# ArcGIS Extentions

Spatial Analyst
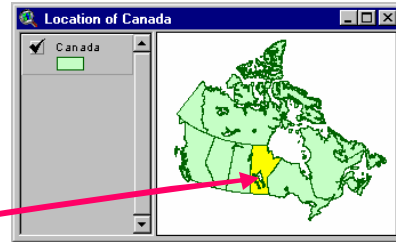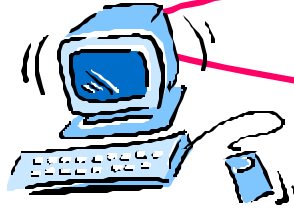
By Sumita Rai

---

# Overview

- What does GIS do?
- How does GIS work – data models
- Extension to GIS – Spatial Analyst
- Spatial Analyst Tasks & Tools
  - Surface Analysis
  - Surface Creation
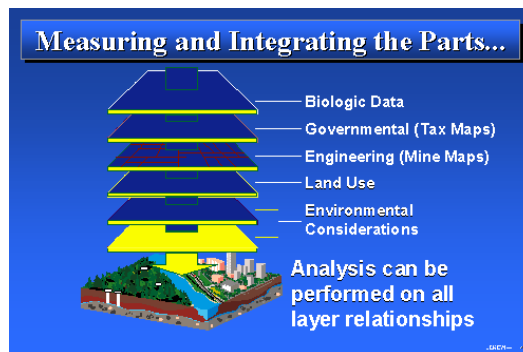  - Raster Calculation
  - Distance Analysis

# What does GIS do?

- GIS is a computer system that helps identify data according to their location

**Location of Canada**

Canada

**Attributes of Canada**

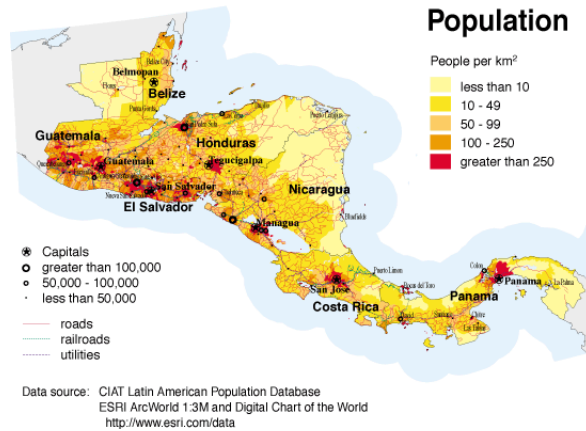| Shape | Province | Births 95 | Deaths 95 | Population 1996 |
|---|---|---|---|---|
| Polygon | Alberta | 39110 | 16625 | 2789528 |
| Polygon | British Columbia | 47995 | 27380 | 3855140 |
| Polygon | Manitoba | 16260 | 9445 | 1143524 |
| Polygon | New Brunswick | 8705 | 6180 | 762501 |
| Polygon | Newfoundland and Labrador | 6085 | 4180 | 570711 |
| Polygon | Northwest Territories | 1630 | 250 | 66568 |
| Polygon | Nova Scotia | 10825 | 7980 | 942796 |
| Polygon | Ontario | 146310 | 82055 | 11252425 |
| Polygon | Prince Edward Island | 1720 | 1115 | 137312 |
| Polygon | Quebec | 86445 | 51835 | 7389137 |
| Polygon | Saskatchewan | 13765 | 8550 | 1022537 |
| Polygon | Yukon Territory | 445 | 145 | 31452 |

# What does GIS do?

GIS stores information about the world as a collection of thematic layers and display this information as maps.

**Measuring and Integrating the Parts...**

Biologic Data

Governmental (Tax Maps)

Engineering (Mine Maps)

Land Use

Environmental Considerations

Analysis can be performed on all layer relationships

# What does GIS do?

Layers include digital basemaps and datasets such as demographics and census data, land utilization, water bodies etc.

