Biodiversity Monitoring Program

Steps and Tools

David H. Greegor, Jr.
Ecologist
SEMARNAT Querétaro
y Cuerpo de Paz

Purposes of this Monitoring Workshop

1. Present <u>process steps</u> for implementing a biodiversity monitoring program

2. Provide examples of <u>monitoring tools</u>

3. Use Parque Nacional Cimatario as proposed monitoring project

References

- Noss, R. F. 1990. *Indicators for Monitoring Biodiversity: A Hierarchical Approach. Conservation Biology, vol. 4, December*.

- *Noss, R.F. and A. Y. Cooperrider. 1994.* ***Saving Nature´s Legacy, Protecting and Restoring Biodiversity****. Island Press. Washington. D.C.*

Noss identifies 4 levels of biodiversity organization and complexity:

1. *Genetic***
2. **Population - Species**
3. **Community - Ecosystem**
4. **Watershed - Regional**

**We will discuss the last three only because the *Genetic* level is not really applicable to this discussion

Levels of Biodiversity Organization

Population-Species

Community-Ecosystem

Watershed-Regional

Process for Biodiversity Monitoring (basically, this is scientific method)

1. **Scoping** (problem and goals)
2. **Inventory** (gather & integrate existing data)
3. **Experimental Design** (involves 3 facets):
   - ***Indicators***
   - ***Design***
   - ***Thresholds***
4. **Sampling** (monitoring)
5. **Validation of Model** (research)
6. **Data Analysis and Management** (adjustments)

1. Scoping

- **Problem**

- **Goals**- 2 types; both essential
  1. **<u>Monitoring goals</u> (science)– specific; quantifiable (e.g., population abundance, sedimentation rate)**

  2. **<u>Management goals</u> (policy) – general; may *not* be quantifiable but understandable; based on science (e.g., maintain viable population, water quality)**

Examples of Goals

- Monitoring
  - Maintain brown pelican population in Gulf of Mexico at a viable population level of 100 individuals/ sq. km.
  - Maintain sedimentation rate in Rio Queretaro below 1000 ppm/year
- Management
  - To keep the pelican population above the endangered species status in Gulf (Endangered Species Act definition)
  - To keep the Rio Queretaro drinkable and swimable

2. Inventory
(gather & integrate existing data)

- Estimate baseline conditions
- Determine hotspots of high species richness
- Summarize historical data (literature, museums, herbariums)

3. Experimental Design
(involves 3 facets)

- Indicators
- Design
- Thresholds

A. Indicators

- Often surrogates of actual biodiversity because biodiversity cannot be measured directly

- Indicators usually involve composition, structure & function characteristics of a population-species, a community-ecosystem, or a watershed-region

Monitoring Tools
(e.g., for species-population level)

Must be able to monitor for:

- **Composition (e.g., relative abundance)**
- **Structure (e.g., age class ratios)**
- **Function (e.g., population survivorship)**

Can include:

- **Census**
- **Habitat Suitability Index**
- **Remote sensing**
- **Population viability analysis**

Criteria for Indicators

- **Need to be a good measure** (e.g. age class ratios) **for element of biodiversity of concern** (population viability)
- **Able to detect problem before too late** (e.g., population at critical low)
- **Experimental control should be available** (e.g., area where population not threatened)
- **Change in indicator below biological threshold should change management practices** (see Thresholds later)
- **Cost effective**
- **If problem and goals are clear, then indicators should be clear**

Indicators for Monitoring at Population-Species Level

Composition	*Structure*	*Function*
✓Abundance ✓Frequency ✓Plant cover ✓Biomass ✓Density	✓Dispersion ✓Range ✓Sex & age ratio	✓Survivorship ✓Mortality ✓Phenology ✓Growth rate ✓Life history ✓Adaptation ✓Acclimation

Monitoring Tools at Population -Species Level

- ✓**Census** (observations, counts, signs, radiotelemetry)
- ✓**Remote sensing** (satellite data)
- ✓**Habitat Suitability Indices** (HSI)
- ✓**Population viability analysis** (dependent on ratio of age classes, etc.)

