Current and Potential Uses for GIS in Academic Arctic Research

Michael F. Goodchild
University of California
Santa Barbara

Workshop objectives

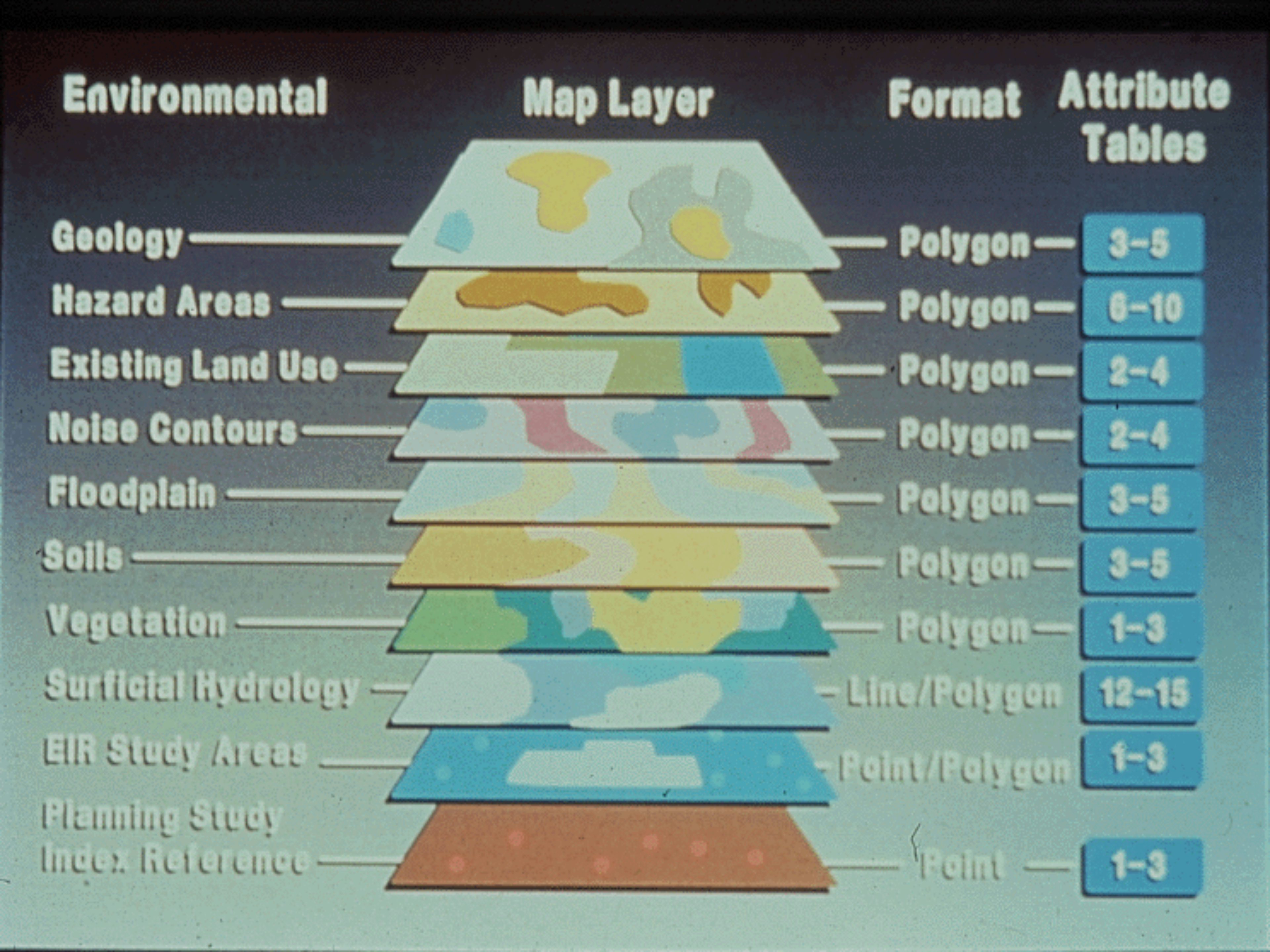
- To promote the creation and flow of georeferenced data and related discoveries
- Consistent with current thinking about GIS
  - technology for communicating what we know about the planet's surface in digital form
  - extending what we know

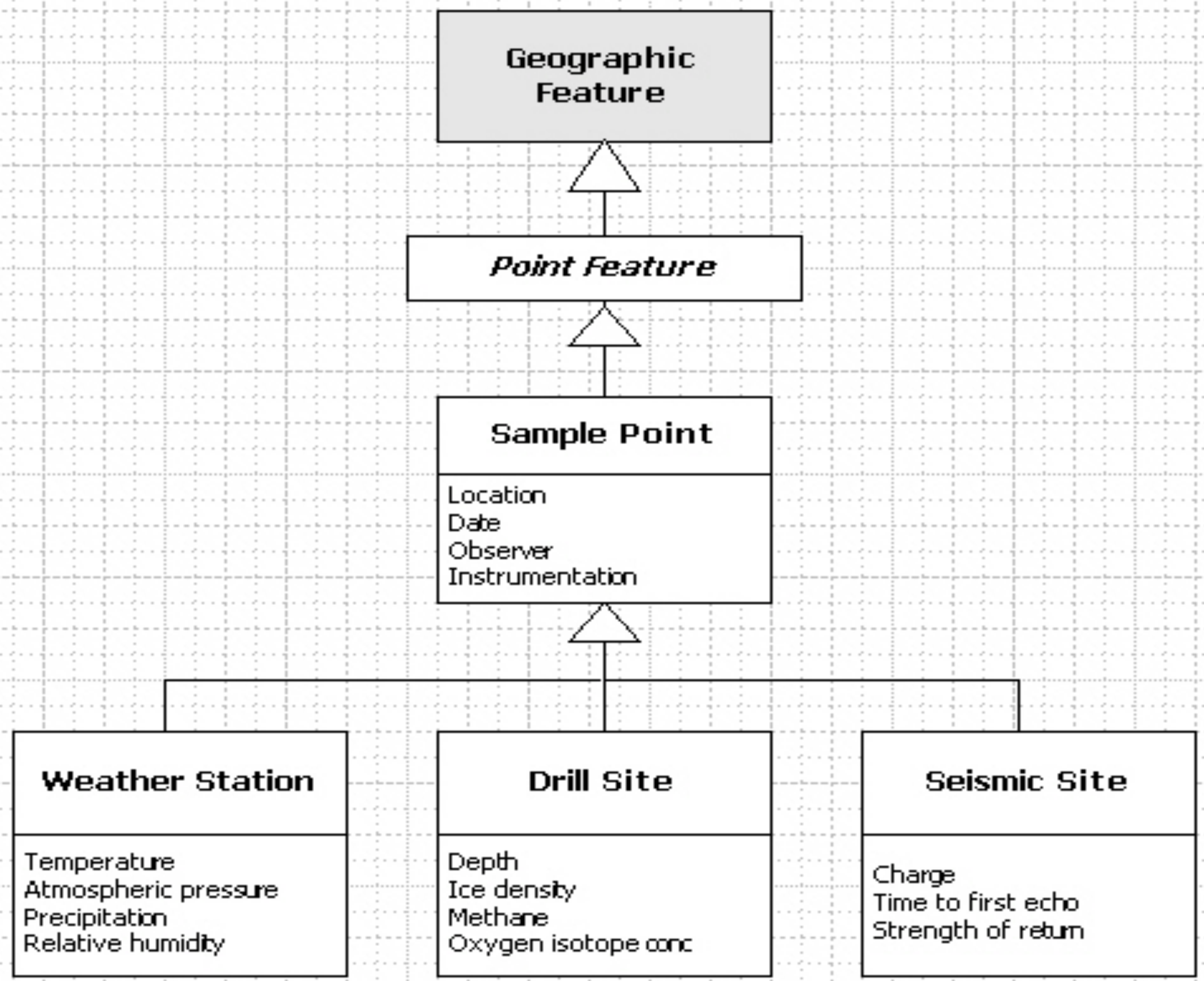
Outline

- GIS
  - functionality and representation
- Geolibraries
  - storing and disseminating
- The Arctic context
- The user perspective

GIS basics

- Geographic information
  - associates points on the Earth's surface with properties (and times)
  - the atomic fact $<\boldsymbol{x},t,\boldsymbol{z}>$
  - maps, Earth images
  - a container of maps and Earth images in digital form
  - organized in layers
    - or in classes of objects


Environmental
Map Layer
Format
Attribute Tables
Geology
Polygon
3-5
Hazard Areas
Polygon
6-10
Existing Land Use
Polygon
2-4
Noise Contours
Polygon
2-4
Floodplain
Polygon
3-5
Soils
Polygon
3-5
Vegetation
Polygon
1-3
Surficial Hydrology
Line/Polygon
12-15
EIR Study Areas
Point/Polygon
1-3
Planning Study Index Reference
Point
1-3


Geographic Feature
Point Feature
Sample Point
Location
Date
Observer
Instrumentation
Weather Station
Temperature
Atmospheric pressure
Precipitation
Relative humidity
Drill Site
Depth
Ice density
Methane
Oxygen isotope conc
Seismic Site
Charge
Time to first echo
Strength of return

