Duke
NICHOLAS SCHOOL OF THE ENVIRONMENT

ENVIRON 761:
Geospatial Analysis for Land & Water Management

Instructor: John Fay & Peter Cada

TA: Kelly Davidson

Agenda

- Introductions
- Course theme & objectives
- Course overview & logistics
- First assignment 

John's GIS Timeline…

1990 First use of GIS in undergrad honors thesis

Used GIS to model nonpoint source pollution (grad thesis)

Helped create and run Univ. of Michigan's 1st GIS lab

GIS Manager at Stanford's Jasper Ridge Biological Station

GIS Manager at Stanford's Ctr for Conservation Biology

2000

Research associate/Instructor at NSOE

2010 Took over ENV 761 from Jennifer Swenson

Peter's GIS Timeline…

2005 First use of GIS during MEM attainment

2007 Started working at Tetra Tech, Inc consulting firm
Supported and led Watershed and Water Quality modeling to support EPA, states, municipalities.
Became GIS Lead for Water Resources Group

2014 Taught GIS for Water Resources to MEMs in Spring

2018 Joined Stantec as Senior Planner and GIS Technical Discipline Lead for Environmental Services line.

2023 Came full circle back to teach GIS @ Nicholas School!

Introductions

- John Fay Instructor/Research Associate, Duke University
- Peter Cada Instructor/Research Associate, Duke University
- TA:

  Kelly Davidson

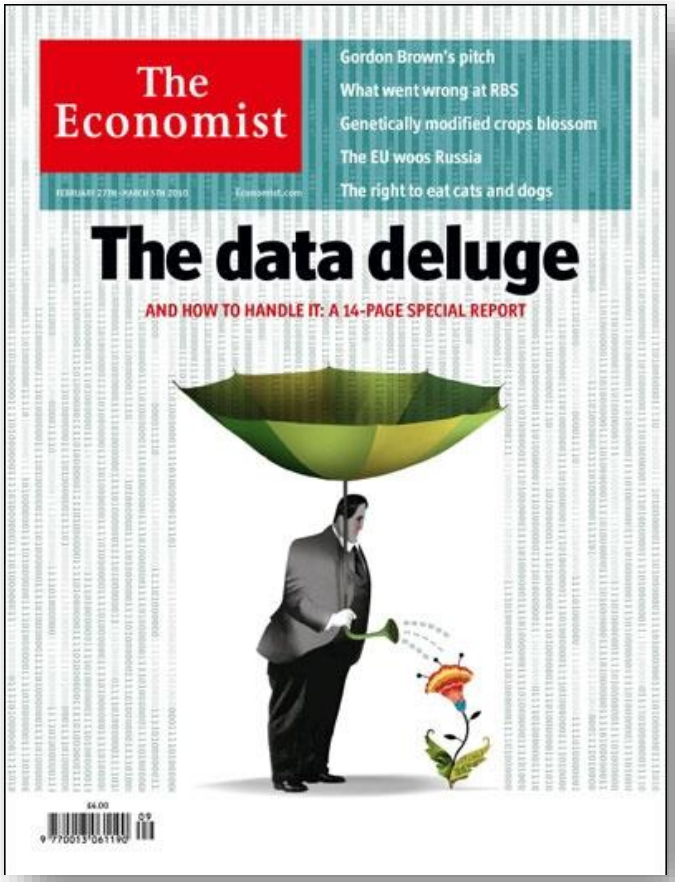
Introductions

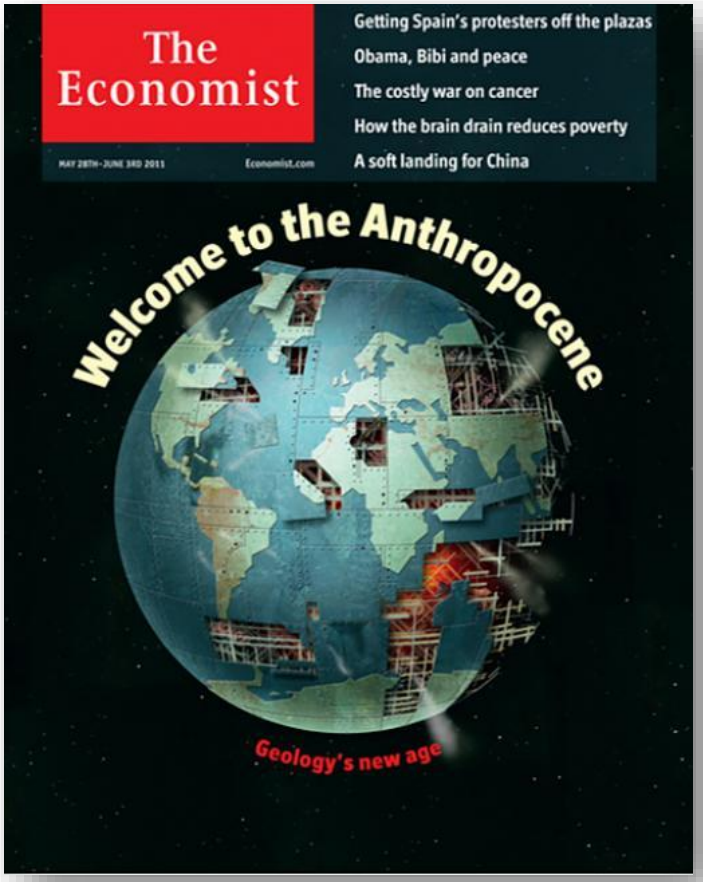
Please introduce yourself and state:

- *Your concentration(s)…*
- *One thing you want to get from this course…*
- *Your favorite hot beverage…*

Course theme…

Lucas Joppa, WWF Fuller Symposium https://vimeo.com/147605501





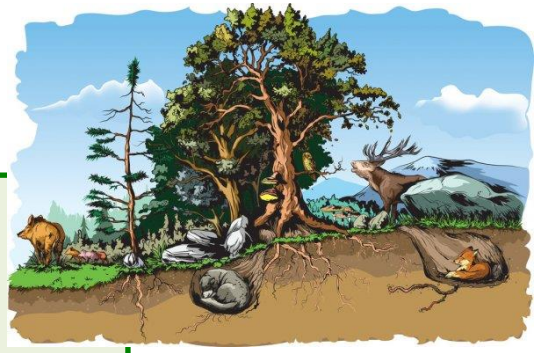
Technology for nature conservation: An industry perspective

Lucas N. Joppa

Ambio 2015, 44(Suppl. 4):S522–S526

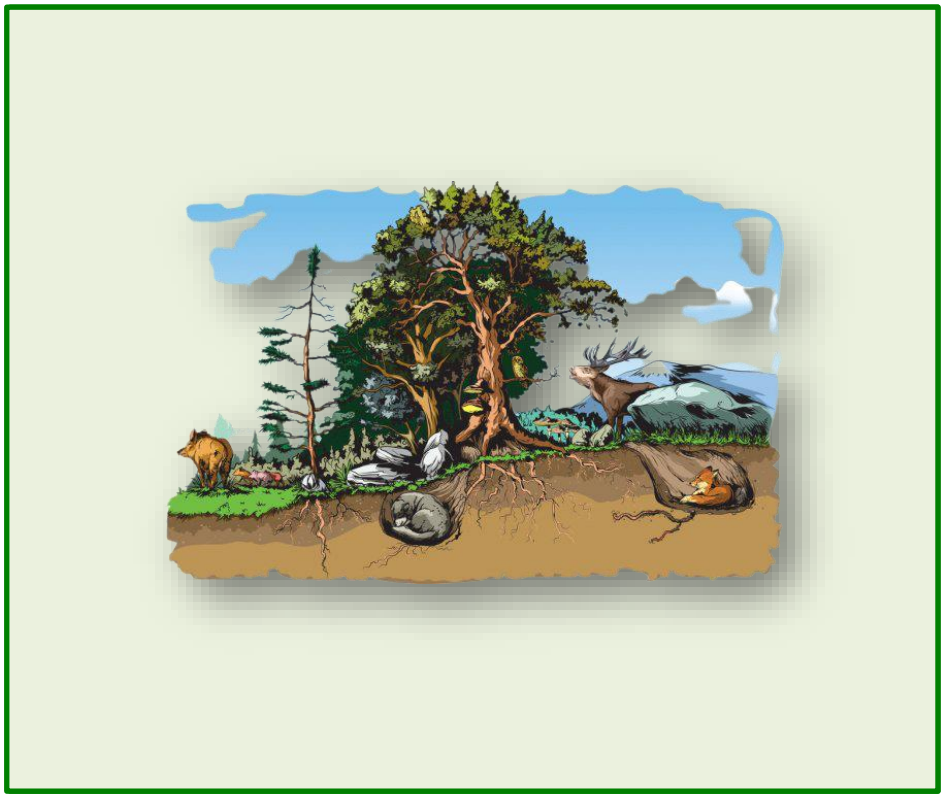
"Land & Water Management"

