FUNDAMENTALS OF GIS

CONTENTS OF THIS LECTURE PRESENTATION

- Basic concept of GIS
- Basic elements of GIS
- Types of GIS data
- Examples of GIS applications

Basic Concept of GIS

○ **What does GIS stand for?**

- Geographic Information Science

  ○ is the science concerned with the systematic and automatic processing of spatial data and information with the help of computers

  ○ is the theory behind how to solve spatial problems with computers

- Geographic Information System

  ○ is a system designed for storing, analyzing, and displaying spatial data

  ○ is the use of hardware, software, people, procedures, and data

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BASIC CONCEPT OF GIS 2/5

- Geographic Information Science
  - presents a framework for using information theory, spatial analysis and statistics, cognitive understanding, and cartography (Longley et al., 2005).

- Geographic Information System
  - focuses on the processes and methods that are used to sample, represent, manipulate and present information about the world (Goodchild, 1992) .

Geographic Information Science   Geographic Information System
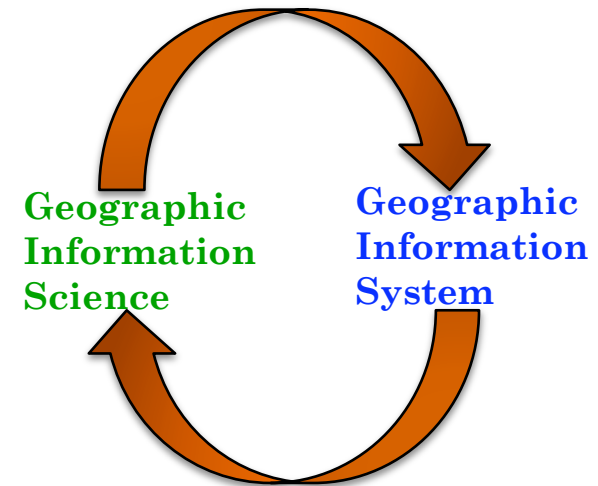
Adopted from Maguire (2010)

"**GI Science** allows us to consider the philosophical, epistemological & ontological contexts of geographic information & **GI Systems** provide the infrastructure, tools and methods for tackling real world problems within acceptable timeframes."

- **Literal Definition**
  - *Geographic* relates to the surface of the earth.
  - *Information* is a knowledge derived from study, experience, or instruction.
  - *System* is a group of interacting, interrelated, or interdependent elements forming a complex whole.
  - *Science* is the observation, identification, description, experimental investigation, and theoretical explanation of phenomena.

Functional Definition

- GIS is a system for inputting, storing, manipulating, analyzing, and reporting data.

Component Definition

- GIS is an organized collection of computer hardware, software, geographic data, procedures, and personnel designed to handle all phases of geographic data capture, storage, analysis, query, display, and output.
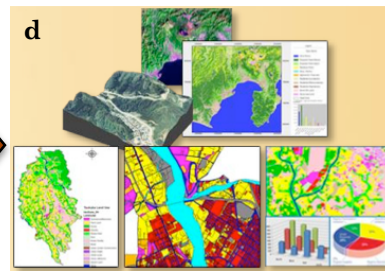
Functions of GIS

- *Data collection*
  - Capture data
- *Data storing, processing & analysis*
  - Store data
  - Query data
  - Analyze data
- *Output production*
  - Display data
  - Produce output

a **b** Own energy source

c

d

- Data collection
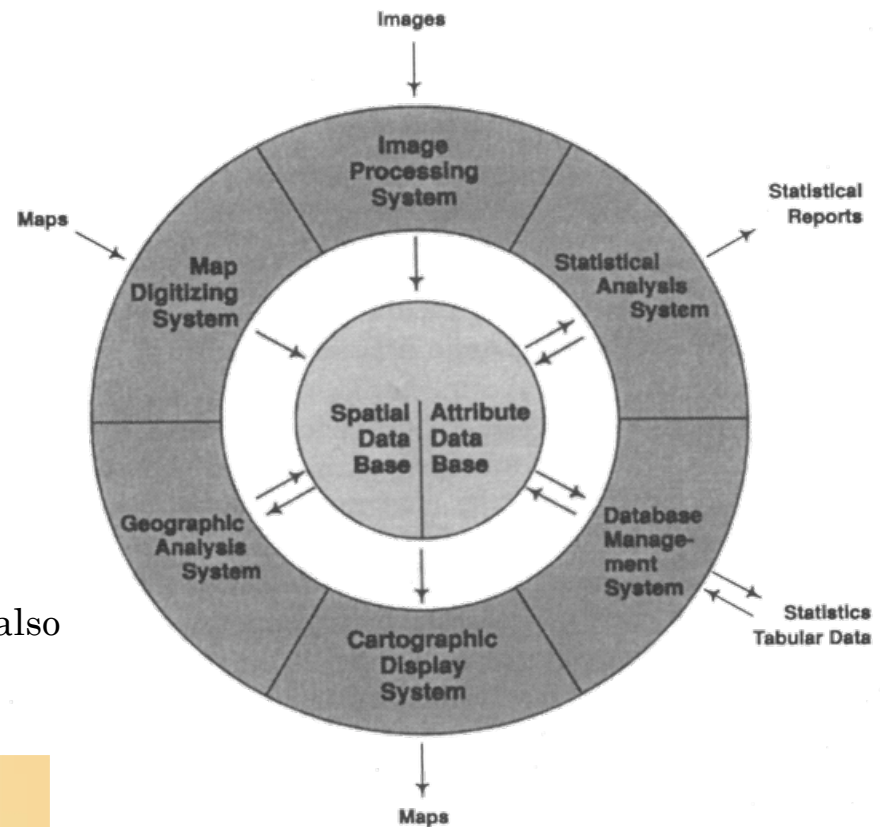 - using GPS & RS
  - paper maps are also sources of data

- Data storing, processing & analysis
- Output production
  - statistical report, maps

Components of GIS

Source: Schuurman (2004)

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Basic Elements of GIS

BASIC ELEMENTS OF GIS

- People
- Data
- Software
- Hardware
- Procedures/Methods

Adopted from:
Brooks (undated)
http://www.mapsofindia.com/gis/gis-components.html
http://bgis.sanbi.org/gis-primer/page_12.htm
http://www.sfu.ca/rdl/GIS/tour/comp_gis.html

