Linking Management and Monitoring:

Concept and Application for Wildlife

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Outline

- Overview of Adaptive Management
- Why monitoring is essential to Ad. Management
- Define biological monitoring
- Considerations for monitoring
- Example of a monitoring program.

Traditional Management

A trial and error approach

- Conventional wisdom
- Best current data (if any)
- Evaluation often not formalized
- No inherent feedback mechanism

Adaptive Management: Philosophy

Traditional management plus…

- A structured process for "learning by doing"
- Management as an experiment
- Hypotheses-testing framework
- Information gained is used to revise management through built-in feedback mechanisms

Adaptive Management: Definitions

A process for continually improving management practices by learning from the outcomes of management programs.

A process where management is applied experimentally to evaluate alternative hypotheses about a system.

Adaptive Management: History

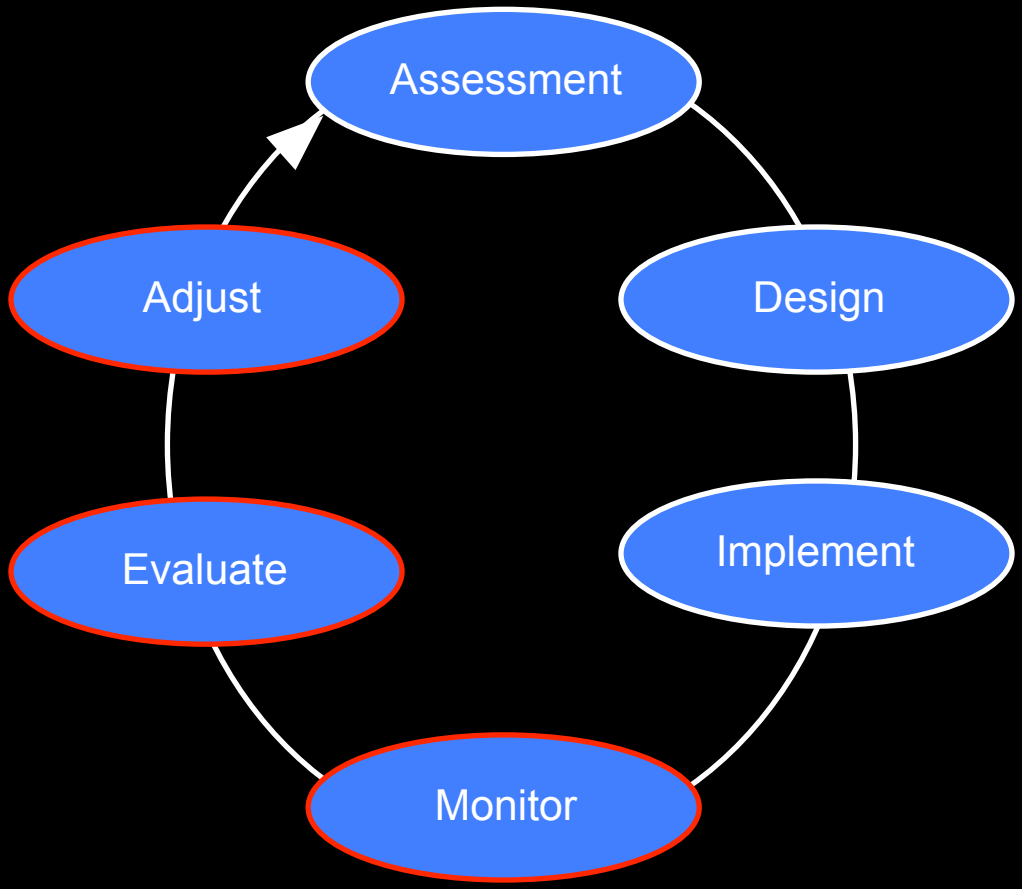
- In 1950s for industrial operations

- For natural resources:
  - Holling, C.S. 1978. Adaptive environmental assessment and management. Wiley.
  - Walters, C.J. 1986. Adaptive management of renewable natural resources. McMillan.