Manage this area…



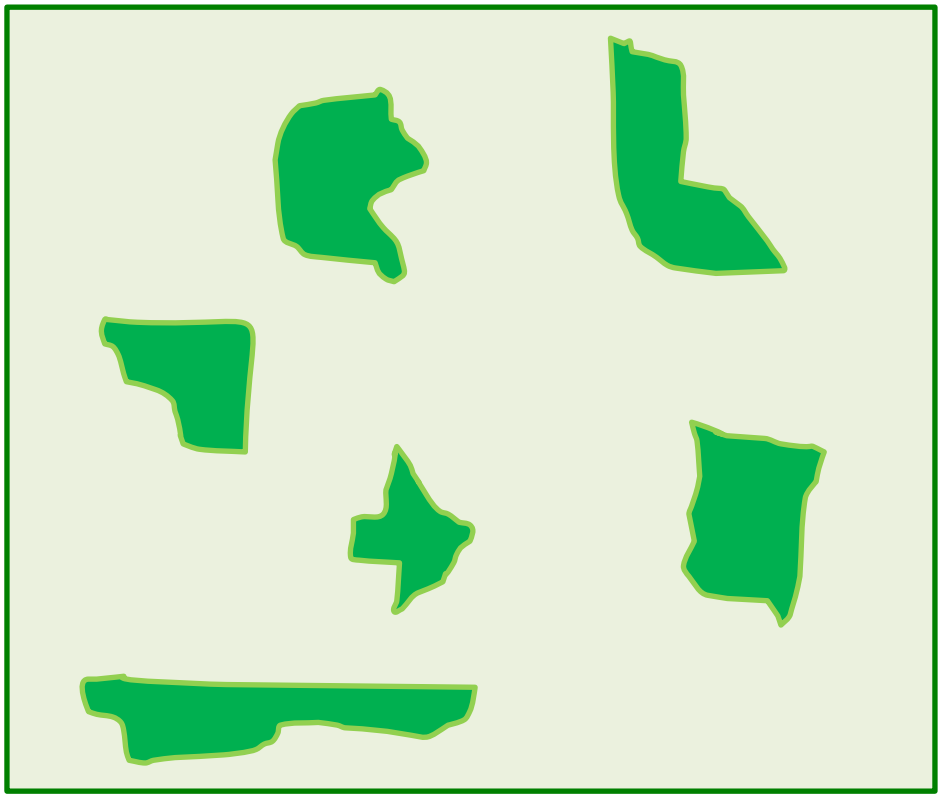
"Land & Water Management"

Manage this area for biodiversity protection…



"Land & Water Management"

What do we need to know in order to prioritize?



- Area = ?
- Protecting what?
- Protecting from?
- Other uses = ?
- Budget = ?
- Time line = ?
- Success = ?

"Conservation & Land Management"

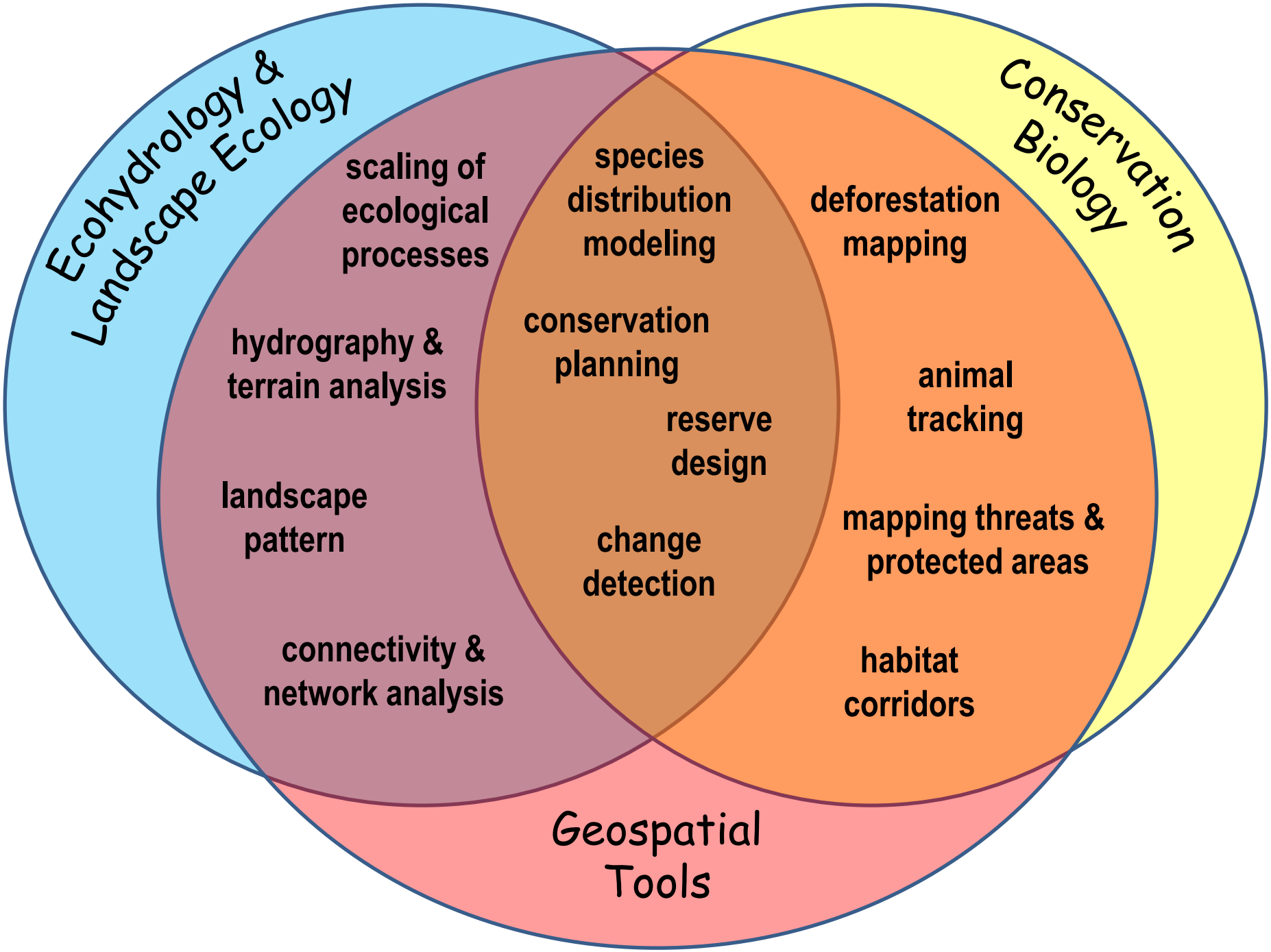
Course theme:

Examine the spatial analysis techniques used to identify and evaluate the factors useful for prioritizing landscapes for ~~conservation.~~

Ecosystem services

Energy resource management

- Defining the "**landscape**"
- Locating conservation **targets** and their condition
- Identifying and evaluating **threats** & **restrictions**
- Designing a **conservation plan**
- **Monitoring** conservation plans


Ecohydrology &
Landscape Ecology
Conservation
Biology
Geospatial
Tools
scaling of
ecological
processes
hydrography &
terrain analysis
landscape
pattern
connectivity &
network analysis
species
distribution
modeling
conservation
planning
reserve
design
change
detection
deforestation
mapping
animal
tracking
mapping threats &
protected areas
habitat
corridors

GIS & Geospatial Analysis

GIS: A tool or a discipline??

Our focus will be on GIS as a tool – an analytical tool which can be applied to specific scientific and management questions in the same way statistics or other analysis techniques are employed.

- How can GIS expand our analytical capabilities?
- How can GIS facilitate access to data and ideas?

