Duke
NICHOLAS SCHOOL OF THE ENVIRONMENT

ENVIRON 761:
Geospatial Analysis for Conservation & Land Management

Instructor: John Fay

TAs: Emily Tucker, Isabel Hillman

Agenda

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

Introductions

- John Fay Instructor/Research Associate, Duke University
  - First interaction with GIS *waaaay* back in 1990
  - GIS-based masters project @ University of Michigan (1992- 1997)
  - GIS analyst at Jasper Ridge Biological Preserve (1997 – 1998)
  - GIS lab manager with Stanford's Center for Conservation Biology (to 2005)
  - Instructor at the Nicholas School (since 2005)
- TAs:

Emily Tucker

Isabel Hillman

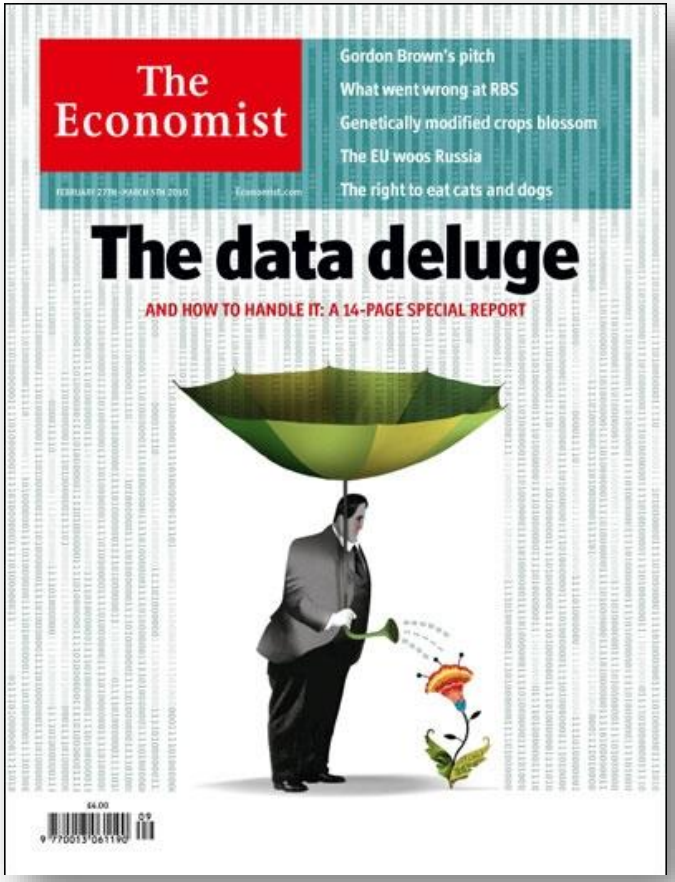
Introductions

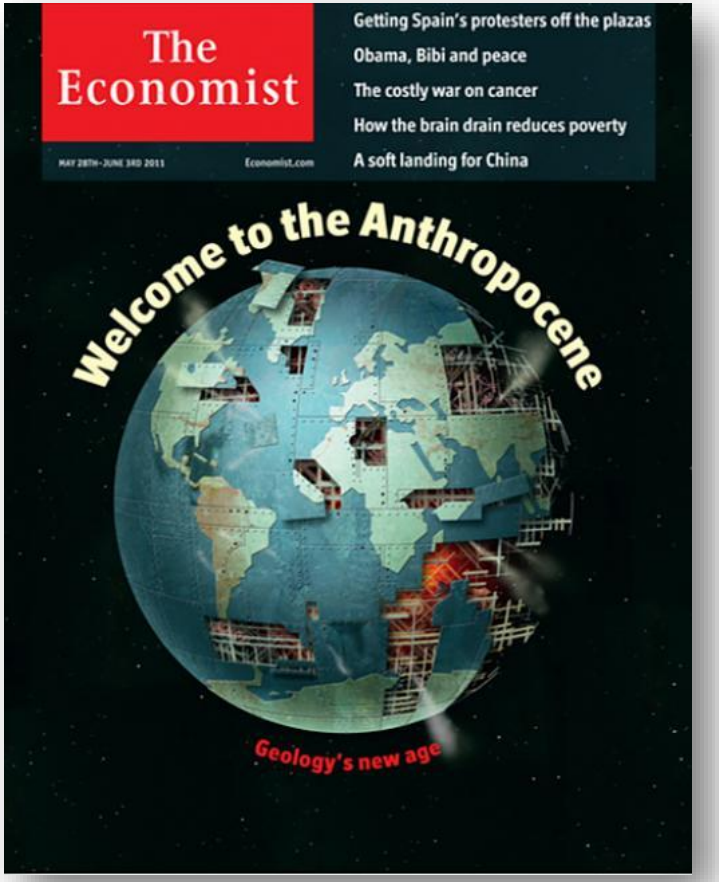
Please introduce yourself and state:

- *Your general area of interest…*
- *Your interest in taking this course…*
- *"Potential" career aspirations…* *(don't be shy…)*
- *Your most & least favorite aspects from ENV 559…*

Course theme…

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





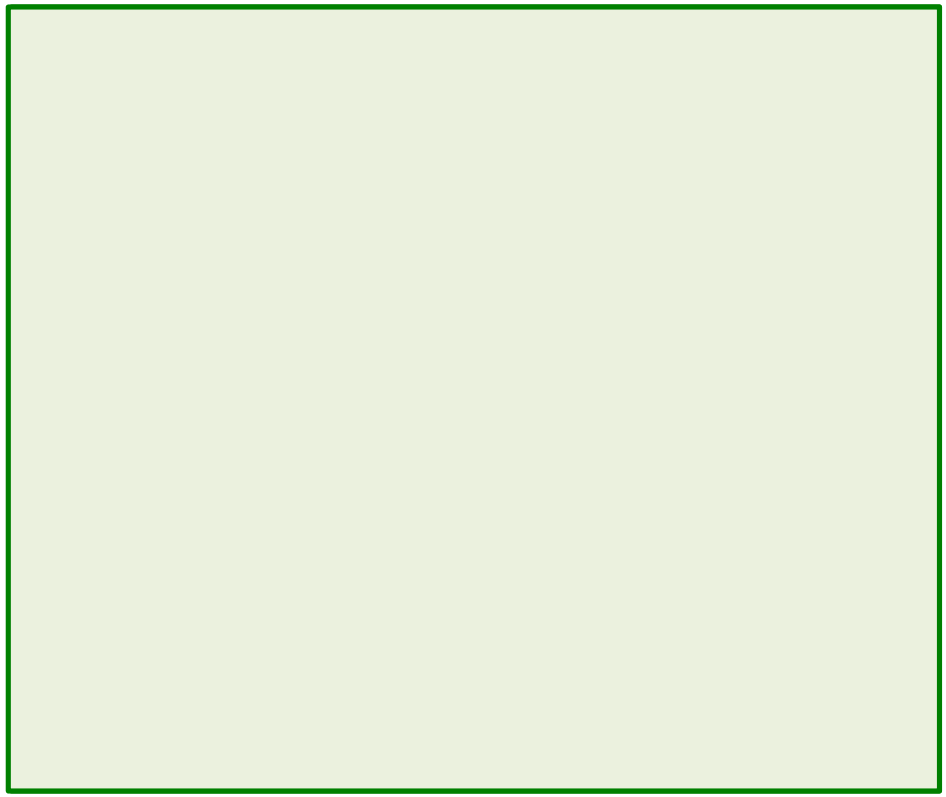
Technology for nature conservation: An industry perspective

Lucas N. Joppa

Ambio 2015, 44(Suppl. 4):S522–S526

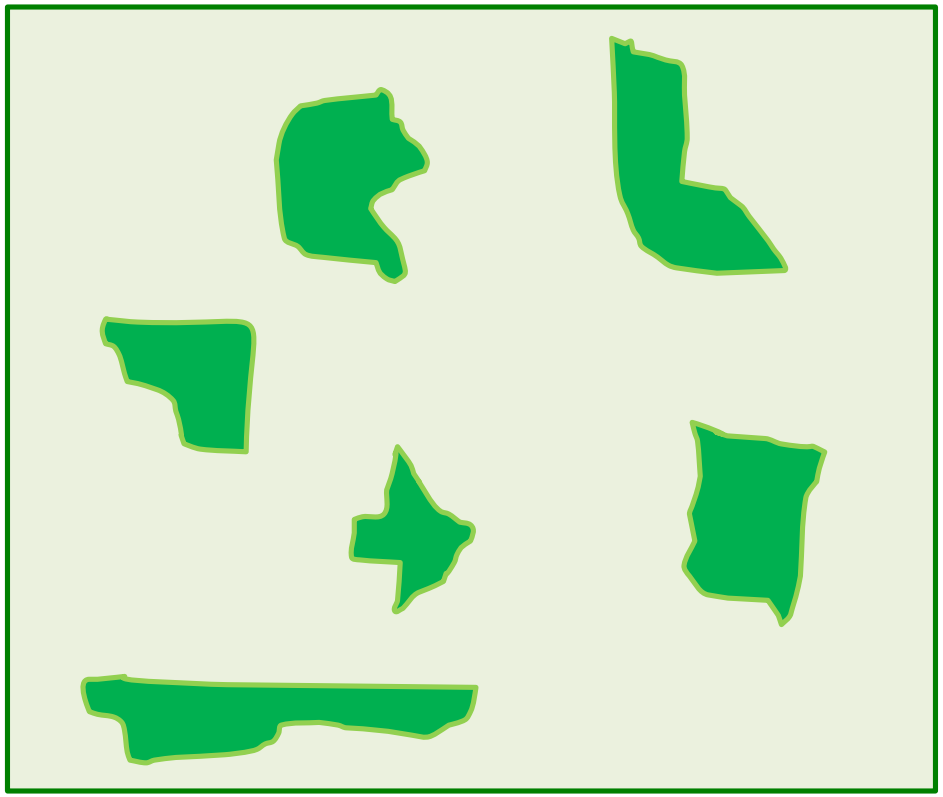
"Conservation & Land Management"

Manage this area for biodiversity protection…



"Conservation & Land 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"