Why Adaptive Management?

- Mistakes are expensive!
- Lots of options but only one may work
- Nature is complex
- High uncertainty and variation

Adaptive Management Process



Active vs. Passive Adaptive Management

- **Active**
  - Apply treatment
  - Assess results
  - Revise practice or continue treatment

- **Passive**
  - No initial treatment
  - Monitor system
  - Assess
  - Take action or continue monitoring

Review - So Why Monitor?

- To assess changes in resources over time
- To evaluate
  - Influence of existing management (active)
  - Needs for new actions (passive)
- As a basis for revising management
- To optimize stewardship of the environment

Part II

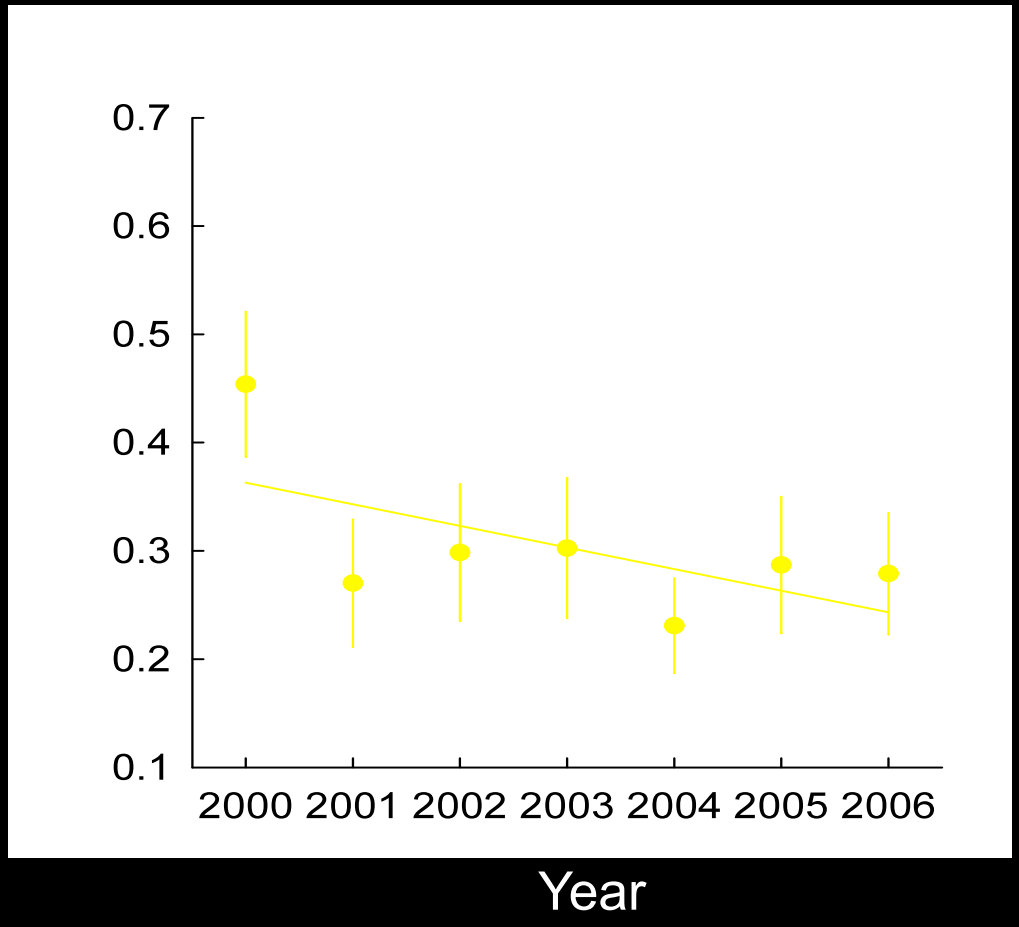
What is biological monitoring?

Considerations for monitoring

What is biological monitoring?