GIS functionality

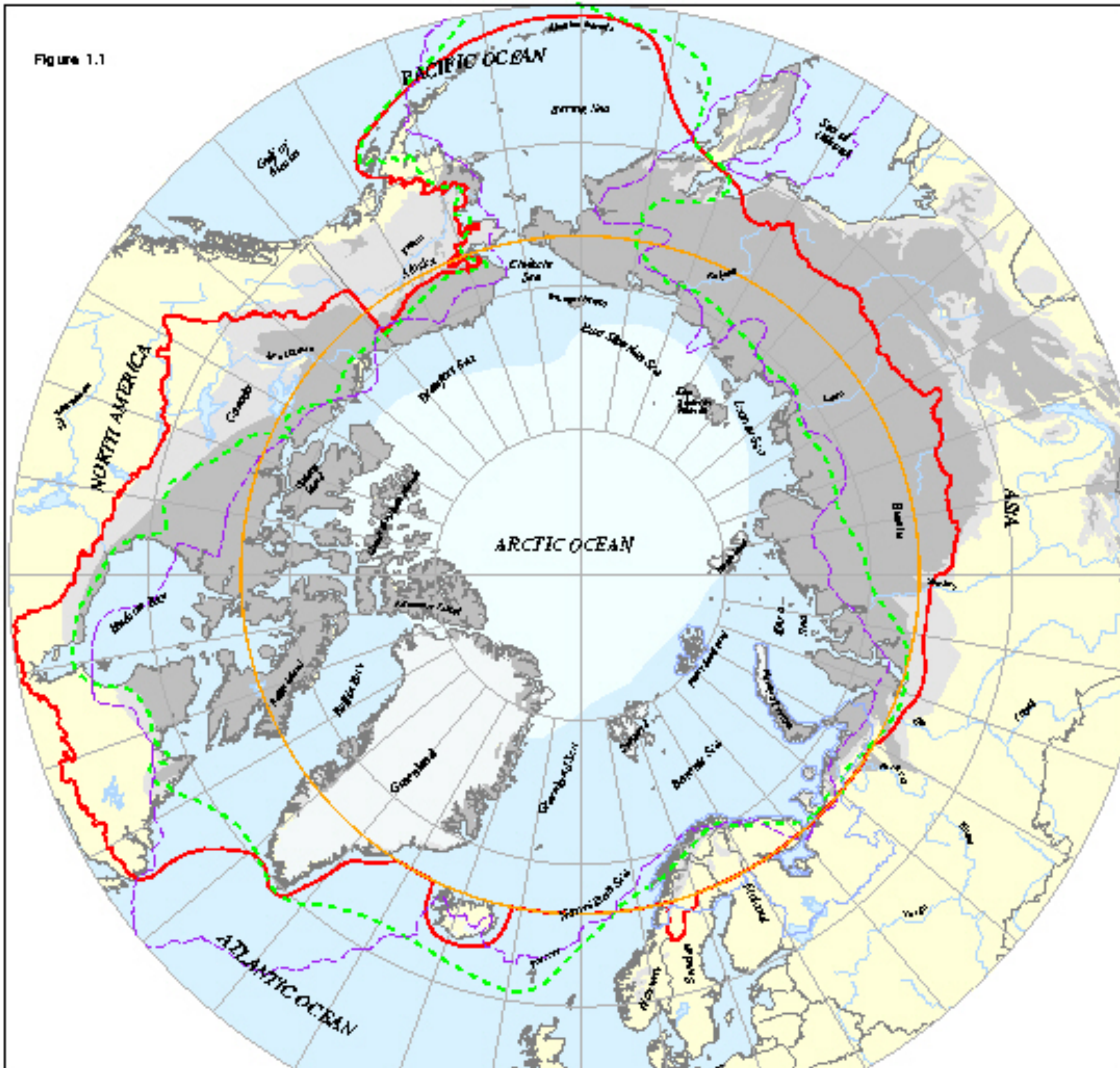
- Basic housekeeping and file management
- Visualization
- Query
- Measurement
- Transformation
- Analysis and hypothesis testing

Modeling using GIS

- Add-ons, coupling
- Finite difference, finite element models
  - hydrology, tides, ecology, climate
- Cellular automata