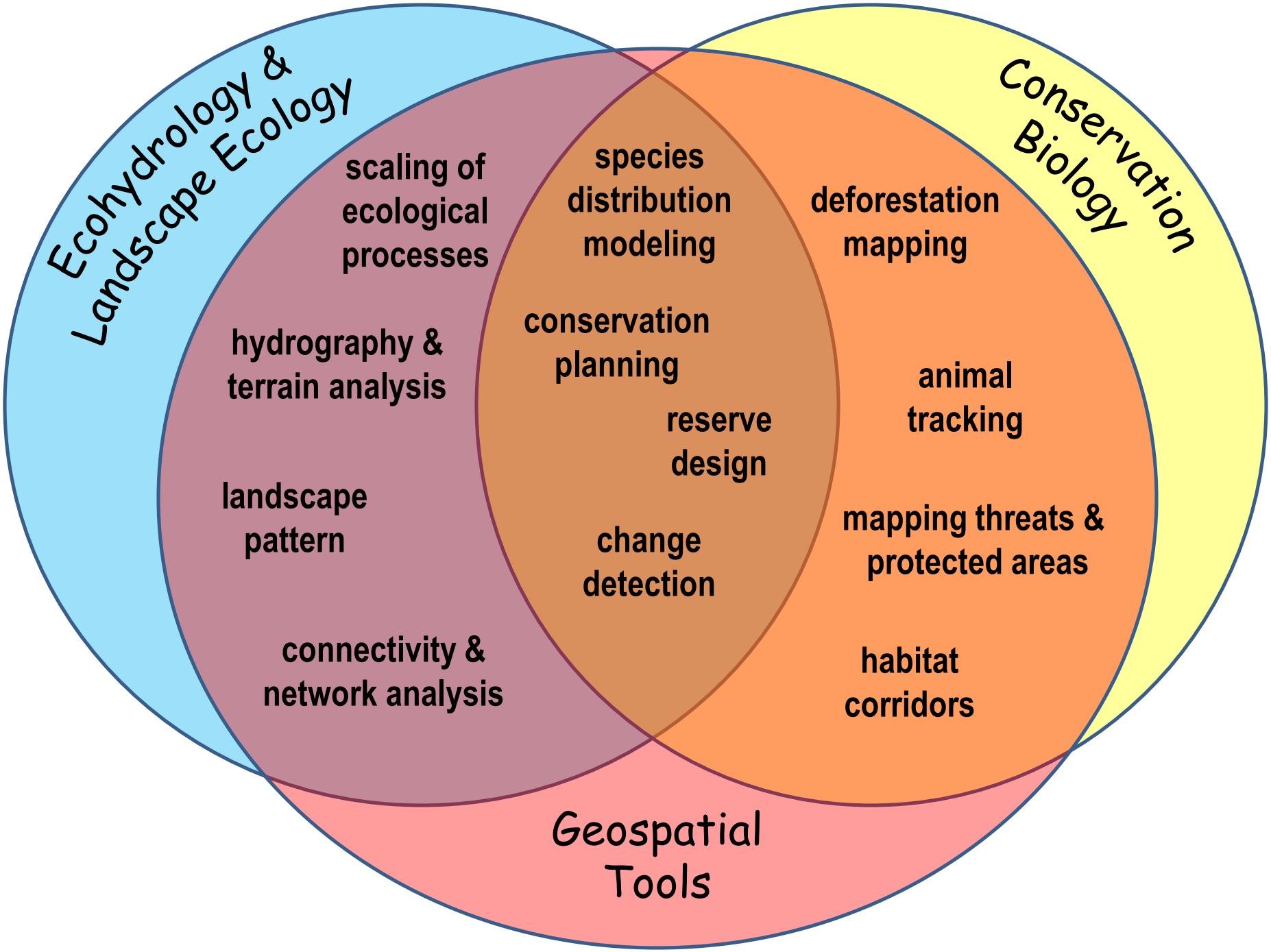
Course theme:

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

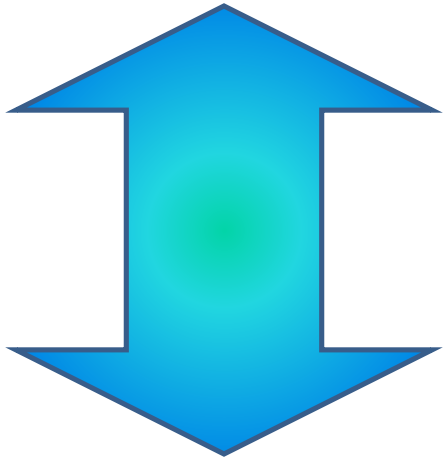
- explicit analysis
- reproducible methods
- powerful media

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 biological resources and the integrity of ecological systems requires nothing less…

Course objectives

- Develop a set of [conservation] GIS skills
- Explore "real world" conservation GIS problems and solutions
- Explore new methods and approaches to solving spatial problems
- Better understand the ecological/conservation 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

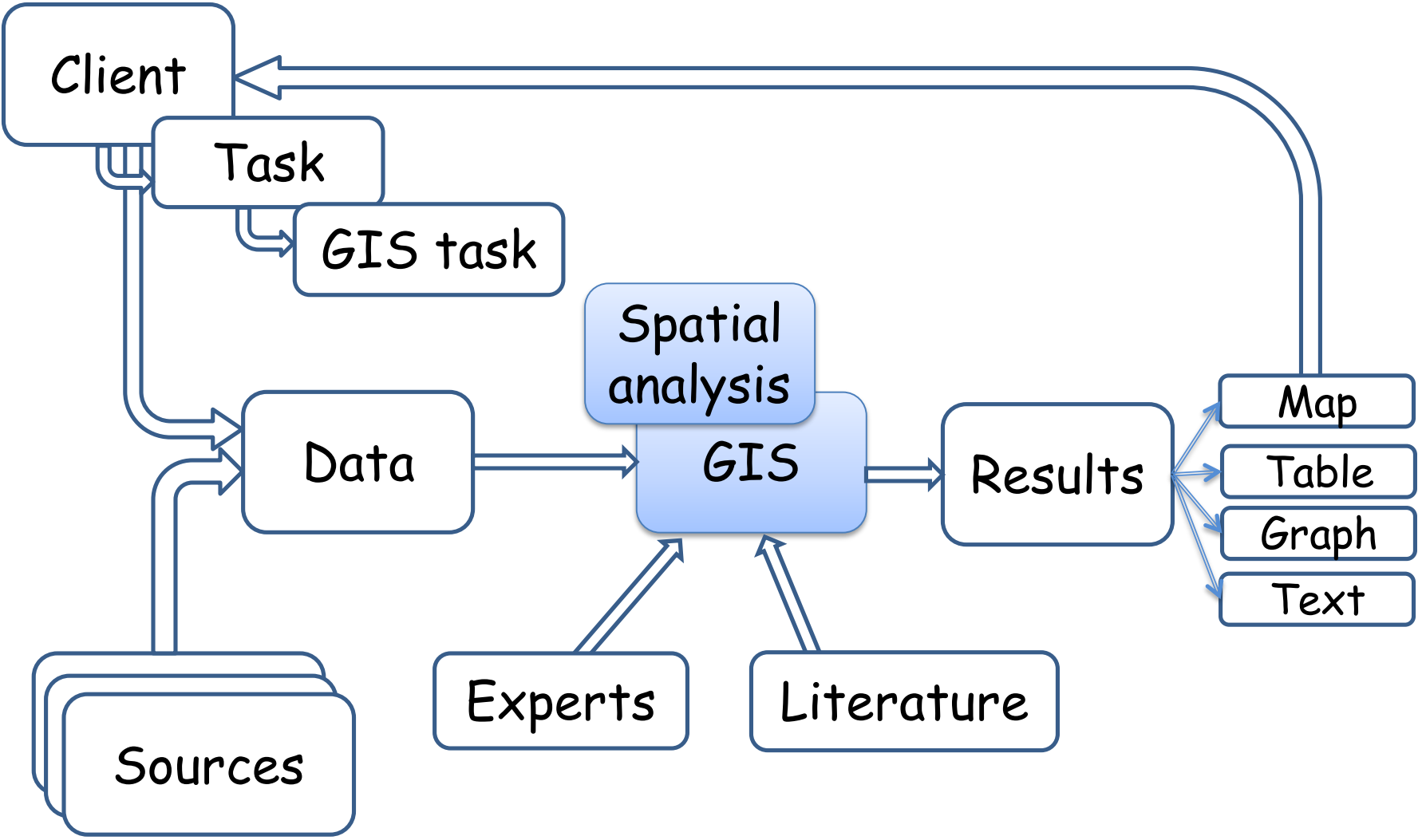
VI. Grab bag…

1. Project-based GIS

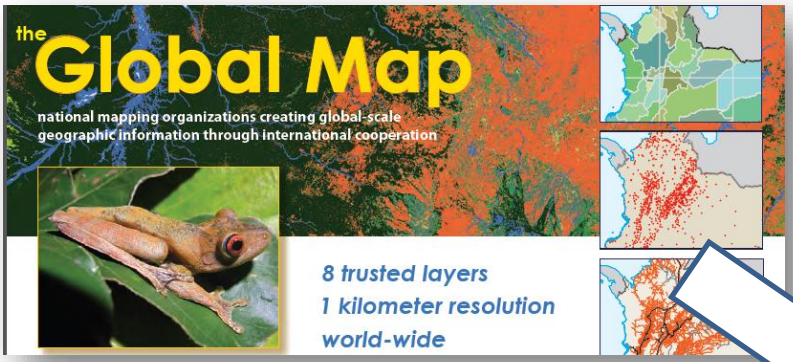
How might we go about organizing & executing a GIS project?