Repeated measurement of a resource over ***time***

- To detect trends
  - Presence
  - Direction (+, –, ∩)
  - Magnitude (rate)



Considerations Before Monitoring

Choose

- Objectives
- Subject
- Methods
- Sampling design
- Sample sizes
- Effort allocation
- Data analysis

What Do We Monitor ?

- Active adaptive management
  - Specific target resource

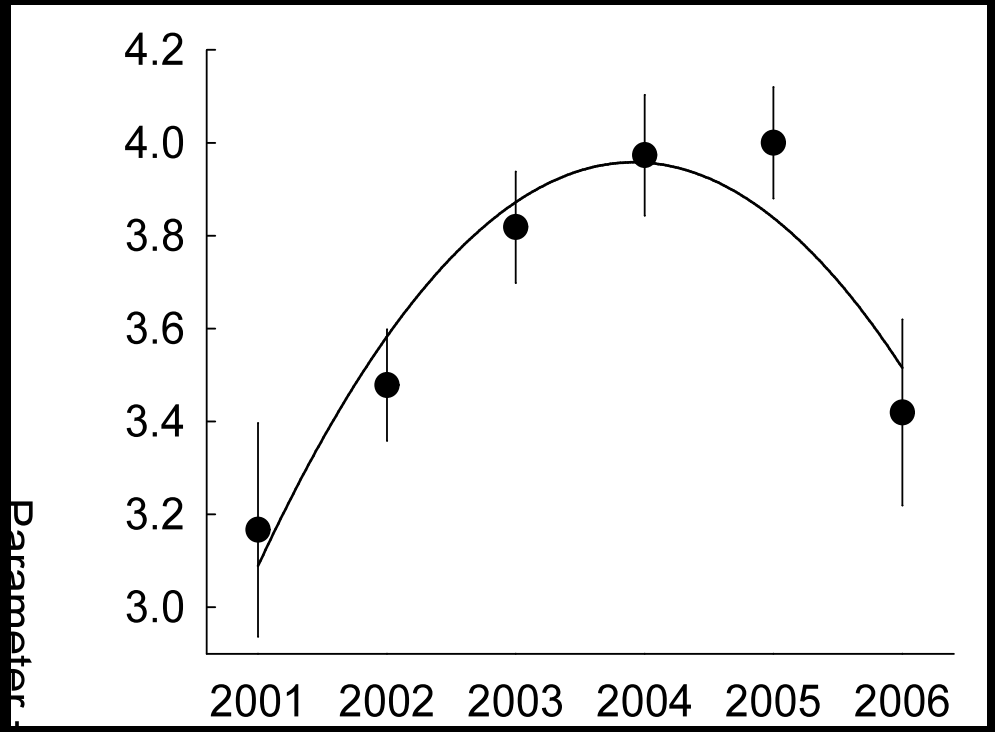
- Passive adaptive management
  - Often General
    - e.g., “maintain native biodiversity”

So how do we decide?

What to Monitor

Parameter - subject of inference across time

- For Wildlife Managers
  - Population
  - Community



Population Parameters

Examples

- Occupancy
- Abundance
- Demographics
- Diet
- Movements (home range size)
- Gene frequencies

Typical Population Parameters

- Occupancy (presence vs. absence) (0 or 1)
  - Proportion of sites occupied
- Abundance (or density) (0…∞)
  - Population size
- Demographics
  - Nest success (0 or 1)
  - Productivity (0, 1, 2, 3…)
  - Growth rate (λ)

Community Parameters

Examples

- Richness
- Evenness
- Diversity
- Energy flow

Often based on population parameters

Other Parameter Categories

Examples

- Climate
  - rain, temperature...
- Landscape attributes
  - cover, use, greenness, fragmentation...
- Chemical cycles
  - carbon fixation, evapotranspiration...
- Water
  - quality, quantity, groundwater or surface, geomorphology...
- Disturbance

Parameter Selection - Decisions

Considerations - ecological and statistical

- Ecological relevance
- Sampling efficiency
- Conservation value
- Threat

Parameter Selection - Decisions

Considerations - management

Value for…

- Assessing relevant change
- Triggering management
- Evaluating and adapting existing management