1. People

- are the most important part of a GIS
- define and develop the procedures used by a GIS
- can overcome shortcoming of the other 4 elements (data, software, hardware, procedure), but not vice-versa
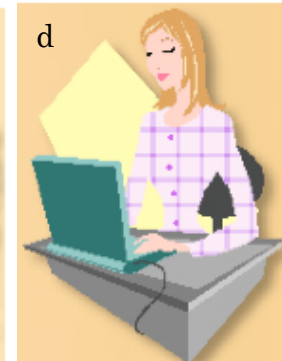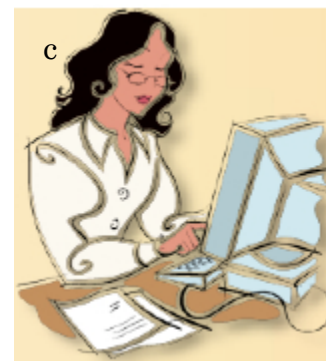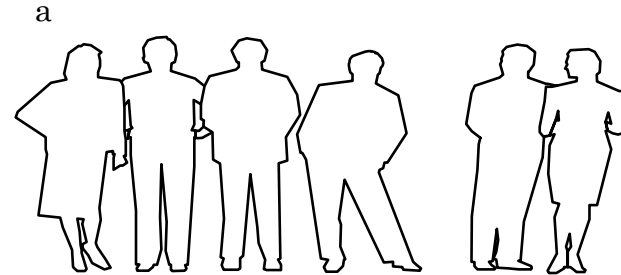
- Ground truth data collection
- Data storing, processing and analysis
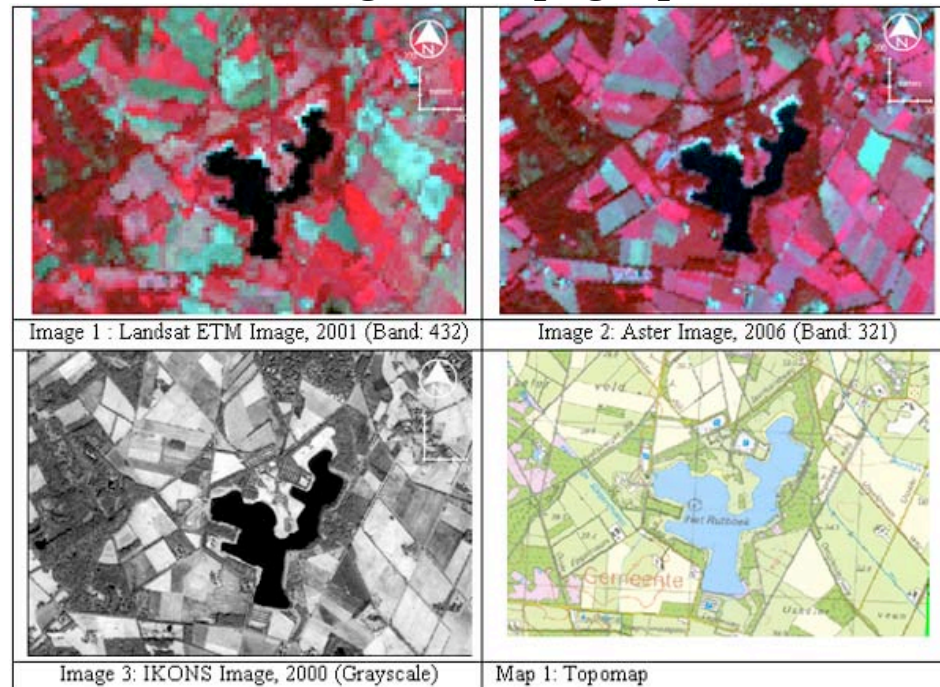
Sources (Photos):
a) Brooks (undated)
b) http://www.asdi.com/remote-sensing/applications/ground-truthing
c), d) Lwin & Murayama (2008)

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2. Data

- Data is the information used within a GIS

- Since a GIS often incorporates data from multiple sources, its accuracy defines the quality of the GIS.

- GIS quality determines the types of questions and problems that may be asked of the GIS
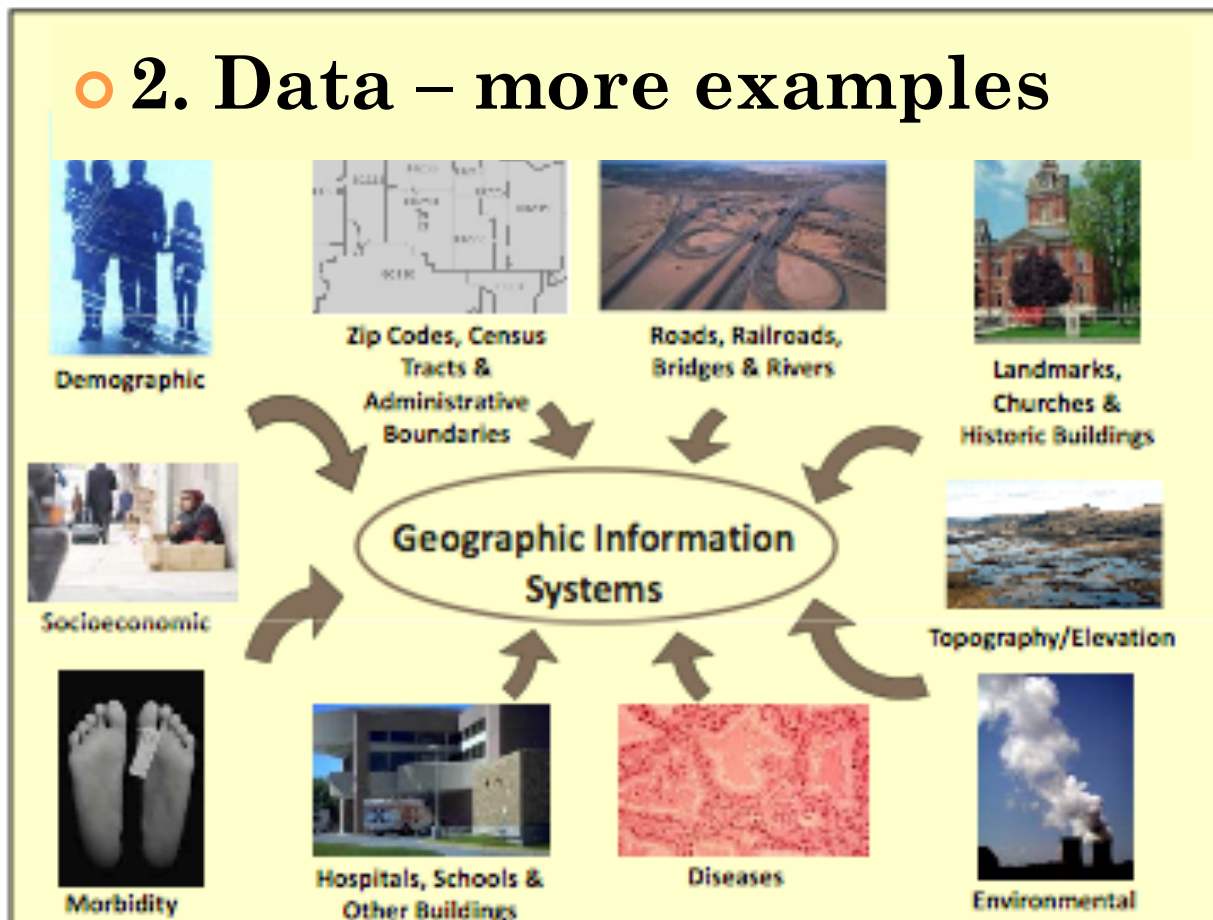
Remote Sensing and topographic data

Image 1 : Landsat ETM Image, 2001 (Band: 432)

Image 2: Aster Image, 2006 (Band: 321)

Image 3: IKONS Image, 2000 (Grayscale)