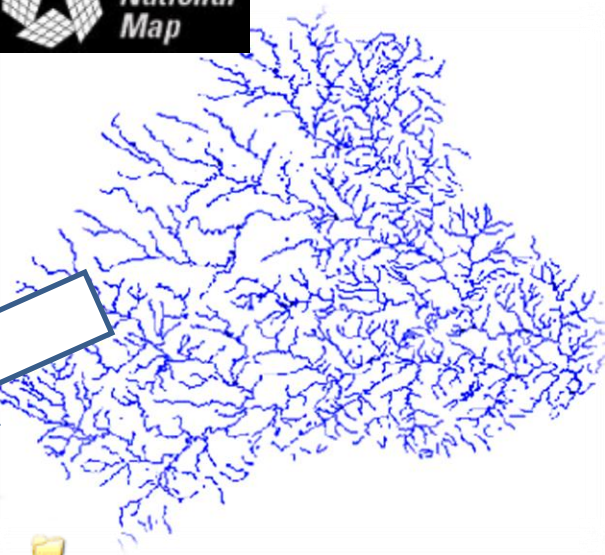
- How can we find the spatial data I need?
- What should we know about datasets before using them?
- How can we communicate our results effectively?

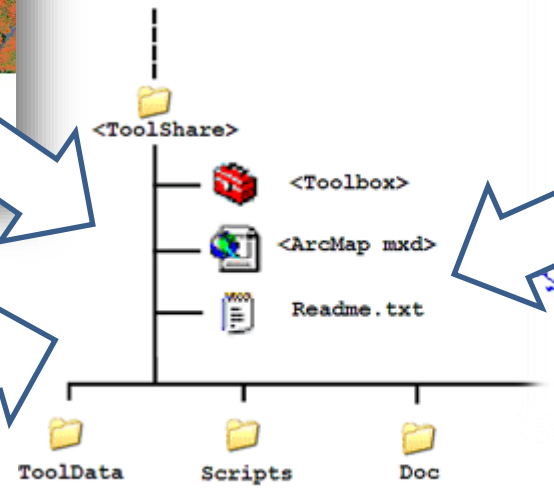
1. Project-based GIS

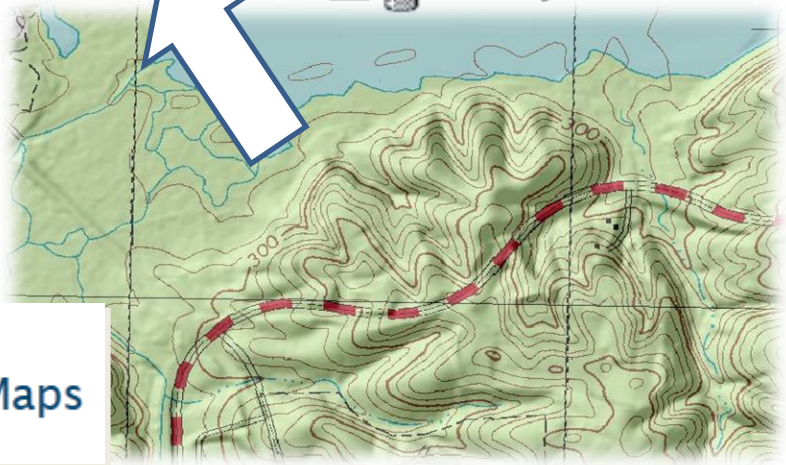


1.1 Locating, obtaining, and organizing data

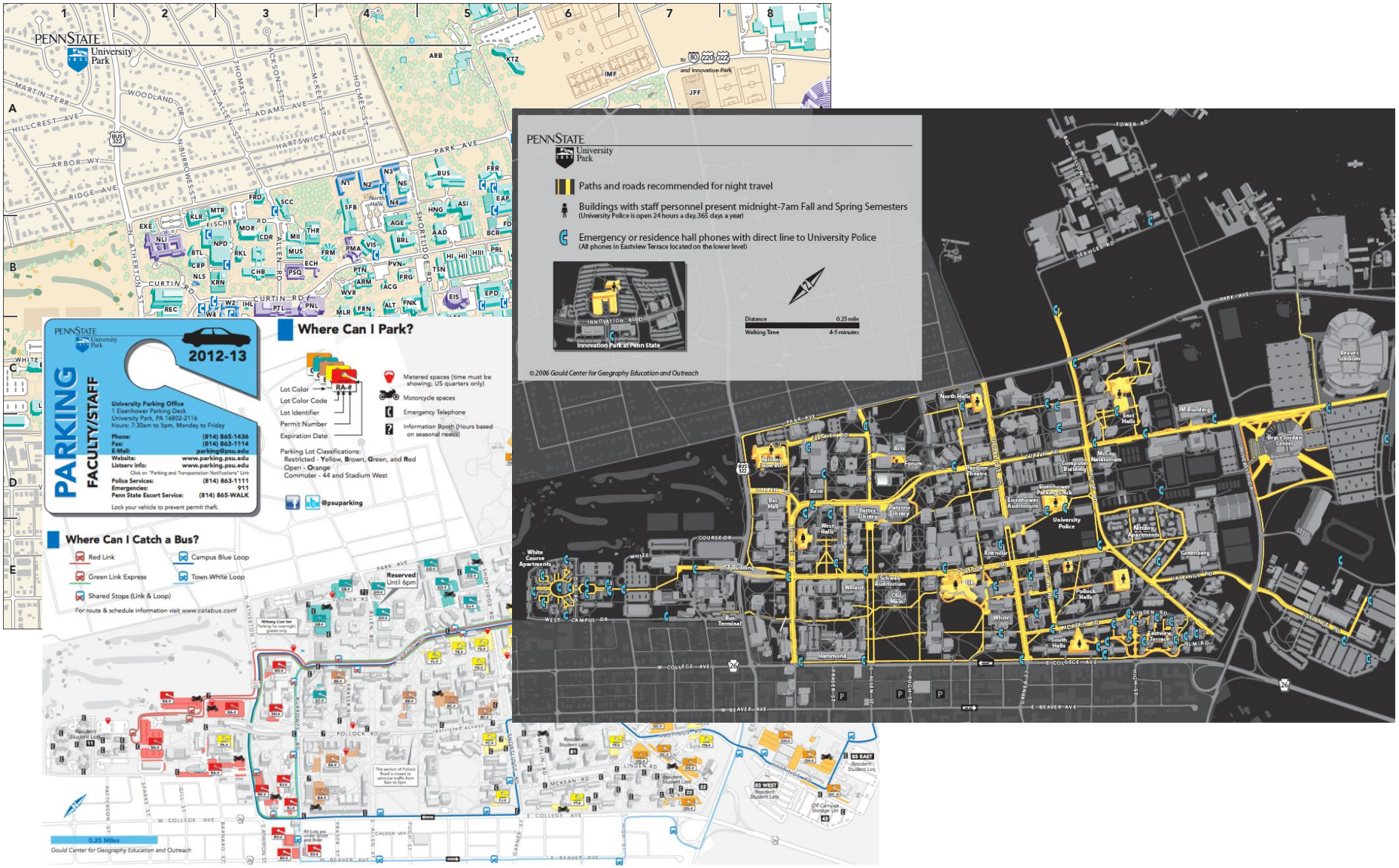








1.2 Communicating results



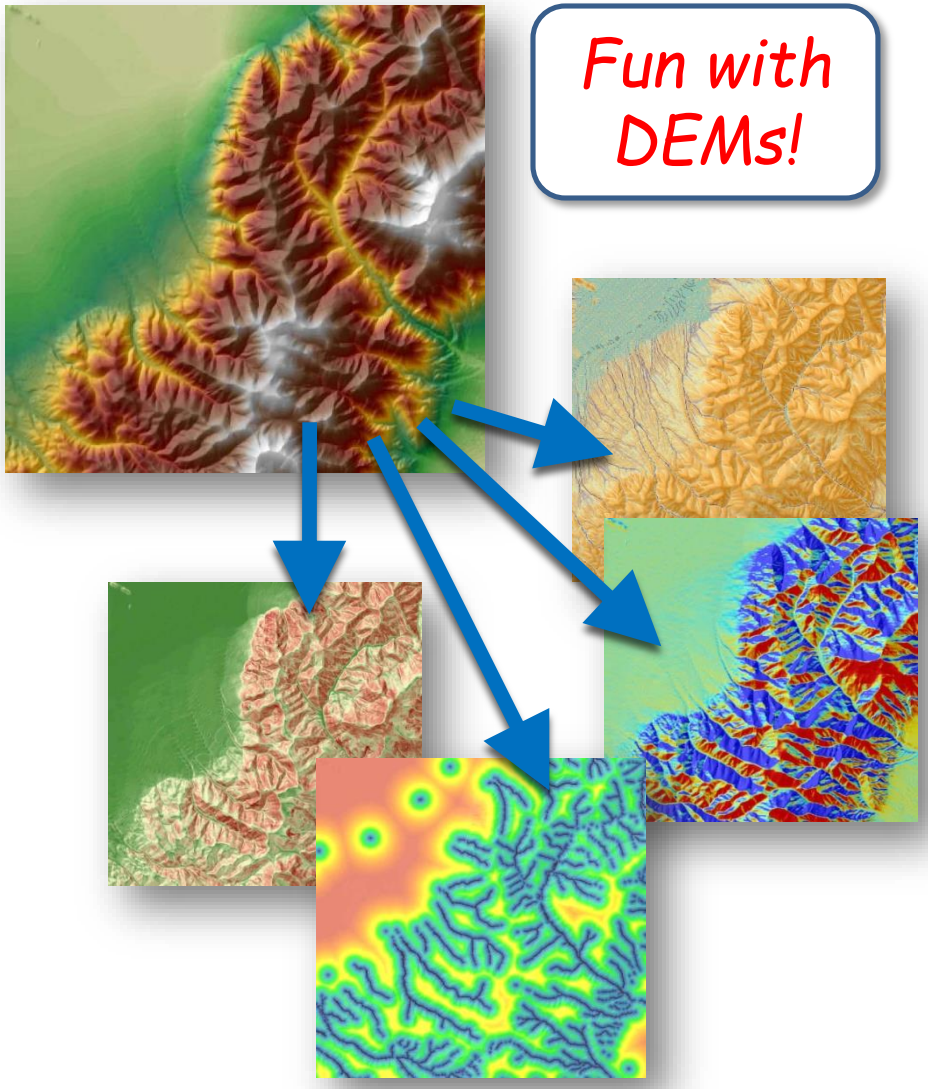
2. Ecohydrology & Terrain Analysis

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

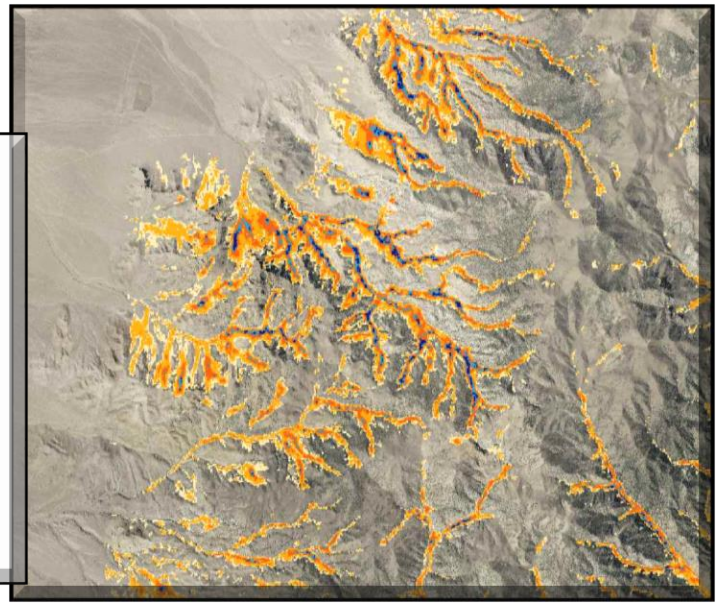