GIS & Geospatial Analysis

Positive aspects

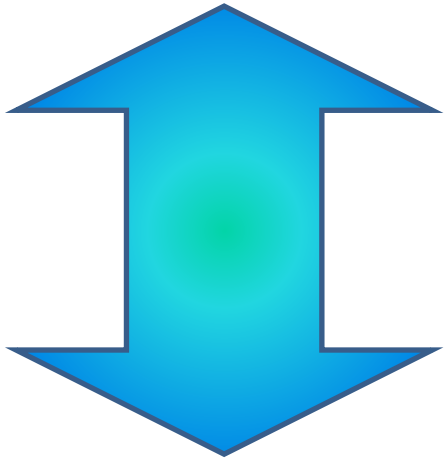
- explicit analysis
- reproducible methods
- powerful media

Negative aspects

- too often believed to be a panacea
- can mask poorly developed analysis
- contributes to "puzzle solving" *vs* problem solving

Researcher vs Practitioner

- A **researcher** needs more time, higher resolution data, more documented relationships, more validation data, better models…



- A **practitioner** needs the map yesterday… wants a "cookbook" approach to get the job done quickly, efficiently, and uniformly

Course theme

The development of more rigorous, objective, and defensible analysis methods to support sound [conservation] decision making…

The increasing rate and magnitude of environmental, economic, social and political problems affecting our land and water resources and the integrity of ecological systems requires nothing less…

Course objectives

- Develop a set of [land & water] GIS skills
- Explore "real world" land management GIS problems and solutions
- Explore new methods and approaches to solving spatial problems
- Better understand the ecological/management context of our GIS actions

What we'll do this semester…

I. Project based GIS

II. Ecohydrology and terrain analysis

III. Species distribution/habitat modeling

IV. Landscape assessment

V. Conservation planning

*VI. Grab bag**

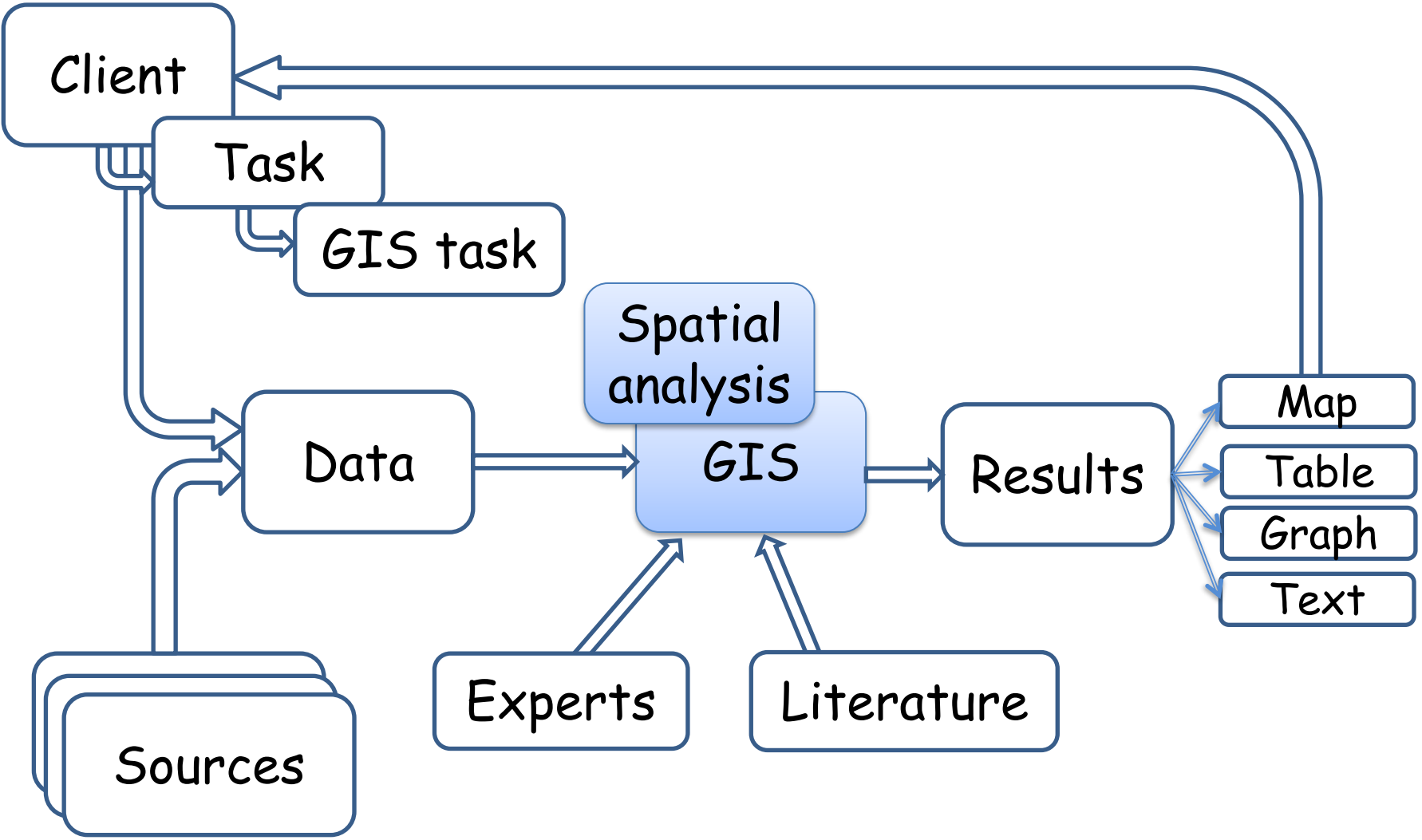
** time permitting*

1. Project-based GIS

How might we go about organizing & executing a GIS project?

- How can we find the spatial data we need?
- What should we know about datasets before using them?
- How can we communicate our results effectively?

1. Project-based GIS



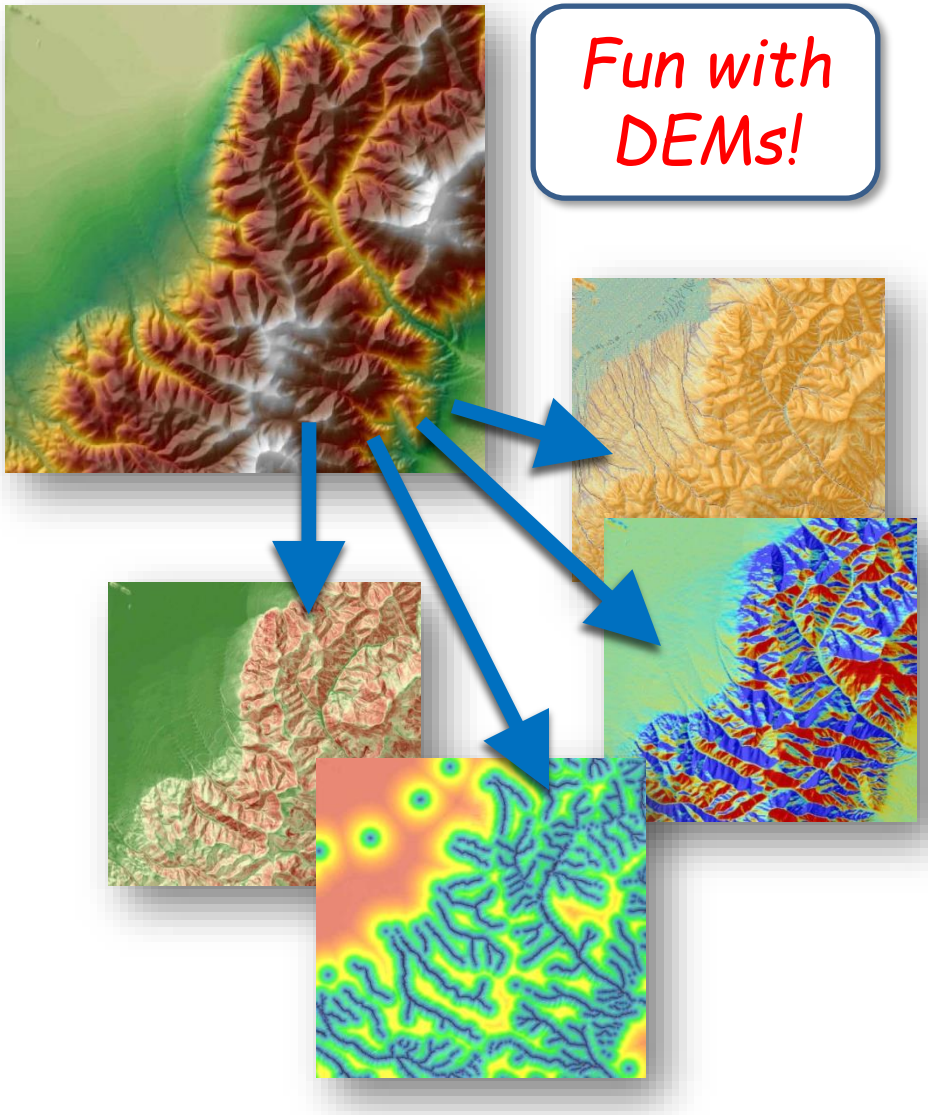
2. Ecohydrology & Terrain Analysis

What information can I derive from digital elevation data?
How can these derived datasets be useful in land mgmt?

- How can we model the flow of water across a landscape? How is this useful to land management?

- What terrain features can I derive from a DEM? How are these useful in land management?

2. Ecohydrology & Terrain Analysis



- Terrain based analysis
  - Exposure
  - Moisture
  - Insolation
- Hydrologic analysis
  - Streams & runoff
  - Watersheds
- Upland analysis
  - Upstream impacts
  - Accumulated flow
  - Distance decay

3. Habitat Modeling

How can we use GIS to predict the likelihood of finding a species at various locations within landscape?