Map 1: Topomap

Ground truth data

Obs. Point	GPS Reading		Present Landuse	ETM Image 2001	IKONOS	Topographic Map
	X	Y		Class Name		Legend Class
1	351642	5783025	Forest	Forest	Forest	Forest
18	350985	5783163	Bare Land	Grassland	Grassland	Grassland
17	351000	5782900	Arable Land	Grassland	Grassland	Grassland
20	350700	5783200	Forest	Forest	Forest	Forest
23	351100	5783000	Grassland	Arable Land	Arable Land	Arable Land

Source: Rahman (2009)

2. Data – more examples

Demographic

Zip Codes, Census Tracts & Administrative Boundaries

Roads, Railroads, Bridges & Rivers

Landmarks, Churches & Historic Buildings

Socioeconomic

Geographic Information Systems

Topography/Elevation

Morbidity

Hospitals, Schools & Other Buildings

Diseases

Environmental

3. GIS software

- It encompasses not only to the GIS package, but all the software used for databases, drawings, statistics, and imaging.
- The functionality of the software used to manage the GIS determines the type of problems that the GIS may be used to solve.
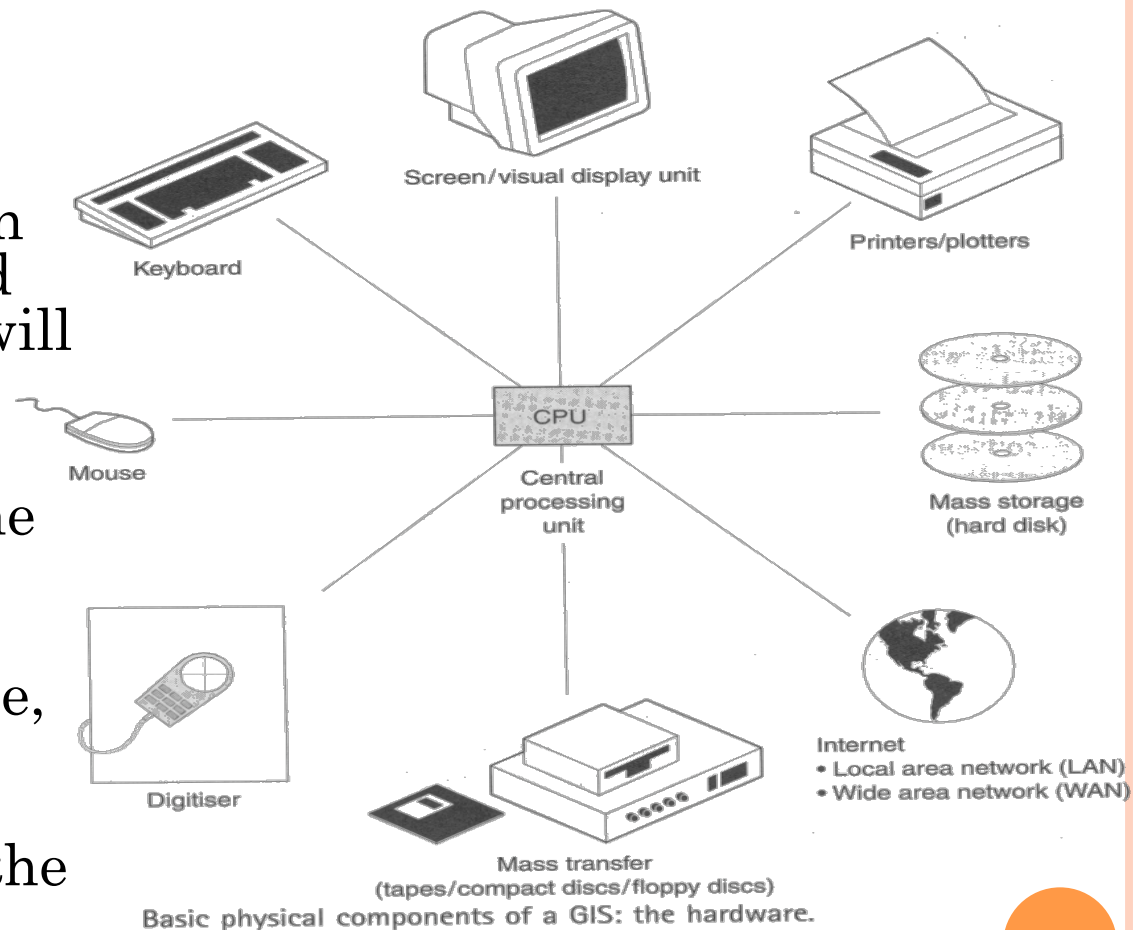- The software used *must* match the *needs* and *skills* of the end user.

Popular GIS Software

- *Vector-based GIS*
  - ArcGIS (ESRI)
  - ArcView
  - MapInfo

- *Raster-based GIS*
  - Erdas Imagine (Leica)
  - ENVI (RSI)
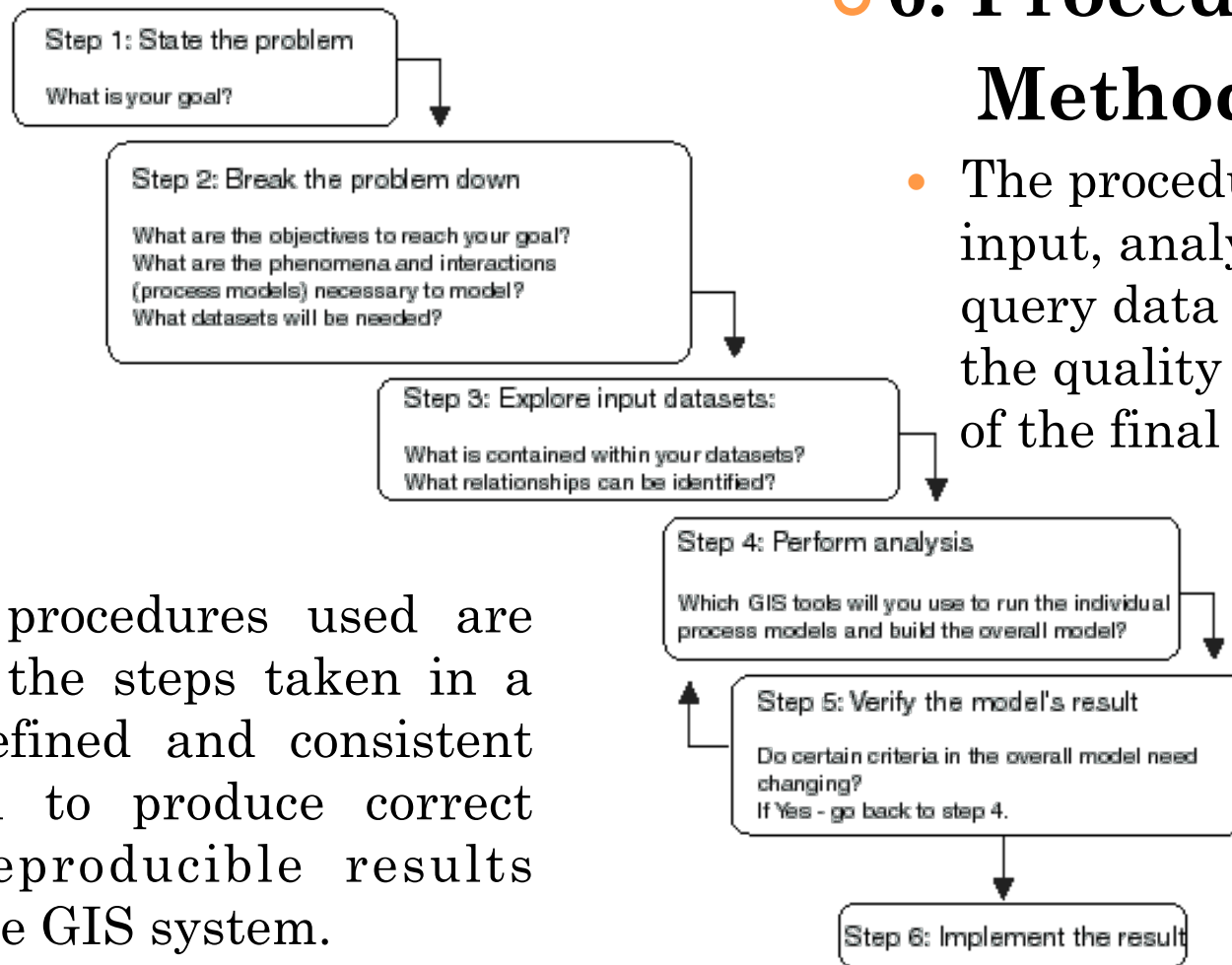 - ILWIS (ITC)
  - IDRISI (Clark Univ.)