Spatial Data Layers

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

Habitat Modeling software

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

Habitat Probability Map



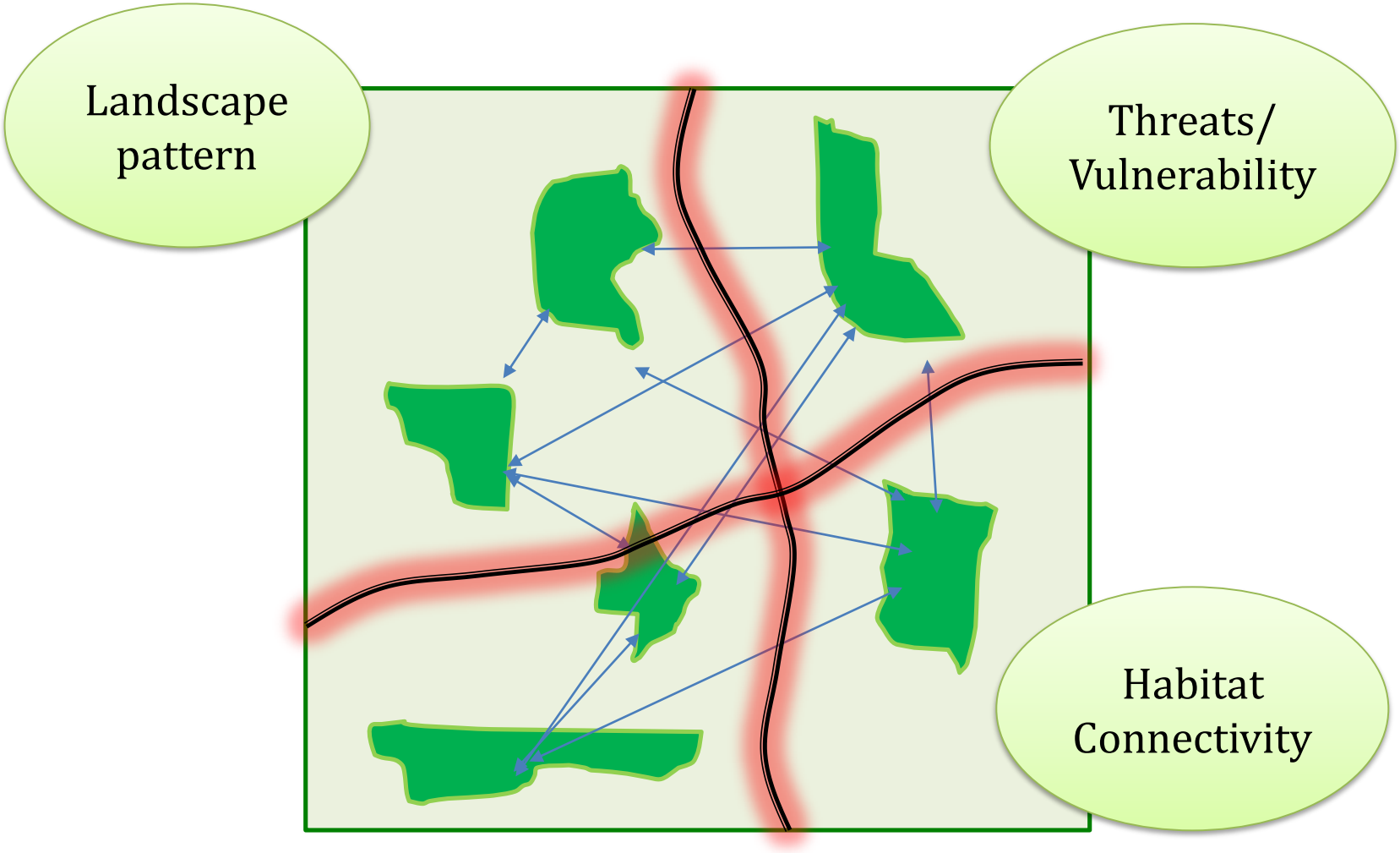
4. Landscape Assessment

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

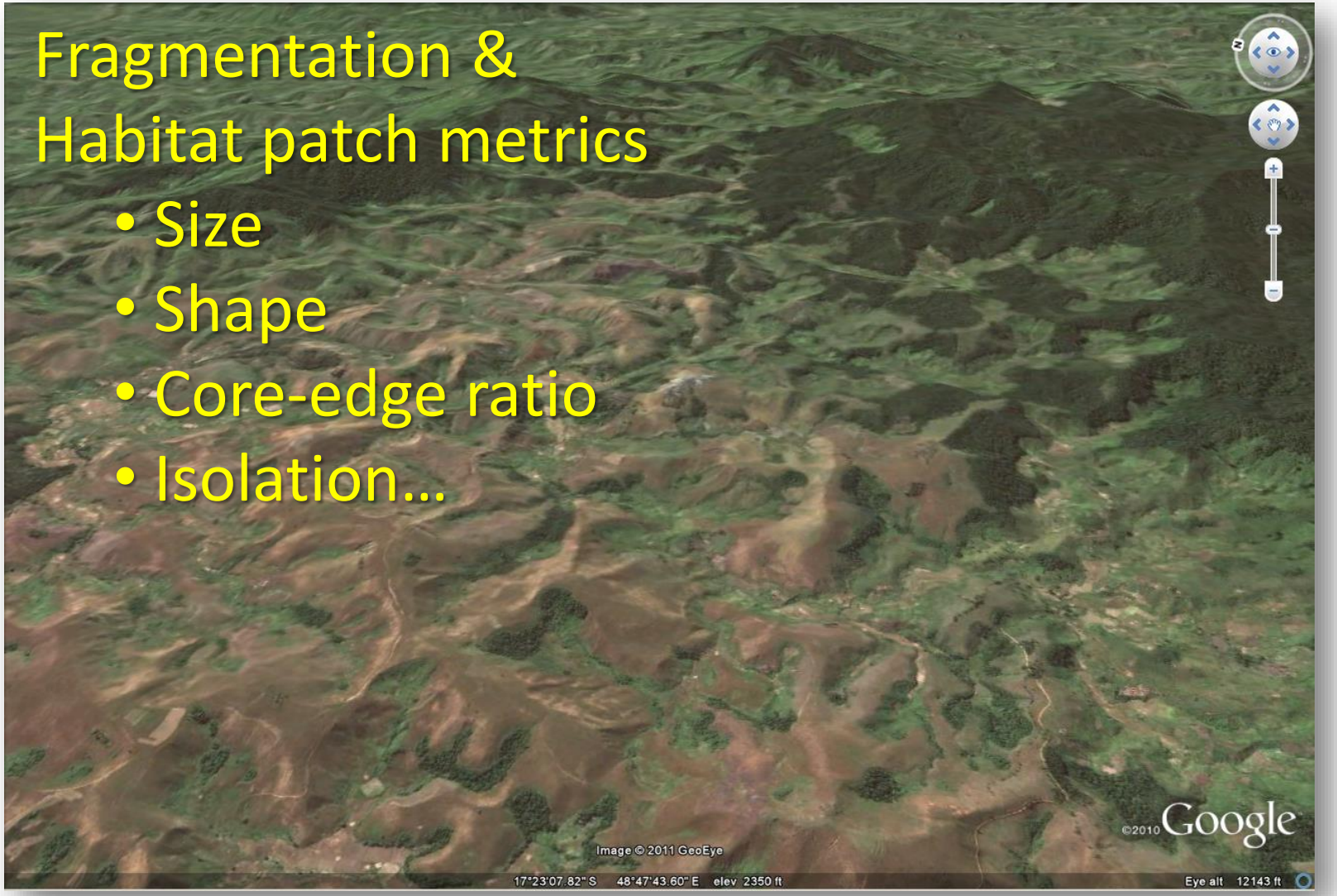
- How do we quantify fragmentation?
- What is connectivity? How do we measure it using GIS?
- How can we use GIS to depict threats to conservation and map their severity across a landscape?

4. Landscape Assessment

Which areas are most important to protect?

