Adaptive Harvest Management for the Taiga Bean Goose

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U.S. Department of the Interior
U.S. Geological Survey

Outline

- What is decision analysis and adaptive management? What are its essential features?
- Finding the right approach for taiga bean geese
  - What is the institutional capacity for management, as well as the sources and degree of uncertainty?
  - How will they influence specification of an adaptive management program?
- A first look at taiga bean geese population dynamics
- Going forward

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What is decision analysis?

- The structuring of a decision problem
  - in terms of *choices, outcomes,* and *values*
  - to identify the choice that is most likely to meet the objectives

- Decisions involve
  - predicting outcomes from alternative choices
  - valuing those outcomes

- The first part is the (objective) role of science; the second part is the (subjective) role of society

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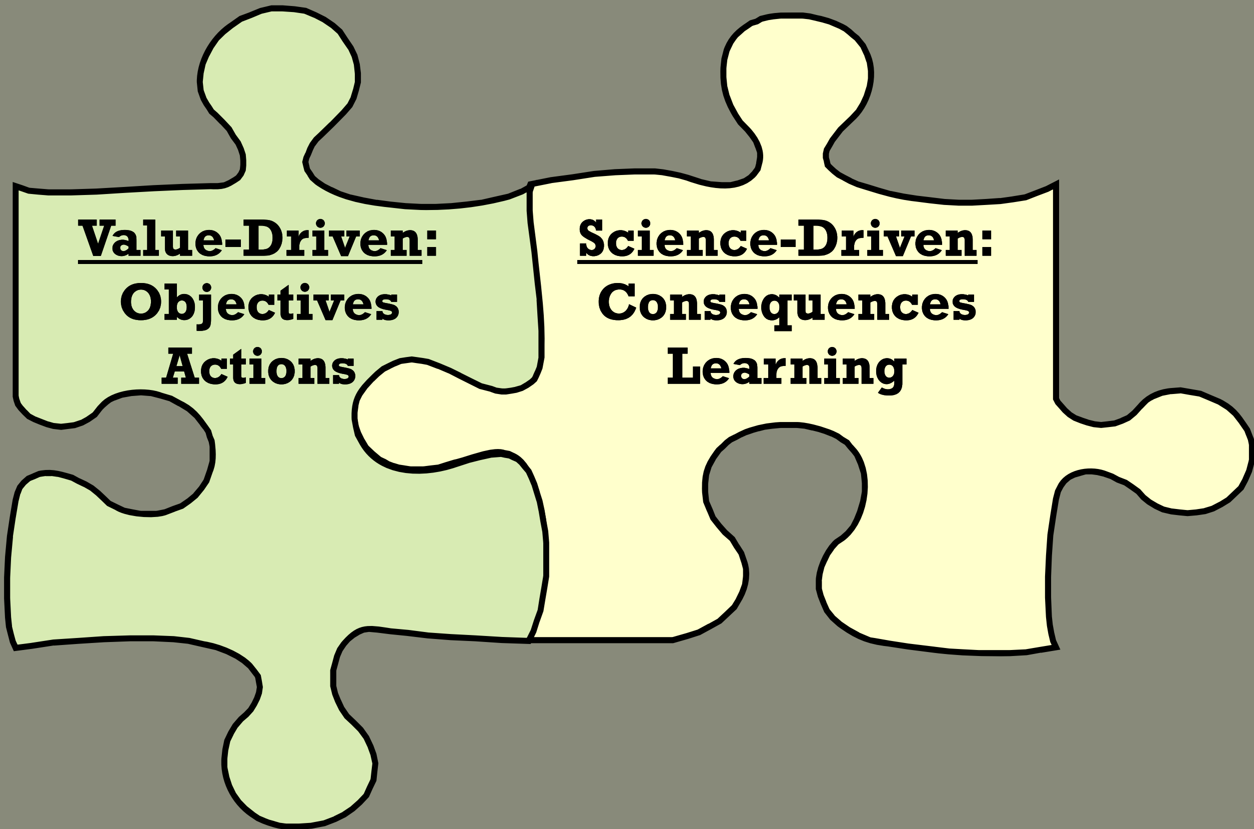
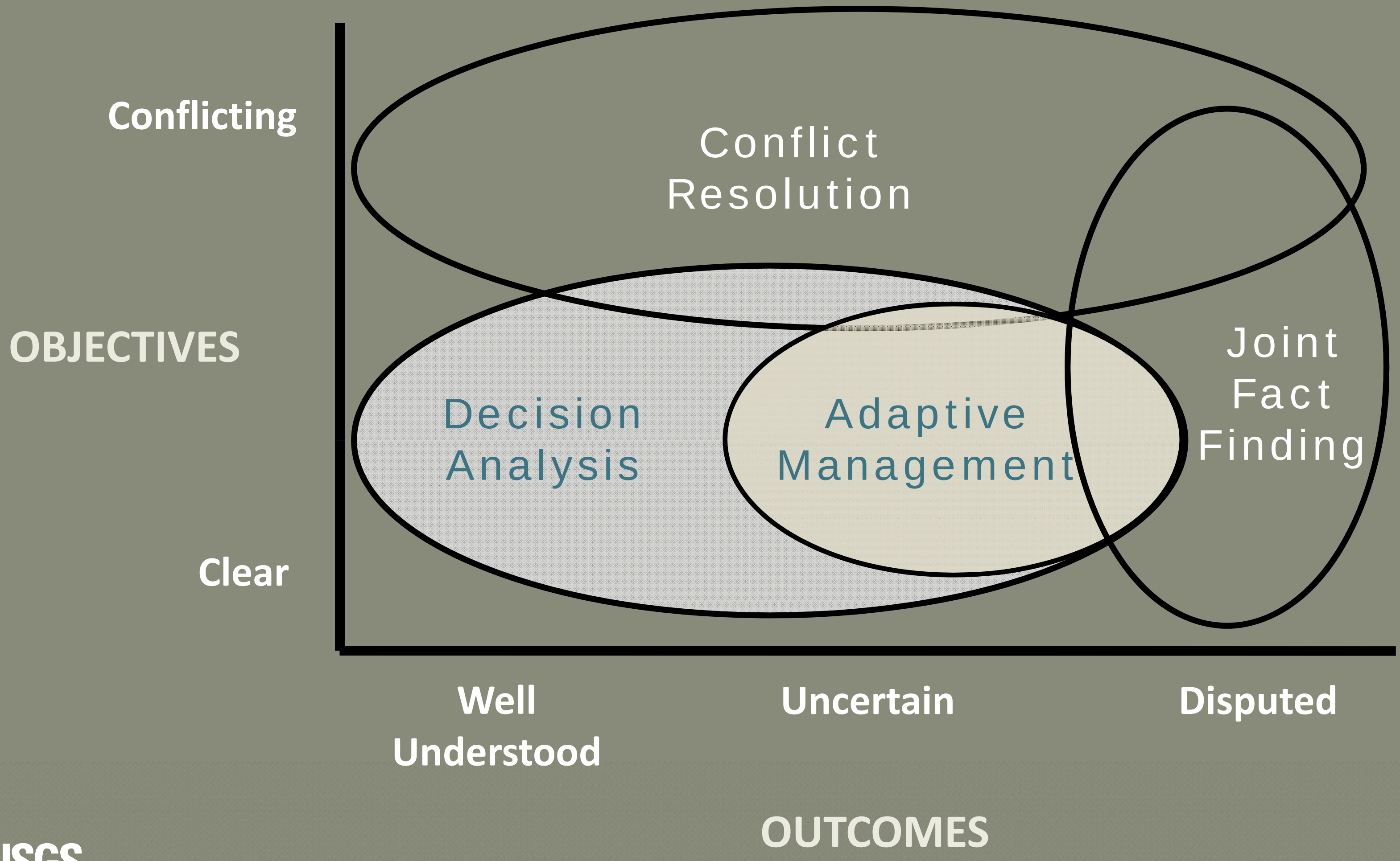
What is decision analysis?