Ecological Relevance

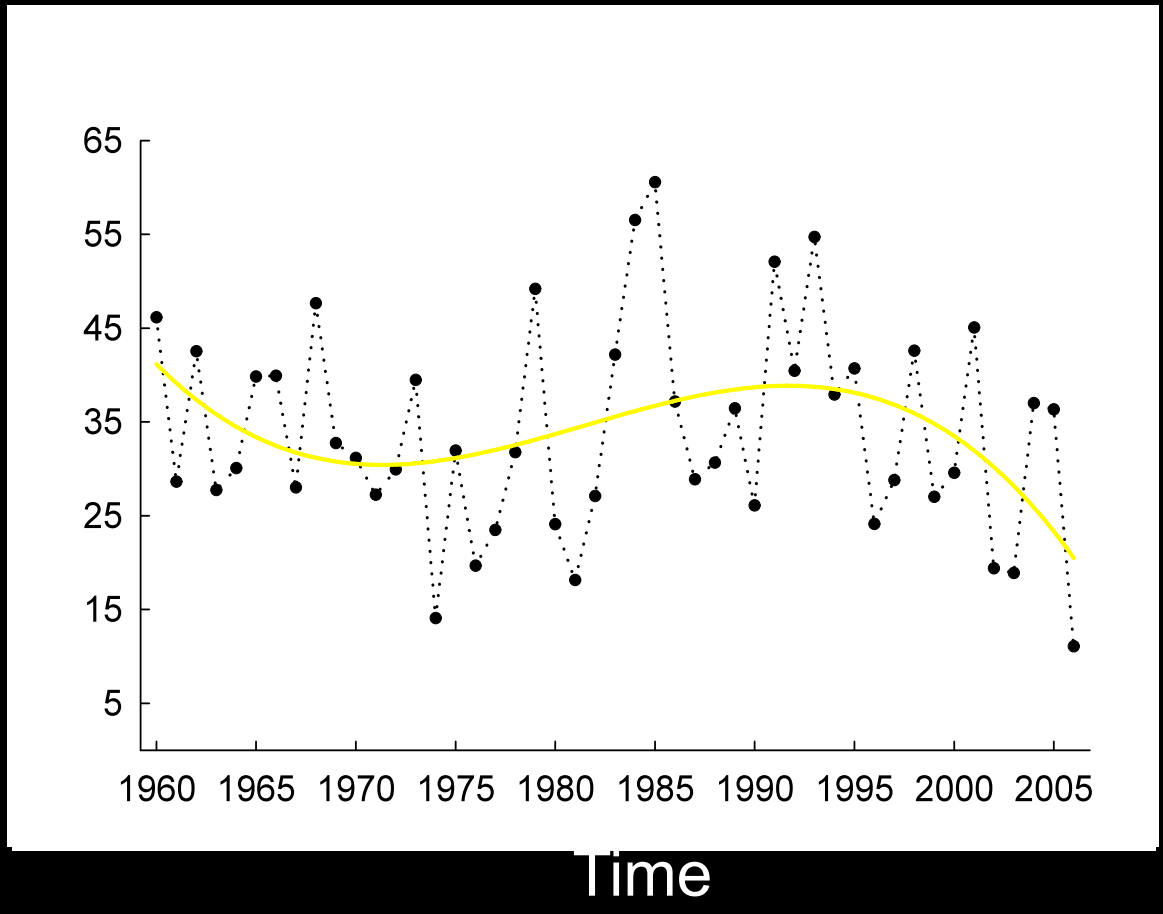
Considerations

- Connection between parameter and larger system
  - Responsiveness to change
- Parameter responds quickly
  - Small lag time

