

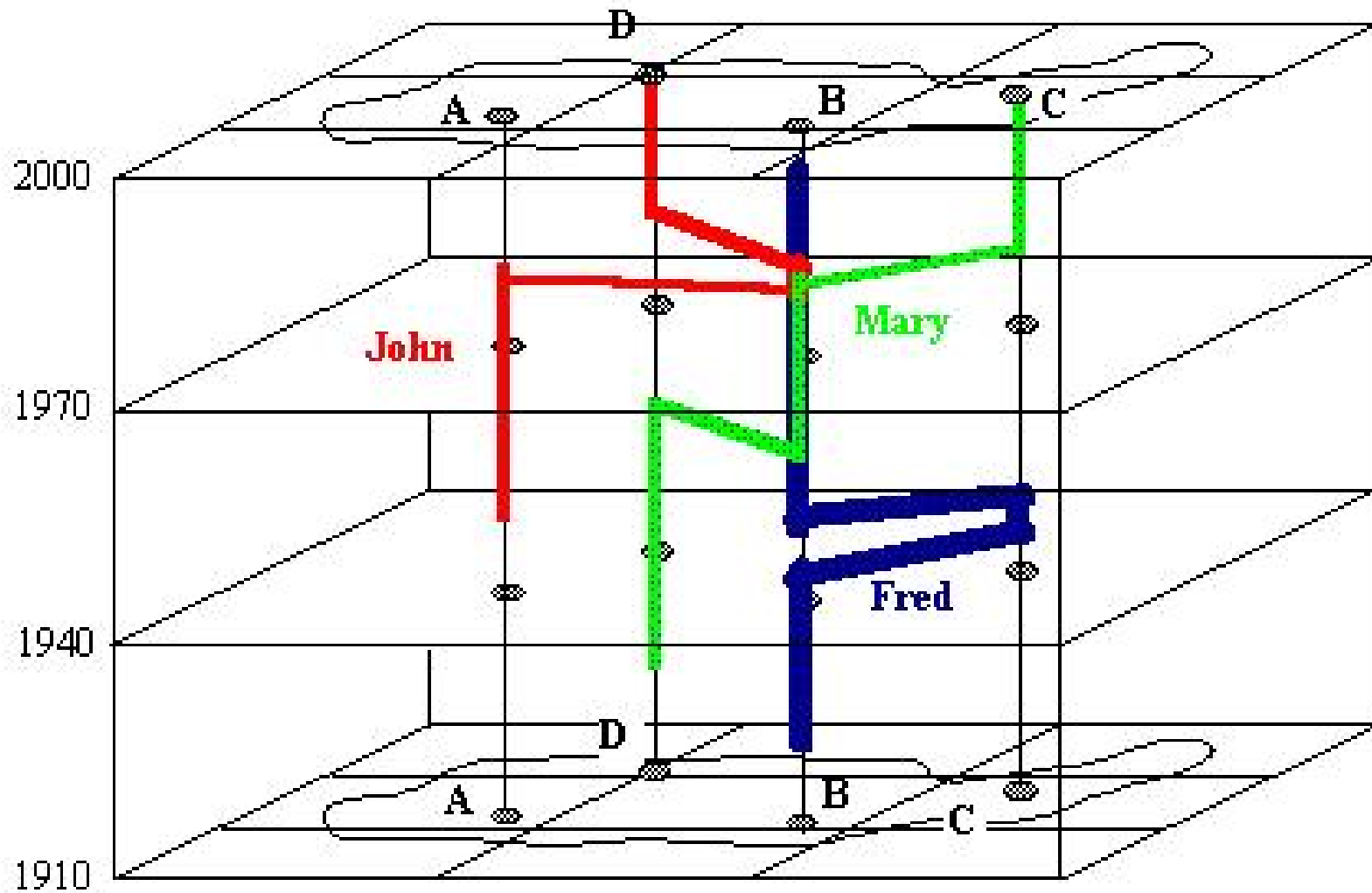
# 3. Representing Geography

# Outline

- What is representation?
- Digital representations
- The fundamental problem
- Discrete objects and fields
- Rasters and vectors
- The paper map

# Sensing the World

- Personal experience limited in time and space
  - One human lifetime
  - A small fraction of the planet's surface
- All additional knowledge comes from books, the media, movies, maps, images, and other information sources
  - From indirect or “remote” sensing



**Schematic representation of the lives of three US citizens in space (two horizontal axes) and time (vertical axis)**

# Representations

- Are needed to convey information
- Fit information into a standard form or model
  - In the diagram the colored trajectories consist only of a few straight lines connecting points
- Almost always simplify the truth that is being represented
  - There is no information in the representation about daily journeys to work and shop, or vacation trips out of town