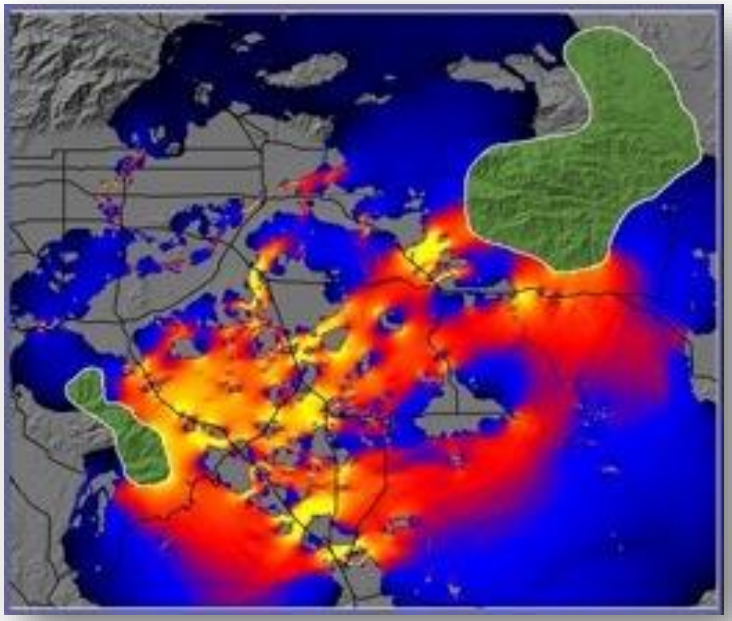


4.1 Landscape Pattern Analysis

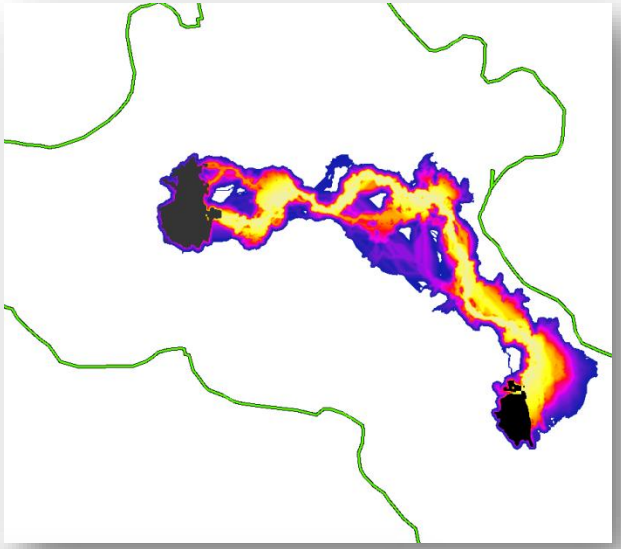


Ambotitafanana, Madagascar

4.2 Corridors & connectivity

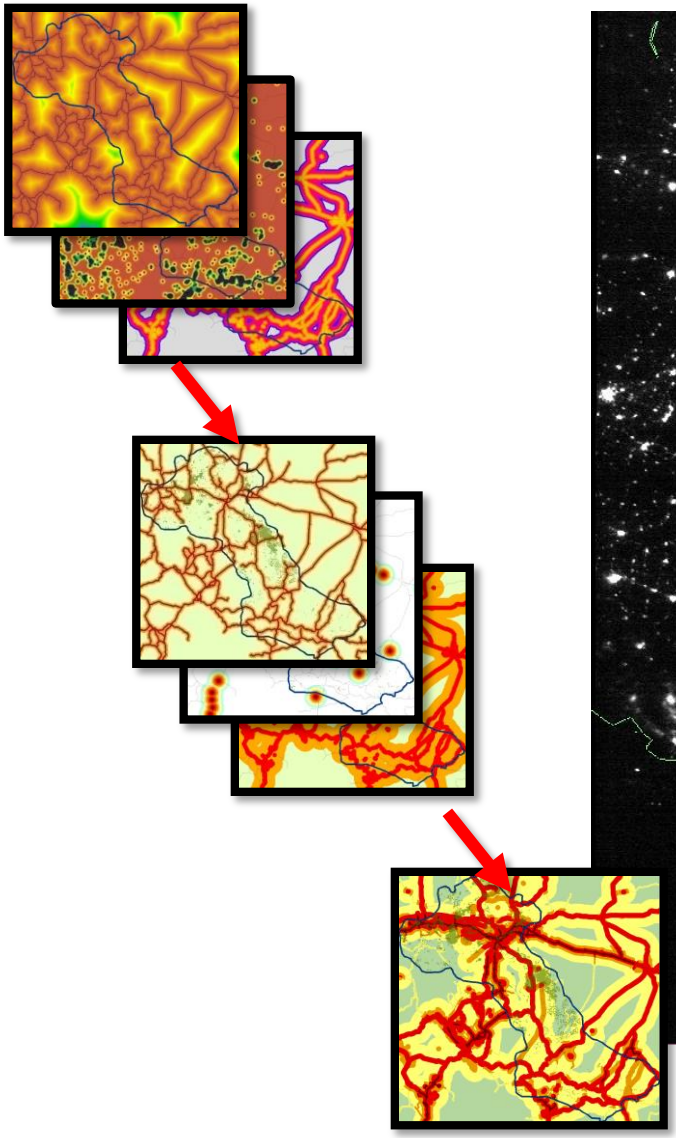


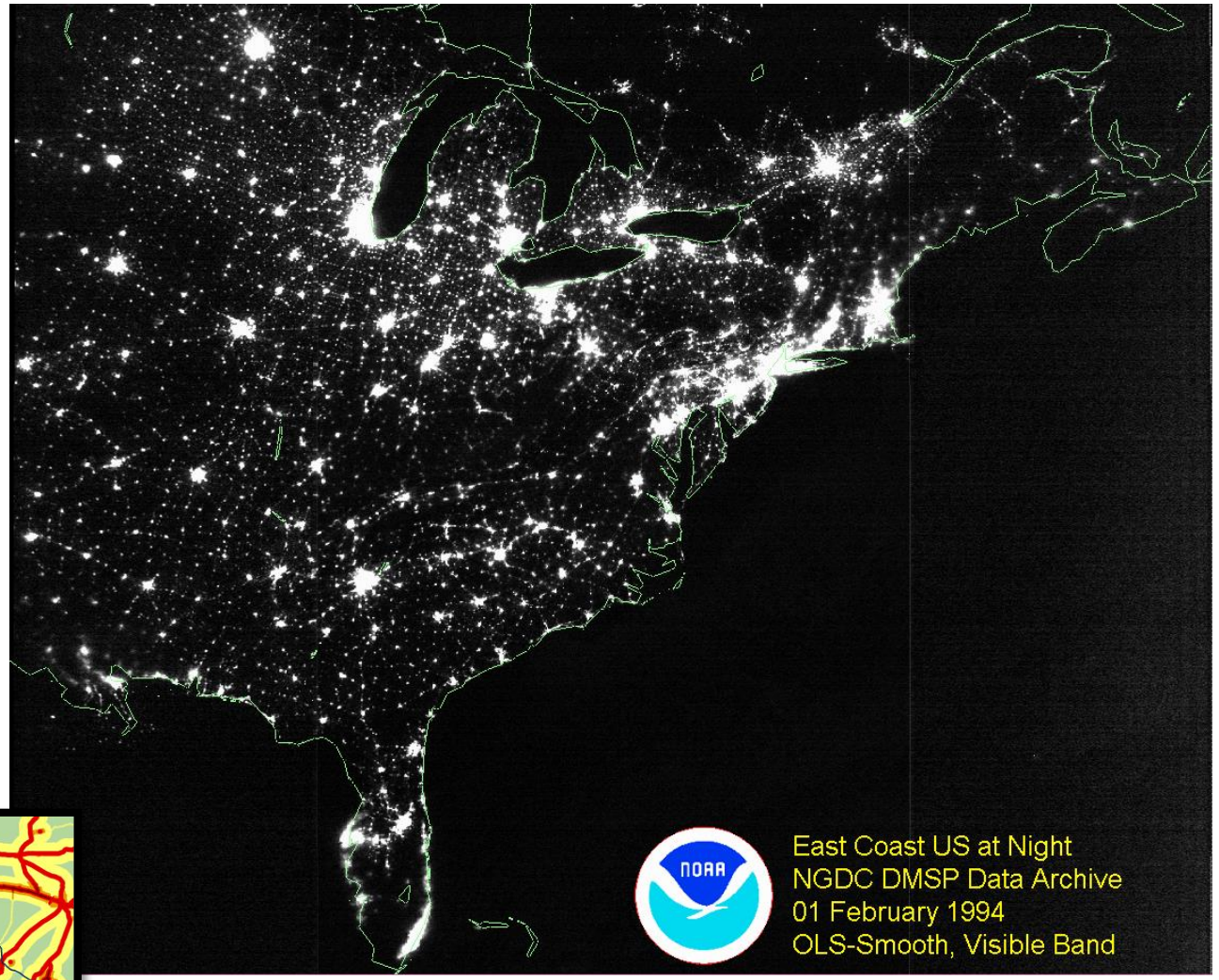
© Brad McRae



© CorridorDesign.org

4.3 Threat analysis



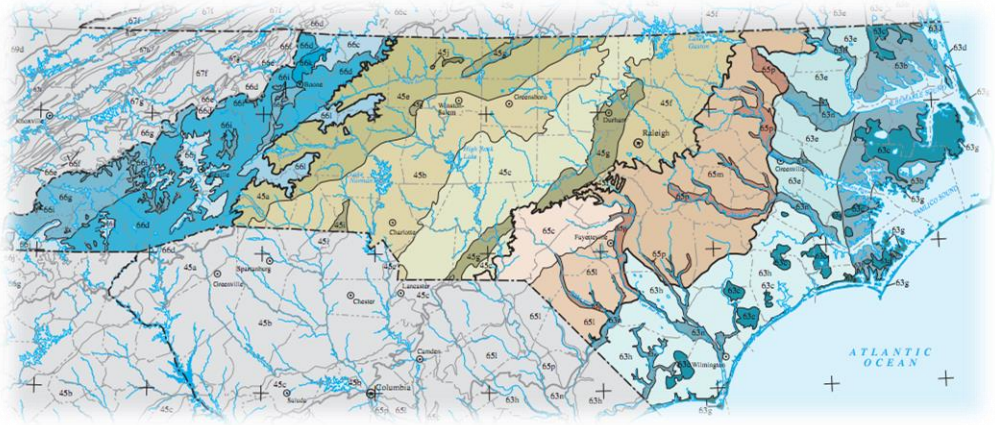


5. Ecoregional planning/site prioritization

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

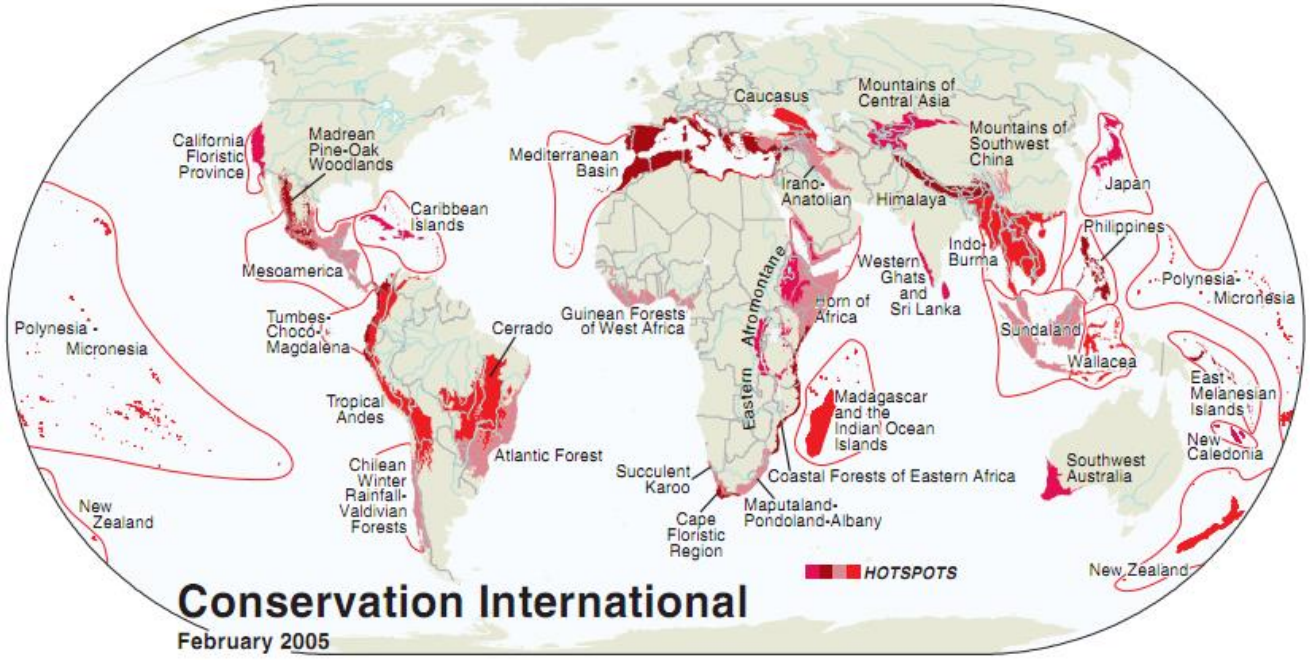
- In devising an ecoregional plan, what should the planning unit be? How can GIS help in this process?
- How to we depict tradeoffs among the various landscape attributes to facilitate decision making?
- With a plan in place, how can GIS help in monitoring the success of the plan?