- How should we represent known locations of species within a landscape using GIS? Unknown locations?
- How can GIS help in devising effective species sampling strategies?
- How does GIS interact with other software to run the statistical analyses to estimate habitat suitability? (Input and Output…)

3. Habitat Modeling

Observation points

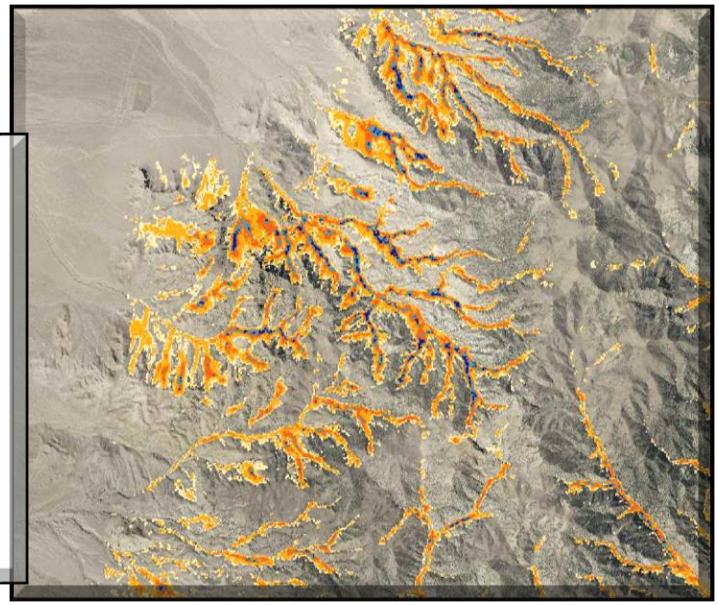
Spatial Data Layers

- Elevation
- Slope
- Insolation
- Distance to water
- Land cover

Habitat Modeling software

- ✓ ArcGIS
- ✓ 'R' / BioMod
- ✓ MaxEnt

Habitat Probability Map



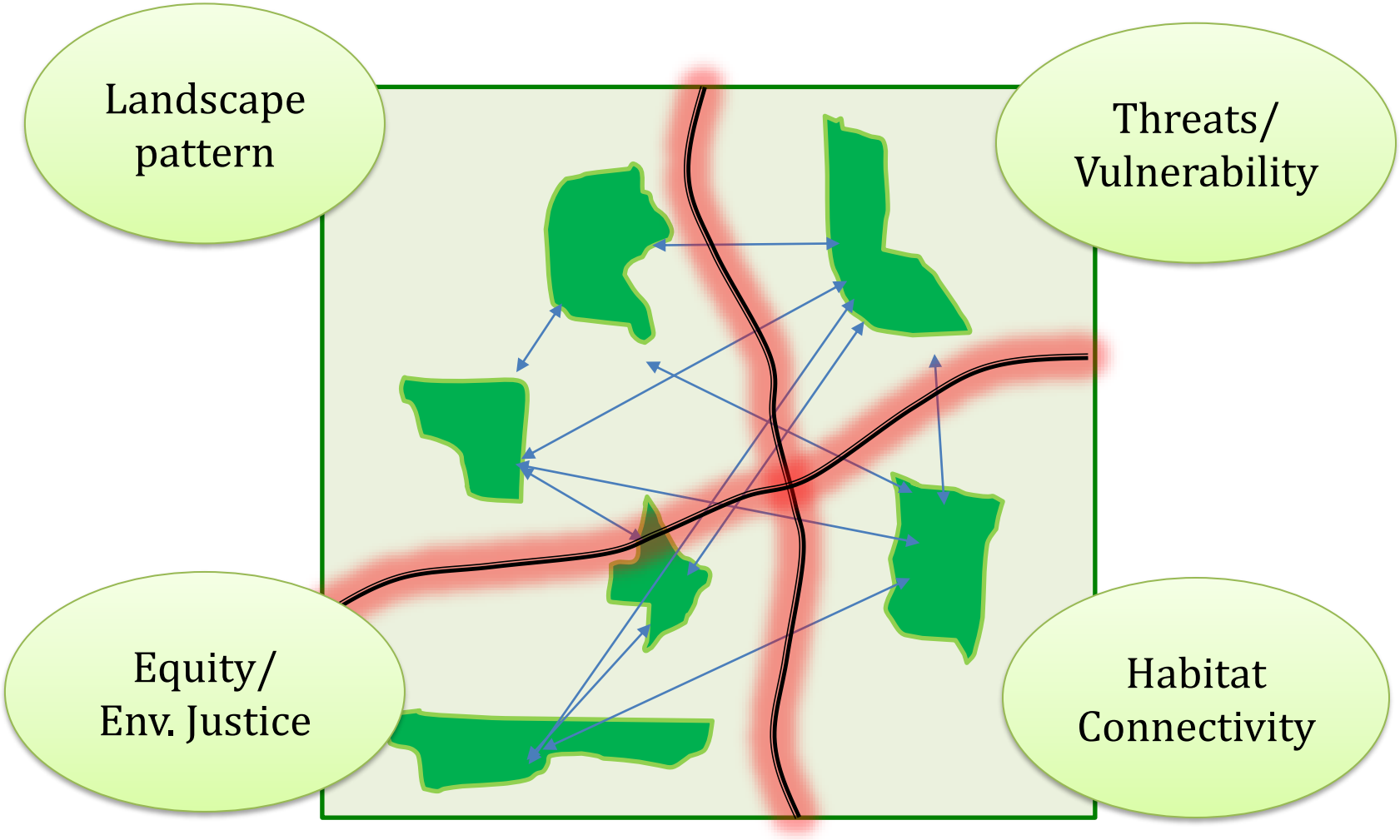
4. Landscape Assessment

What attributes of a landscape can we measure using GIS? How are these attributes used to represent the "health" of a landscape?

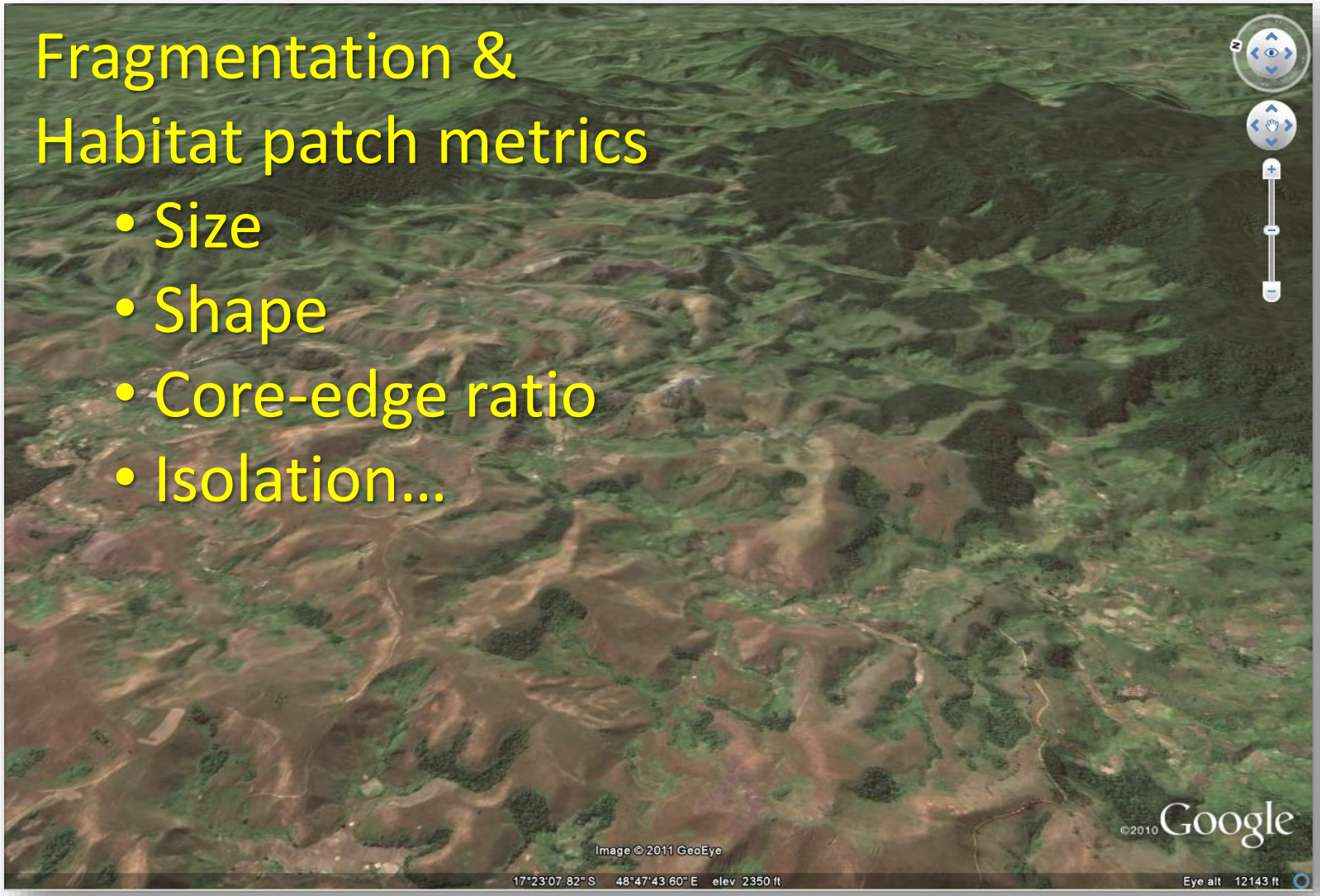
- How do we quantify **fragmentation**?
- What is **connectivity**? How do we measure it using GIS?
- How can we use GIS to depict **threats** to conservation and map their severity across a landscape?
- How do we address **equity** and **environmental justice** in our landscape decisions?

