems design study directed by Prof. R. Vachon of Auburn University and involving participating faculty from 17 universities. ERISTAR, an acronym for Earth Resources Information Storage, Transmission, Analysis and Retrieval, represents "an earth resources information management network of state information centers administered by the respective states and linked to federally administered regional centers and a national center." The study starts with the premise that "there should be a national information management system under the auspices of the Federal Government," but does not conclude that the system should be totally federally administered. The report considers a variety of alternative approaches to an ERISTAR network along a limited set of dimensions and spells out the operation and implementation of one such alternative in considerable detail, accompanied by consideration of several tradeoffs. "ERISTAR is a user-oriented system," with a national center and regional and state centers.

Although the ERISTAR study represents a useful effort and contains a great deal of information, it does not rest upon a detailed analysis of user needs. The report does not appear to incorporate detailed cost considerations as in Chapter 4 of our report. It was carried out at a time when a proposal existed in the federal government to establish a Department of Natural Resources and the ERISTAR system's design may reflect this emphasis. In our EODMS study, several other major alternatives were also considered.

Land Satellite Project - General Accounting Office, January 1976. Report P3AD-F6-F4.

This study was performed by the General Accounting Office in order to advise Congress on the progress and management of NASA's LANDSAT programs. The study is primarily concerned with the need and expected benefits of the project; project status; progress related to costs, schedule, performance; and international implications.

The analysis reports on the budgetary status of the LANDSAT programs, the need for improvements and improved user relations, the need for long-range planning and a decision on whether LANDSAT should be made operational.

Various international problems related to the use of LANDSAT data are also explored.

The GAO study came to the following conclusions and recommendations:

1) Congress should have the most up-to-date and complete cost estimates for the LANDSAT program.

2) NASA should estimate the costs of the LANDSAT - C principal investigator program.

3) NASA should develop a plan for providing formal training to LANDSAT data users.

4) A plan for meeting the requirements of the various users should be developed as sensor technology improves.

5) NASA should take a leading role in defining the need for an operational LANDSAT program.

User Data Dissemination Concepts for Earth Resources (UDDCER) Systems Control, Inc. and Aeronutronic Ford Corporation, prepared for NASA Ames Research Center, June, 1976.

The study considers systems for disseminating earth resources satellite data (particularly advanced LANDSAT - type Data) to a dispersed user community on a rapid turnaround basis. The study timeframe is 1985-1995 and has several major objectives, among which are:

1) To develop a flexible parametric system approach, or methodology for the evaluation of network configurations for the dissemination of earth resources data.

2) To configure several data dissemination networks which would satisfy predicted user requirements.

3) To identify key technology developments to implement these data dissemination networks.

The UDDCER study made basic assumptions about the satellite network which would be available to supply the raw data and about the data loads user needs in the 1985-1995 timeframe might impose. Two satellites are assumed to provide coverage, one sun-synchronous and one geostationary, of the continental U.S. and Alaska. A user survey was conducted which seems to have concentrated primarily on federal agencies, although some state agencies were contacted. The system would supply preprocessed "raw" satellite data to the user community. The report outlines the required system parameters and the configuration necessary to deliver the preprocessed data in a timeframe of a few hours to two days.

The system configuration which the UDDCER study concludes would be most useful would consist of a central preprocessing center linked by domestic communications satellite to data reception stations at the regional and/or state level. The focus of the study seems to be on how to get "raw" data rapidly to users. It does not consider delivery of interpreted "priority products." The UDDCER study appears to be devoid of consideration of non-technical factors which might influence the design of an EODMS.

<u>TERSSE: Definition of the Total Earth Resource System for the Shuttle Era.</u> General Electric Space Division Report, Sponsored by NASA Johnson Space Center, March 1975. (Executive Summary and Eight Volumes)

This major study performed by GE's Space Division assisted by the Environmental Research Institute of Michigan has the following objectives:

"To define system performance requirements for the total operational and research Earth Resources System in the 1980's.

To identify critical research and technology development needs.

To define the role of Space Shuttle in the total System."

The methodology employed was to examine user needs, develop Earth Resources System (ERS) mission requirements, define the system and role of the space shuttle in it. Requirements of five federal organizations (Interior, USDA, NOAA, EPA and the Corps of Engineers) were analyzed.