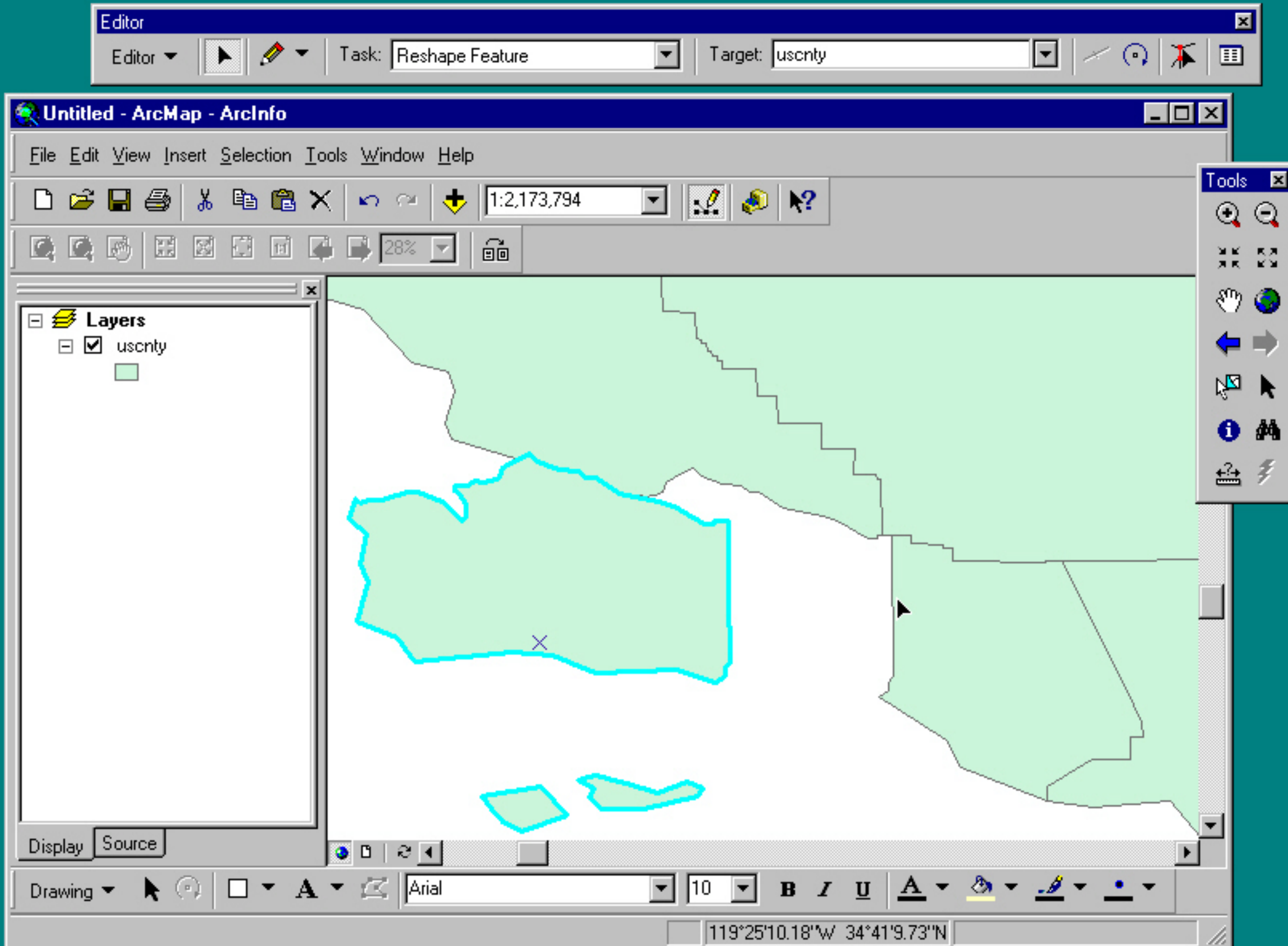
Diffusion model

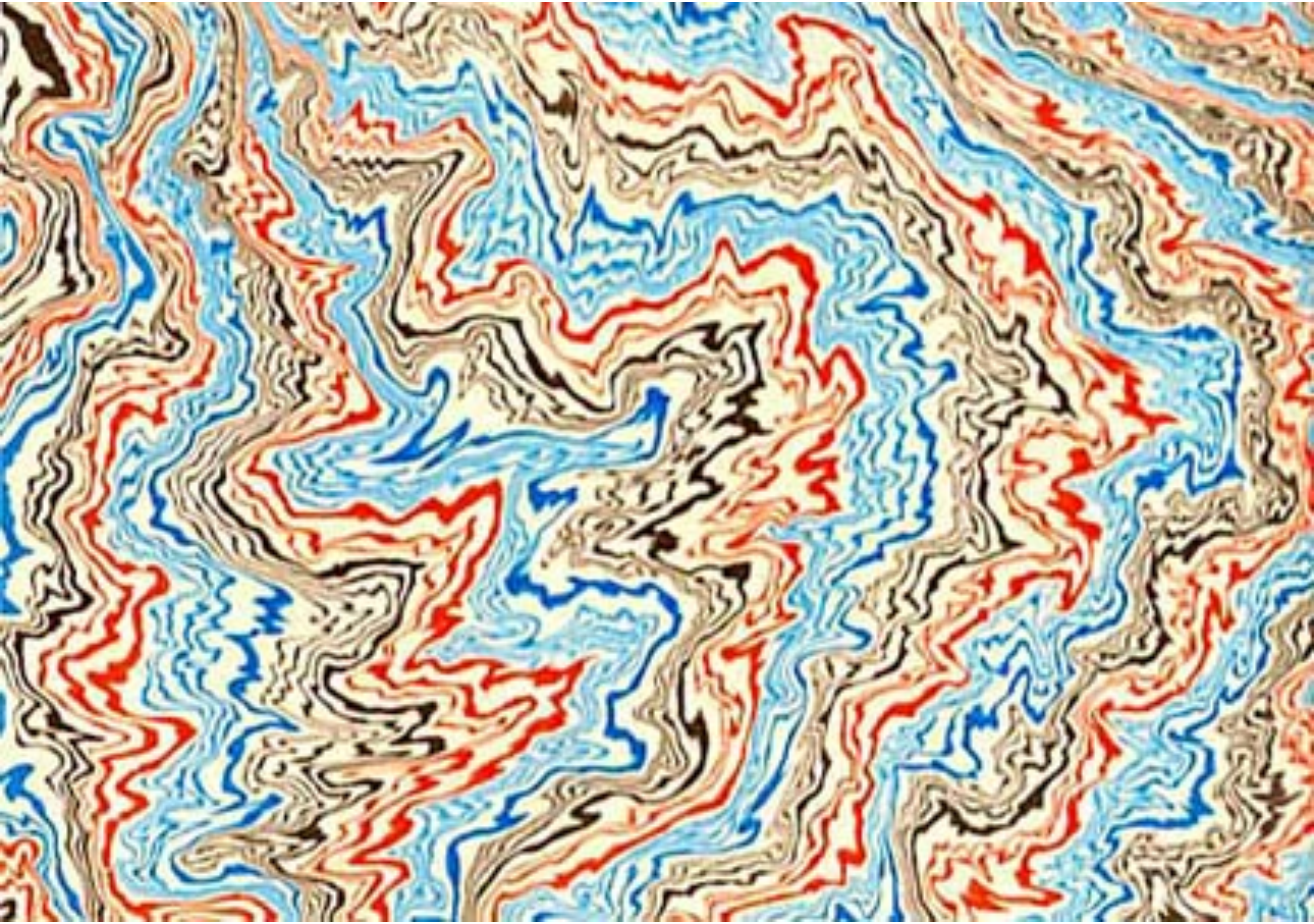
Figure 1.1


PACIFIC OCEAN
Bering Sea
Gulf of Alaska
Alaska
Chukchi Sea
East Siberian Sea
Beaufort Sea
Laptev Sea
NORTH AMERICA
Canada
ARCTIC OCEAN
ASIA
Hudson Bay
Baffin Bay
Greenland
Greenland Sea
Barents Sea
Kara Sea
Norwegian Sea
Sweden
Finland
Norway
ATLANTIC OCEAN

Representation options

- Raster
- Vector
- Discrete objects
  - points, lines, areas, volumes, and their attributes
- Fields
  - functions of location $f(x,y,z,t)$


Editor
Editor
Task: Reshape Feature
Target: uscnty
Untitled - ArcMap - ArcInfo
File Edit View Insert Selection Tools Window Help
1:2,173,794
28%
Tools
Layers
uscnty
Display
Source
Drawing
Arial
10
119°25'10.18"W 34°41'9.73"N

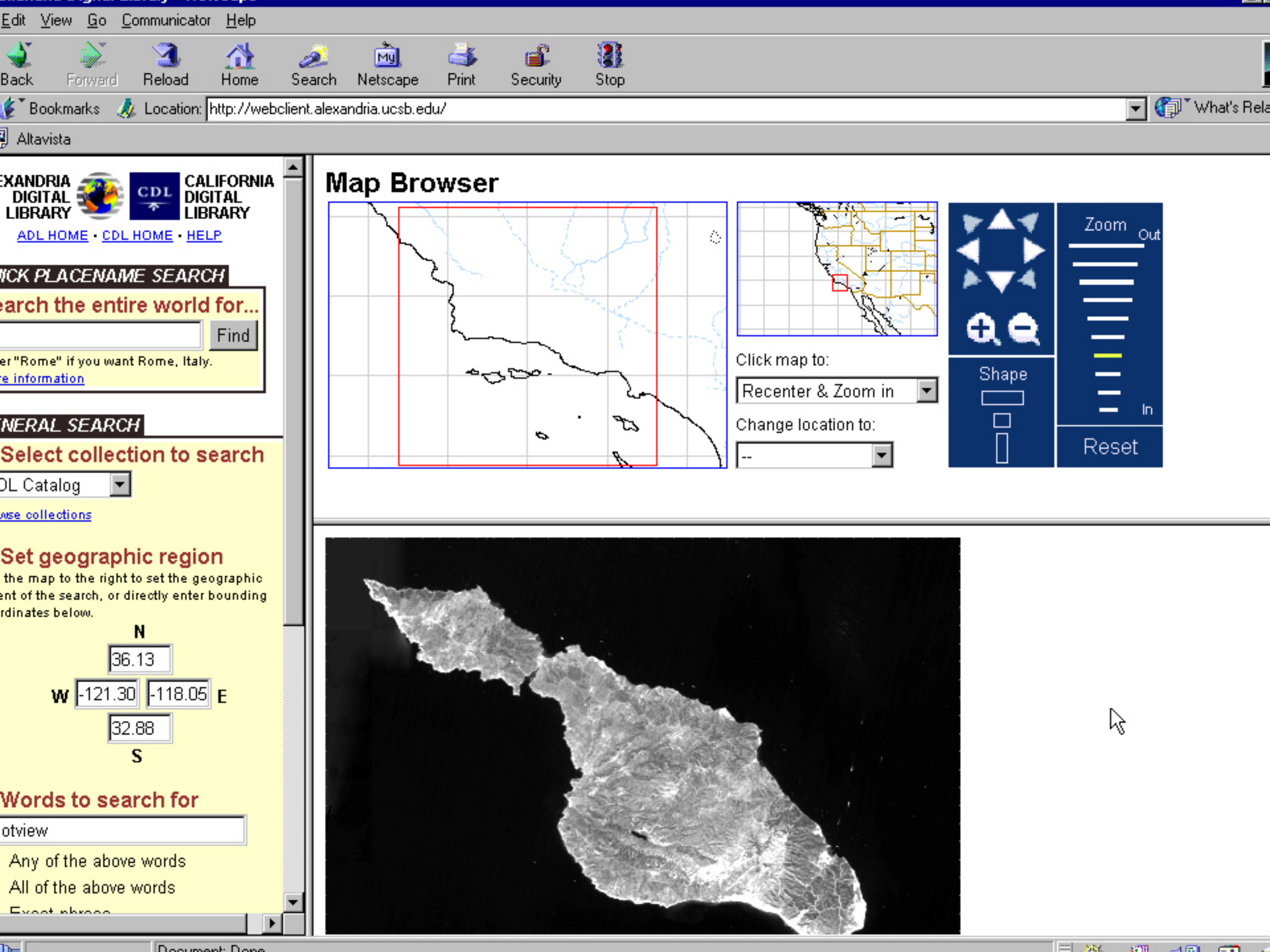


Value of a GIS approach

- Visualization
  - easy access, query
  - geographic context
- Integration
  - between layers, between disciplines
- Spatial analysis
  - interpretation of patterns, residuals, outliers
- Spatially explicit modeling

Sharing and communicating data

- Geographic location as a search key
- The geolibrary
  - a library whose primary search mechanism is geographic
  - what have you got about *there*
  - impossible to build a physical one
- Any information object with a footprint


Edit View Go Communicator Help
Back
Forward
Reload
Home
Search
Netscape
Print
Security
Stop
Bookmarks
Location: http://webclient.alexandria.ucsb.edu/
What's Rela
Altavista
EXANDRIA DIGITAL LIBRARY
CDL
CALIFORNIA DIGITAL LIBRARY
ADL HOME • CDL HOME • HELP
ICK PLACENAME SEARCH
earch the entire world for...
Find
er "Rome" if you want Rome, Italy.
re information
NERAL SEARCH
Select collection to search
DL Catalog
wse collections
Set geographic region
the map to the right to set the geographic
ent of the search, or directly enter bounding
rdinates below.
N
36.13
W
-121.30
-118.05
E
32.88
S
Words to search for
otview
Any of the above words
All of the above words
Map Browser
Click map to:
Recenter & Zoom in
Change location to:
--
Shape
Zoom
Out
In
Reset
Document: Done