5. Ecoregional planning/site prioritization

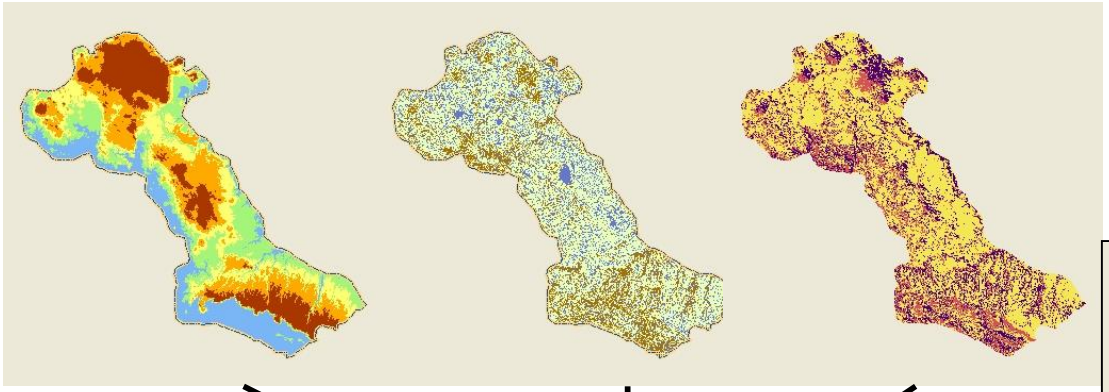


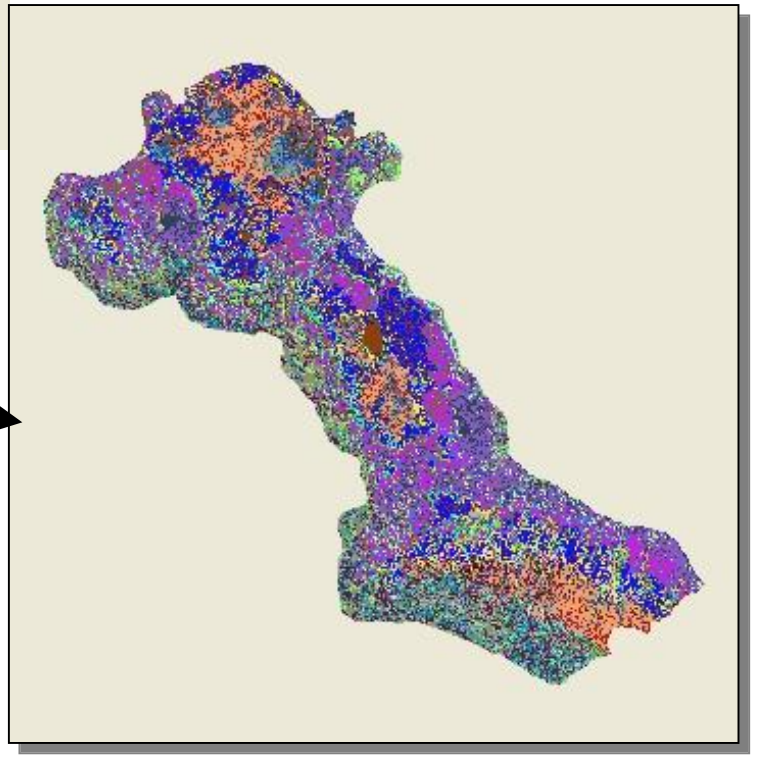
Biodiversity/
Gap Analysis

Systematic
Conservation
Planning



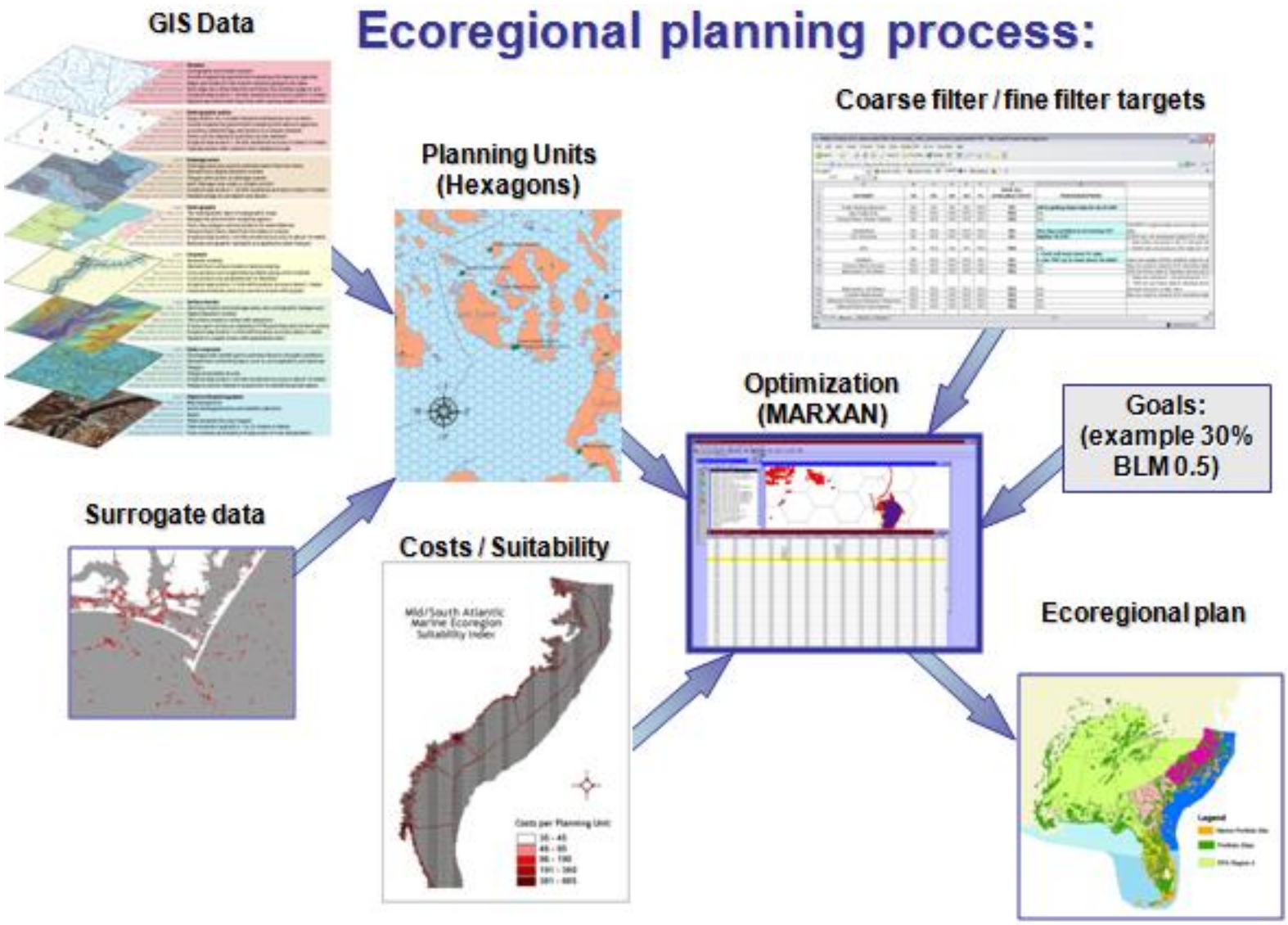
5.1 Biodiversity mapping & Gap analysis



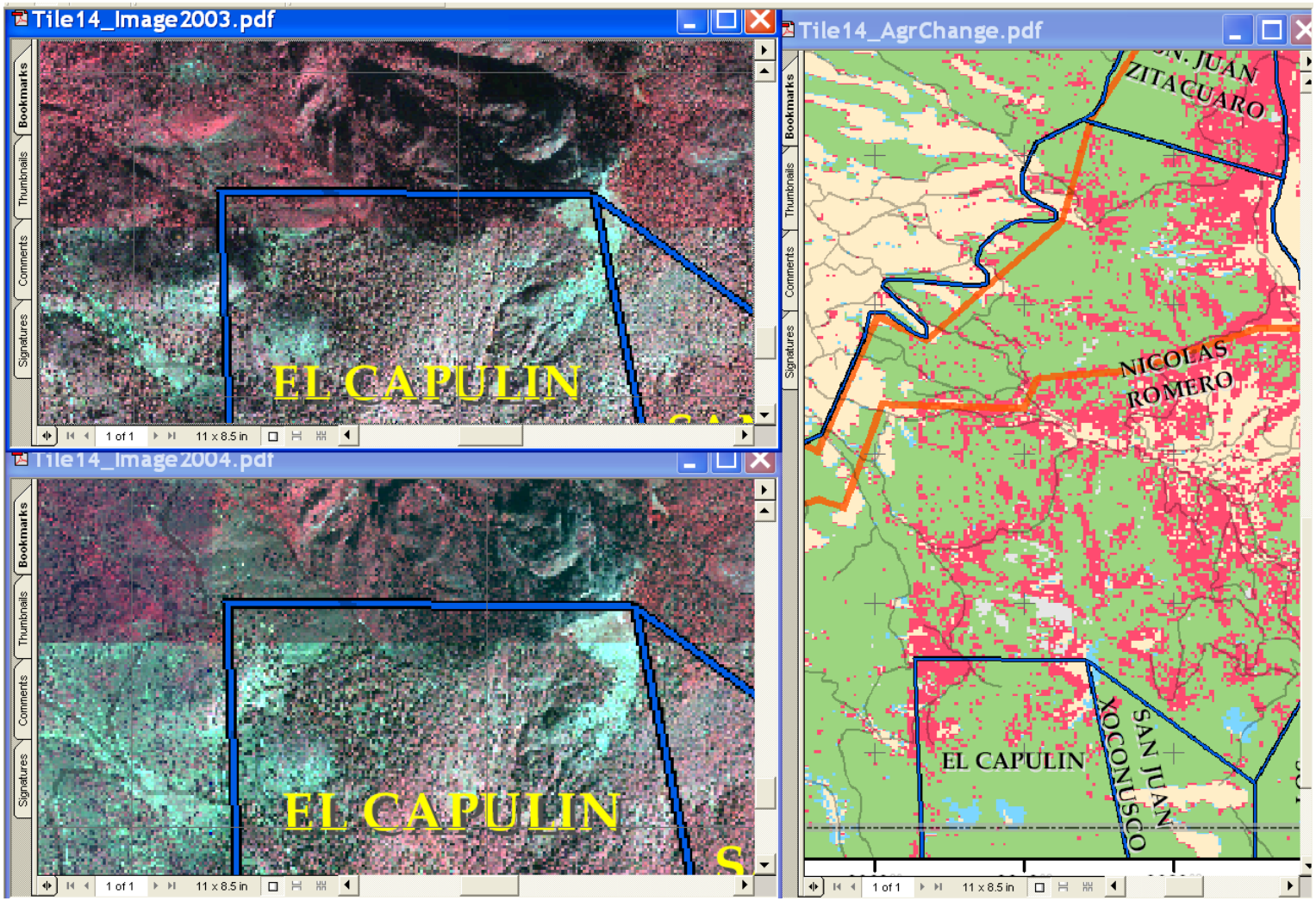


p	ln(p)	p * ln(p)	-Σ(p * ln(p))
43.5%	-0.832	-0.36210	
32.6%	-1.121	-0.36540	
8.7%	-2.442	-0.21244	1.213
4.4%	-3.135	-0.13637	
4.4%	-3.135	-0.13637	