In addition, over 100 non-federal organizations were analyzed, many by direct interview.* The Executive Summary of the TERSSE Report doesn't break out the fraction of these organizations which are state, local or regional agencies. Private sector users included in non-federal requirements are highlighted.

A conclusion of the TERSSE study is that "future operational systems should be tailored to individual resource management missions. There is not one system, but several, in the future Earth/Resources Program." Thirty such resource management missions are defined for the 1980's, in the broad categories of Agriculture, Energy/Minerals, Forest, Land, Marine, Water. A total systems architecture is then constructed, based upon requirements for platforms, sensors and ground systems for these missions. It is concluded that the best system concept is "a hierarchical architecture with distributed extractive processing and centralized preprocessing and that "future systems will be more like current NOAA and DOD programs," that is, oriented to specific "disciplines" or even sub-missions within those disciplines. Thus the result is somewhat similar to the approach taken in System A of Chapter 6 of our EODMS Report.

The TERRSE Report uses a "classical systems approach" to the problem of defining systems. There appears to be little, if any, consideration of the institutional and political issues to be faced in creating an operational EODMS. The emphasis on defining individual missions results in a lack of consideration of the substantial economies which are possible (see Chapter 4, EODMS Report) by taking advantage of overlaps in data

*The user requirements portion of the TERSSE study might have been classified as a "Data Needs Analysis" and included in Appendix D.

inputs to priority information products of interest to state agencies.

Some additional TERSSE conclusions are as follows:

1) Different sensor and platform configurations (systems) should be tailored to different resource management missions.

2) Multi-platform systems are required.

3) Scanner development requires steady progress.

4) Satellite data must be processed in combination with data from other sources.

5) User model development should be emphasized.

6) The space shuttle has an important role to play in future earth resource missions.

Earth Resource Ground Data Handling Systems for the 1980's. NASA Technical Memorandum NASA TM X-62, 240, Ames Research Center, March 1973.

In a March 1973 report, Van Vleck et al. examined earth resources ground data handling systems for the 1980's. The study contains a summary of requirements for earth resources disciplines and derived relationships between tasks accomplished in various applications sectors and spatial resolution. Although firm user requirements were not available, the analysis indicates "that a data rate on the order of 2×10^{11} bits per day will be generated, and a ground resolution on the order of ten to twenty meters will be required" to handle some 75-90% of all requirements. A range of system alternatives were explored, with emphasis upon technical aspects.

APPENDIX F

STATE LEVEL ACTIVITIES IN REMOTE SENSING AND COMPUTERIZED GEOGRAPHIC INFORMATION SYSTEMS

F.1 INTRODUCTION

EODMS project staff developed information on applications of remote sensing and use of automated geographic information systems in the five state study region. The study of geographic information systems was later extended to assessment of such activities in all 50 states. In addition, a number of geographic information systems were evaluated in detail in order to find out what factors seemed to be critical for their success.

In this appendix, we summarize the results of these studies very briefly. For considerably more detail the reader is referred to various EODMS reports, including the Preliminary Needs Analysis Report (Chapters 2, 3, and 4) (F-1) and the thesis by Power. (F-2)

The first section of this appendix is a summary of remote sensing activities in the five state region. The second section summarizes the work on geographic information systems.

F.2 REMOTE SENSING ACTIVITY IN THE FIVE STATE REGION

F.2.1 Physical Description of the Region

This study focuses primarily on the five-state midwestern region consisting of Illinois, Iowa, Minnesota, Missouri and Wisconsin (see Figure F-1).

The region's major urban areas include Minneapolis-St. Paul, Milwaukee, Chicago, Des Moines, St. Louis and Kansas City. The Missisisppi River divides the region and with its tributaries has a significant effect on all five states. Two of the states border on the Great Lakes and one shares an international boundary with Canada. Besides its many waterways,