Adaptive management as decision analysis



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Adaptive management

- Management in the face of uncertainty, with a focus on its reduction
- Often referred to as "learning by doing"
- Formal applications involve the use of decision theory to:
  - Provide an analytical structure to the management problem
  - Help focus debate about objectives, possible management actions, and resource behaviors
  - Provide optimal management decisions in the face of uncertainty
  - Modify management policies based on what is learned

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Essential features of AM problems

- Decisions must be *dynamic* (repeated over time)
- There must be *uncertainty* as to the impacts of management (*and* the uncertainty must matter)
- Management actions must be *differentially informative*
- Monitoring can be used to *compare* predictions and realized resource responses

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A protocol for AHM

- ***Components***
  - An objective function
    - by which alternative management policies can be compared
  - A limited set of alternative management actions
    - describing varying levels of harvest pressure
  - A set of population models
    - describing alternative hypotheses about the effects of harvest and environmental factors on waterbird abundance
    - and a relative measure of credibility ("weight") for each model
  - A monitoring program
    - that allows for state-dependent regulatory decisions
    - that permits a comparison of model-based predictions with observed population responses (i.e., learning)

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A protocol for AHM

- ***Process***
  - Each year (or whenever appropriate), an optimal harvest action is identified based on:
    - management objective(s)
    - status of the resource (and relevant environmental conditions)
    - current model weights
  - Given a harvest decision, model-specific predictions are made for changes in waterbird abundance
  - When monitoring data become available, model weights are increased to the extent that predictions and observations agree (and decreased to the extent that they don't)
  - Repeat

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Two aspects of adaptation

- State dependency
  - Changing harvest ***actions*** based on the state of the resource
  - E.g., population size and relevant environmental conditions
- Knowledge dependency
  - Changing harvest ***policy*** based on the state of knowledge
  - E.g., degree of evidence for competing models of population dynamics

