Spatial Technology for The Survey and Monitoring of Invasive Species

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The Basic “Invasives” Problem

To survey, inventory, and monitor invasive plants, their invasion characteristics, document control treatments, and evaluate the results.

In short, to measure, document, and analyze.

Basic Tools

- Measurement
  - GPS – (Global Positioning System)
    - A device for measuring geographic coordinates at any location on the earth.
  - Documentation and Analysis
  - GIS – (Geographic Information System)
    - A database for maintaining and analyzing spatial features and the relationships between features as they are defined through geographic coordinates or measurements.

Global Positioning System (GPS)

- A constellation of 24 man-made “stars” (satellites) composed of very accurate atomic clocks put into an approximately 12 hour orbit at an altitude of 20,000 km (meaning that at least 6 satellites should be “viewable” at any time.)

- The system is maintained by the US Department of Defense giving users access to “quality” measurements anywhere on (or near) the surface of the earth at any time of the day or night.

How does GPS work?

- Satellites are at known points orbiting the earth
- Their range is defined by the difference in time between sending and receiving a signal
- Using resection trigonometry, the location of the receiver clock can be calculated
- Most error in the range intersection is due to error in the receiver clock

Trigonometry

- Quick Trigonometry review –
  - One radius measurement locates me to any point along a circle
  - Two radius measurements narrows my position to only two points
  - A third radius will narrow the position to only one value
  - If the timing offset is consistent, a fourth radius measurement will compensate the errors

And remember, we should usually have six satellites available (in perfect conditions)
**Working with the geodatabase**

**Creating a geodatabase**

**Accuracy**

- **Basic Accuracy** (Post May 1,2000)
  - Uncorrected 10-30 meters (30-100’)

- **WAAS (Wide Area Augmentation System)**
  - Realtime correction 0.5 – 10 meters (2 – 30 ft)
  - Terrestrial based low cost, limited range, terrain obstructions
  - Satellite based has wide coverage but also high cost

- **DGPS (Differential GPS)**
  - Post Processing (<0.01m) 0.1 ft

**Measures of Precision**

- The symmetry of the satellites will control the level of precision
- These symmetry factors are known as
  - GDOP
  - PDOP
  - VDOP

**Reliability**

- Many factors can contribute to decrease reliability
  - Receiver quality
  - Proximity to buildings or other obstructions (cliffs, etc.), tree canopy
  - Multipathing
  - Microwave or other radio interference
  - Blunders (wrong setup parameters)
  - Weight of receiver unit
  - Power source

**Transportability**

- Projections and datums are important when converting unprojected coordinates to a map

**Useful Conclusions on GPS**

- Buy the best equipment that you can afford that will give you the level of reliable accuracy that you need
- Carefully plan (and execute) data collection trips
  - Watch satellite geometry – PDOP, GDOP
- Be sure to understand
  - Datums and projections of data target
- Be sure to check
  - Cables, batteries, setup options
- Be sure to avoid sources of interference
  - Microwaves, buildings, cliffs, trees, etc.

**Managing Real-World Objects**

* A GIS is more than just a database with coordinates…
Geodatabases Abstract Knowledge

GIS abstracts and serves a geospatial business logic through database tables!

Geodatabase Objects

Topology is About Relationships

- A field of study focusing on the properties of shapes that remain constant when the shapes are deformed (e.g. through projections or datum transformations)
  - Projection independent properties
    - connectivity (contiguity), adjacency, and containment
  - Projection dependent properties
    - area, shape, distance, and direction

Understanding Behavior

- Topology gives us the syntax and vocabulary for defining what we learn through our research
  - How strong is the species preference for steep slopes, for specific aspects, or soils? Why is it where it is?
  - How can we expect a species to respond to treatments? How can spatial considerations affect the results?
  - What was my return on investment for a treatment? Where can I expect even better returns for my efforts?
- Spatial Analysis, Geographic Business Logic, and Spatial Modeling gives us answers to questions, … but only when we learn how to ask the questions!

Data Modeling and Initiatives

- SAMAB (SAIN) – a great start at collecting and disseminating descriptive spatial data
- NBII (ISIN) – a great forum for building on the sharing of spatial knowledge
- 2003 Biodiversity Modeling Workshop: Results and Recommendations - “planning for the eventual shift from descriptive to functionally mechanistic models will be important to accurately depict both current and potential future species distributions.”

Spatial Statistics and Analysis

- New collection of analytical tools that come standard with ArcGIS 9 licenses

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Useful Conclusions on GIS

- Think of a GIS as a method of utilizing a database to model everything you know about a species or a treatment, not just a way to build a “map”
  - Learn to “model” instead of just how to “store” data
- Let the computer do the “work” of maintaining databases and analyzing relationships while you “think” of useful questions
  - Learn the language of GIS instead of being caught up in technology
- Share your data, but be sure it is useful by creating appropriate metadata
  - Learn to share “information” and “knowledge” instead of raw data