Indicators for Monitoring at Community-Ecosystem Level

Composition	*Structure*	*Function*
✓Relative abundance ✓Frequency ✓Richness ✓Proportions of endemics, exotics, T&E, etc.	✓Soil-water variables ✓Stream gradient ✓Vegetation (biomass, density, patchiness) ✓Pool, riffle, run ratios ✓Physical features ✓Water quality	✓Productivity ✓Parasitism ✓Herbivory ✓Predation ✓Colonization ✓Extinction rates ✓Nutrient cycling rates

Monitoring Tools at Community-Ecosystem Level

- ✓ **Aerial photos**
- ✓ **Remote sensing data**
- ✓ **Photo stations**
- ✓ **Habitat Suitability Indices** (HSI)
- ✓ **Species diversity indices**
- ✓ **Natural resource inventories**
- ✓ **Sampling methods** (transects, quadrats, trapping)
- ✓ **Physical habitat measurements**
- ✓ **Instream flow measurements**
- ✓ **Sediment transport**
- ✓ **Channel stability**

Indicators for Monitoring at Watershed-Regional Level

Composition	*Structure*	*Function*
✓Species distributions ✓Landscape types	✓Heterogeneity ✓Patchiness ✓Fragmentation ✓Perimeter-area ratios ✓Habitat layer distribution	✓Disturbance processes ✓Nutrient cycling rates ✓Erosion rates ✓Hydrologic & geomorphic processes ✓Land use trends

Monitoring Tools at Watershed-Regional Level

- ✓Remote sensing data
- ✓Aerial photos
- ✓GIS/Google Earth
- ✓Mathematical indices of patterns, vertical layering, diversity, connectivity (corridors, etc.), edge, spatial heterogeneity, etc.

B. Design

- Statistics important
- Control area desirable
- If no control area, extrapolate from existing conditions and use intuition and common sense

C. Thresholds (2 types)

- **Biological** – point where irreversible change may occur in population, ecosystem (e.g., African elephants, China pandas are close)

- **Management** – point where management must change to avoid *biological threshold* (e.g., ESA species listing); design must focus on this before too late

4. Sampling

- The sampling *is* the monitoring in reality

- It is critical to have steps 1-3 (scoping, inventory, & experimental design) accomplished or *monitoring is a waste of time*

5. Validation of Model

- Test how well indicators of the model correspond to real ecological phenomena:

Example model: Rising average daytime temperatures are impacting the composition, structure and function of lizard populations in Parque Cimatario

- Models are dynamic and almost always need adjusting

6. Data Analysis and Management

- Periodically data need to be analyzed & management practices adjusted

- Level of human impacts determines difficulty of adjustment. Examples:
  - Rio Queretaro water quality ***vs.*** Gulf Oil Spill
  - Sierra Gorda deforestation ***vs***. global climate change

Example of Proposed Biodiversity Monitoring Program

(at Population-Species Level)