Sampling Efficiency I

Considerations

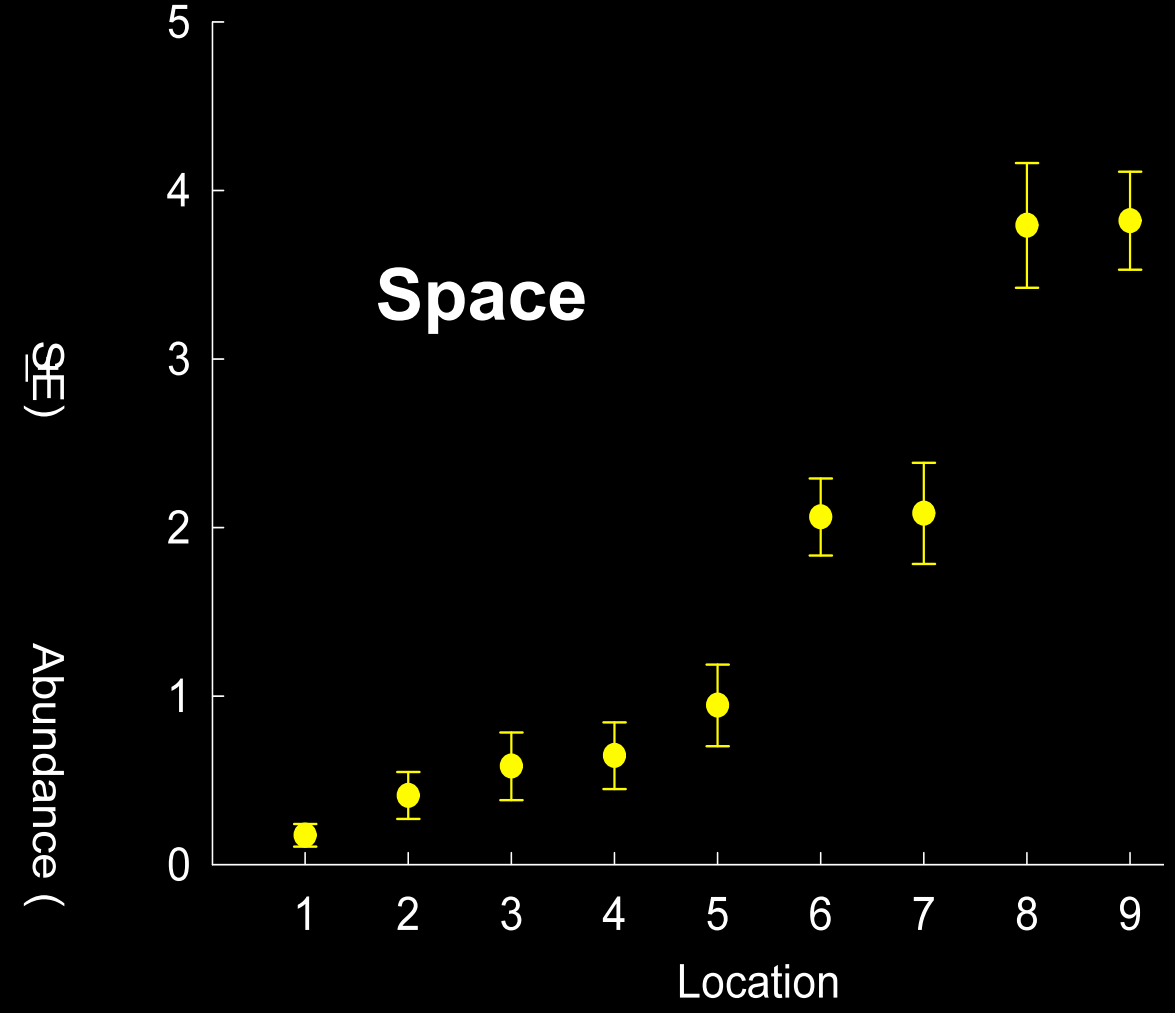
- Method available
- High detectability
- Low random variation
- Low sampling error
- Time and $