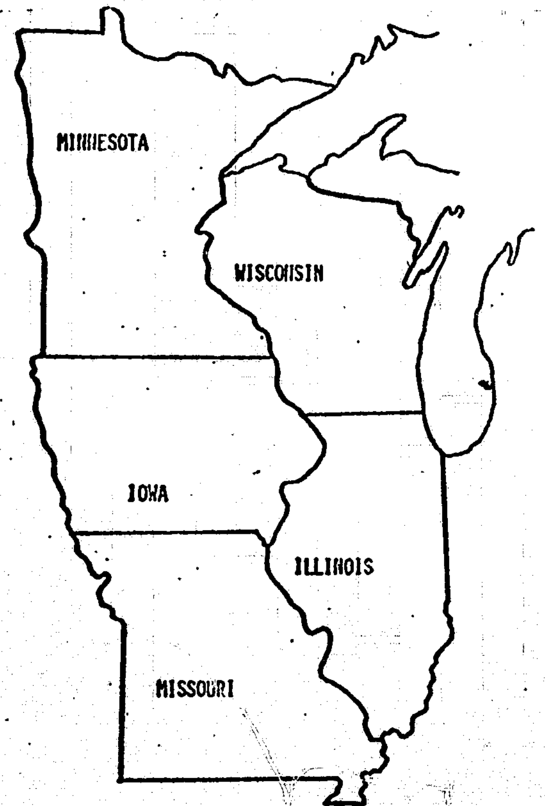

Figure F-1: Five-State Study Region

the region has a variety of other geological features including plains, mountains and forests. Associated with the plains located in the western portion of the region is extensive agricultural activity. Throughout the area occur mining and drilling activities for coal, ferrous and non-ferrous metals, and petroleum. The region is located entirely within the temperate zone so weather conditions vary seasonally with the occurence of frequent floods, tornadoes, severe storms and extremes of temperature.

F.2.2 Government Organization and Remote Sensing Activities in the Five-State Region

Agencies with responsibilities for Earth resources tasks in the five-state region exist at all levels of government from local to federal. Many levels of responsibility exist in a given discipline or application area with differing degrees of responsibility and authority associated with different levels. There are many differences among the states as to which agency or level is responsible for carrying out various tasks. Chapter 3 and 4 of the PNA Report (F-1) contain detailed information on organization for Earth resources tasks. Appearing there also are exhaustive descriptions of sub-state regional authorities such as regional planning organizations, '208' planning districts, transportation authorities, councils of government and sewer districts. Some of these regional agencies have interstate jurisdictions.

Within the five-state region, the range of remote sensing activities underway includes a cross-section of federal, state, local, regional and private sector programs. All types of remotely sensed data are in use, including satellite, high and low altitude aircraft and various ground-based methods. Table F-1 shows the wide variation in range and level of remote sensing activities according to the state agency(s) responsible for Earth resources tasks in each of eleven applications areas as of December

Table F-1: Summary of State Agency Remote Sensing Activities

Application	Illinois	Iowa	Minnesota	Missouri	Wisconsin
Agriculture	Dept. of Agriculture 3	Dept. of Agriculture 3	Dept. of Agriculture 3	Dept. of Agriculture 3	Dept. of Agriculture 3
Climate and Weather	Dept. of Registration and Higher Education Water Survey 1,2		State Climatologist Div. of Waters Dept. of Natural Resources State Planning Agency 3		
Environment	Environmental Protection Agency 1,3	Dept. of Environmental Quality 1,3	Pollution Control Agency Environmental Quality Council 1,3	Dept. of Natural Resources Div. of Environmental Quality 1,3	Dept. of Natural Resources Div. of Environmental Standards Div. of Services Environmental Impact 1,2,3
Fisheries	Dept. of Conservation Div. of Fisheries 3	Conservation Commission Fisheries Section 1,3	Dept. of Natural Resources Div. of Fish and Wildlife 3	Dept. of Conservation Div. of Fisheries 1,3	Dept. of Natural Resources Div. of Forestry, Wild-life, and Recreation Fisheries Section 1,3
Forestry	Dept. of Conservation Div. of Forestry 3	Conservation Commission Forestry Section 1,3	Dept. of Natural Resources Div. of Lands and Forestry State Planning Agency 1,3	Dept. of Conservation Div. of Forestry 1,3	Dept. of Natural Resources Div. of Forestry, Wild-life, and Recreation Forestry Section 1,3
Geology and Mineral Resources	Dept. of Mines and Minerals Geological Survey 1,3	Dept. of Soil Conservation Geological Survey 1,2	Dept. of Natural Resources Div. of Minerals Geological Survey State Planning Agency 3	Dept. of Natural Resources Geological Survey 1,2,3	Geological Survey 3

Key: 1 Technical capability for remote sensing generation or analysis
2 Remote sensing research program
3 User of externally generated remote sensing data