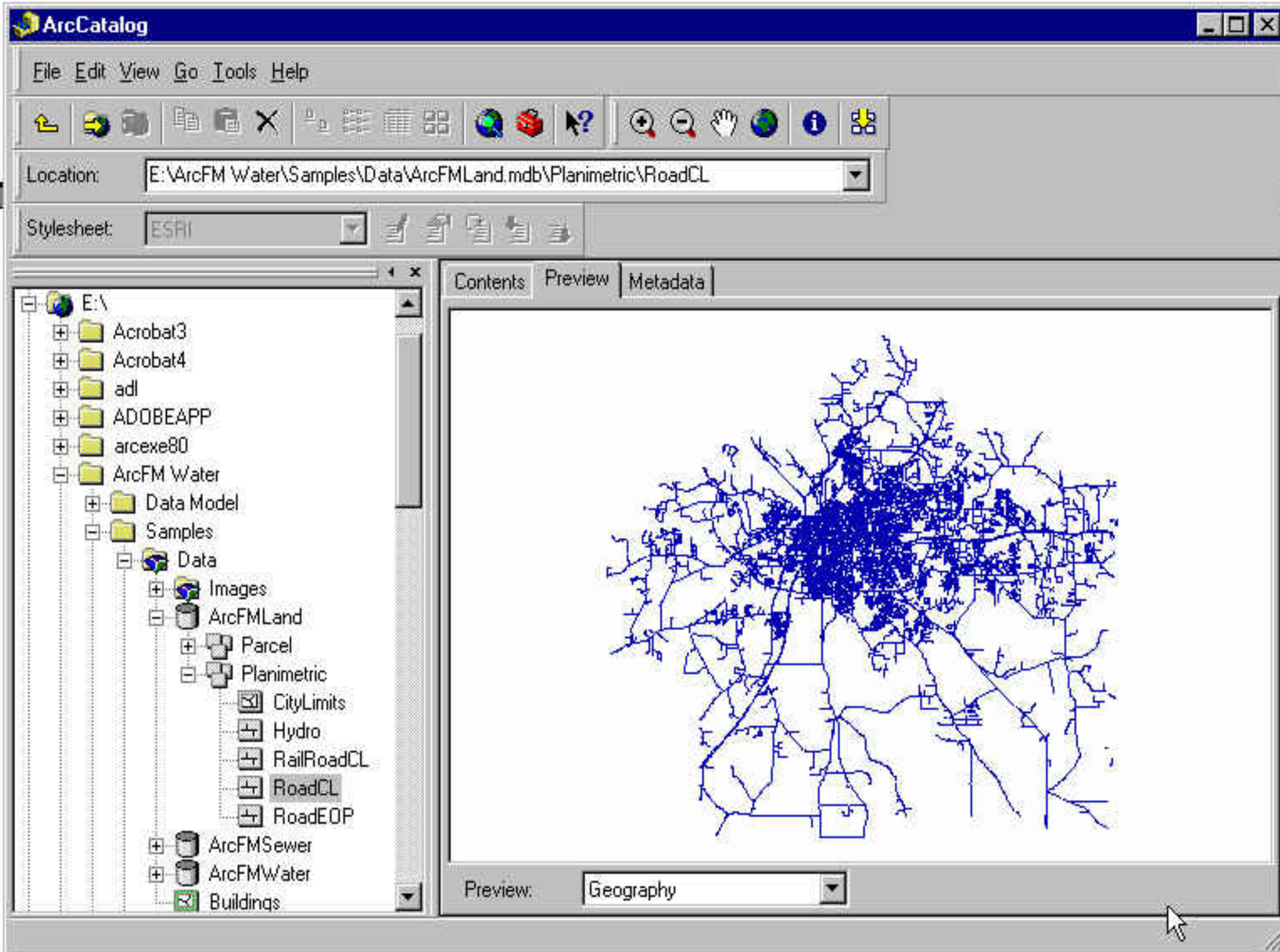
NRC report

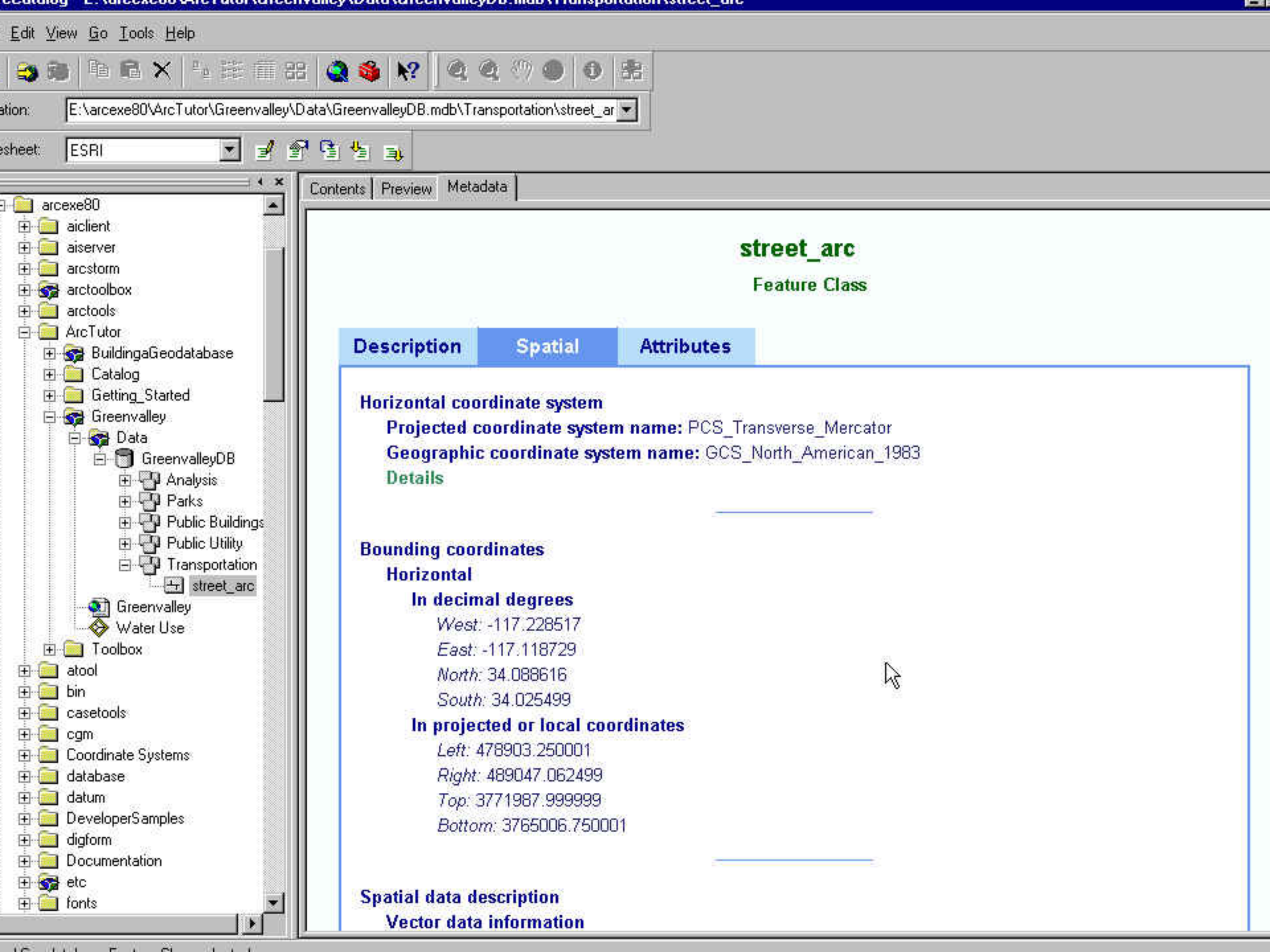
- "Distributed Geolibraries: Spatial Information Resources", 1999