Sampling Efficiency II

Considerations

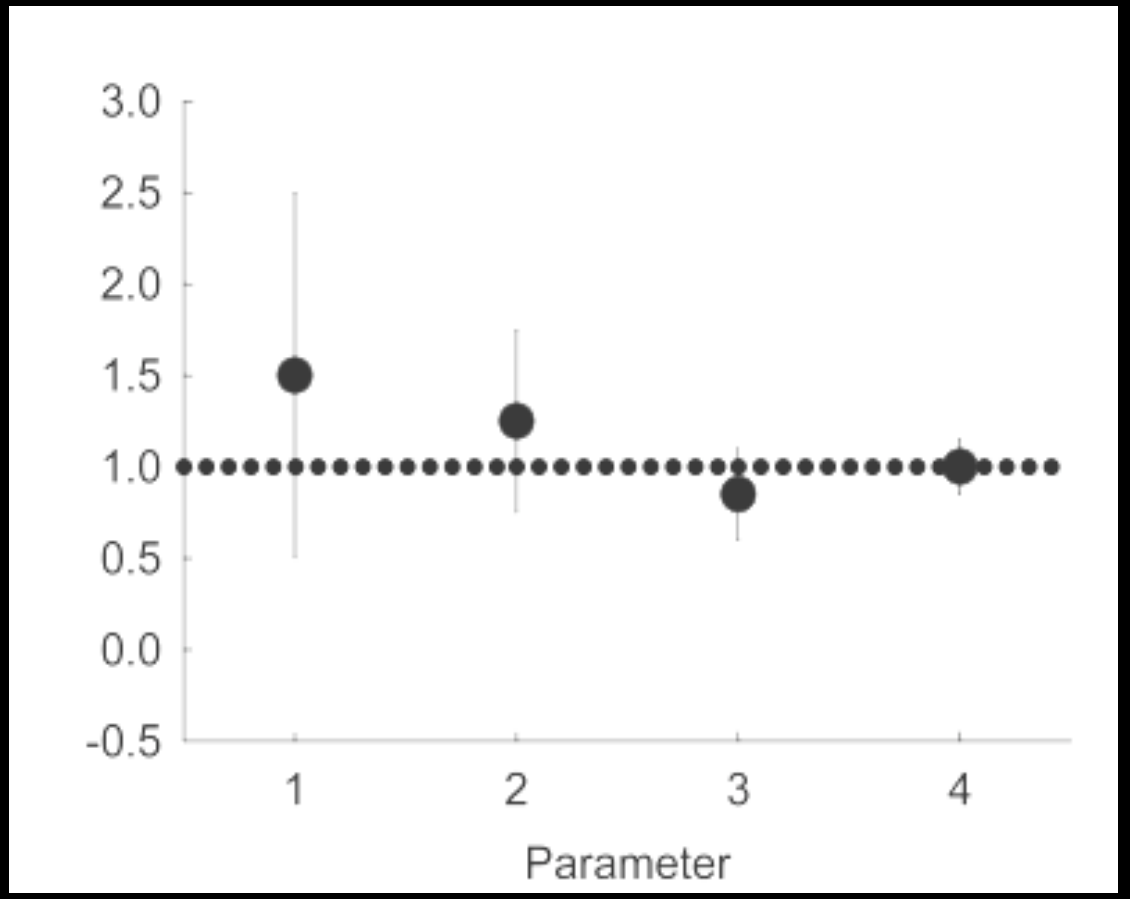
- Low random variation

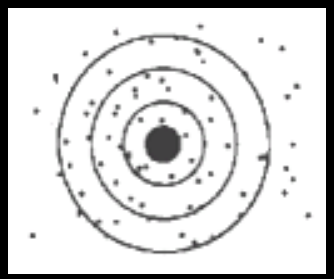


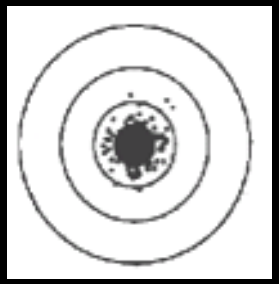
Sampling Efficiency III

Considerations

- Low sampling error







Sampling IV - Detectability

"Probability of detecting an individual provided it is present"

Some individuals present but undetected

- False negative results

No adjustment = biased estimates

If We Don't Adjust for Detectability ☹

Problems

- Changes in population size unknown
- Changes in detectability big problem
- Comparisons among species not possible

Changing Detectability

Is detectability here….