**Population**

People per km²

less than 10
10 - 49
50 - 99
100 - 250
greater than 250

⊛ Capitals
○ greater than 100,000
○ 50,000 - 100,000
· less than 50,000

—— roads
—— railroads
········· utilities

Data source:  CIAT Latin American Population Database
ESRI ArcWorld 1:3M and Digital Chart of the World
http://www.esri.com/data

Belmopan
Belize
Guatemala
Guatemala
Honduras
Tegucigalpa
San Salvador
El Salvador
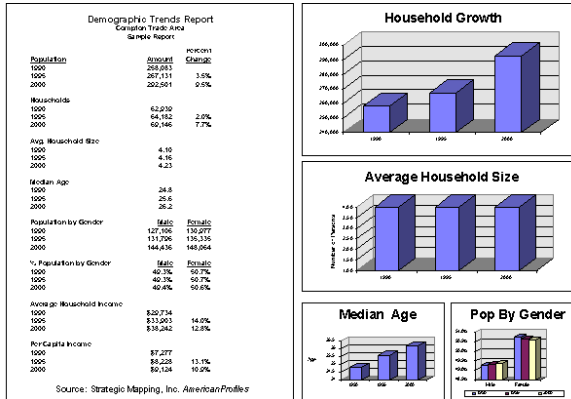Nicaragua
Managua
Costa Rica
San Jose
Panama

---

# What does GIS do?

Geography is the glue that binds these layers together and GIS is the tool that allows us to see relationships between them

# What does GIS do?

ArcGIS provides basic capabilities like data visualization, querying and analysis capabilities, along with the ability to create and edit geographic data.



# Overview

- What does GIS do?
- **How does GIS work – data models**
- Extension to GIS – Spatial Analyst
- Spatial Analyst Tasks & Tools
  - Surface Analysis
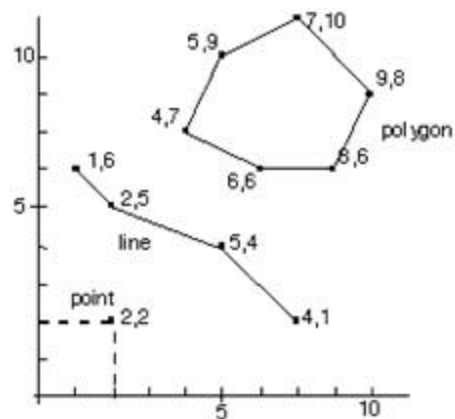  - Surface Creation
  - Raster Calculation
  - Distance Analysis

# GIS data models

- GIS work with three types of geographic models –

  o **Vector Model**

  o **Raster Model**

  o **Triangulated Model**

# Vector Model

Vector data, models information about points, lines, and polygons as a x, y coordinate
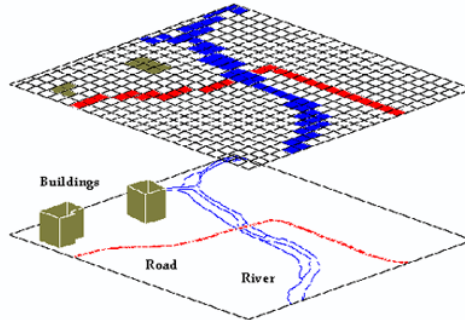
o Points - City, Tree
o Lines - River, Road
o Polygons - Forest, Lake

# Raster Model



- Row
- Column
- Cell Size
- Resolution

Buildings

Road    River

A raster model is a collection of grid cells where each cell has a value.

Raster data is used to model continuously varying features such as soil type, vegetation, or elevation.

www.unescap.org/stat/pop-it/pop-wit/mo6d.htm.

# Triangular Irregular Network (TIN)

o The TIN data structure is defined by two elements: a set of input points with x,y, and z values, and a series of edges connecting these points to form triangles

o Like grids, TINs are used to represent continuous surfaces such as elevation
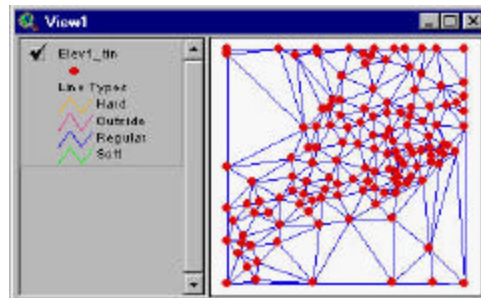
# Overview

- What does GIS do?
- How does GIS work – data models
- **Extension to GIS – Spatial Analyst**
- Spatial Analyst Tasks & Tools
  - Surface Analysis
  - Surface Creation
  - Raster Calculation
  - Distance Analysis

# Why do we need extensions?

- To augment the basic capabilities of ArcGIS
  - The extension I will talk about:
    - ArcGIS Spatial Analyst