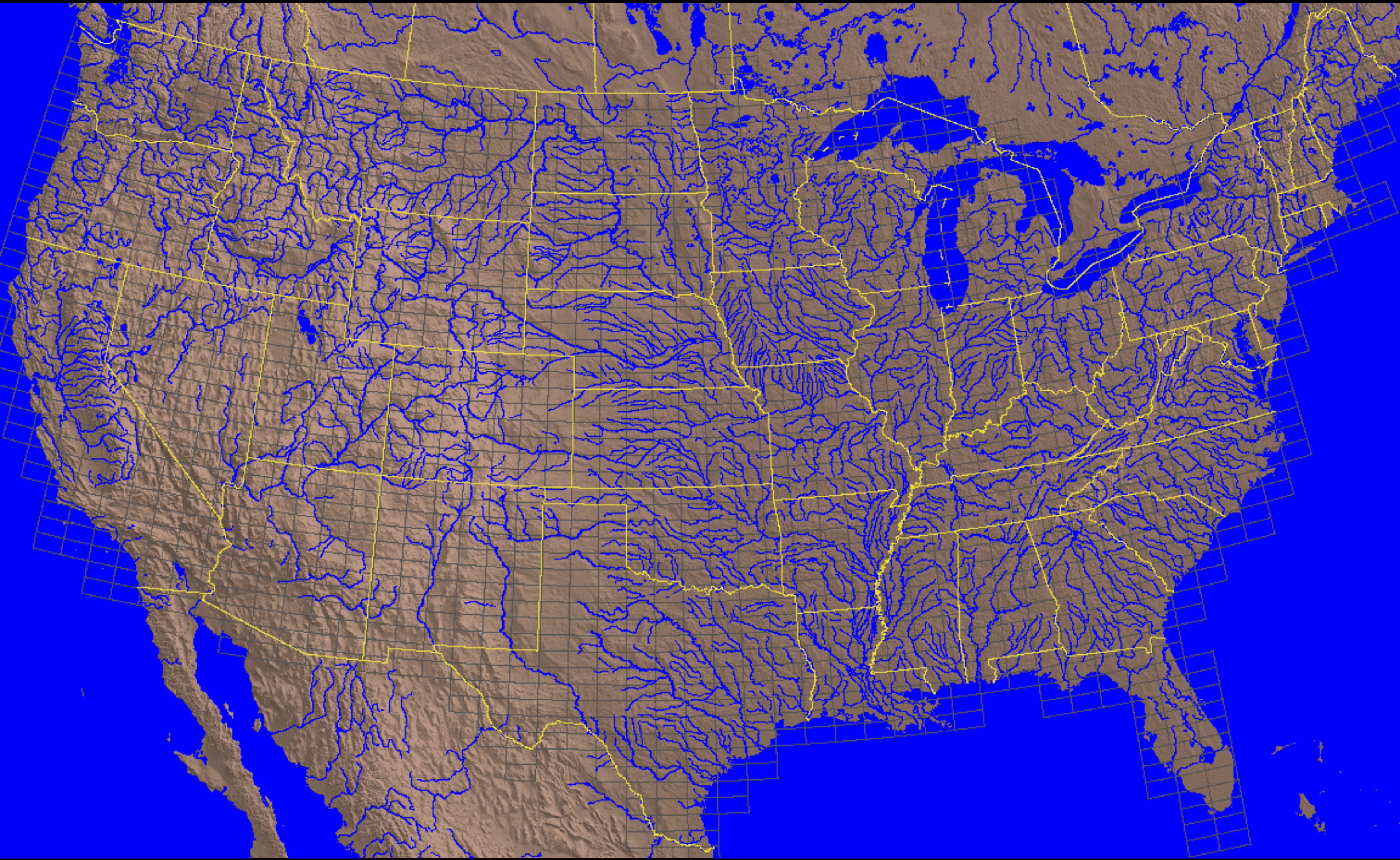
www.nap.edu

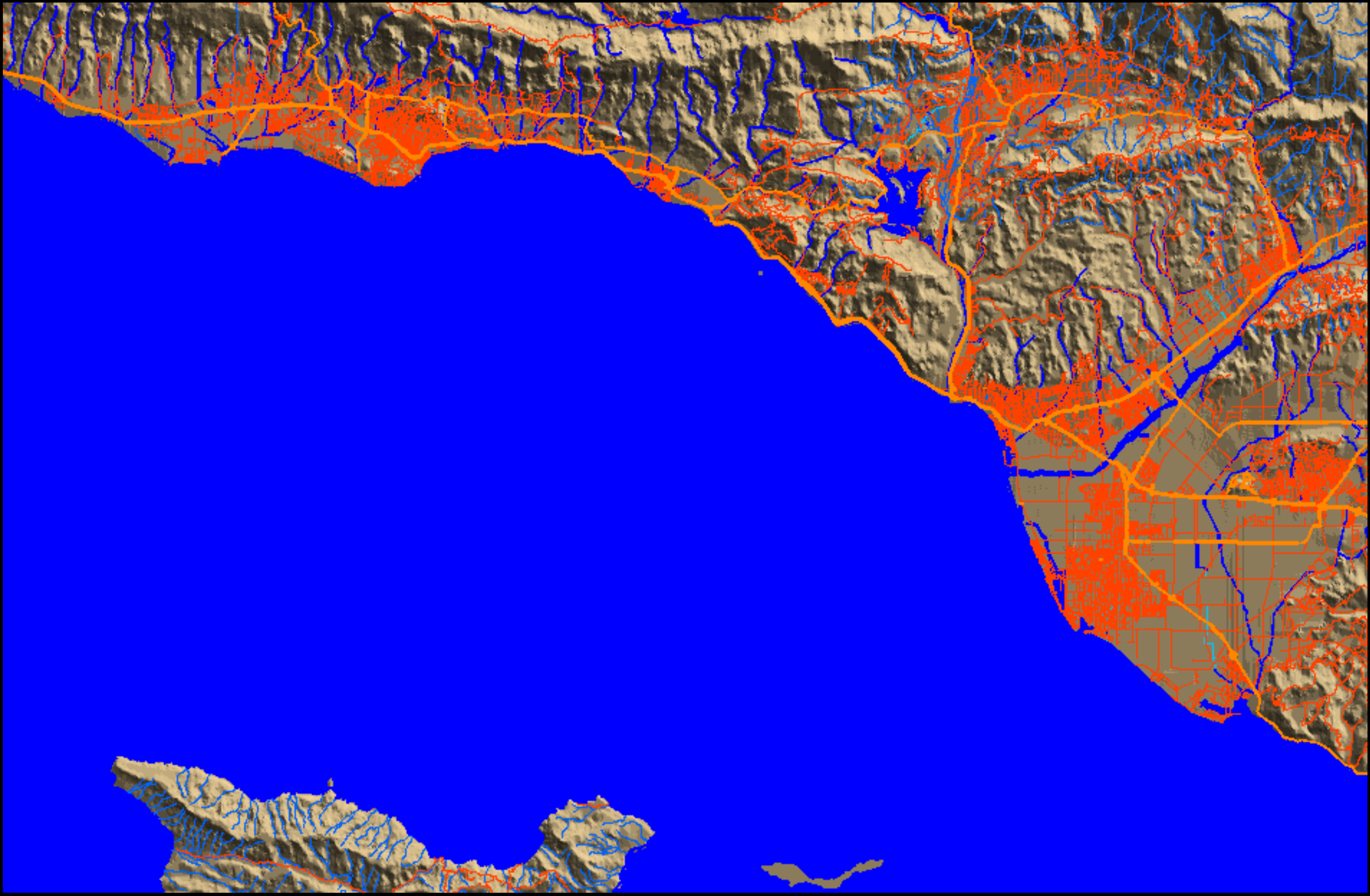
Organizing information by location

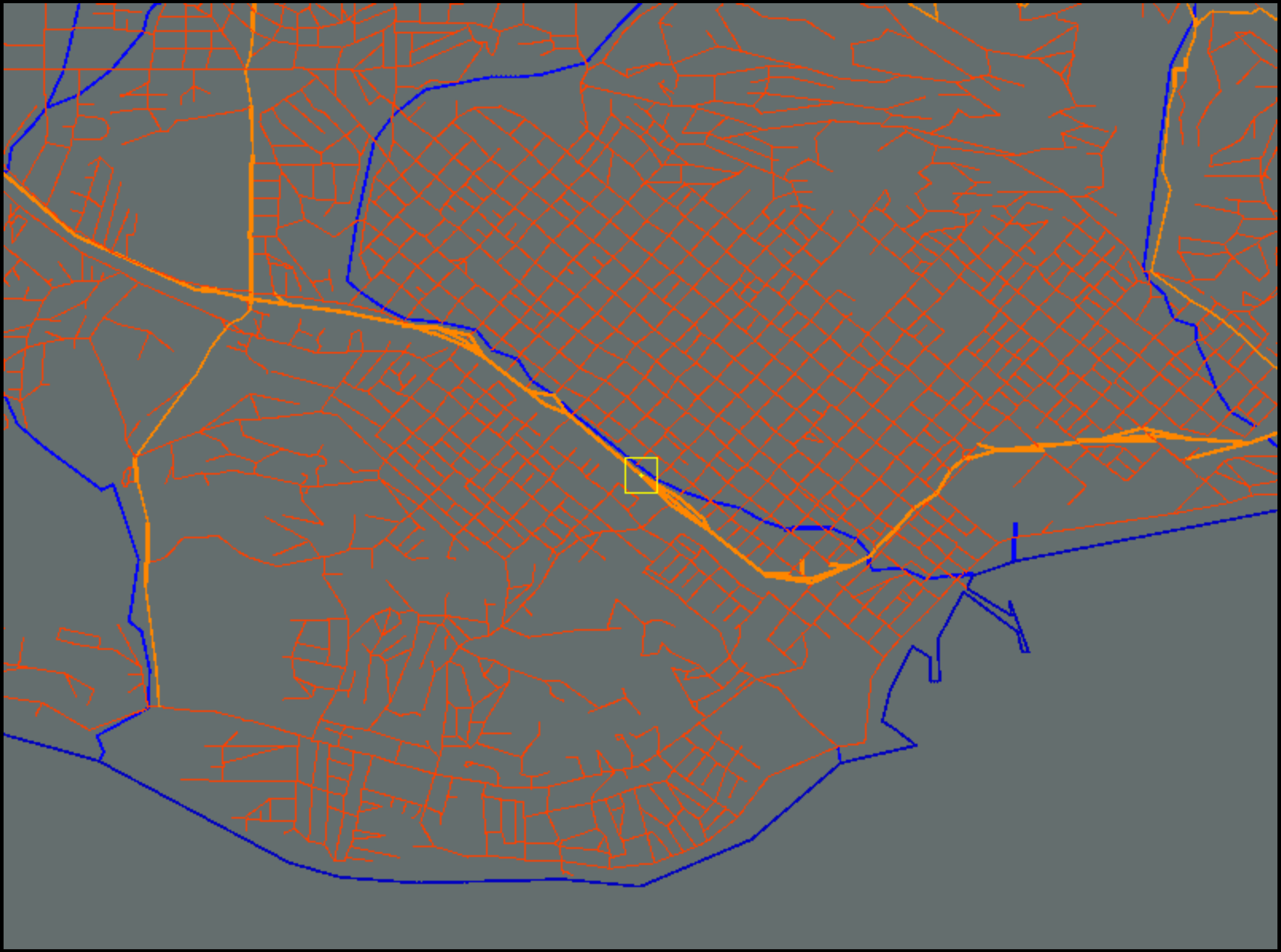
- Information with a geographic footprint
- Organizational metaphors
  - the desktop, office, workbench
  - the surface of the Earth
- Metadata
  - the description needed to support search
  - FGDC Content Standard for Digital Geospatial Metadata