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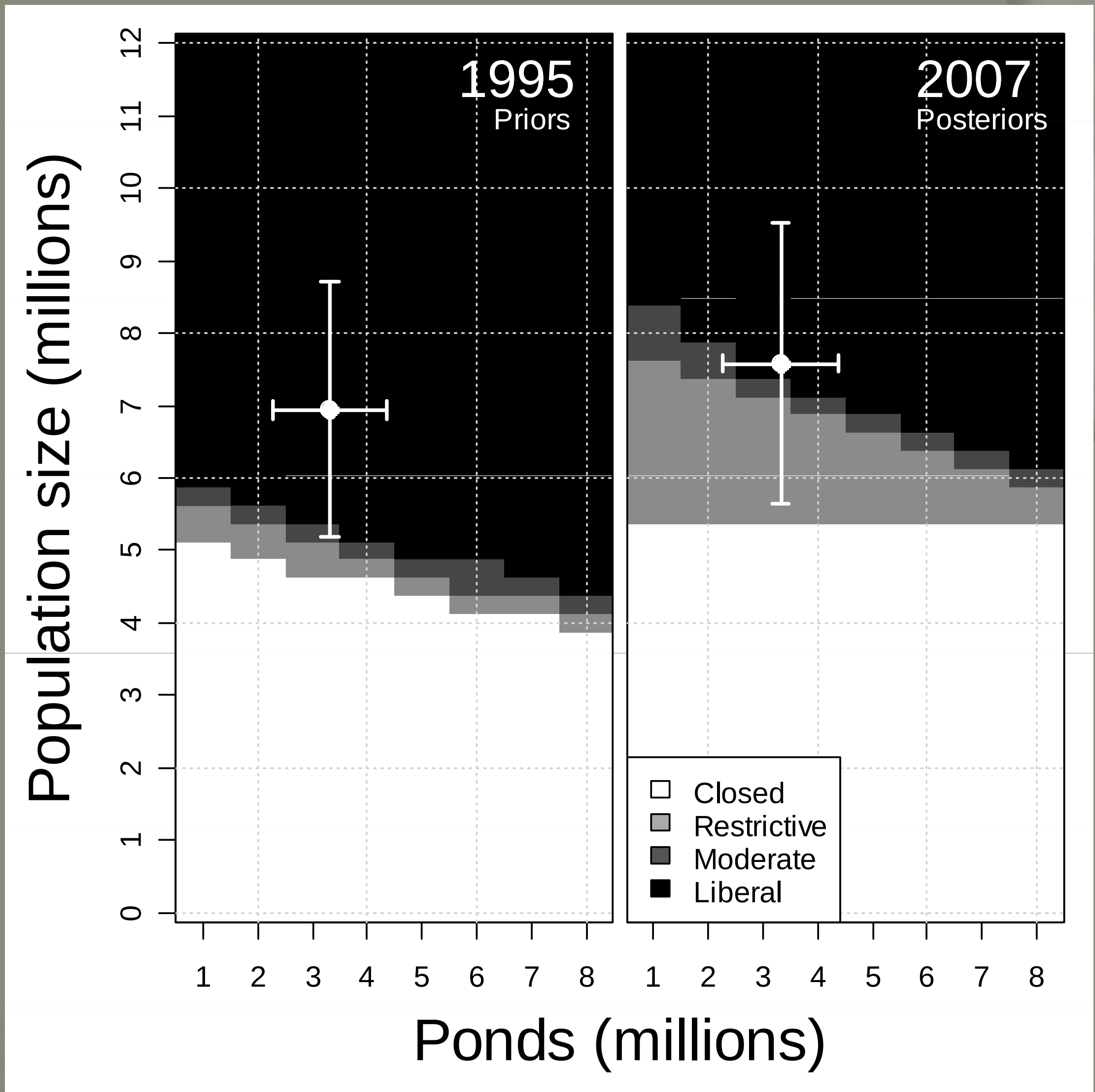