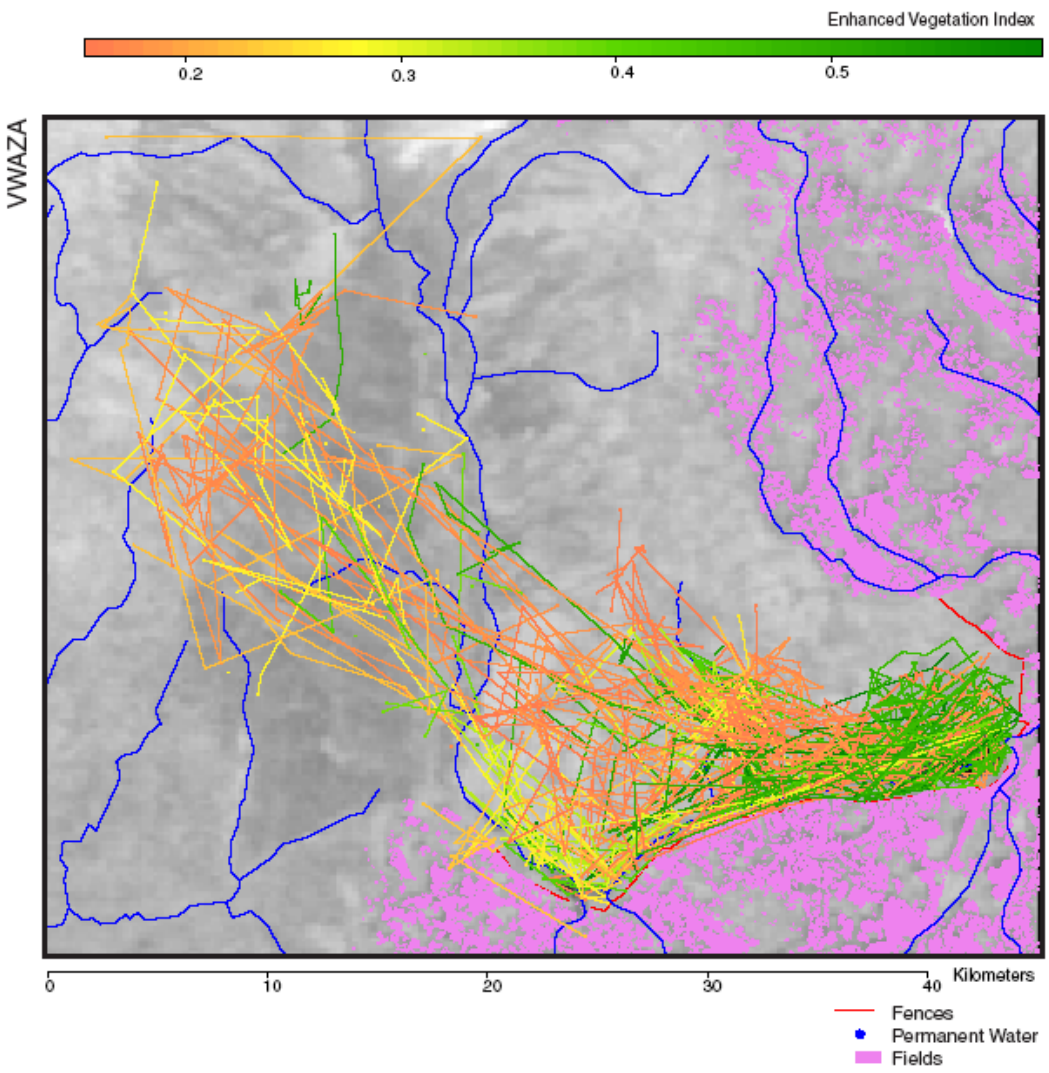
5.2 Systematic Conservation Planning



5.3 Monitoring & Change detection

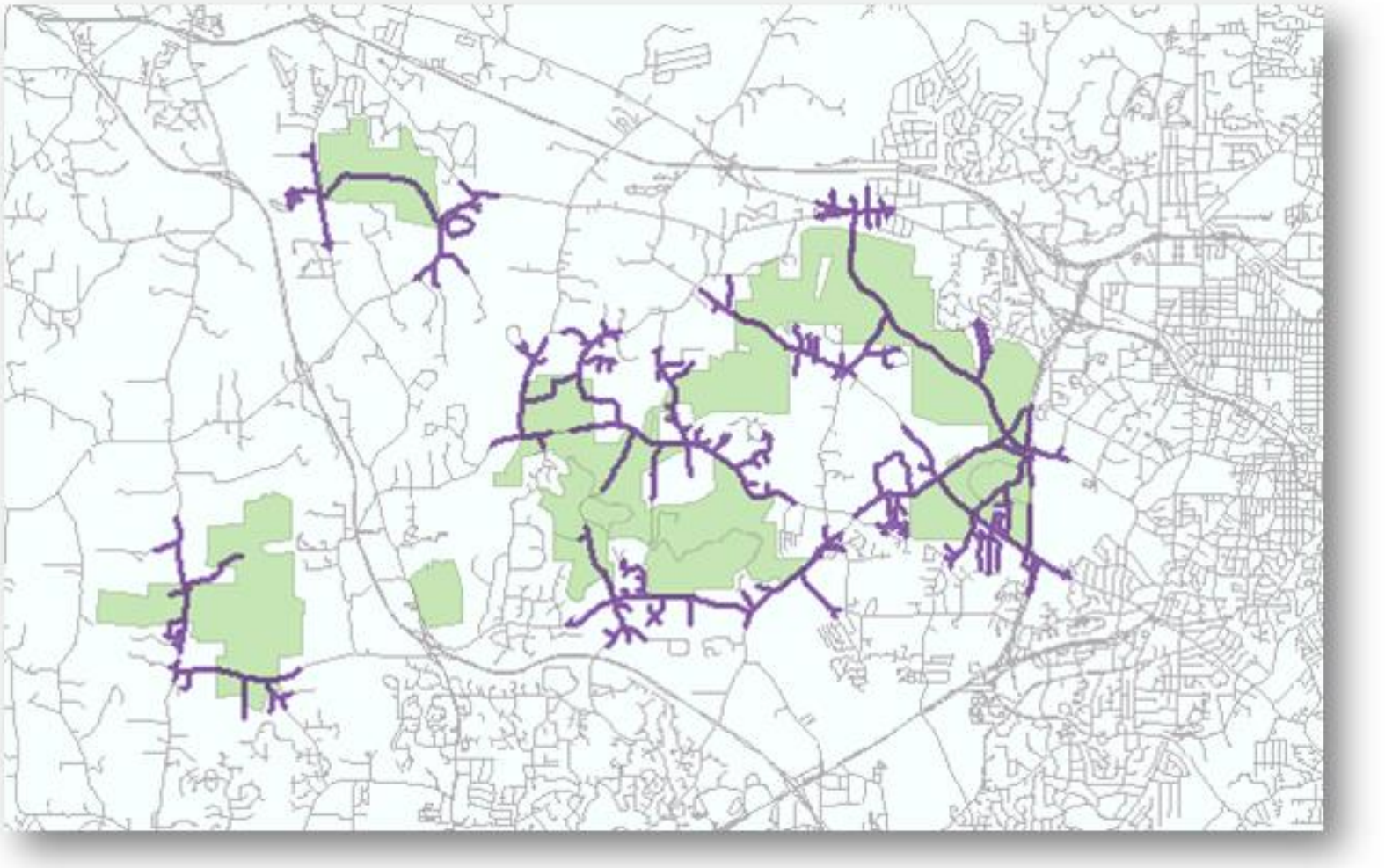


5.4 Animal tracking & movement

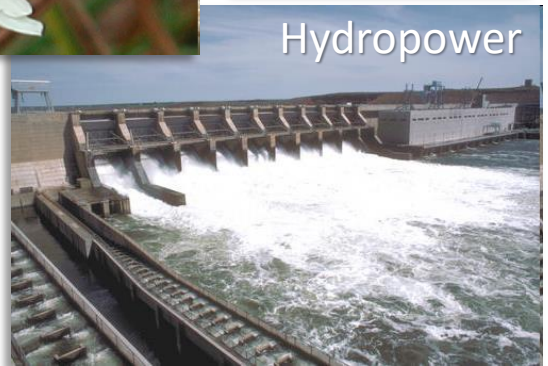


6.* Network analysis

Roads within 10 minutes of a walk to Duke Forest

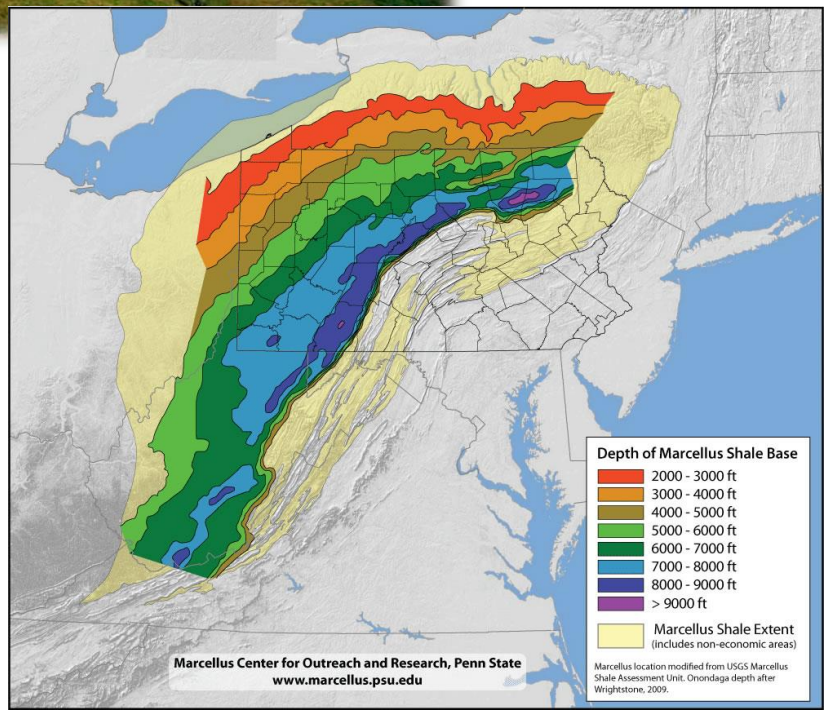


6.* Ecosystem service bundling

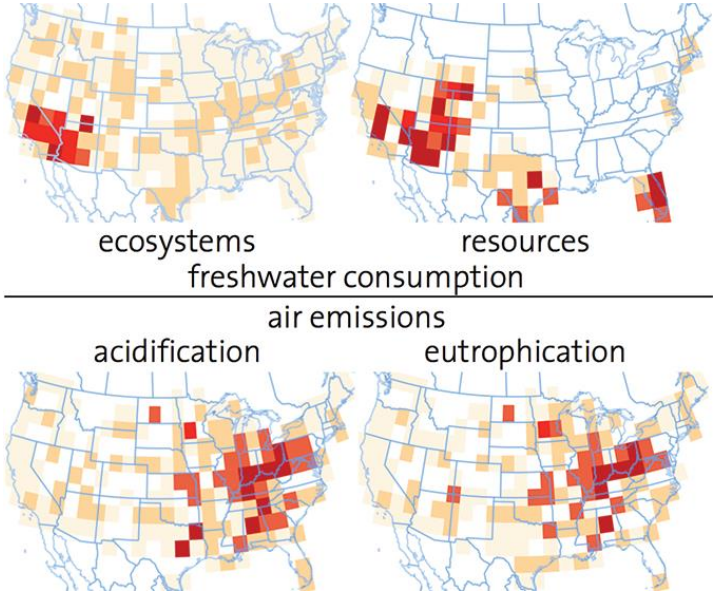


6.* Energy resource management

LARIS KARKLIS/THE WASHINGTON POST



6.* GIS and Life Cycle Assessment



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 Calendar

Date	Topic	Lecture	Lab Topic	Lab Tasks
9-Jan	**Course Introduction**	Course Introduction	Lab introduction/Best practices	Masoala workspace prep
14-Jan	**Project Based GIS**	Intro/Geospatial Data I	SL: Using ArcGIS Online	Using ArcGIS Online
		Geospatial Data II	P1: Pipeline Assessment	Data gathering & prep
21-Jan	*MLK Day*		*no class*	
		Guest: TNC-NC (Liz Kailes)		Open Lab: Spatial analysis
28-Jan		Communicating results		Visual critiques
	Ecohydrology/Terrain Analysis	Ecohydrology	P2: Sierra Costera Site Assessment	Surface & hydrologic analysis
4-Feb		Terrain analysis		Terrain analysis
		Riparian analysis		Riparian/floodplains & Planning units
11-Feb		Guest: LiDAR (D. Schaffer Smith)		Open Lab: Finish analysis
	Habitat Modeling	Habitat modeling approaches	P3: Salamander habitat model	Data prep
18-Feb		Fuzzy sets and fuzzy analysis		Rule based model
		Guest: GJAM (A Schwantes)		Maxent model
25-Feb		Model evaluation		Model evaluation
		Machine learning (K. Bradbury)		Open Lab
4-Mar	**Landscape analysis**	Habitat patches & patch geometry	SL: Patch geometry	Compute patch geometry attributes
		Patch corridors & connectivity	SL: Patch connectivity	Compute patch connectivity attributes
11-Mar	*Spring break*		*no class*	
	Spring break		*no class*	
18-Mar		Guest: Road Xings (R. Sutherland)		[Connectivity demos]
		Patch sensitivities	SL: Patch threats	Compute patch threat attributes
25-Mar	**Conservation planning**	Computing biodiversity	SL: Computing biodiversity	Compute GAP & Zipcode richness