Table F-1: Summary of State Agency Remote Sensing Activities (continued)

Application	Illinois	Iowa	Minnesota	Missouri	Wisconsin
Land Reclamation	Dept. of Mines and Minerals Div. of Land Reclamation 1,3	Dept. of Soil Conservation Div. of Mines and Minerals 1,3	Div. of Minerals Dept. of Natural Resources 3	Dept. of Natural Resources Div. of Environmental Quality Land Reclamation Program 1,3	
Land Use Planning	Dept. of Local Government Affairs Office of Research and Planning 3	Office of Planning and Research 3	State Planning Agency 3	Office of Administration Div. of State Planning and Budget Regional State Office of Planning 3	Dept. of Local Affairs and Development Div. of State-Local Affairs Bureau of Local Regional 3
Transportation	Dept. of Transportation Div. of Aeronautics Div. of Highways 1,3	Commission of Aeronautics State Highway Commission 1,3	Dept. of Aeronautics Dept. of Highways Dept. of Transportation 1,3	Highway Dept. Dept. of Transportation Div. of Highway Safety 1,3	Dept. of Transportation Transit Right-of-Way Authority 1,3
Water Resources	Dept. of Transportation Div. of Waterways Dept. of Registration and Higer Education Water Survey 1,2	Dept. of Enviornmental Quality Div. of Water Quality Geological Survey Natural Resources Council 1,2	Dept. of Natural Resources Geological Survey Div. of Water Lakeshore and Flood Plain Zoning State Planning Agency 1,3	Dept. of Natural Resources Div. of Enviornmental Quality Clean Water Commissions Geological Survey 1,3	Dept. of Natural Resources Div. of Environmental Standards Bureau of Water Quality Div. of Enforcement Bureau of Water Regulation and Zoning 1,3
Wildlife	Dept. of Conservation Div. of Wildlife 3	Conservation Commission Wildlife Section 1,3	Dept. of Natural Resources Div. of Fish and Wildlife 1,3	Dept. of Conservation Div. of Wildlife 1,3	Dept. of Natural Resources Div. of Forestry, Wild-life and Recreation Bureau of Wildlife and Fisheries Wildlife Section 1,3

Key: 1 Technical Capability for remote sensing generation or analysis
2 Remote sensing research program
3 User of externally generated remote sensing data

1975. The numbers appearing in the table indicate an agency's: (1) technical capability to generate remotely sensed data in-house, (2) performance of remote sensing research, or (3) use of externally-generated data. In many cases more than one number applies to a single agency.

Activities in each of these agencies are discussed in detail in Chapter 3 of the Preliminary Needs Analysis Report. Many, if not most, natural resources and other geographically-oriented agencies have used or tried to use remotely sensed data on one or more occasions. Most agencies are aware of LANDSAT data, but most are unable to do much with it with existing funds, personnel, and access. Also, for agencies which have been heavy users of high resolution aerial photography such as highway departments and urban planning agencies, current LANDSAT resolution is usually inadequate.

Three of the five states have established interagency groups to coordinate the gathering, use and distribution of remotely sensed data within the state government. In Illinois, a NASA employee on loan to the state has informally provided coordination of remote sensing activities. The Iowa Geological Survey and the Missouri Interdepartmental Council for Natural Resources Information accomplish this purpose for their respective states.

Besides the state and sub-state remote sensing activities, several university personnel in the region have worked as ERTS (LANDSAT) Principal Investigators (PI's). A few additional universities have Remote Sesning Centers or related activities which provide technical advice and perform research. In Chapter 3 of the PNA are lists of PI's, university centers and study groups that are or have been involved in remote sensing application or technology research.

A wide variety of federal remote sensing programs are or have been underway in the five-state region. Several federal agencies have sizeable facilities in the region which are using remote sensing or remote sensing information. These federal organizations include the USGS, the USDA, the Department of the Interior and the Department of Defense.

The private sector currently provides, under contract, much of the remotely sensed data used by state, regional and local governments. Private companies in the utility, mining, and petroleum industries are major users as well as sources of remote sensing data.