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4. Hardware

- The type of hardware determines, to an extent, the speed at which a GIS will operate.
- Additionally, it may influence the type of software used.
- To a small degree, it may influence the types/ personalities of the people working with the GIS.

Keyboard

Screen/visual display unit

Printers/plotters

Mouse

CPU
Central processing unit

Mass storage (hard disk)

Digitiser

Mass transfer (tapes/compact discs/floppy discs)

Internet
- Local area network (LAN)
- Wide area network (WAN)

Basic physical components of a GIS: the hardware.

Source: Schuurman (2004)

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A conceptual model for solving spatial problems

Step 1: State the problem

What is your goal?

Step 2: Break the problem down

What are the objectives to reach your goal?
What are the phenomena and interactions
(process models) necessary to model?
What datasets will be needed?

Step 3: Explore input datasets:

What is contained within your datasets?
What relationships can be identified?

Step 4: Perform analysis

Which GIS tools will you use to run the individual
process models and build the overall model?

Step 5: Verify the model's result

Do certain criteria in the overall model need
changing?
If Yes - go back to step 4.

Step 6: Implement the result

Source: ESRI

6. Procedures/ Methods

- The procedures used to input, analyze, and query data determine the quality and validity of the final product.

- The procedures used are simple the steps taken in a well defined and consistent method to produce correct and reproducible results from the GIS system.

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Types of GIS Data

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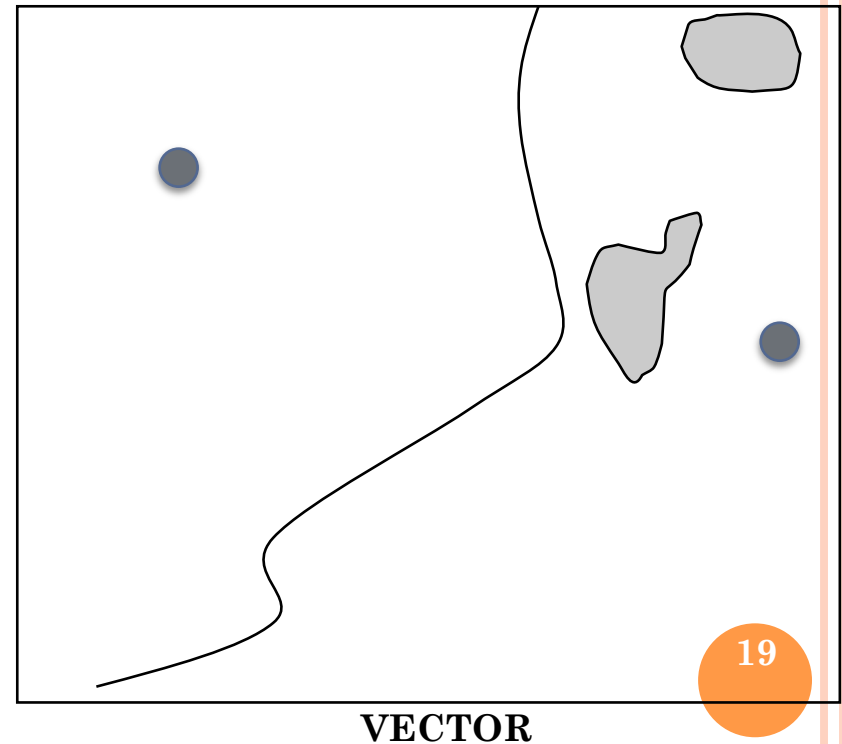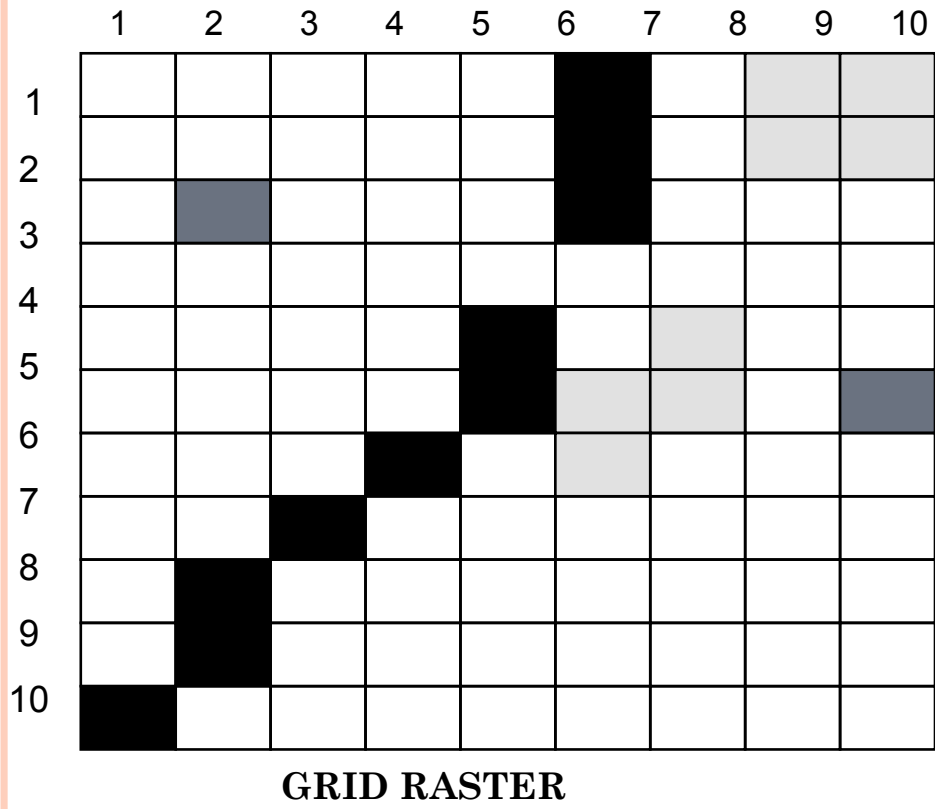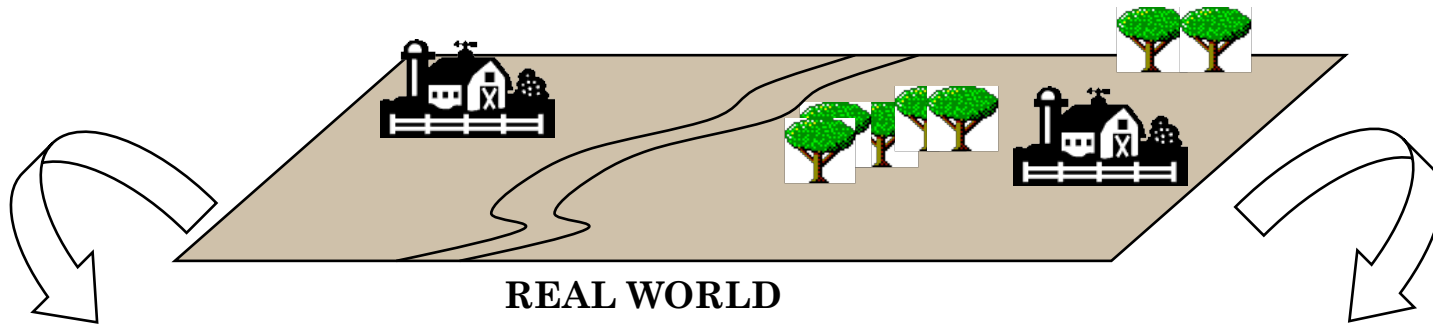# TYPES OF GIS DATA 1/3