# ArcGIS Spatial Analyst

- **ArcGIS Spatial Analyst** allows us to perform tasks such as:
  - **Surface analysis** – how steep is a location?
  - **Surface creation** – highest rainfall from precipitation data.
  - **Raster calculation** – helps combine different data :- Walmart could look at household population , income level, other stores in vicinity to select a future store location.
  - **Distance Analysis** – what is the shortest distance between two locations.
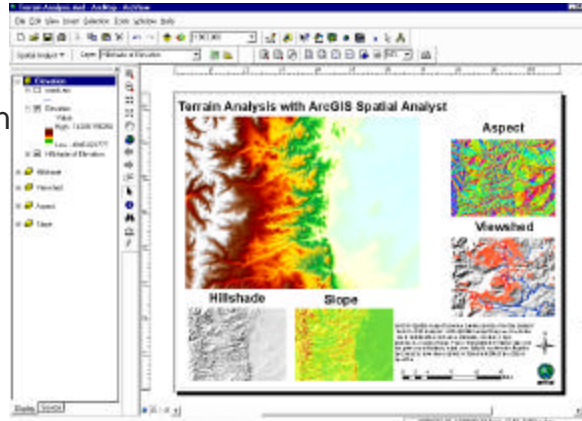
# Overview

- What does GIS do?
- How does GIS work – data models
- Extension to GIS – Spatial Analyst
- Spatial Analyst Tasks & Tools
  - Surface Analysis
  - Surface Creation
  - Raster Calculation
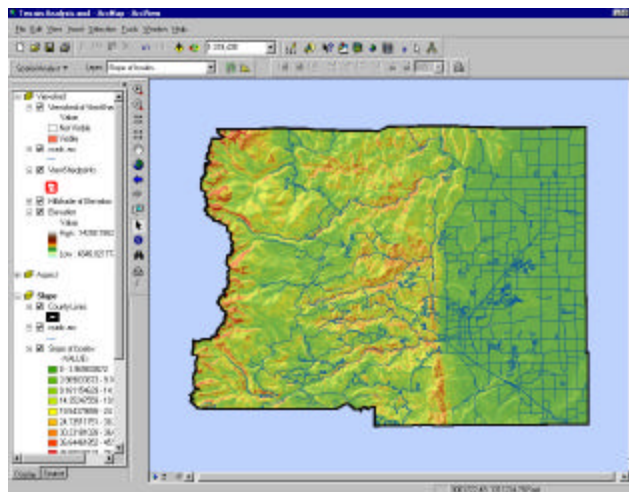  - Distance Analysis

# Surface Analysis

Surface Analysis tools derive useful Geospatial information from elevation surfaces such as
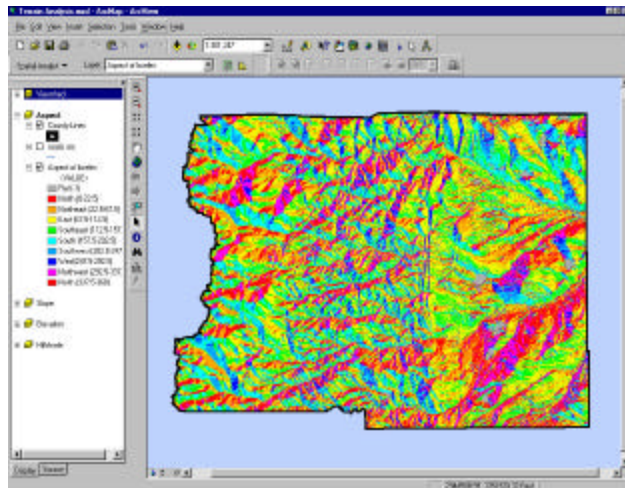
- Slope
- Aspect
- Hillshade
- Viewshed

# Surface Analysis – Slope Tool

Used to analyze the angular component of a terrain – Can answer questions like where to build a ski resort based on the degree of slope
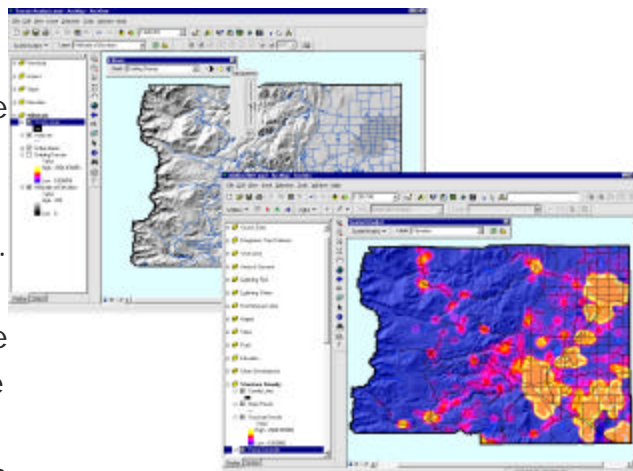
# Surface Analysis – Aspect Tool