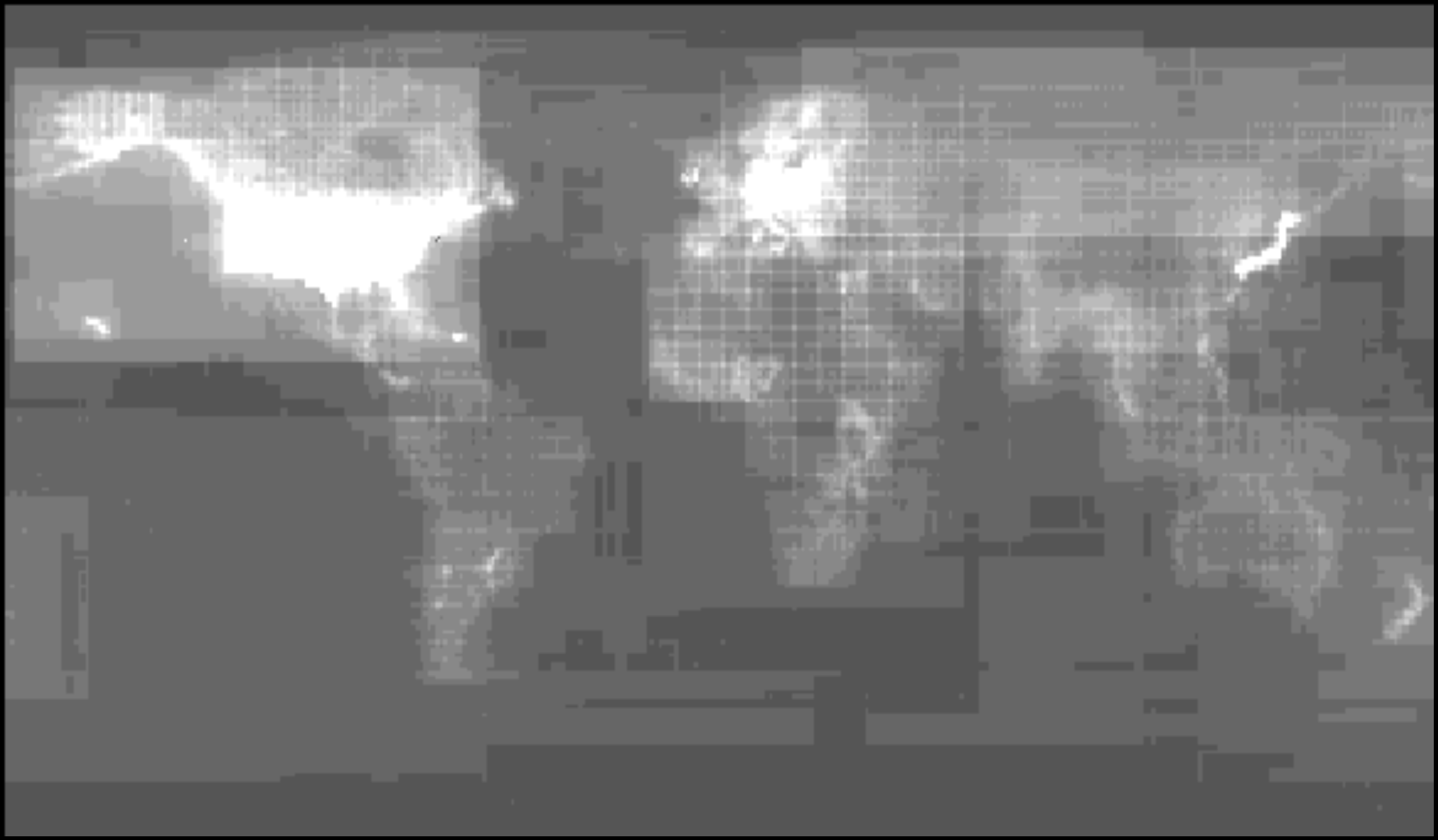

ArcCatalog
File Edit View Go Tools Help
Location: E:\ArcFM Water\Samples\Data\ArcFMLand.mdb\Planimetric\RoadCL
Stylesheet: ESRI
Contents
Preview
Metadata
E:\
Acrobat3
Acrobat4
adl
ADOBEAPP
arcexe80
ArcFM Water
Data Model
Samples
Data
Images
ArcFMLand
Parcel
Planimetric
CityLimits
Hydro
RailRoadCL
RoadCL
RoadEOP
ArcFMSewer
ArcFMWater
Buildings
Preview:
Geography


Edit View Go Tools Help
ation: E:\arcexe80\ArcTutor\Greenvalley\Data\GreenvalleyDB.mdb\Transportation\street_ar
esheet: ESRI
arcexe80
aiclient
aiserver
arcstorm
arctoolbox
arctools
ArcTutor
BuildingaGeodatabase
Catalog
Getting_Started
Greenvalley
Data
GreenvalleyDB
Analysis
Parks
Public Buildings
Public Utility
Transportation
street_arc
Greenvalley
Water Use
Toolbox
atool
bin
casetools
cgm
Coordinate Systems
database
datum
DeveloperSamples
digform
Documentation
etc
fonts
Contents
Preview
Metadata
street_arc
Feature Class
Description
Spatial
Attributes
Horizontal coordinate system
Projected coordinate system name: PCS_Transverse_Mercator
Geographic coordinate system name: GCS_North_American_1983
Details
Bounding coordinates
Horizontal
In decimal degrees
West: -117.228517
East: -117.118729
North: 34.088616
South: 34.025499
In projected or local coordinates
Left: 478903.250001
Right: 489047.062499
Top: 3771987.999999
Bottom: 3765006.750001
Spatial data description
Vector data information









CLM of the Alexandria Digital Library

Knowing where to look

- Approaches to CLM
  - by data type
    - ortho.mit.edu
  - by area of the globe
    - Arctic Data Directory
  - the one stop shop
    - www.fgdc.gov
  - a new generation of search engines
    - identifying footprints

GATEWAY TO THE ARCTIC

The International Arctic Environment Data Directory

Supporting the information needs of the Arctic Council and the Arctic Community

Providing an efficient and up-to-date service for locating and assessing sources of Arctic environment data and information

Search ADD member sites for:

Search

Council meeting #7: *June 7 - 9, 2000*
Minutes
Work Plan 2000-2001

Click on the flag of an ADD Member Country to view its Information Sites and Data Sources:

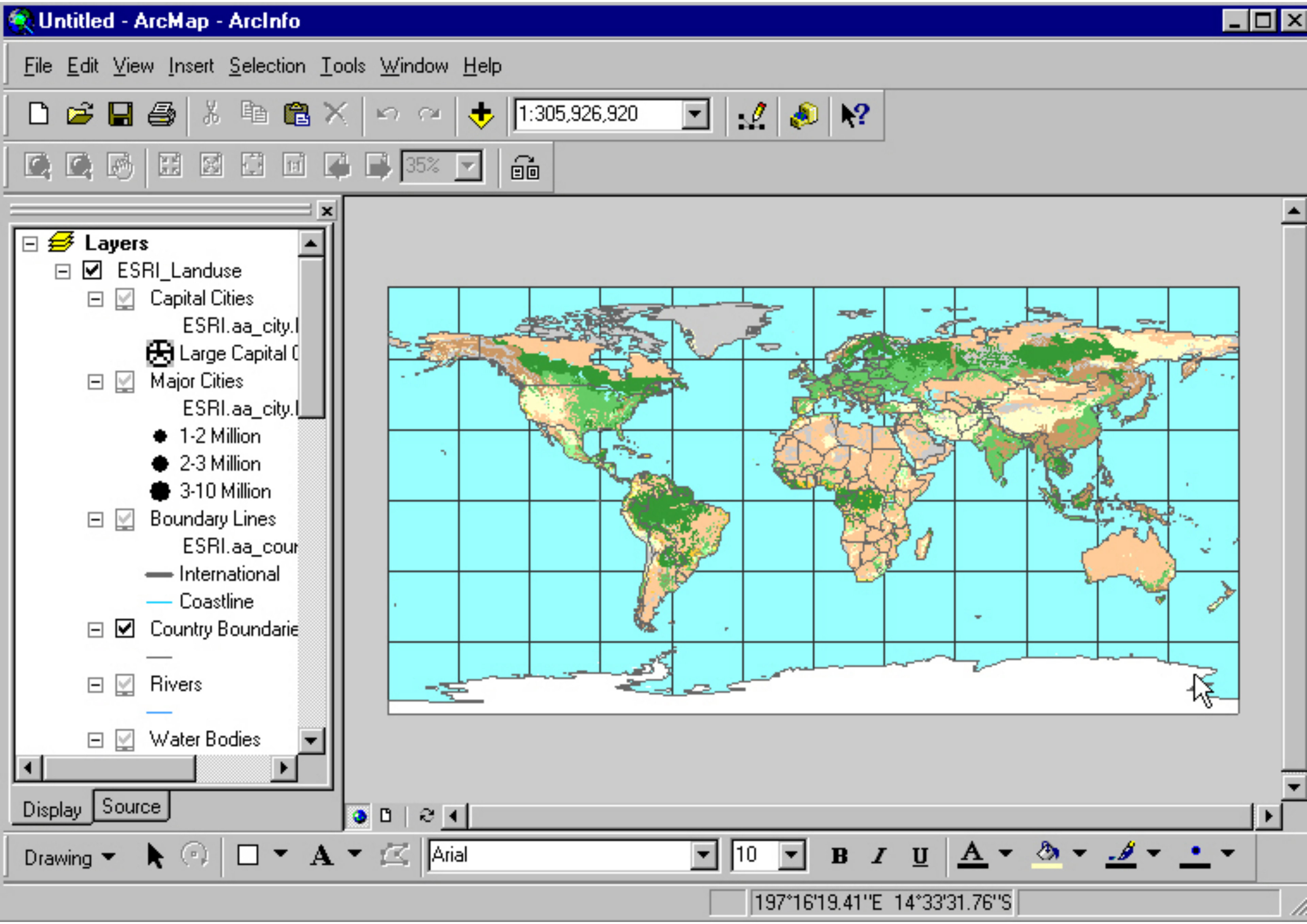
Canada Denmark Finland Germany Greenland