- Vector
  - In the vector data model, features on the earth are represented as:
    - Points
    - Lines
    - Polygons
- Raster
  - In the raster data model, a geographic feature like land cover is represented as:
    - single square cells
- Attribute
  - Attribite values in a GIS are stored as *relational database* tables.
  - Each feature (point, line, polygon, or raster) within each GIS layer will be represented as a record in a table.

- A GIS stores information about the world as layers of spatial features (customers, buildings, streets, and so
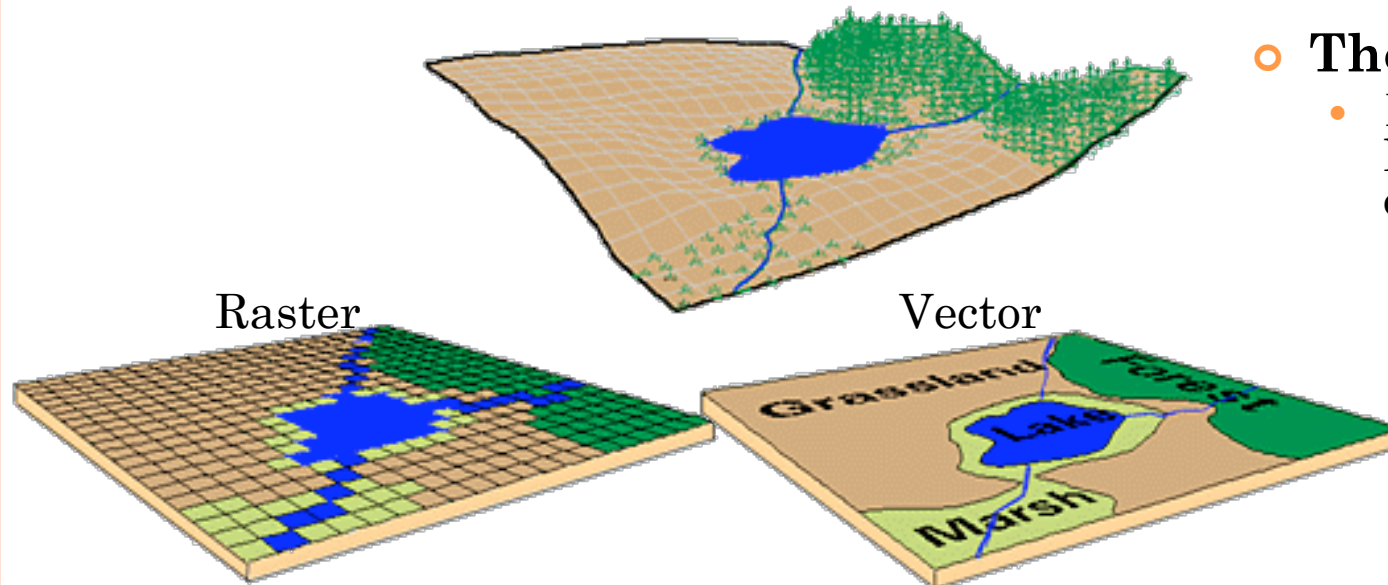

Source: ESRI

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TYPES OF GIS DATA 2/3

REAL WORLD

GRID RASTER

VECTOR

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Source: Brooks (undated)
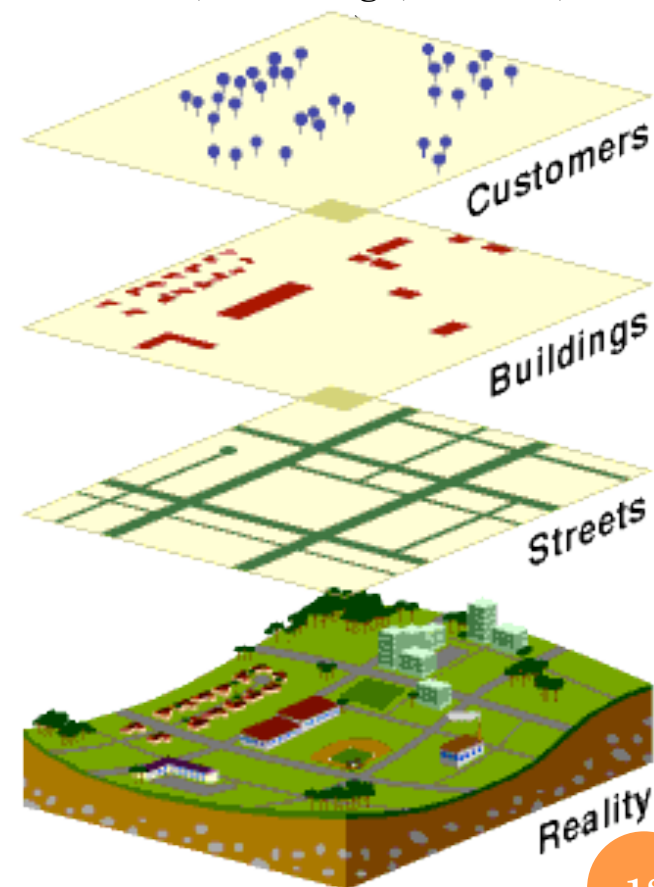
TYPES OF GIS DATA 3/3

The Real World

- In this example, our landscape consists of:
  - Points rolling hills
  - Lines grassland
  - Polygons lake
  - rivers
  - forest stands
  - marsh

Raster

Vector

Raster data attributes

ROW	COL	LU_CODE
1	1	2
1	2	2
1	3	2
1	4	2
...		
1	19	101

LU_CODE	LAND_COVER	NAME	CELLS
1	forest	Sherwood Forest	100
2	grassland	Marshall Field	150
100	lake	Blue Lake	75
3	marsh	Okeefenokee Swamp	55
101	river	Suwanee River	20

- Each cell has a coordinate representation within the table and a numeric value (i.e., LU_CODE)
- Each LU_CODE is associated with a full description through a *relational* join.