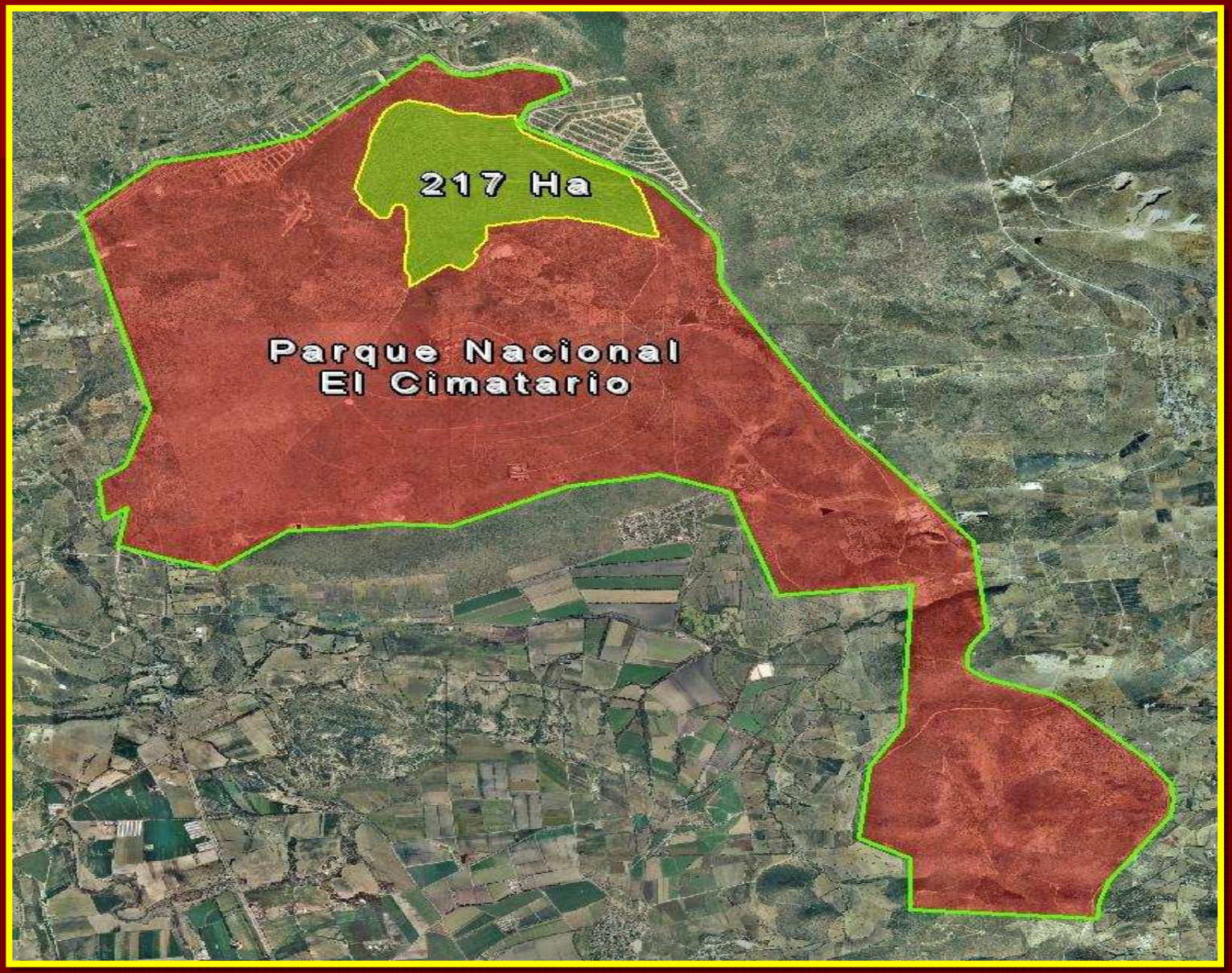
Lizard Biodiversity and Population Stability in *Parque National Cimatario*, Queretaro, Central México