# Digital Representation

- Uses only two symbols, 0 and 1, to represent information
  - N symbols (bits)  $\Rightarrow 2^N$  distinct values
- Many standards allow various types of information to be expressed in digital form
  - [MP3](#) for music
  - [JPEG](#) for images
  - [ASCII](#) for text
  - GIS relies on standards for geographic data

# Why Digital?

- Economies of scale
  - One type of information technology for all types of information
- Simplicity
  - $0,1 \Rightarrow \text{on,off}$
- Reliability
  - Systems can be designed to correct errors
- Easily copied and transmitted
  - Perfect copies
  - At close to the speed of light

# Accuracy of Representations

- Representations can rarely be perfect
  - Details can be irrelevant, or too expensive and voluminous to record
- It's important to know what is missing in a representation
  - Representations can leave us uncertain about the real world



# The Fundamental Problem

- Geographic information links a place, and often a time, with some property of that place (and time)
  - “The temperature at 34 N, 120 W at noon local time on 12/2/99 was 18 Celsius”
- The potential number of properties is vast
  - In GIS we term them *attributes*
  - Attributes can be physical, social, economic, demographic, environmental, etc.

# Types of Attributes

- Nominal, e.g. land cover class
  - Distinction (“a” is/is not “b”)
- Ordinal, e.g. a ranking
  - Significance (“a” is  $X$ -er than “b”)
- Interval, e.g. Celsius temperature
  - Relative magnitude (“a” is  $N$  units  $X$ -er than “b”)
    - interpolable
- Ratio, e.g. Kelvin temperature
  - Absolute magnitude (“a” is  $N$  times  $X$ -er than “b”)
    - scalable

# Cyclic Attributes

- Do not behave as other attributes
  - What is the average of two compass bearings, e.g. 350 and 10?
- Occur commonly in GIS
  - Wind direction
  - Slope aspect
  - Flow direction
- Special methods are needed to handle and analyze

# The Fundamental Problem contd.

- The number of places and times is also vast
  - Potentially infinite
- The more closely we look at the world, the more detail it reveals
  - Potentially *ad infinitum*
  - The geographic world is infinitely complex
- Humans have found ingenious ways of dealing with this problem
  - Many methods are used in GIS to create representations or *data models*

# Discrete Objects and Fields

- Two ways of conceptualizing geographic variation
  - The most fundamental distinction in geographic representation
- Discrete objects
  - The world as a table-top
  - Objects with well-defined boundaries

# Discrete Objects

- Points, lines, and areas
- Countable
- Persistent through time, perhaps mobile
- Biological organisms
  - Animals, trees
- Human-made objects
  - Vehicles, houses, fire hydrants