Source: http://gis.washington.edu/phurvitz/professional/SSI/attrib.html

Vector data attributes

Polygon attributes

AREA	PERIMETER	LU_ID	LU_CODE	NAME
200	500	1	1	Sherwood Forest
1250	10000	2	2	Marshall Field
175	250	3	100	Blue Lake
100	295	4	3	Okeefenokee Swamp

LENGTH	LU_ID	LU_CODE	NAME
45	4	101	Suwanee River
50	5	101	Suwanee River
35	6	101	Suwanee River

Line attributes

- Because the vector data represent both linear & polygonal features, there are 2 attribute tables.
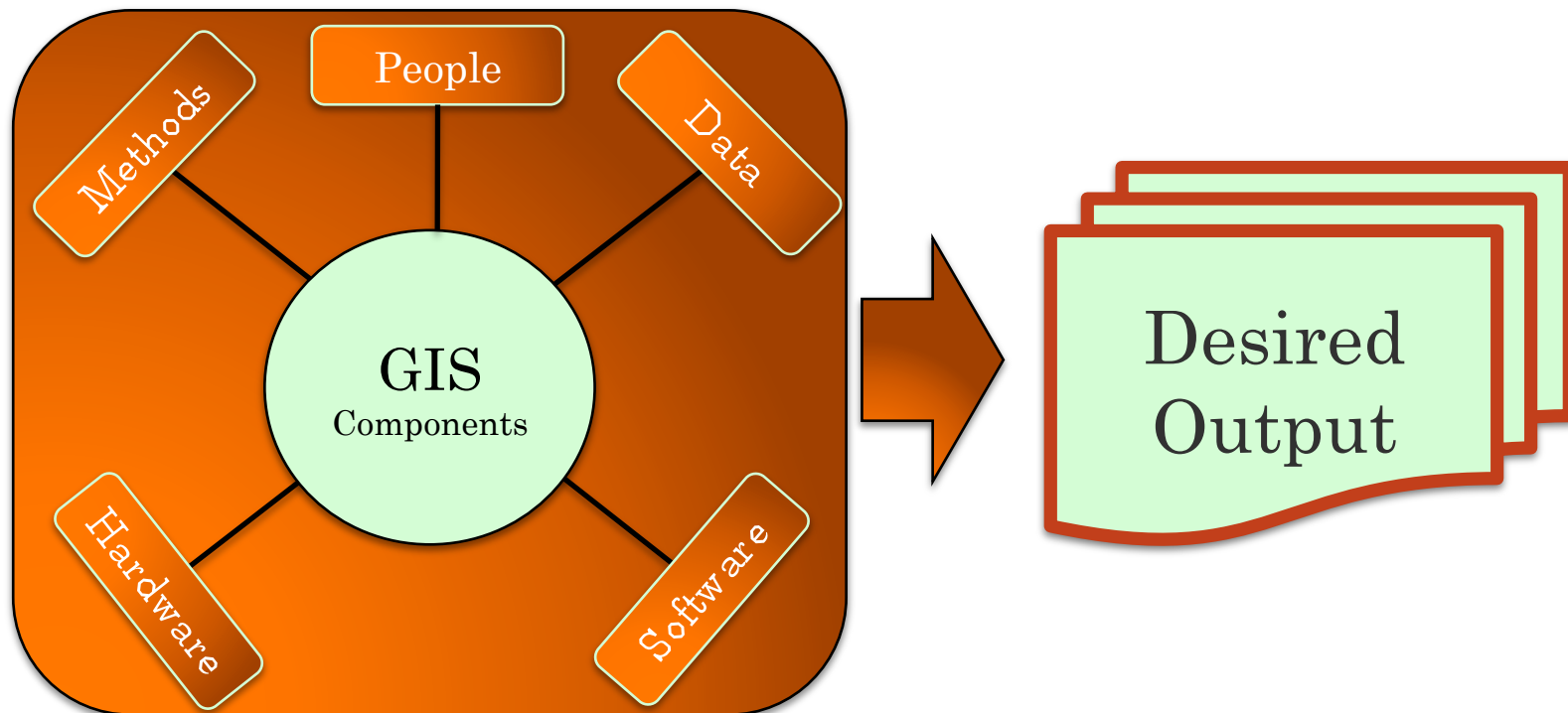
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Examples of GIS Applications

 A Framework for GIS Analysis

Source: ESRI

- **Integrating the five basic elements of GIS to produce the desired output.**

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○ **Suitability analysis for the best site for a new school**
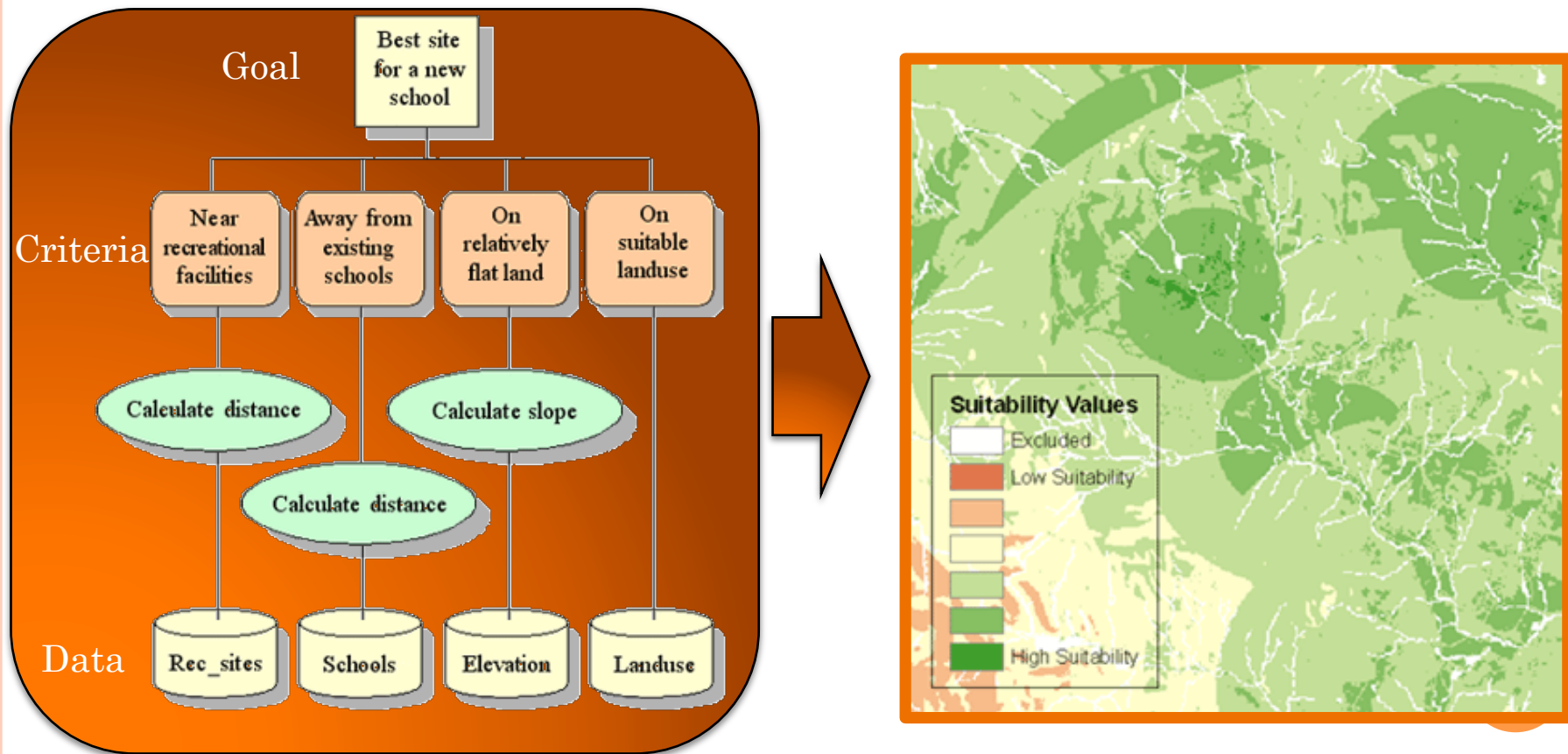
Source: ESRI