4. Landscape Assessment

Which areas are most important to protect?

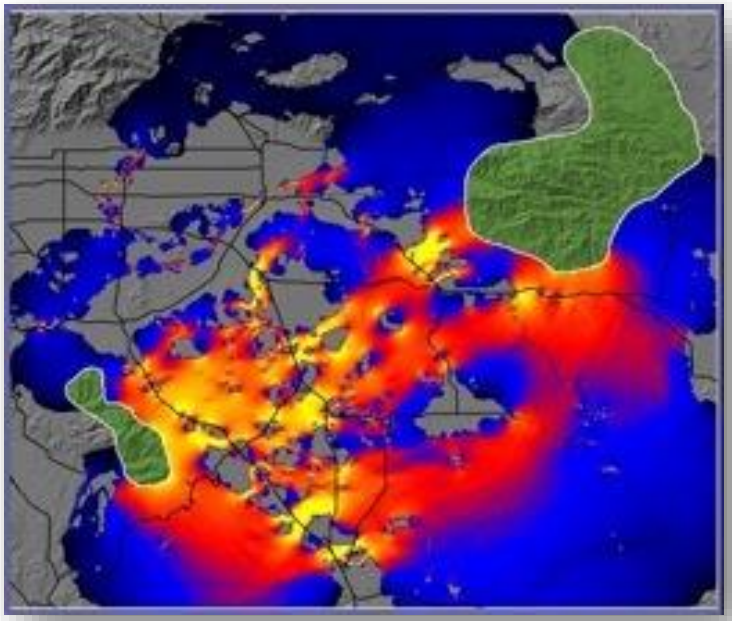


4.1 Landscape Pattern Analysis

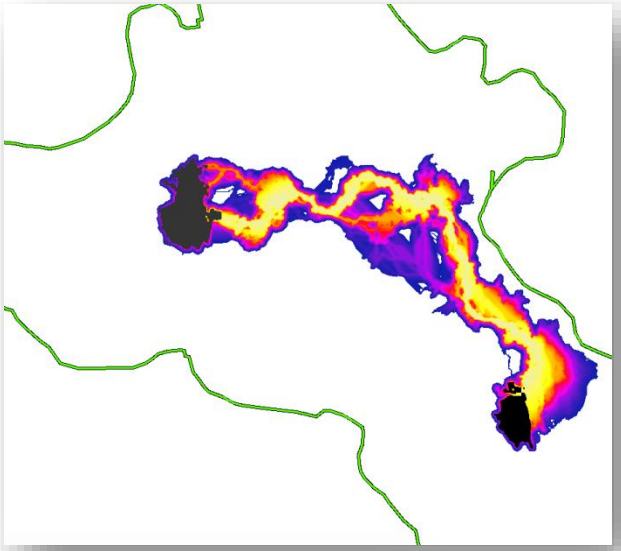


Ambotitafanana, Madagascar

4.2 Corridors & connectivity

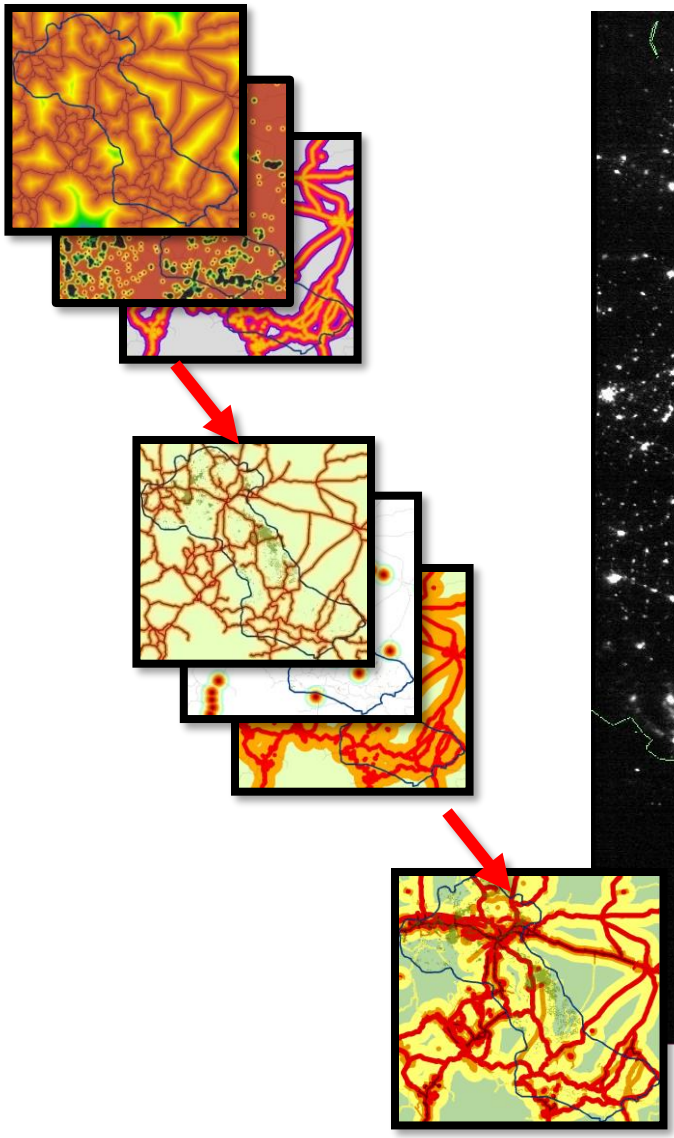


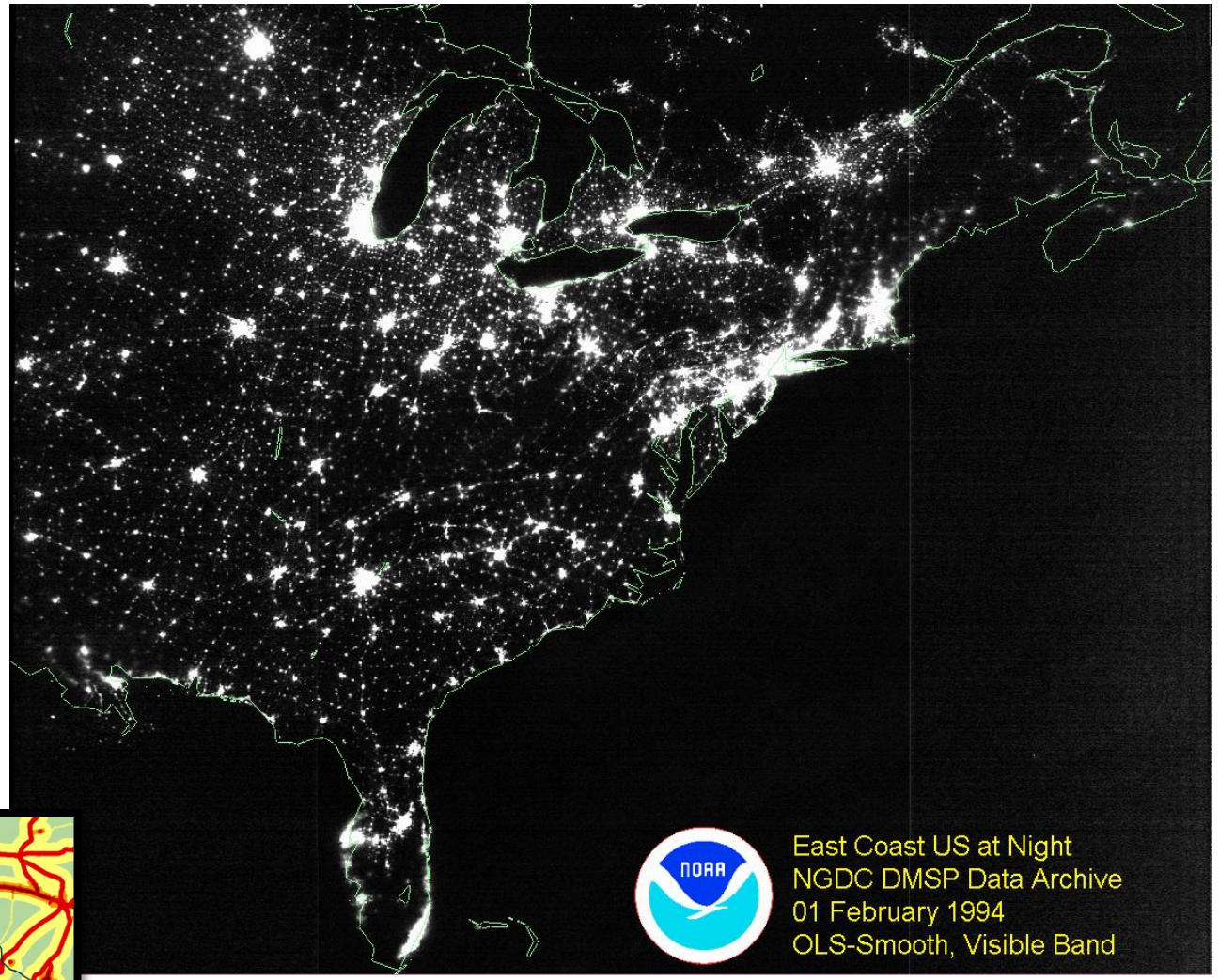
© Brad McRae



© CorridorDesign.org

4.3 Threat analysis





4.4 Equity and Environmental Justice

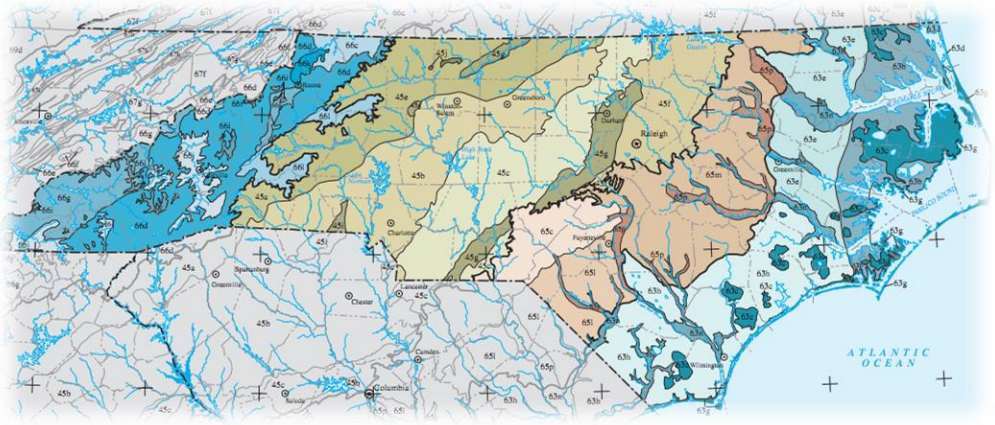
Fragmented city fabric with apathy towards natural assets.