F.2.3 Developments in Computerized Geographic Information Systems

Many states, federal agencies, and local jurisdictions have experimented with or implemented computerized geographic information systems. We analyzed over thirty such systems at several levels in order to learn something of the functional nature of their operations and to try to determine what factors might explain the degree of success they have achieved, if any. For eleven systems, thirty-one functional attributes were examined such as ownership, products available, funding sources, problems encountered and so on. The analysis was based on interviews with system personnel, published reports, and other compendia. Success, as measured by user satisfaction rather than engineering performance, was found to be highest for those systems developed in-house by people familiar with user needs and for systems designed to meet a few needs well. Systems appear to be better received when they can produce map and photographic, as well as computer outputs. The field is quite young and it is too early to judge the ultimate success of many systems.

In addition to these detailed analyses, we also catalogued all known state-level activities in computerized geographic information systems.

The results appear as Table 2-19 in the Preliminary Needs Analysis Report. Some level of activity was noted in 37 states, including all five of the study region states, as of October 1975.

APPENDIX G: CURRENT FEDERAL SYSTEMS RELEVANT TO EODMS DEVELOPMENT*

G.1 PRESENT SYSTEM FOR LANDSAT DATA DISSEMINATION

Figure G-1 depicts the current experimental system for handling and dissemination of LANDSAT data. Satellite images are sent in digital form to several receiving stations, from which they are sent to NASA's National Data Processing Facility (NDPF) at Goddard Space Flight Center. Some radiometric and geometric correction is performed to produce images and the data are recorded on high density digital tapes (HDDT's) or computer compatible tapes (CCT's). The tapes are then sent to the USGS's EROS data center in Sioux Falls, South Dakota, and to USDA's Aerial Photography Field Office (APFO) in Salt Lake City, Utah. The EROS Center produces photographic imagery for sale. EROS does not interpret the product into themes; users must perform their own interpretation. The APFO supplies LANDSAT data to USDA users but does not generally disseminate to a wider user community.

EROS maintains a data base management system capable of determining which data are available to fill a user request. The system delivers imagery products on demand rather than on a regular schedule, but some users have standing orders for all data covering a given area. The biggest user of this uninterpreted data is the private sector; for example, major oil corporations have been acquiring LANDSAT data and performing their own interpretation. Although some state agencies do utilize data from EROS, effective utilization is currently hampered by their lack of technical capability and by the high cost of interpretation.

*See Appendix F and references (G-1, G-2) for discussions of computerized geographic information systems and remote sensing activity in federal, state and local agencies.