○ **Mapping population density**

U.S. Population Density
(By Counties)

MAP KEY
Population per
square mile
■ 250 or more
■ 50 - 249.9
■ 10 - 49.9
□ less than 10
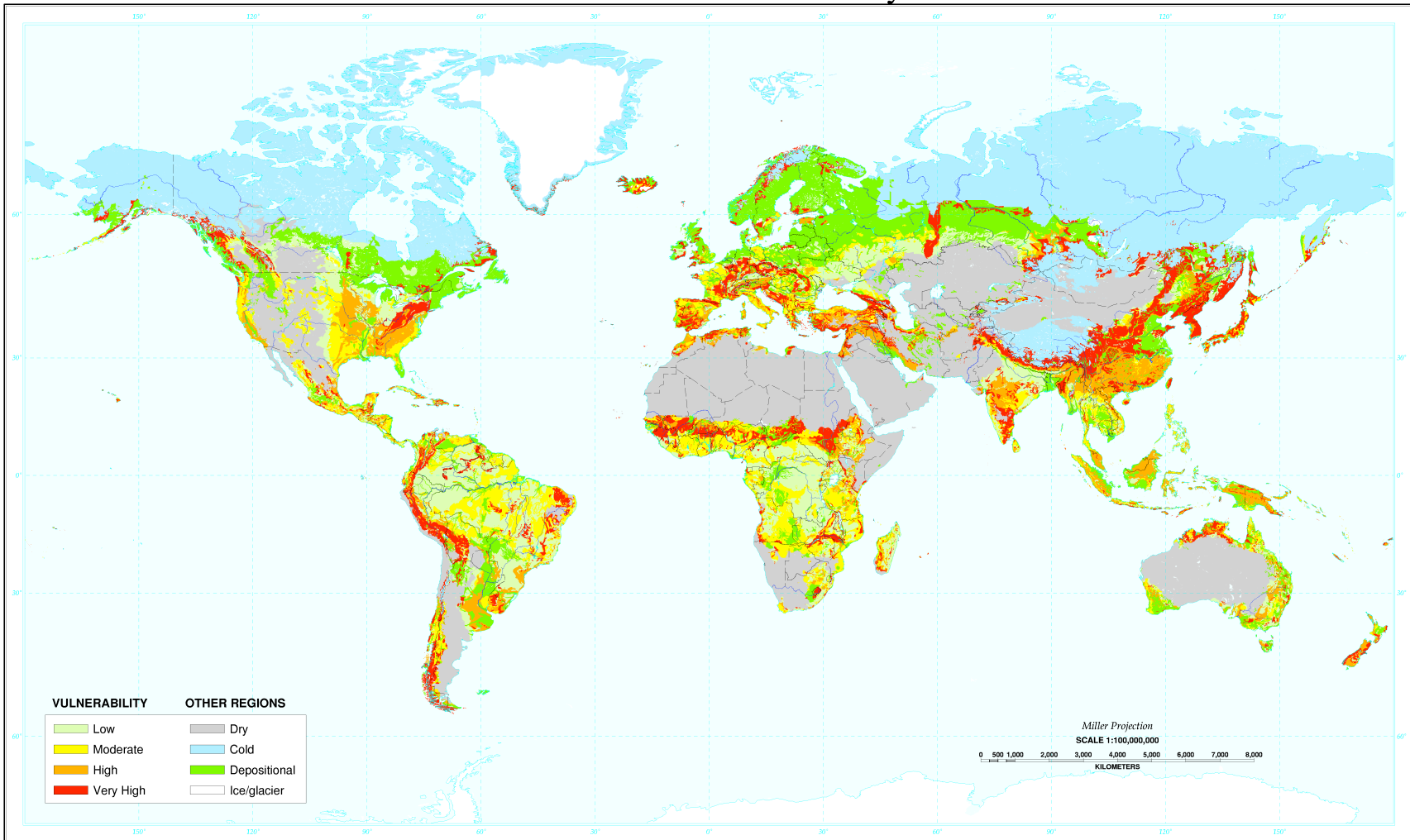
Source: http://www.census.gov/dmd/www/pdf/512popdn.pdf