Photo: Johnny Miller, Unequal Scenes, Mumbai

5. Ecoregional planning/site prioritization

After measuring so many aspects of a landscape, how do we combine them to devise a comprehensive ecoregional plan?

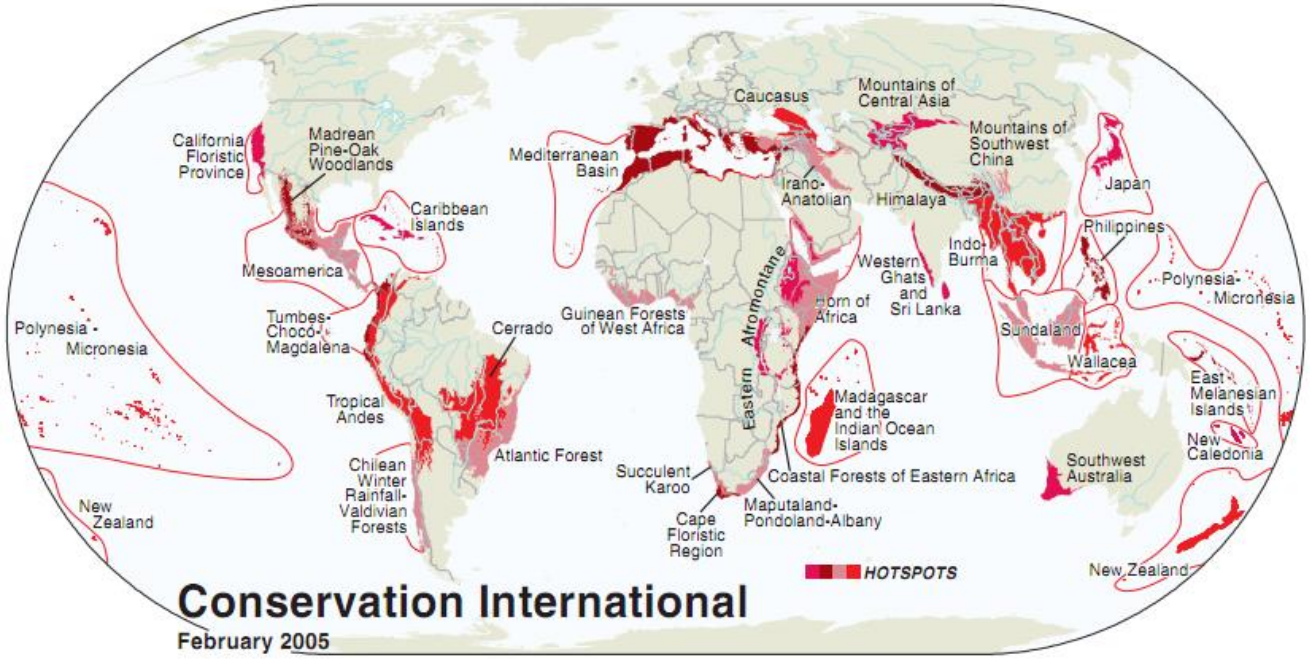
- In devising an ecoregional plan, what should the planning unit be? How can GIS help in this process?
- How to we depict tradeoffs among the various landscape attributes to facilitate decision making?
- With a plan in place, how can GIS help in monitoring the success of the plan?