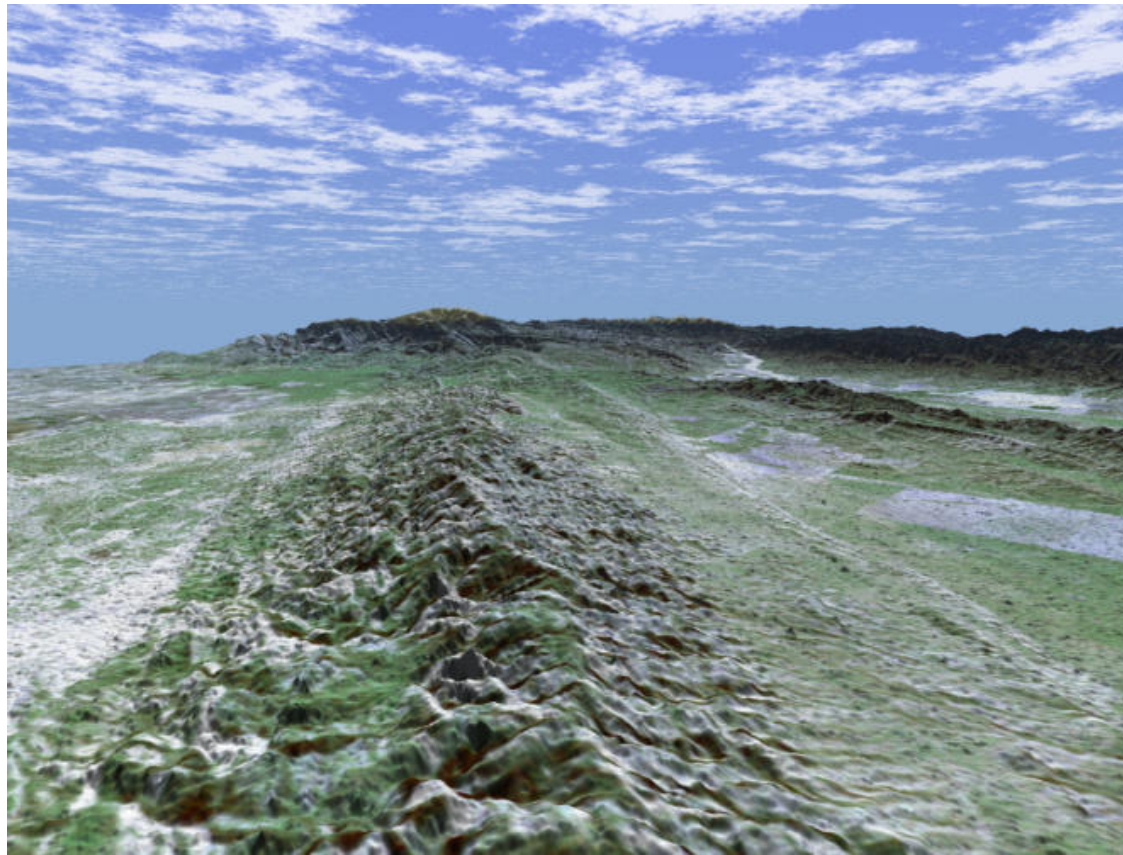
# Fields

- Properties that vary continuously over space
  - Value is a function of location
  - Property can be of any attribute type, including direction
- Elevation as the archetype
  - A single value at every point on the Earth's surface
  - The source of metaphor and language
    - Any field can have slope, gradient, peaks, pits

# Examples of Fields

- Soil properties, e.g. pH, soil moisture
- Population density
  - But at fine enough scale the concept breaks down
- Identity of land owner
  - A single value of a nominal property at any point
- Name of county or state or nation
- Atmospheric temperature, pressure





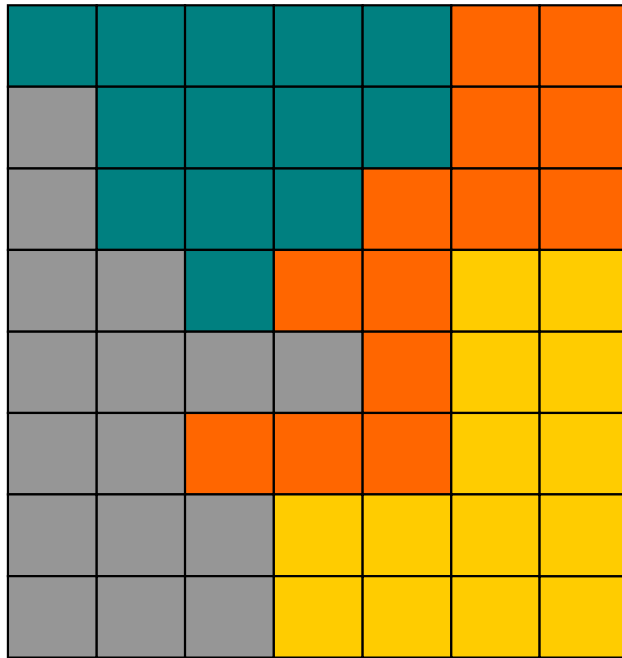
**Phenomena conceptualized as fields. The illustration shows elevation data from the Shuttle Radar Topography Mission draped with an image from the Landsat satellite, looking SE along the San Andreas Fault in Southern California, plus a simulated sky**

# Difficult Cases

- Lakes and other natural phenomena
  - Often conceived as objects, but difficult to define or count precisely
- Weather forecasting
  - Forecasts originate in models of fields, but are presented in terms of discrete objects
    - Highs, lows, fronts

# Rasters and Vectors

- How to represent phenomena conceived as fields or discrete objects?
- Raster
  - Divide the world into square cells
  - Register the corners to the Earth
  - Represent discrete objects as collections of one or more cells
  - Represent fields by assigning attribute values to cells
  - More commonly used to represent fields than discrete objects



### Legend

-  Mixed conifer
-  Douglas fir
-  Oak savannah
-  Grassland

Raster representation. Each color represents a different value of a nominal-scale field denoting land cover class.

# Characteristics of Rasters

- Pixel size
  - The size of the cell or picture element, defining the level of spatial detail
  - All variation within pixels is lost
- Assignment scheme
  - The value of a cell may be an average over the cell, or a total within the cell, or the commonest value in the cell
  - It may also be the value found at the cell's central point

# Vector Data

- Used to represent points, lines, and areas
- All are represented using coordinates
  - One per point
  - Areas as polygons
    - Straight lines between points, connecting back to the start
    - Point locations recorded as coordinates
    - May have “holes”
  - Lines as *polylines*
    - Straight lines between points

# Raster vs Vector

- Volume of data
  - Raster becomes more voluminous as cell size decreases
- Source of data
  - [Remote sensing](#), elevation data come in raster form
  - Vector favored for administrative data
- Software
  - Some GIS better suited to raster, some to vector

# The Paper Map

- A long and rich history
- Has a scale or *representative fraction*
  - The ratio of distance on the map to distance on the ground
- Is a major source of data for GIS
  - Obtained by digitizing or scanning the map and registering it to the Earth's surface
- Digital representations are much more powerful than their paper equivalents