Iceland Norway Russia Sweden UK

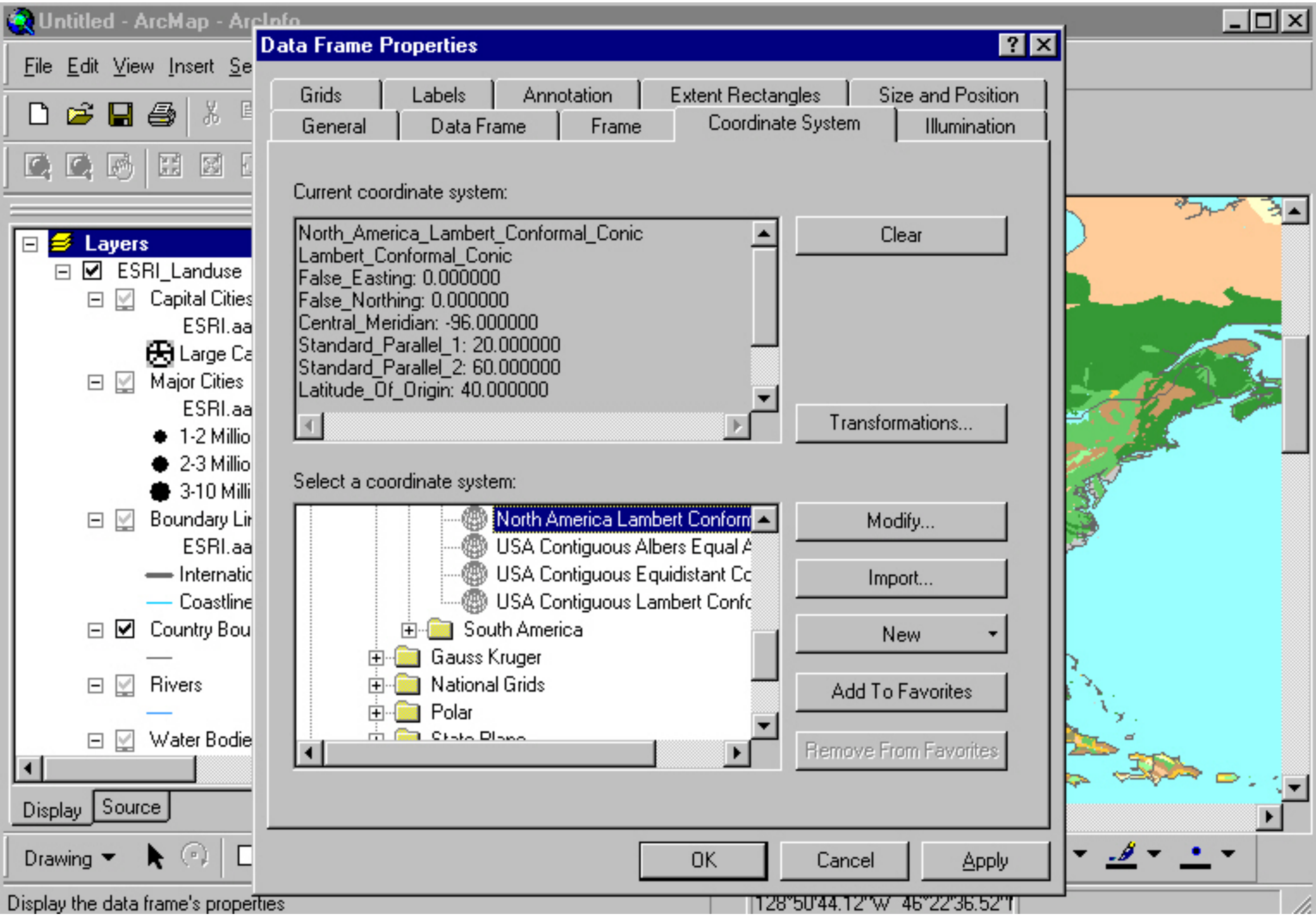
U.S.A.

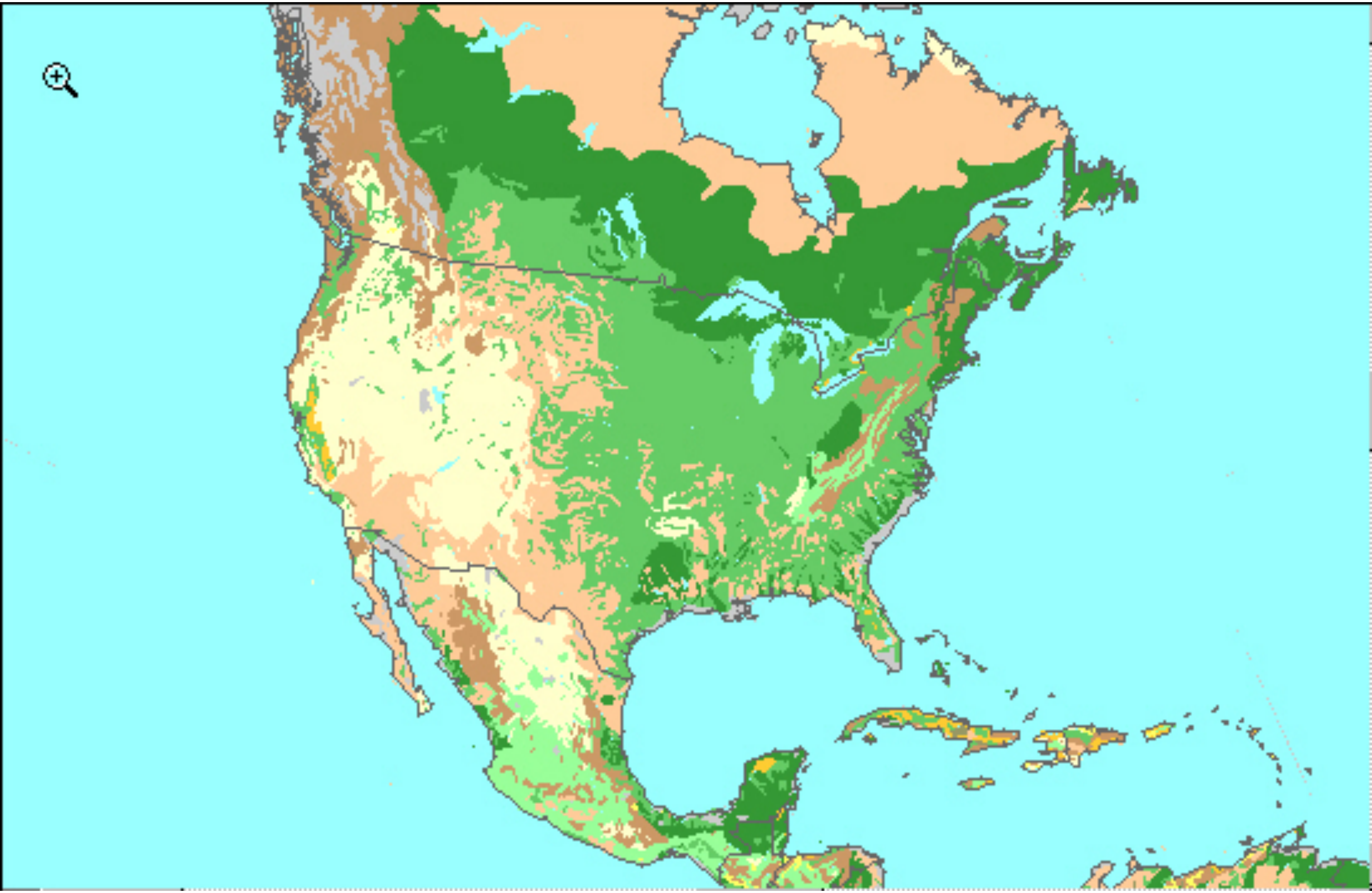
Click on the Logo of an ADD Member Organization to view its Information Sites and Data Sources:


geography network explorer - Netscape
geography network explorer
HOME
SITE MAP
HELP
FIND CONTENT
VIEW CONTENT
Browse
Search
DEFINE SEARCH AREA
Find Place for Search
DEFINE SEARCH CRITERIA
Type of Content
All Geographic Content
Data Theme
All Data Themes
Keyword (e.g. water)
SEARCH
Find and View Geographic Content
The Geography Network Explorer enables you to discover and access a wide variety of geographic content. This content includes map services, data sets, custom solutions, and much more. To find this content, you may use the tools on the left to:
• Browse Featured Content, or
• Search for Any Content
Once you have found what you are looking for, you can view the content in this window or with your favorite viewing tool.
Document: Done



Untitled - ArcMap - ArcInfo
File Edit View Insert Selection Tools Window Help
1:305,926,920
35%
Layers
ESRI_Landuse
Capital Cities
ESRI.aa_city.l
Large Capital C
Major Cities
ESRI.aa_city.l
1-2 Million
2-3 Million
3-10 Million
Boundary Lines
ESRI.aa_cour
International
Coastline
Country Boundarie
Rivers
Water Bodies
Display
Source
Drawing
Arial
10
B
I
U
A
197°16'19.41"E 14°33'31.76"S