Sceloporus serrifer has gone locally extinct in certain central México sites

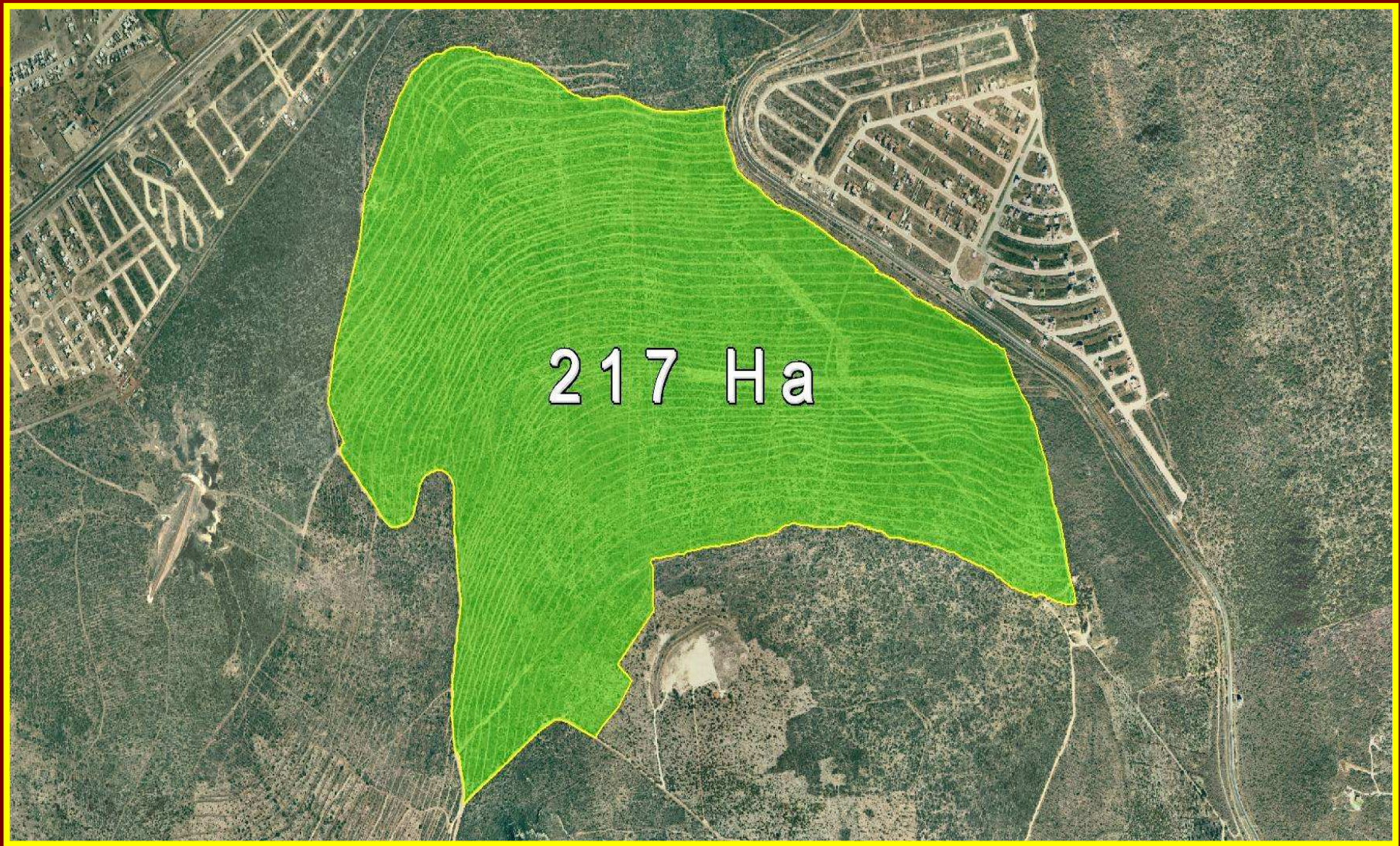
Parque Nacional Cimatario

Parque Cimatario Offices

Parque Nacional de Cimatario



Parque Nacional de Cimatario
Natural Area of Protection



Two Dominant Vegetation Communities in Parque Cimatario

Matorral Crasicaule

- **Shrubs**
- **Ave. Less than 4 m. high**
- **6.2% park area**

Bosque Tropical Caducifolio

- **Trees**
- **Ave. 4-12 m. high**
- **77% park area**

Typical Bosque-Matorral Vegetation

Sceloporus sp. in Natural Area

Lizard Habitat in Natural Area

Grasshopper Biodiversity in Parque Cimatario – 10 families, 38 species

Bursera is Most Abundant of 9 Tree Species of Importance in Protected Areas

Process for Biodiversity Monitoring

1. Scoping
2. Inventory
3. Experimental Design
4. Sampling
5. Validation of Models
6. Data Analysis and Management

1. **Scoping** (problem, goals)