Changing Detectability

Same as detectability here….

No Way!

Monitoring and Detectability ☺

Estimate and adjust for detectability

- Many methods available
  - Observational
  - Capture-recapture

Assessing Detectability I

Observational Methods

- Distance sampling
- Repeated sampling
- “Removal” methods
- Double observers

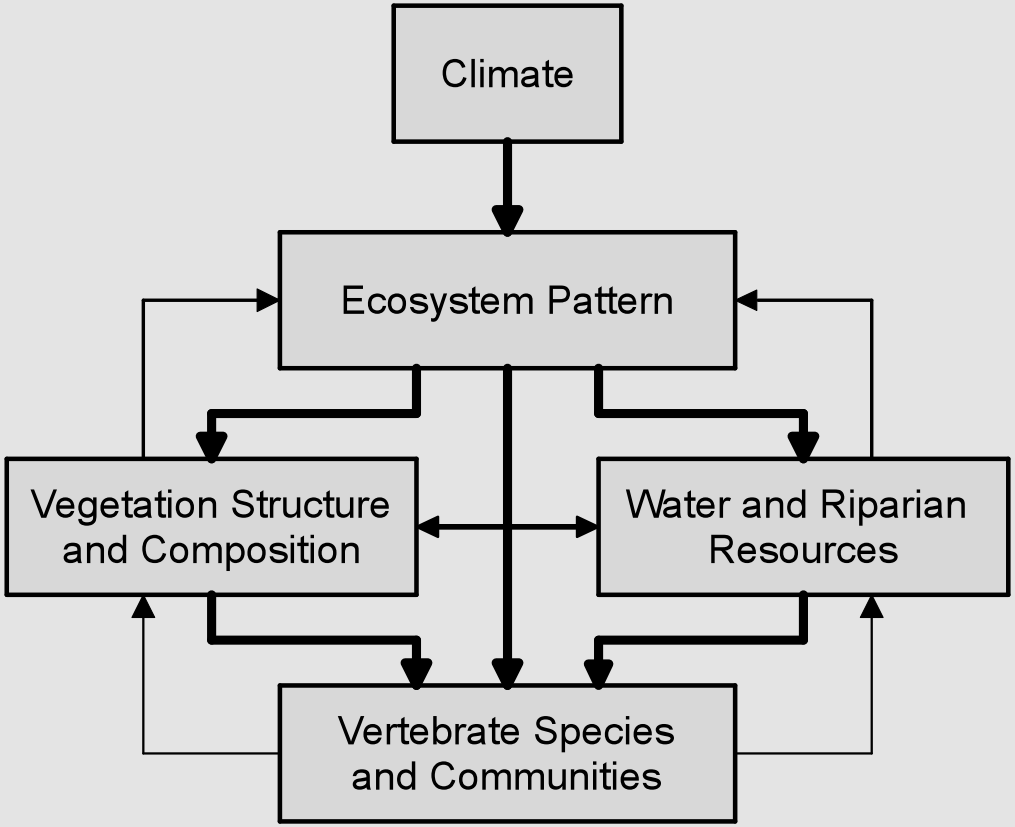
Assessing Detectability II

Capture-recapture

- Closed-population models
- Open-population models
- Marked subsets - Radio tracking
- Trapping webs with distance sampling

Biodiversity Monitoring – Big Picture

Hierarchy of parameters linkages



Importance of Linkages

Biotic and abiotic factors linked

- Measuring both can provide insight into...
  - Causes of change
  - Foreshadow future changes
  - Strategies for addressing changes
  - Knowledge of system
- Other advantages
  - Stressors often unknown when program is conceived
  - Flexibility
  - Faster response time

Conclusions

- Monitoring is an essential part of management
- But we can’t monitor everything in a system
- Thoughtful design with improve success
- Broad range of considerations for monitoring
- Monitoring a linked suite of parameters more insightful