5. Ecoregional planning/site prioritization

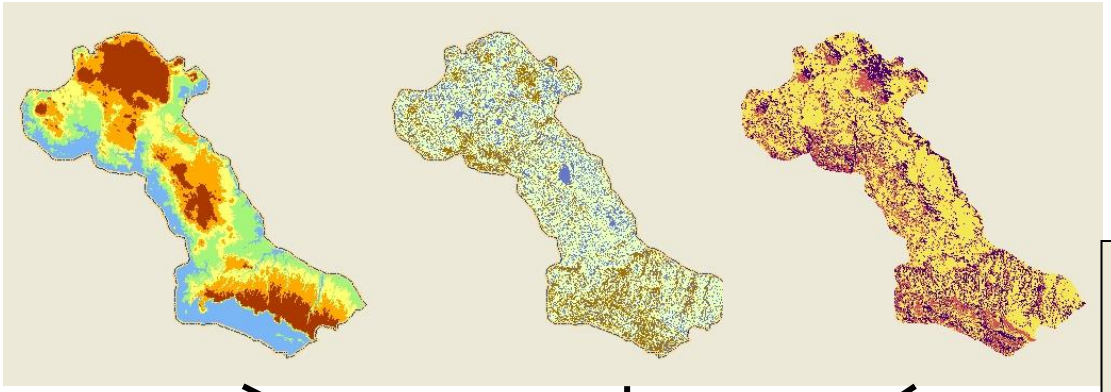


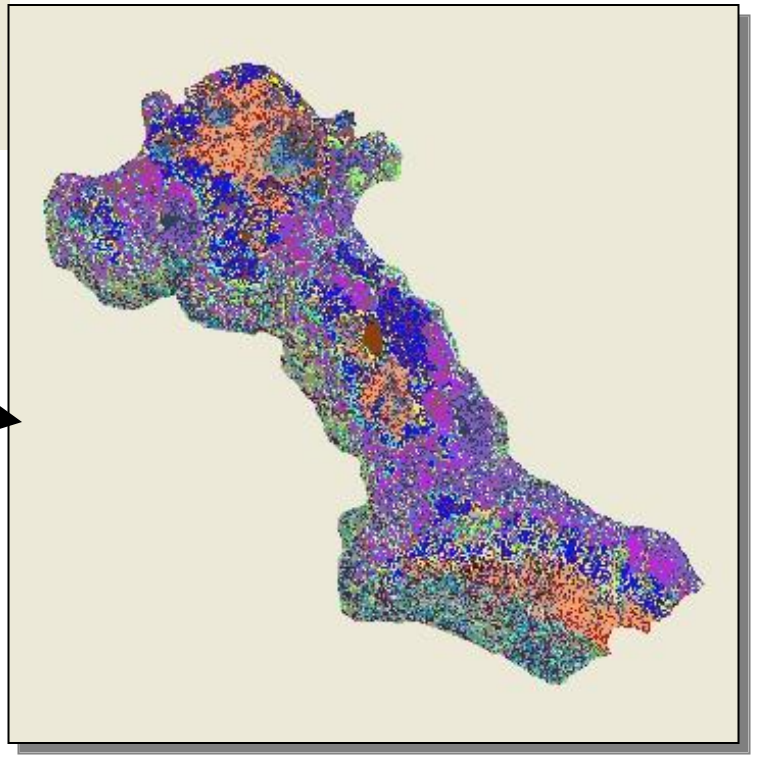
Biodiversity/
Gap Analysis

Systematic
Conservation
Planning



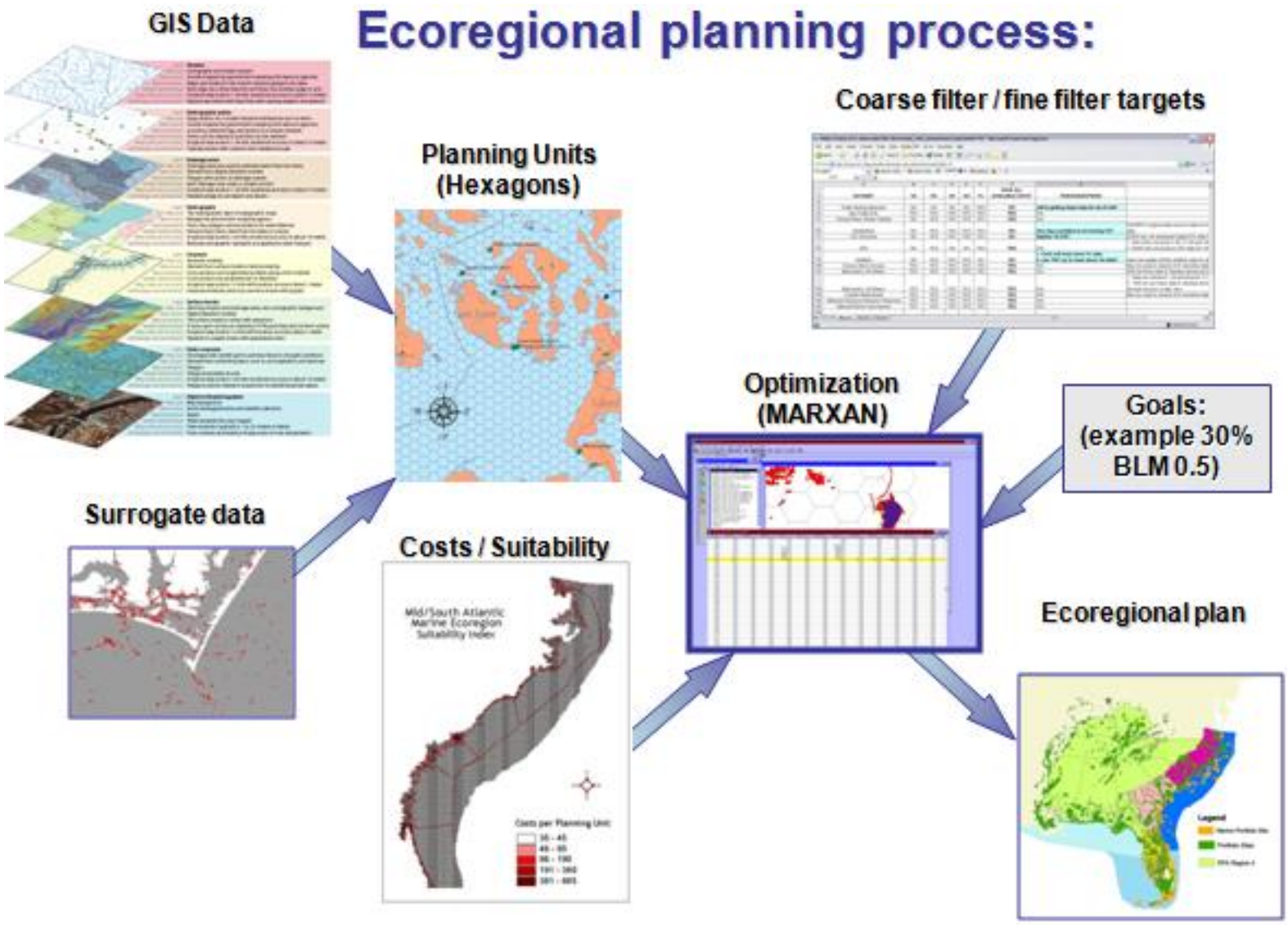
5.1 Biodiversity mapping & Gap analysis



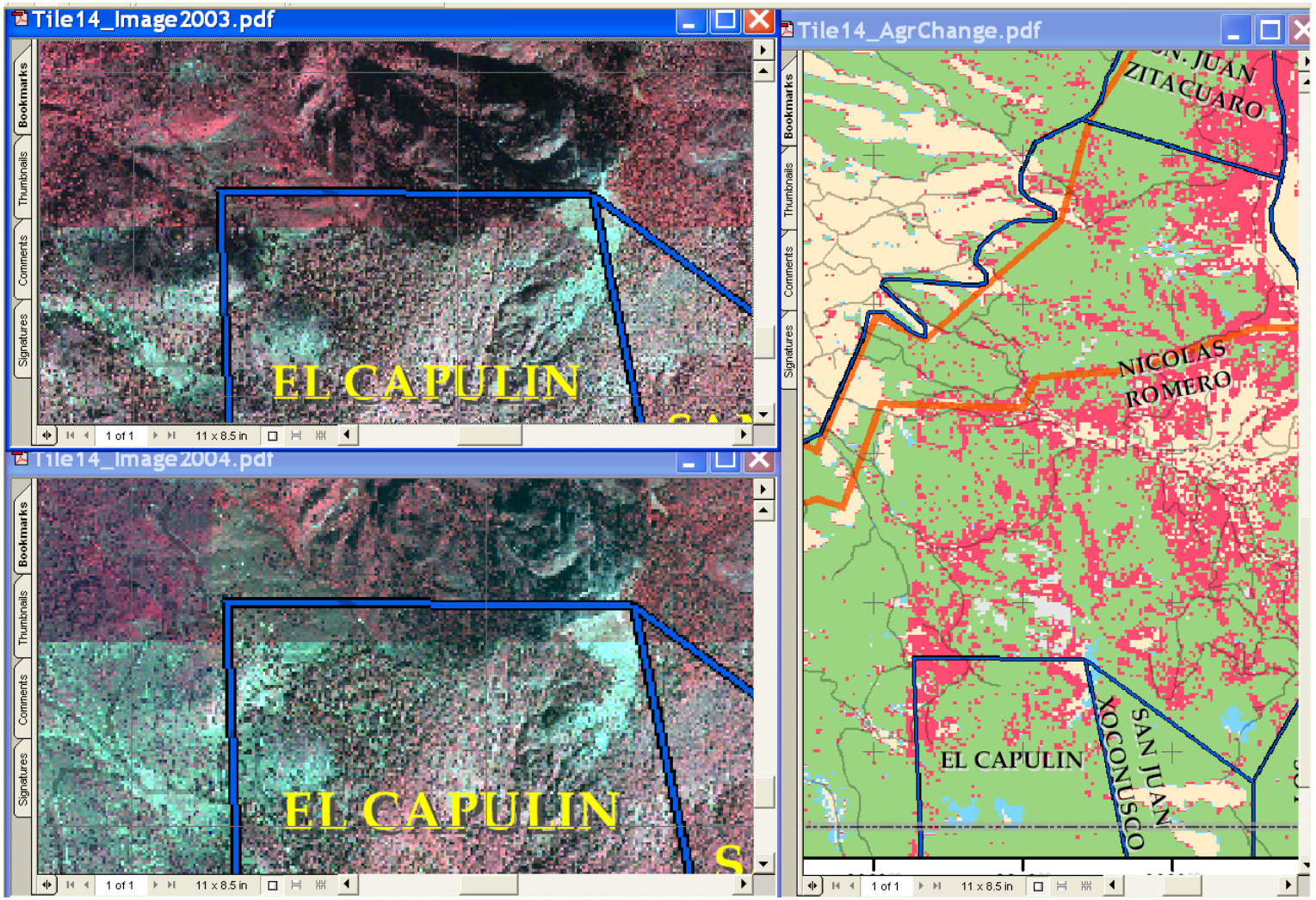


p	ln(p)	p * ln(p)	-Σ(p * ln(p))
43.5%	-0.832	-0.36210	
32.6%	-1.121	-0.36540	
8.7%	-2.442	-0.21244	1.213
4.4%	-3.135	-0.13637	
4.4%	-3.135	-0.13637	