Problem

- *Lizard populations and biodiversity around the world are deteriorating at an unprecedented rate, including Central Mexico.*

- *What are factors in Parque Cimatario:*
  - *Temperature increase?*
  - *Food decrease?*
  - *Cover reduction?*

Monitoring Goals

- **Goal 1: <u>Monitor</u>** relationship between lizards and temperature increases in Parque Cimatario
- **Goal 2: <u>Monitor</u>** changes in grasshopper biodiversity and abundance in Parque Cimatario
- **Goal 3: <u>Monitor</u>** *Bursera* plant cover changes over time

Management Goal

- **Goal 4**: **<u>Management</u>** of Parque Cimatario to enhance biodiversity and abundance of lizards by a) increasing areas of complete protection from grazing, wood cutting; and b) increasing abundance of better cover species than *Bursera*, e.g., Acacia sp. (huizache)

2. Inventory- some current articles on lizards and climate change

- **Global Warming Blamed for Pattern of Lizard Deaths** (*Washington Post*)
- **Are Lizards Toast** (*Science*)
- **Erosion of Lizard Diversity by Climate**
- **Change and Altered Thermal Niches** (*Science*)
- **Mass Lizard Extinctions Looming; Global Warming Blamed** (*National Geographic)*

3. Experimental Design

- Indicators
- Design
- Thresholds

Some Indicators for Monitoring lizards, grasshoppers, *Bursera* plants

Composition	*Structure*	*Function*
✓Abundance ✓Richness ✓Plant cover ✓Grasshopper biomass	✓Dispersion ✓Sex & age ratios	✓Survivorship ✓Mortality ✓Acclimation

Monitoring tool <u>examples</u> for lizards, grasshoppers, and *Bursera* plants

Lizard Population Monitoring Tools

- **Transects**: walking censuses along permanent lines (observations, noosing)
- **Trapping**: lizard fences and pitfall traps

Grasshopper Population Monitoring Tools

- **Transects**: Census using sweep nets
- **Trapping**: funnel, pitfall traps, etc.

Plant Population Monitoring Tools

- **Transects** (cover, recolonization)
- **Point-quarter** *or* **Quadrant** (diversity, density, composition)
- **Quadrats** (diversity, composition)
- **Photo Stations** (cover, growth rate, recolonization)

Transect for lizard fences, grasshopper netting, *Bursera* photo stations

3. Experimental Design

- Indicators
- Design
- Thresholds

Some Design Components

- Establish Parque Cimatario as a global Long Term Ecological Research (*LTER*) site
- Establish population baselines now and begin monitoring lizards, grasshoppers, and cover plants this fall
- Set up weather/climate monitoring stations within natural area

3. Experimental Design

- Indicators
- Design
- Thresholds

Suggested Thresholds

- **<u>Monitoring</u>** – when lizards are not reproducing successfully
- **<u>Management</u>** – a 20% decrease in lizard abundance over next 5 years

The Future: August 2010 - ?

4. **Sampling** (actual monitoring)

5. **Validation of Models**

6. **Data Analysis and Management**

Homework:
Develop a Biodiversity Monitoring Program for the Gulf of Mexico Oil Spill Disaster

1. Scoping ?
2. Inventory ?
3. Experimental Design ?
4. Sampling ?
5. Validation of Models ?
6. Data Analysis and Management ?

A Few Questions to Ask

- **What** would your monitoring & management goals be?
- **Where** are the species hotspots now?
- **What** organizational level(s) would you study (species-population, community-ecosystem, watershed-regional)? All levels?

- **How (or could) you find a control area?**
- **How would you determine management & biological thresholds?**
- **What monitoring tools would you use to evaluate populations, ecosystems, regions?**
- **When would you begin sampling or monitoring (now, after oil stops)?**

David H. Greegor, Jr.

Correos:

- david.haynie@queretaro.semarnat.gob.mx
- dgreegor@gmail.com