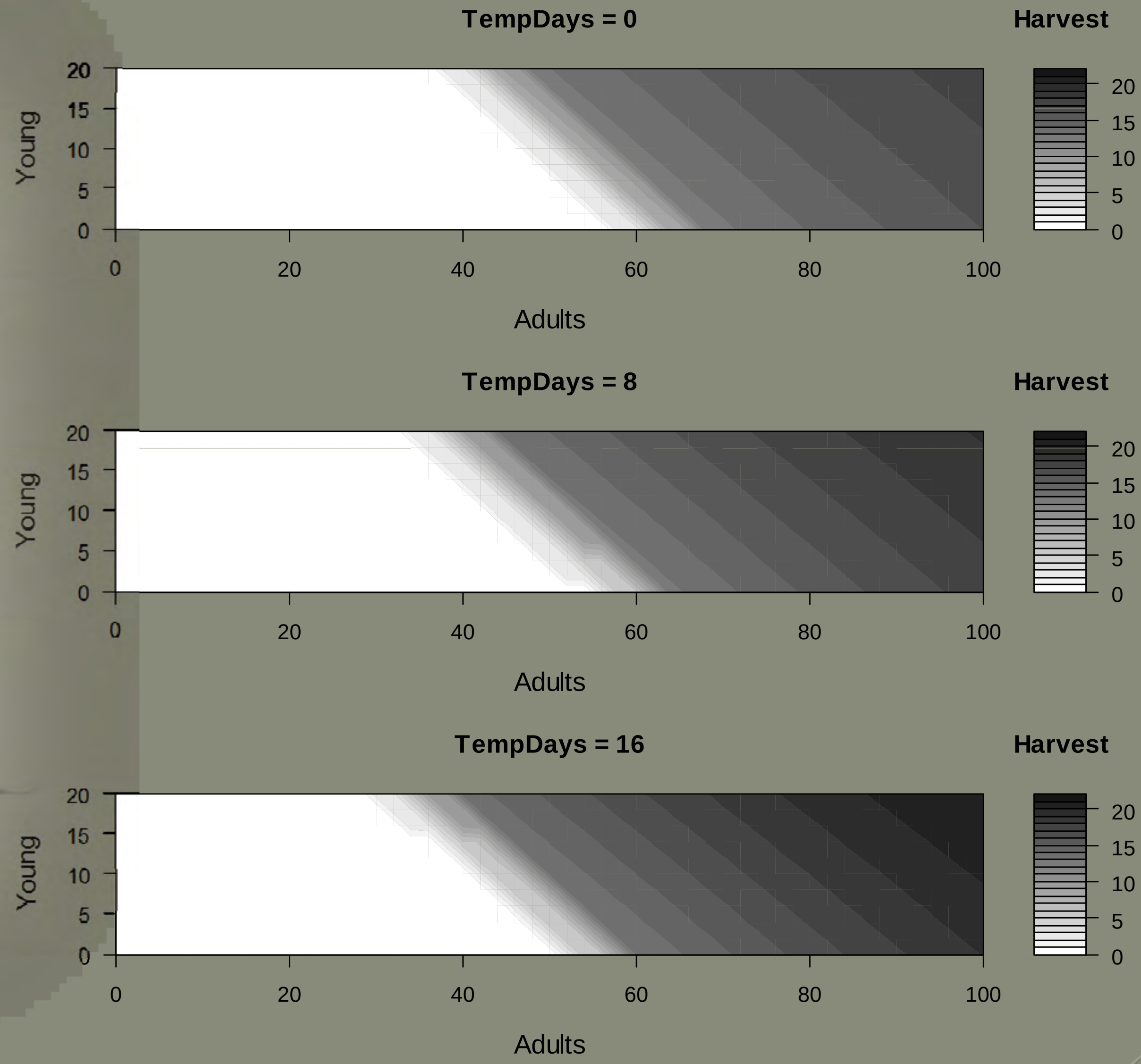
Adaptation in Mallard AHM