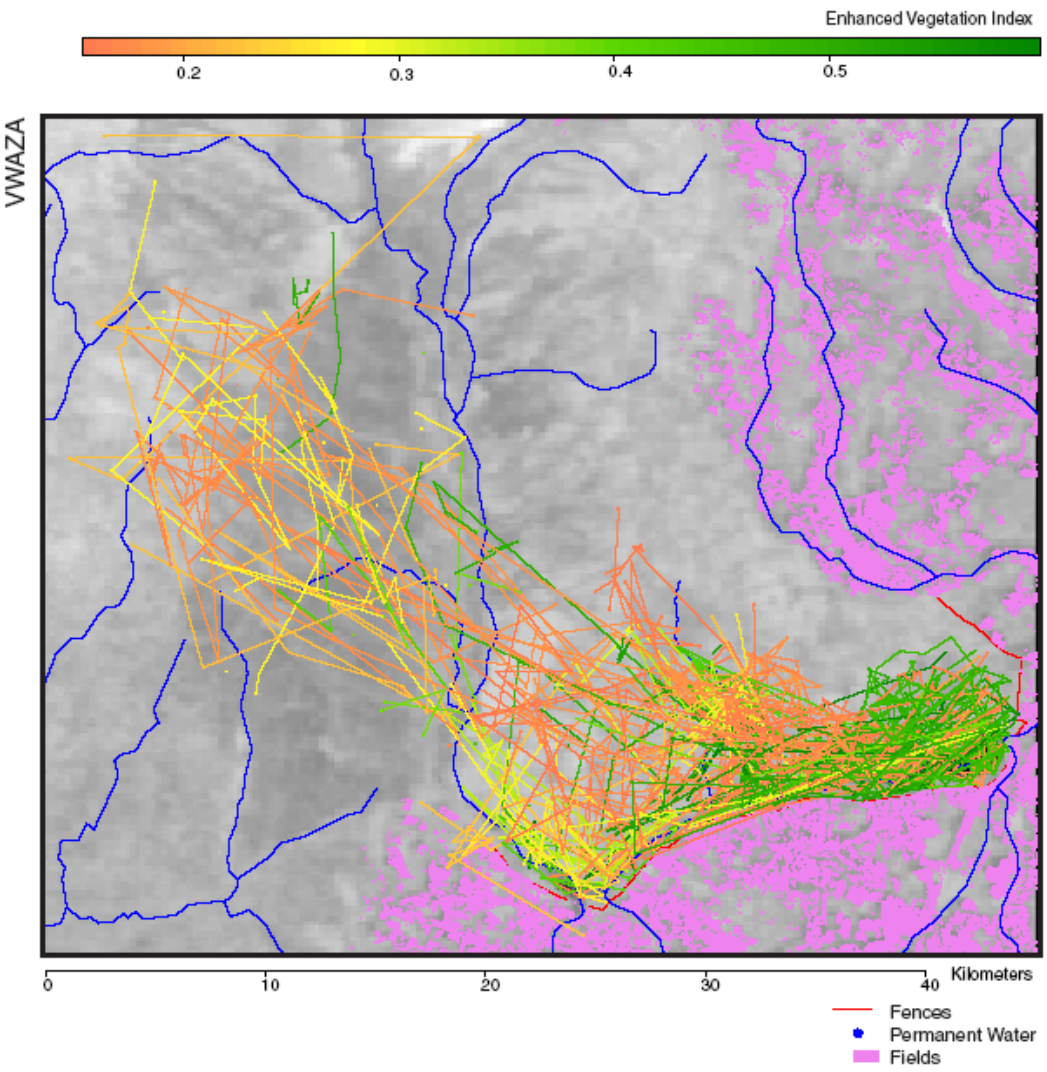
5.2 Systematic Conservation Planning



5.3* Monitoring & Change detection

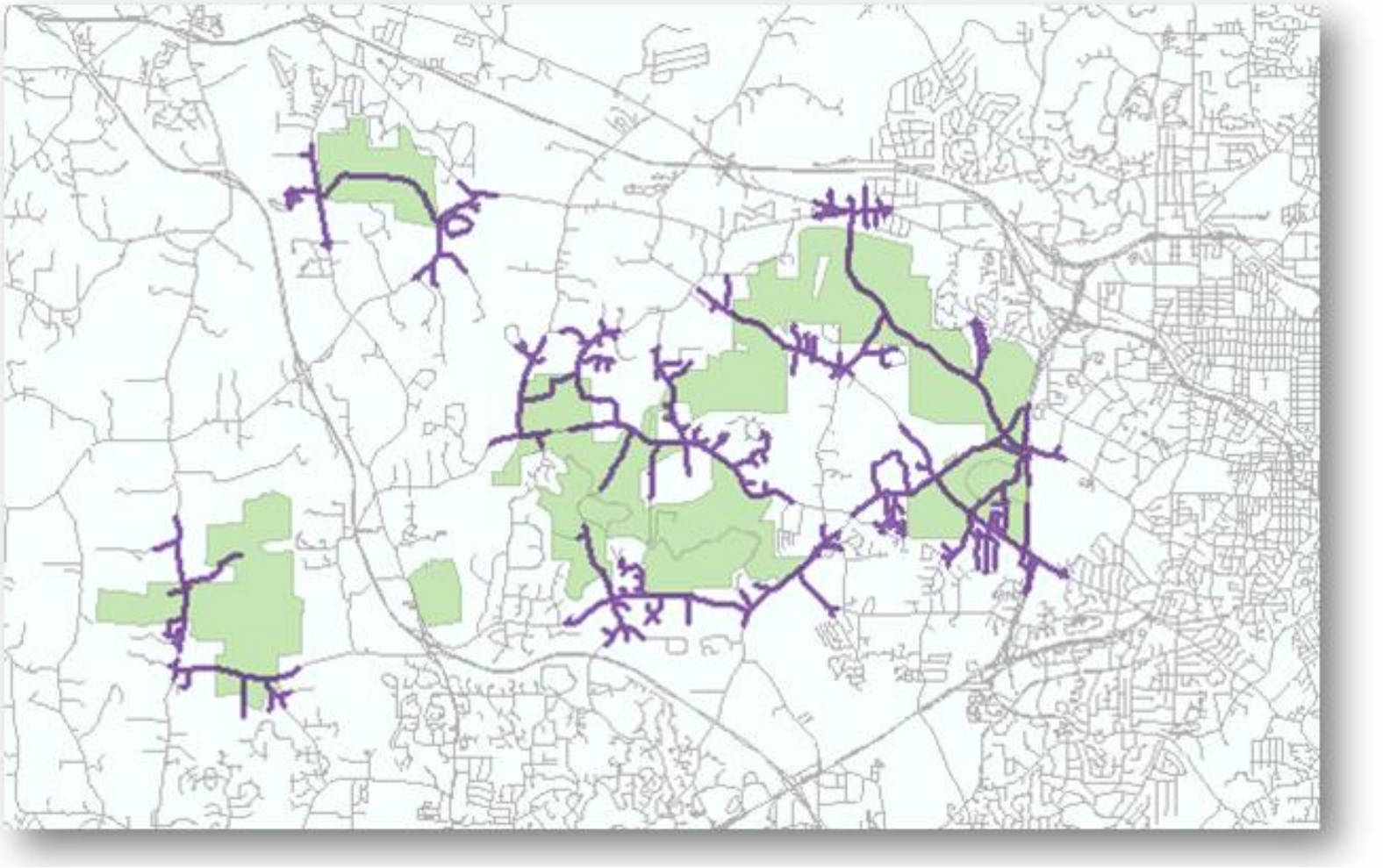


6.* Animal tracking & movement



6.* Network analysis

Roads within 10 minutes of a walk to Duke Forest



Course Format

Emphasis on technical skill development

Activities include

- Participating in weekly lectures and discussions
- Planning & conducting GIS-based analyses addressing a broad range of conservation related issues
- Concisely summarizing spatial analysis & results
- Developing and executing a course project

Course Format

This is a flipped class…

- Asynchronous component
  - Watch recordings (lectures & lab run-throughs)
  - Work on lab exercises
- Synchronous component (in person)
  - Discussion/activities
  - Guest speakers
  - Question & answer sessions
  - Open lab time

Course Website

https://env761.github.io

“Short” Labs

- Designed to ensure you understand and can execute specific analyses
- No extended write up; answer questions posed

https://env761.github.io/overview/deliverables.html

Projects (aka “long labs”)

- Grades based on:
  - Ability to obtain, prepare, & organize the data required for analysis
  - Sound analytical workflow and workflow execution
  - Effectiveness in communicating your results

https://env761.github.io/overview/deliverables.html

Course project

A geospatial analysis that goes beyond what is taught explicitly in lab exercises

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An opportunity to demonstrate your expertise in executing a GIS analysis

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Course projects will reveal additional real world challenges to performing spatial analysis…

https://env761.github.io/project/overview.html

For Tuesday, January 15th…

- Lab overview & account setup
- Lab 0 - GIS workspace organization