		Prioritization & MARXAN	SL: Prioritization	MARXAN
1-Apr		Monitoring & Change detection	SL: Monitoring and change detection	
	Grab bag	Spatial statistics	SL: Crime Mapping	
8-Apr		Dasymetric mapping	SL: Population Mapping	
		Network models	SL: Duke forest network analysis	
15-Apr				
	Course Recap			

Course Logistics

Grading

Projects (n=3)	36%
Short Labs (n=~9)	44%
Course Project:	20%

Authorized absences and late labs

Contact me if you expect to be gone…
Sickness & family emergency also excusable
Unexcused late assignments docked 5% per day

Lab Projects (3 total; 36%)

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

pct	Deliverable	Due
5.5%	Short Lab 1: ArcGIS Online	18-Jan
12%	Project 1: Albertine Rift Pipeline Analysis	28-Jan
12%	Project 2: Sierra Costera Site Assessment	13-Feb
12%	Project 3: Salamander Habitat Suitability Model	4-Mar
5.5%	Short Lab 2: Patch Geometry	*TBA*
5.5%	Short Lab 3: Patch Connectivity Analysis	*TBA*
5.5%	Short Lab 4: Patch Threat Analysis	*TBA*
5.5%	Short Lab 5: Computing Biodiversity	*TBA*
5.5%	Short Lab 6: Reserve design/optimization	*TBA*
5.5%	Short Lab 7: Monitoring and Change detection	*TBA*
5.5%	Short Lab 8: Duke Forest Service Area	*TBA*

“Short” Labs (~8 total; 44%)

- Designed to ensure you understand and can execute specific analyses

- No extended write up; answer questions posed

pct	Deliverable	Due
5.5%	Short Lab 1: ArcGIS Online	18-Jan
12%	Project 1: Albertine Rift Pipeline Analysis	28-Jan
12%	Project 2: Sierra Costera Site Assessment	13-Feb
12%	Project 3: Salamander Habitat Suitability Model	4-Mar
5.5%	Short Lab 2: Patch Geometry	*TBA*
5.5%	Short Lab 3: Patch Connectivity Analysis	*TBA*
5.5%	Short Lab 4: Patch Threat Analysis	*TBA*
5.5%	Short Lab 5: Computing Biodiversity	*TBA*
5.5%	Short Lab 6: Reserve design/optimization	*TBA*
5.5%	Short Lab 7: Monitoring and Change detection	*TBA*
5.5%	Short Lab 8: Duke Forest Service Area	*TBA*

Today in lab

- account set-up
- lab guidelines & best practices
- GIS workspace organization