Pink-footed goose AHM



Capacity for adaptation

- State depedency
  - Changing harvest ***actions*** based on the state of the resource
  - Appropriate degree depends on
    - Variability of environment
    - Frequency of monitoring
    - Frequency of harvest actions
- Knowledge dependency
  - Changing harvest ***policy*** based on the state of knowledge
  - Appropriate degree depends on
    - Level of uncertainty in resource dynamics and effects of harvest
    - Precision of monitoring
    - Precision of harvest actions

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Approaches to developing a management strategy

State Dependency

- *State dependent* – harvest actions change based on observed changes in resource status
- *State independent* – actions change infrequently or not at all

Knowledge Dependency

- *Non-Adaptive* – use best understanding of population dynamics
- *Adaptive* – harvest policy evolves based on what is learned about resource's response to harvest
- *Robust* – policy is chosen such that it performs reasonably well regardless of the resource's response to harvest

Finding the right approach

Uncertainty →
←Precision of actions, monitoring

State-Independent Robust	State-Dependent Robust
State-Independent Adaptive	State-Dependent Adaptive
State-Independent Non-Adaptive	State-Dependent Non-Adaptive

Environmental variation; Frequency of actions, monitoring→

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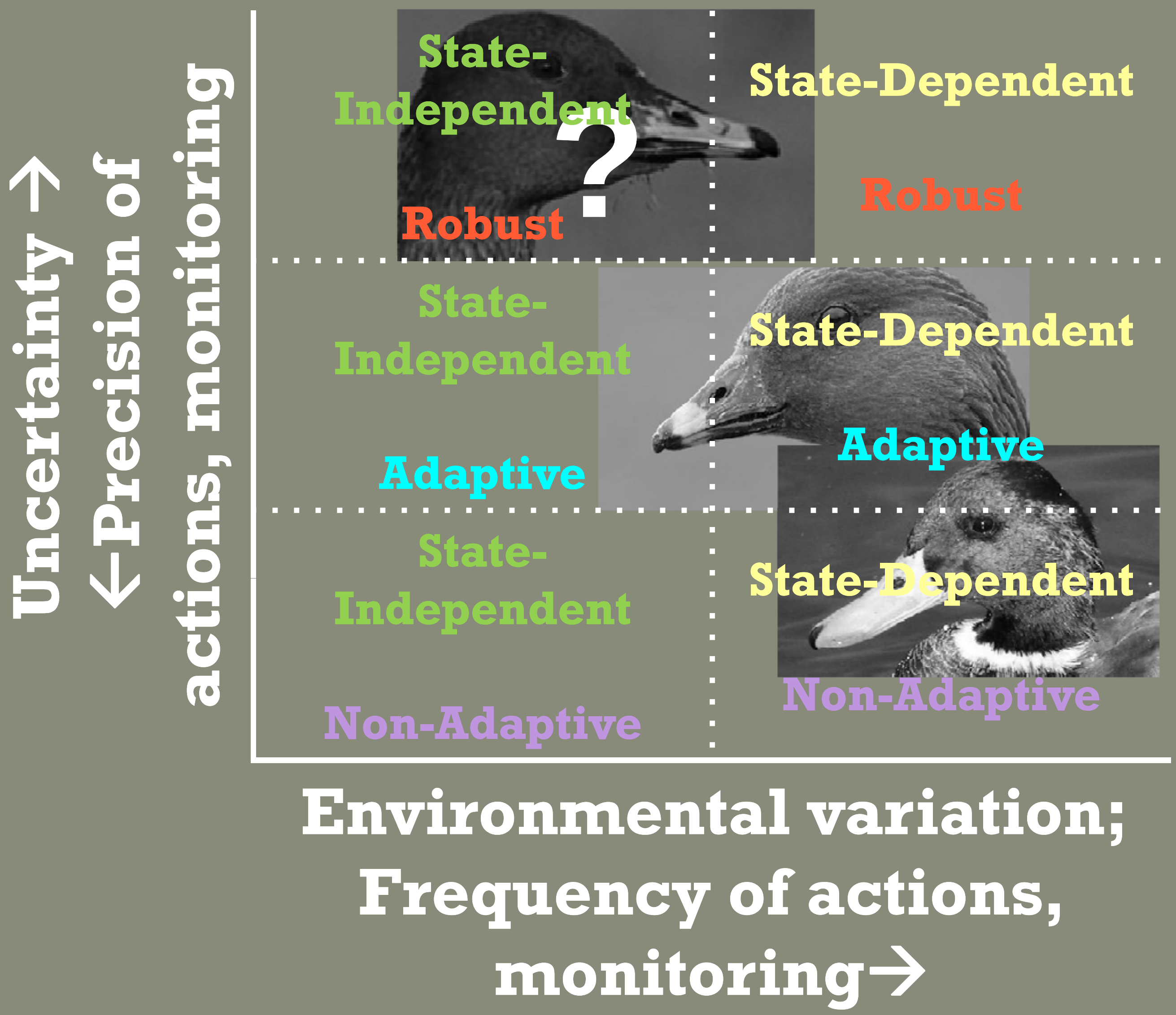
Finding the right approach



Finding the right approach

- Robust, state-independent strategies are most appropriate where uncertainty is high and control over harvest is limited

- An adaptive, state-dependent strategy would only be appropriate if:
  - population size and harvests could be monitored reliably
  - control over harvests was reasonably good
  - there was an agreed-upon (relatively short) cycle of decision making

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Framing the problem

- What do we value?
  - Who are the stakeholders?
  - What do they wish to achieve?
  - How will they reconcile tradeoffs?
  - What is their tolerance for risk?
- What are the harvest actions available?
  - Spatial scale (degree of heterogeneity among countries)?
  - Temporal scale (how often can a new action be taken)?
  - Organizational scale (single or aggregate species)?
- How will consequences be predicted?
  - What are key environmental drivers?
  - How will population dynamics be modeled?
  - How is realized harvest related to actions?
  - What are key sources of uncertainty?

A first look at taiga bean geese

- λ = 0.97 based on population estimates from mid-90's (100k), 2005 (70-90k), and 2009 (63k)
- Halving time = 21 years
- Projected population size in 2013 = 55k