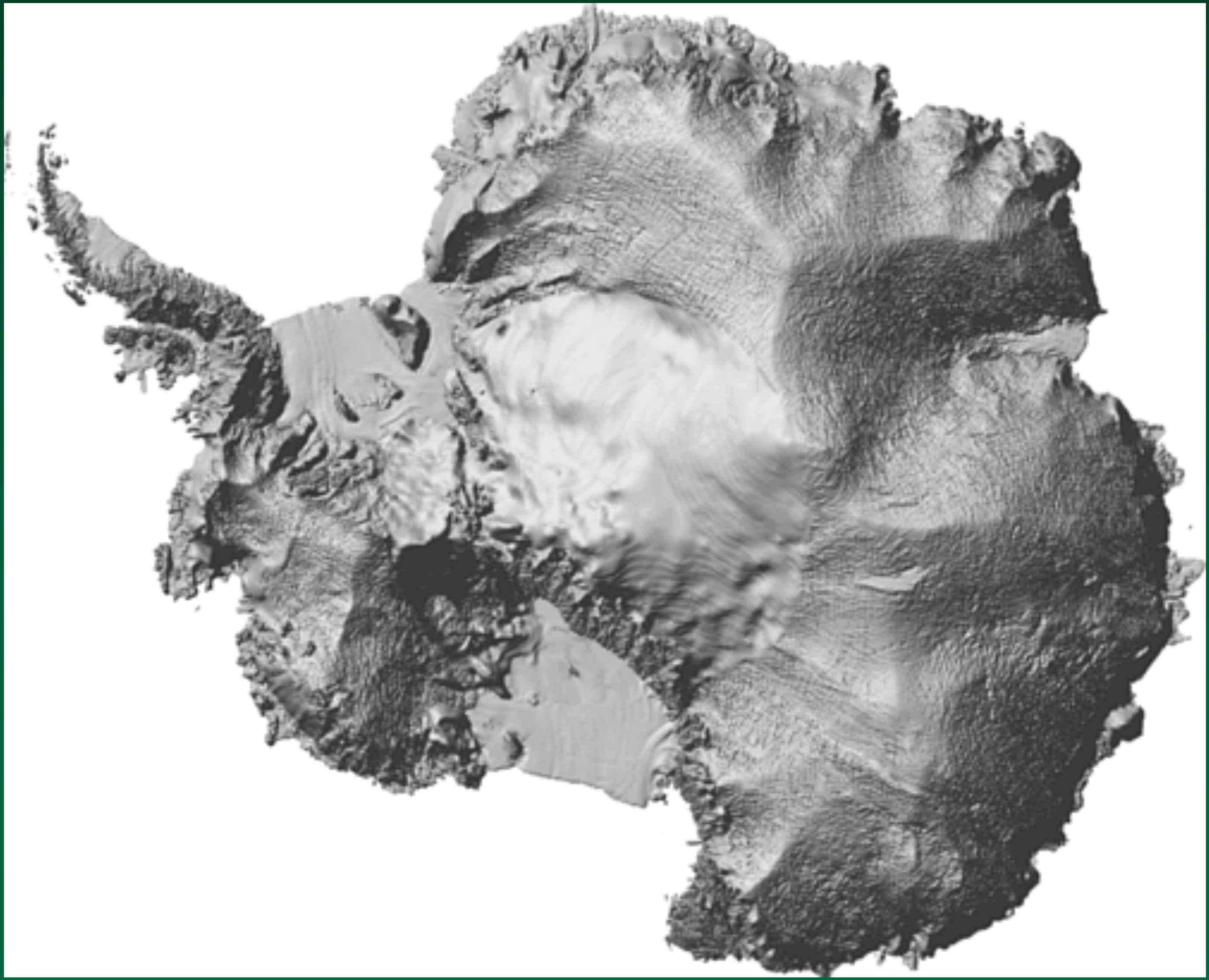

Untitled - ArcMap - ArcInfo
Data Frame Properties
Grids
Labels
Annotation
Extent Rectangles
Size and Position
General
Data Frame
Frame
Coordinate System
Illumination
Current coordinate system:
North_America_Lambert_Conformal_Conic
Lambert_Conformal_Conic
False_Easting: 0.000000
False_Northing: 0.000000
Central_Meridian: -96.000000
Standard_Parallel_1: 20.000000
Standard_Parallel_2: 60.000000
Latitude_Of_Origin: 40.000000
Clear
Transformations...
Select a coordinate system:
North America Lambert Conform
USA Contiguous Albers Equal A
USA Contiguous Equidistant Co
USA Contiguous Lambert Confo
South America
Gauss Kruger
National Grids
Polar
Modify...
Import...
New
Add To Favorites
Remove From Favorites
OK
Cancel
Apply
File Edit View Insert Se
Layers
ESRI_Landuse
Capital Cities
Large Ca
Major Cities
1-2 Millio
2-3 Millio
3-10 Milli
Boundary Lir
Internatio
Coastline
Country Bou
Rivers
Water Bodie
Display
Source
Drawing
Display the data frame's properties
128°50'44.12"W 46°22'36.52"



The Arctic context

- Symmetry with Antarctica?
  - NSF/USGS Antarctic GIS Workshop 1995
  - SOLA Planning Workshop 1997
  - importance of base mapping, data integration

Hongxing Liu’s Antarctic DEM



Is there symmetry?

- Many national rights to data
- Land vs ocean
  - lack of fixed features, moving surface
  - fixed ocean floor
- Wright and Bartlett, *Marine and Coastal Geographic Information Systems* (Taylor and Francis, 2000)

A user perspective

- Build or buy
  - skill levels vary among academic researchers
  - from Unix hackers to the computer-challenged
- GIS is COTS
  - the open GIS software community is small (e.g. GRASS)
  - industry is shifting to reusable software components

The Unix hacker

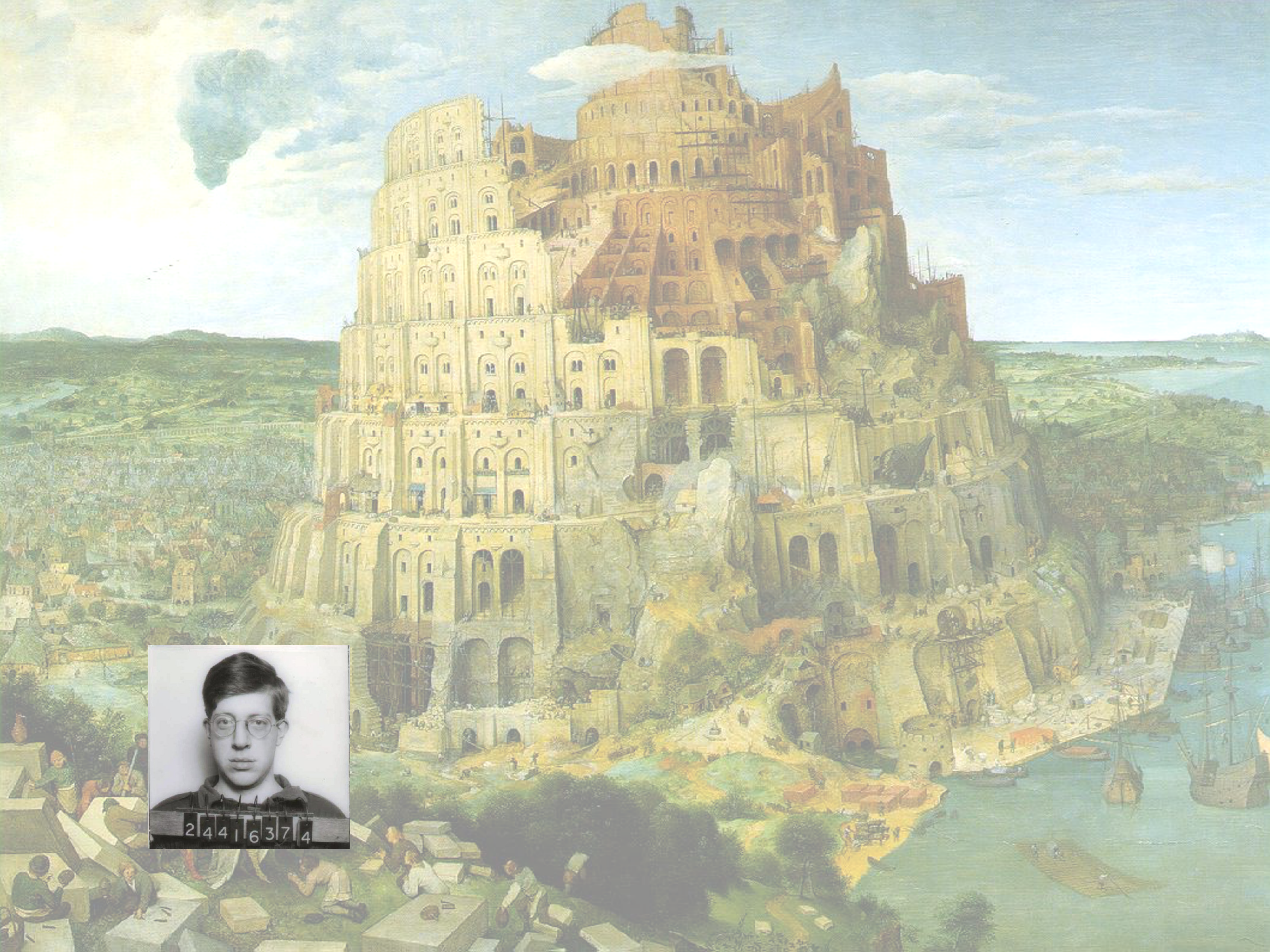
- Uses discipline-specific and science-specific standards
  - DODS, HDF, CDF
- Will use geolibrary tools
- Will use GIS when there is a need for:
  - integration across disciplines
  - collaboration outside the discipline
  - interaction with policy-makers

The computer-challenged

- Will use geolibrary tools
- Will use GIS as the preferred solution for display of data, analysis, modeling

Impediments to data sharing

- Horizontal vs vertical integration
- IP issues
  - the private sector
  - international variation in practices
- The CLM problem
- The interoperability problem


2441637 4

Concluding comments

- Is the Arctic special?
  - if not, build on experience from other spatial data infrastructure efforts
- A user perspective
  - the scientist needs to see that GIS adds sufficient value to offset the perceived diversion of resources

GIS

- Comprehensive technology for working with geographic data
- Integrating data through common geographic location
- Seeing data in easily comprehended form
- Seeing data in context

GIS as infrastructure

- The Hubble telescope, the South Pole station
- Mechanisms for storing and sharing data
  - computational models
- Tools, training, experience
- To promote a science that is more integrated, leads to new insights, more readily linked to policy