Aspect tools helps identify slope direction or the compass direction a hill faces.
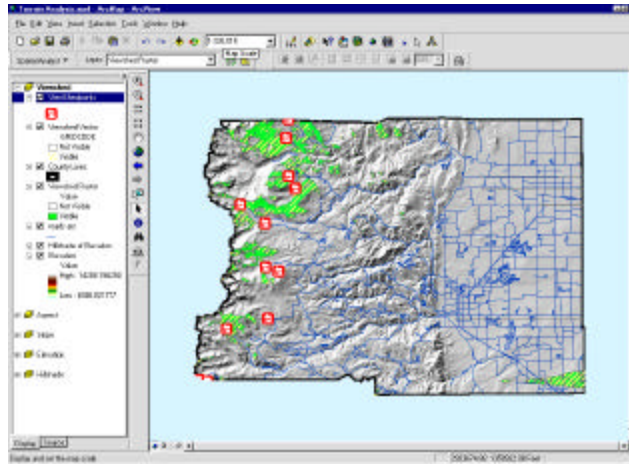


# Surface Analysis – Hillshade

■ Hillshade is used to determine the Hypothetical illumination of a surface. For e.g. hillshade can be used to determine the length of time and intensity of the sun in a given location

# Surface Analysis – Viewshed

Viewshed identifies the cells in an input raster that can be seen from one or more observation points or lines



# Overview

- What does GIS do?
- How does GIS work – data models
- Extension to GIS – Spatial Analyst
- Spatial Analyst Tasks & Tools
  - Surface Analysis
  - Surface Creation
  - Raster Calculation
  - Distance Analysis

# Surface Creation

- ArcGIS Spatial Analyst includes the following interpolation tools to create a surface from sample data measurements
  - Spline
  - Inverse Distance Weighted
  - Kriging (Ordinary, Universal)
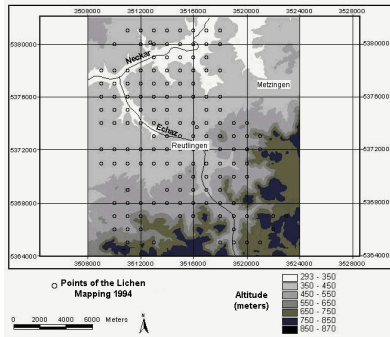
# Surface Creation - Spline

Spline estimates values using a mathematical function that minimizes overall surface curvature.

Discrete point measurements, are transformed to continuous surfaces by the spline algorithm.
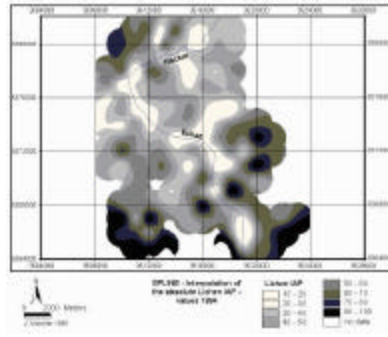


Before SPLINE    After SPLINE

⊢—⊣ GRAIN tolerance
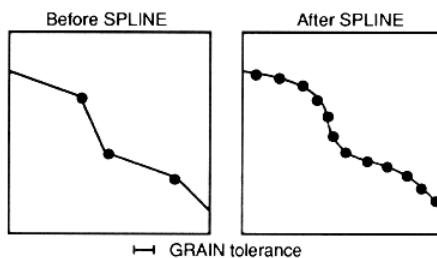
www.gis_univie_ac.at/.../kriz/karto_geoinfo/work/g2/1.html