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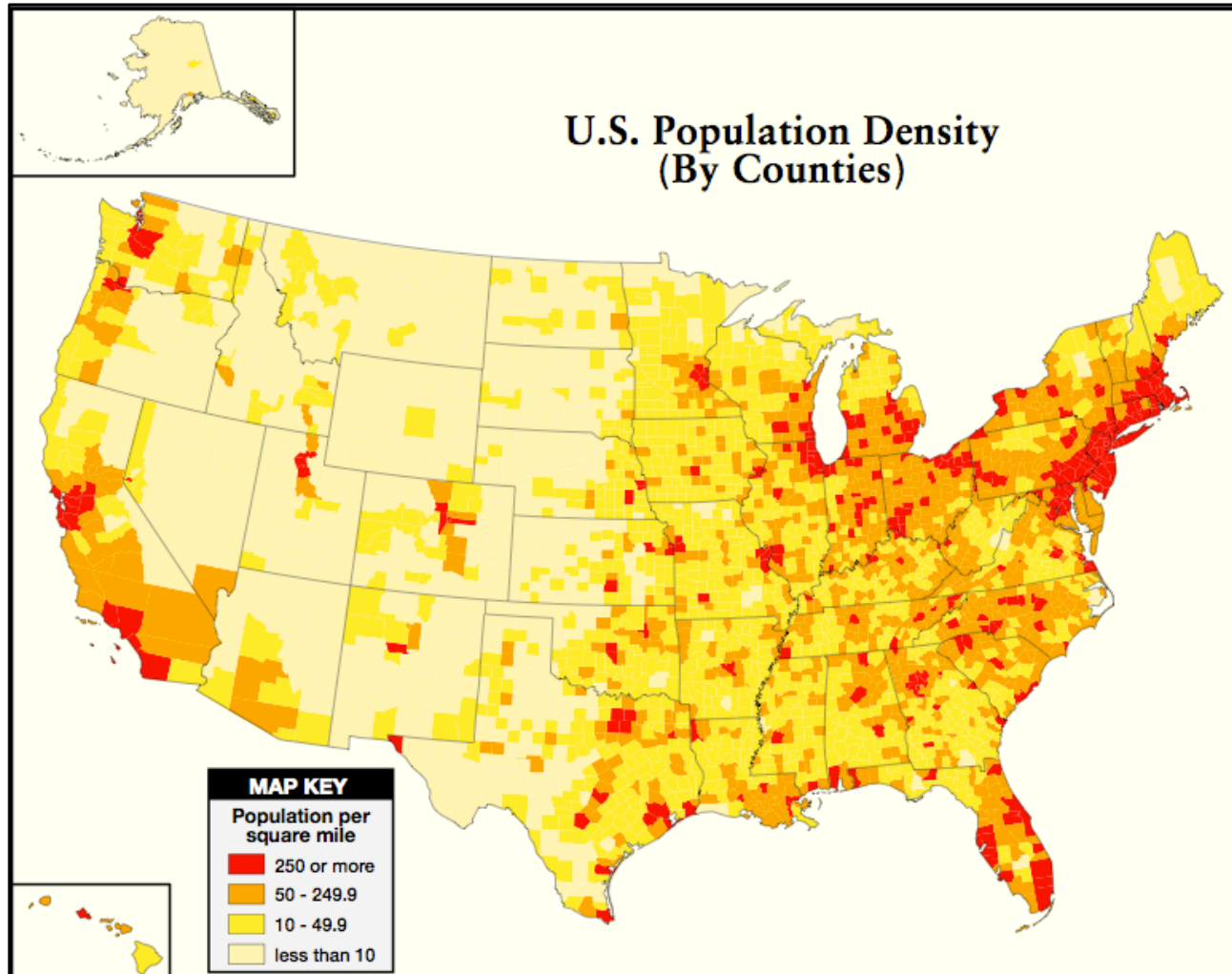
Water Erosion Vulnerability

U.S. Department of Agriculture
Natural Resources Conservation Service
Soil Survey Division
World Soil Resources

VULNERABILITY

- Low
- Moderate
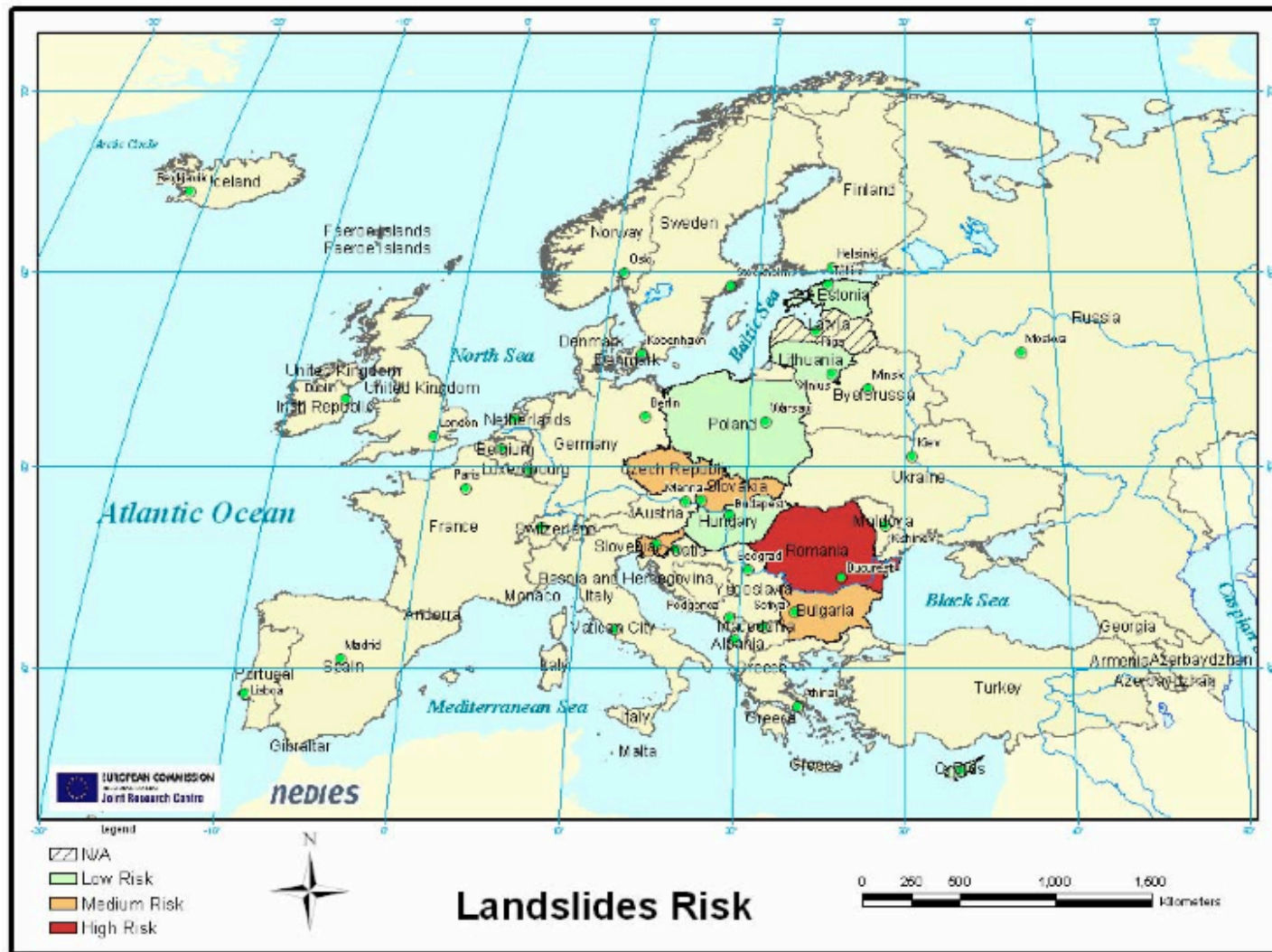- High
- Very High

OTHER REGIONS

- Dry
- Cold
- Depositional
- Ice/glacier

Miller Projection
SCALE 1:100,000,000

Country boundaries are not authoritative.

Washington D.C. 2002

Source: http://soils.usda.gov/use/worldsoils/mapindex/erosh2o.html

- **Landslide Risk Mapping**

Source: http://www-eaps.mit.edu/faculty/perron/files/Booth09.pdf

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- http://www.sfu.ca/rdl/GIS/tour/comp_gis.html

- http://www.mapsofindia.com/gis/gis-components.html

- http://www.picsearch.com/pictures/fashion/jewelry/watch%20brands/garmin.html

- http://bgis.sanbi.org/gis-primer/page_12.htm