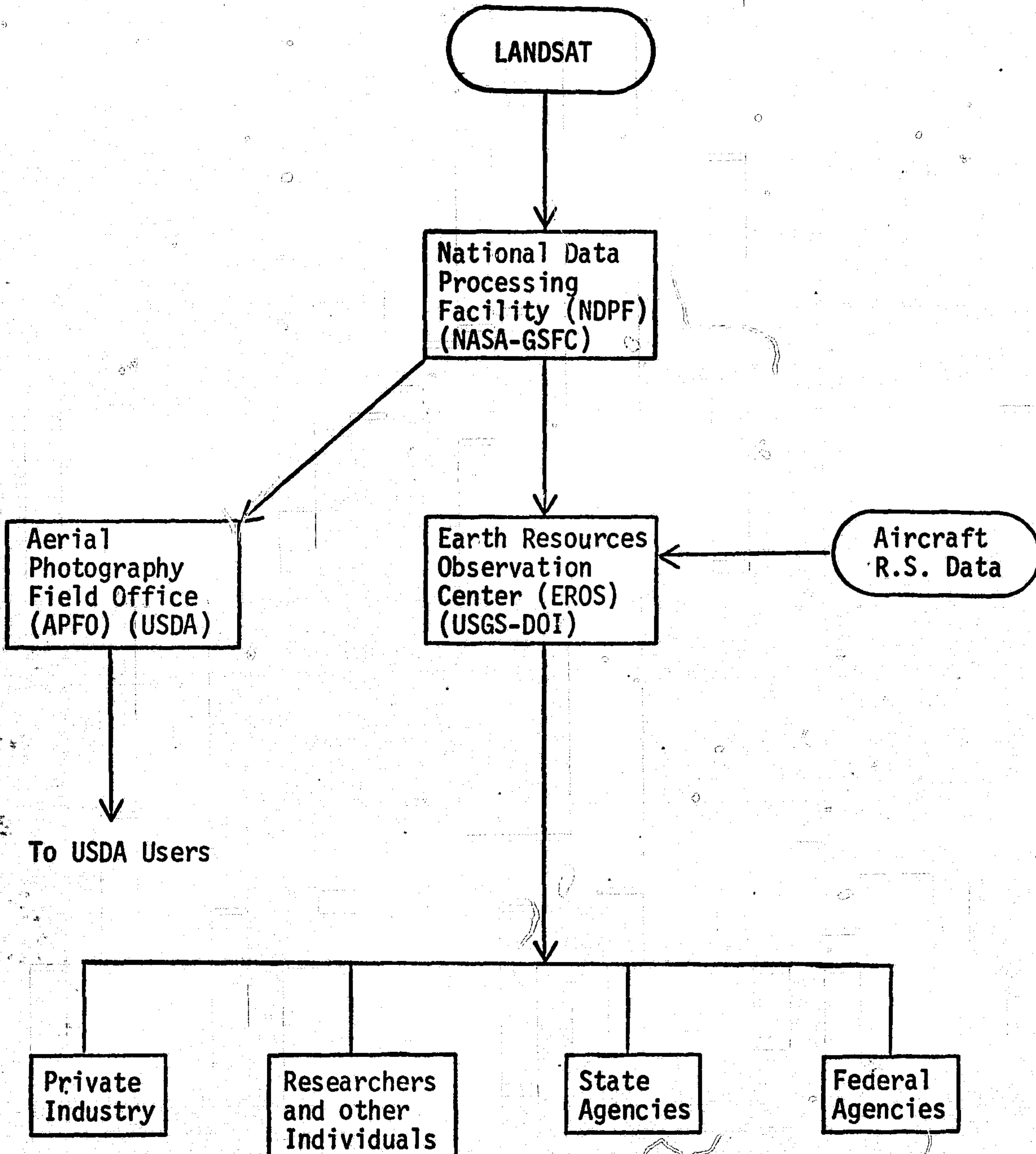

Figure G-1: Current Experimental System for LANDSAT Data Dissemination

EROS also plans to develop a sophisticated, all-digital system for correction of the data to finer specifications than is now possible (G-3) and to preprocess digital data for delivery to users within a few days. However, no interpreted products will be produced in the sense that they are defined in Chapter 4.

G.2. NATIONAL CARTOGRAPHIC INFORMATION CENTER

The USGS National Cartographic Information Center (NCIC) represents a major source of government information in the form of maps, imagery, digitized maps and imagery, and geodetic data. NCIC has branches at the four regional USGS Mapping Centers at Reston*, Va., Rolla, Mo., Denver, Colo., and Menlo Park, Calif., and would like to establish branch offices in all 50 states, with computer links to NCIC centers. The NCIC constitutes a potentially important move toward fulfilling the EODMS system functions of access, retrieval and transfer of data, particularly in view of the preponderance of map formats among the priority products.

At present NCIC can either sell information products or refer requests to an agency which can provide the information. NCIC has been systematically acquiring information on what cartographic data exists in order to: a) make existing data accessible, b) help coordinate high-altitude aircraft imagery acquisition, and c) influence emerging data handling systems within individual federal agencies.

NCIC is now implementing a computerized Aerial Photography Summary Record System (APSRS) which will be capable of listing sources of available imagery in response to queries regarding any given geographic area. These queries may specify the area of interest by county, by quadrangle (i.e.,

*NCIC headquarters are in Reston, Va; the mapping center there has capability for performing specialized tasks over and above those at the other mapping centers.

7 1/2' USGS topographic map) or by quadrilateral (four corner method).

G.3 OTHER CURRENT ACTIVITY

Several other federal government agencies are likely to be involved in a public sector EODMS, including the U.S. Department of Agriculture, the Bureau of Land Management, and the U.S. Forest Service. Each of these agencies is active in planning information system development. We have outlined the activities of these agencies and some brief scenarios for single agency data management sytems in a previous report.(G-3)

The Defense Mapping Agency (DMA) of the Department of Defense conducts its own domestic and foreign earth observation program. Some of the DMA activity is classified and therefore unavailable to the civilian sector. Thus we have considered the development of a civilian public sector EODMS separate from the military sector but with some interaction.

The NOAA Environmental Data Service at Camp Spring, Maryland, disseminates satellite data to the National Weather Service. This system is an example of an operational, disciplinary system. NASA's role is limited to launching weather satellites, for which it is reimbursed by NOAA.

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