# Surface Creation - Spline



Before Spline           After Spline

---
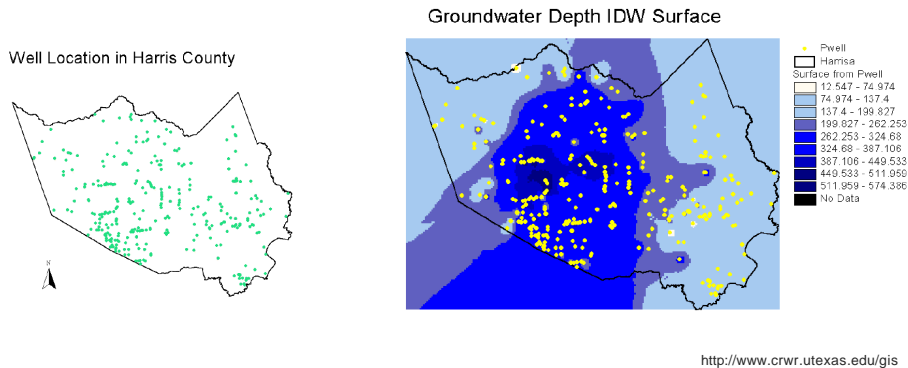
# Surface Creation - IDW

- **The Inverse Distance Weighted** (IDW) interpolator assumes that each input point has a local influence that diminishes with distance.
  - Weights points closer to the processing cell greater than those farther away.
  - A specified number of points, or optionally all points within a specified radius, can be used to determine the output value for each location.

# Surface Creation - IDW

The USGS Ground Water Data Report provides the depth to groundwater table in each well in Harris County

Well Location in Harris County

Groundwater Depth IDW Surface



http://www.crwr.utexas.edu/gis

---

# Surface Creation - Kriging

- Kriging is based on statistical models that include autocorrelation.
- Weights are based on:
  - The distance between the measured points and the predicted location AND
  - The overall spatial arrangement among the points.

# Surface Creation - Kriging
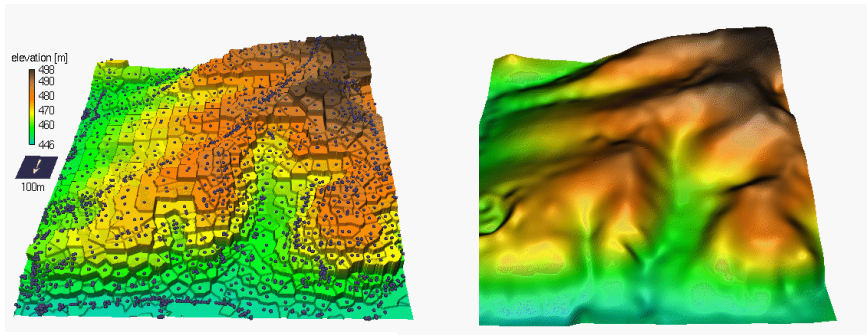


Scattered points

Raster after Kriging

skagit.meas.ncsu.edu/~helena/publwork/talks/interpmeth.html

---

# Overview

- What does GIS do?
- How does GIS work – data models
- Extension to GIS – Spatial Analyst
- **Spatial Analyst Tasks & Tools**
  - Surface Analysis
  - Surface Creation
  - Raster Calculation
  - Distance Analysis

# Raster Calculation

- Takes any number of data sets and combine them with certain parameters
- It is a tool for
  - Calculating map algebra
  - Map functions
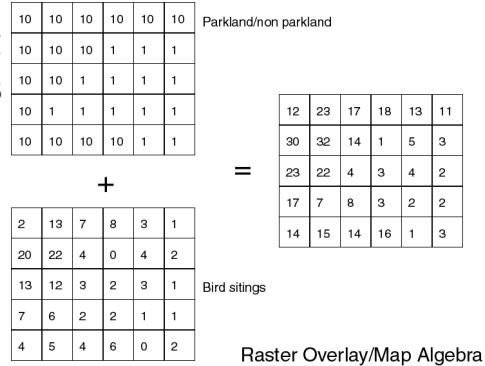  - Conducting queries

# Map Algebra

- Map algebra can be performed to identify relationships between layers, or to derive indices that describe phenomena
- Map calculations create a new layer
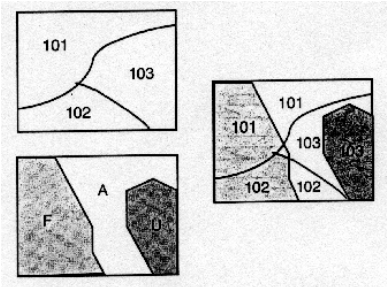
# Map Algebra

Map Algebra deals with operations on map,it supports three types of expressions:

- Arithmetic
- operators
- Boolean operators
- Relational operators

| 10 | 10 | 10 | 10 | 10 | 10 |
|----|----|----|----|----|----|
| 10 | 10 | 10 | 1 | 1 | 1 |
| 10 | 10 | 1 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 1 | 1 |
| 10 | 10 | 10 | 10 | 1 | 1 |

Parkland/non parkland

+

| 2 | 13 | 7 | 8 | 3 | 1 |
|----|----|----|----|----|----|
| 20 | 22 | 4 | 0 | 4 | 2 |
| 13 | 12 | 3 | 2 | 3 | 1 |
| 7 | 6 | 2 | 2 | 1 | 1 |
| 4 | 5 | 4 | 6 | 0 | 2 |

Bird sitings

=

| 12 | 23 | 17 | 18 | 13 | 11 |
|----|----|----|----|----|----|
| 30 | 32 | 14 | 1 | 5 | 3 |
| 23 | 22 | 4 | 3 | 4 | 2 |
| 17 | 7 | 8 | 3 | 2 | 2 |
| 14 | 15 | 14 | 16 | 1 | 3 |

Raster Overlay/Map Algebra

http://www.sfu.ca/gis/web355/icons/8_Roverlay.gif

---

# Map Functions

- Cell statistics(Local): only use data in a single cell to calculate an output value
  - Used to analyze a certain phenomenon over time – land use over a period of time
  - Two main types of local operation:
    - reclassification and
    - overlay

# Map Functions

- Neighborhood(Focal): is a function of the input cells in some specified neighborhood of the location
  - e.g.variety of different land cover types in each neighborhood
- Zonal statistics: calculated for each zone, based on values from another dataset. A Zone is all the cells in a raster that have the same value
  - e.g.Number of accidents on each road in a town

# Raster calculation - Query

- Single layer numeric example: elevation > 2000 ft
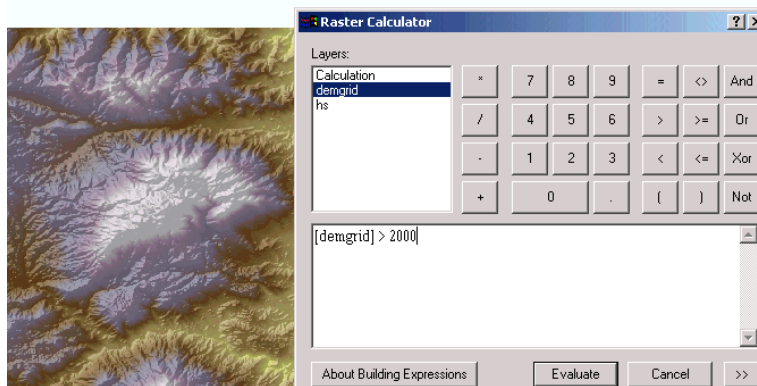
# Overview

- What does GIS do?
- How does GIS work – data models
- Extension to GIS – Spatial Analyst
- **Spatial Analyst Tasks & Tools**
  - Spatial Analysis
  - Spatial Creation
  - Raster Calculation
  - Distance Analysis

# Distance analysis

- Provides information such as
  - Distance to the nearest hospital from certain areas
  - Finding all restaurants in a certain area
  - Shortest or least cost path from one location to another

# Distance analysis

- Distance mapping tools:
  - Straight Line Distance functions (Euclidean)
  - Cost Weighted Distance functions

# Straight Line Distance functions

- Provides the distance from each cell in the raster to the closest source.
- Answers questions like
  - What is the distance to the closest town?
  - Which town am I closet to? &
  - What is the direction to the closest town?

# Cost Weighted Distance functions

- Provides the least accumulative cost from each cell to the nearest, cheapest source.
- Expected applications
  - Minimize construction cost for routing new roads
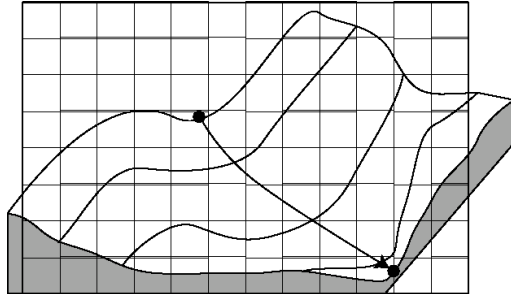


Least cost path over a raster surface. The first step is to compare elevation values around the starting point. The lowest value is chosen and the process is iteratively repeated until the end point is reached.

http://www.sfu.ca/gis/web355/icons/8_Roverlay.gif

# Questions?