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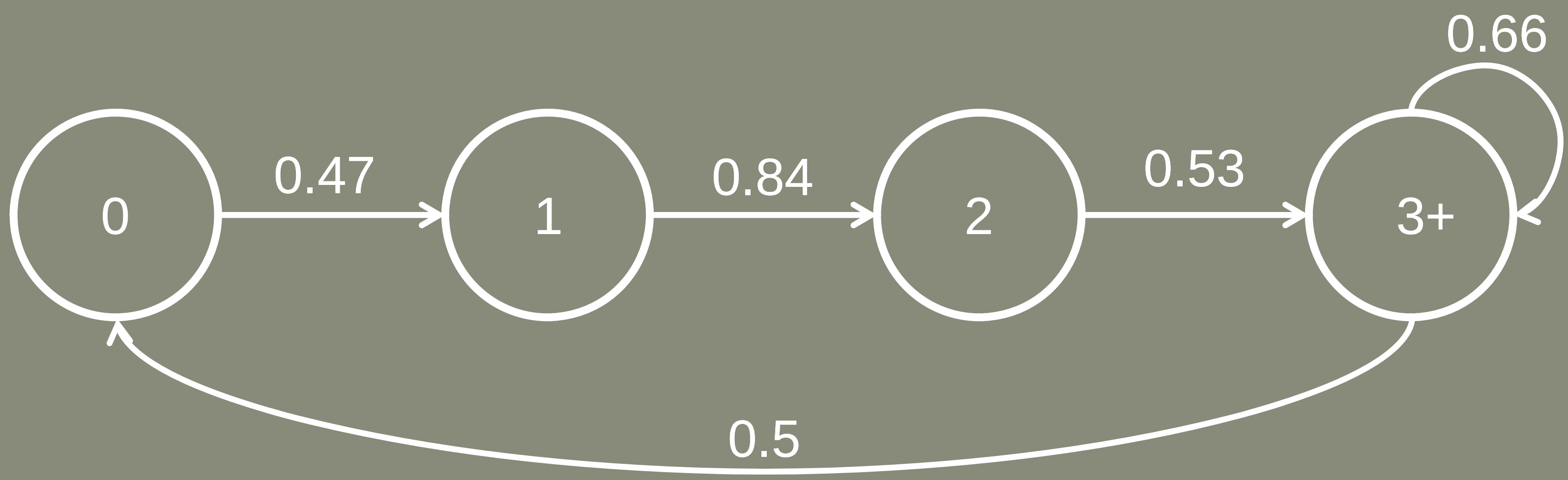
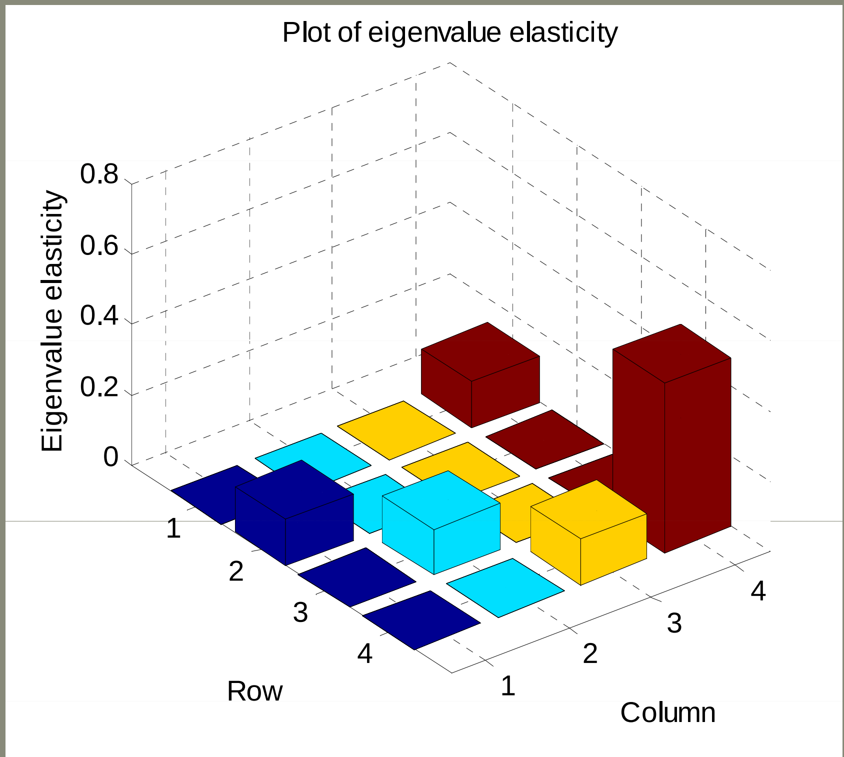
A first look at taiga bean geese



$$\begin{vmatrix} 0.00 & 0.00 & 0.00 & 0.50 \\ 0.47 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.84 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.53 & 0.66 \end{vmatrix}$$

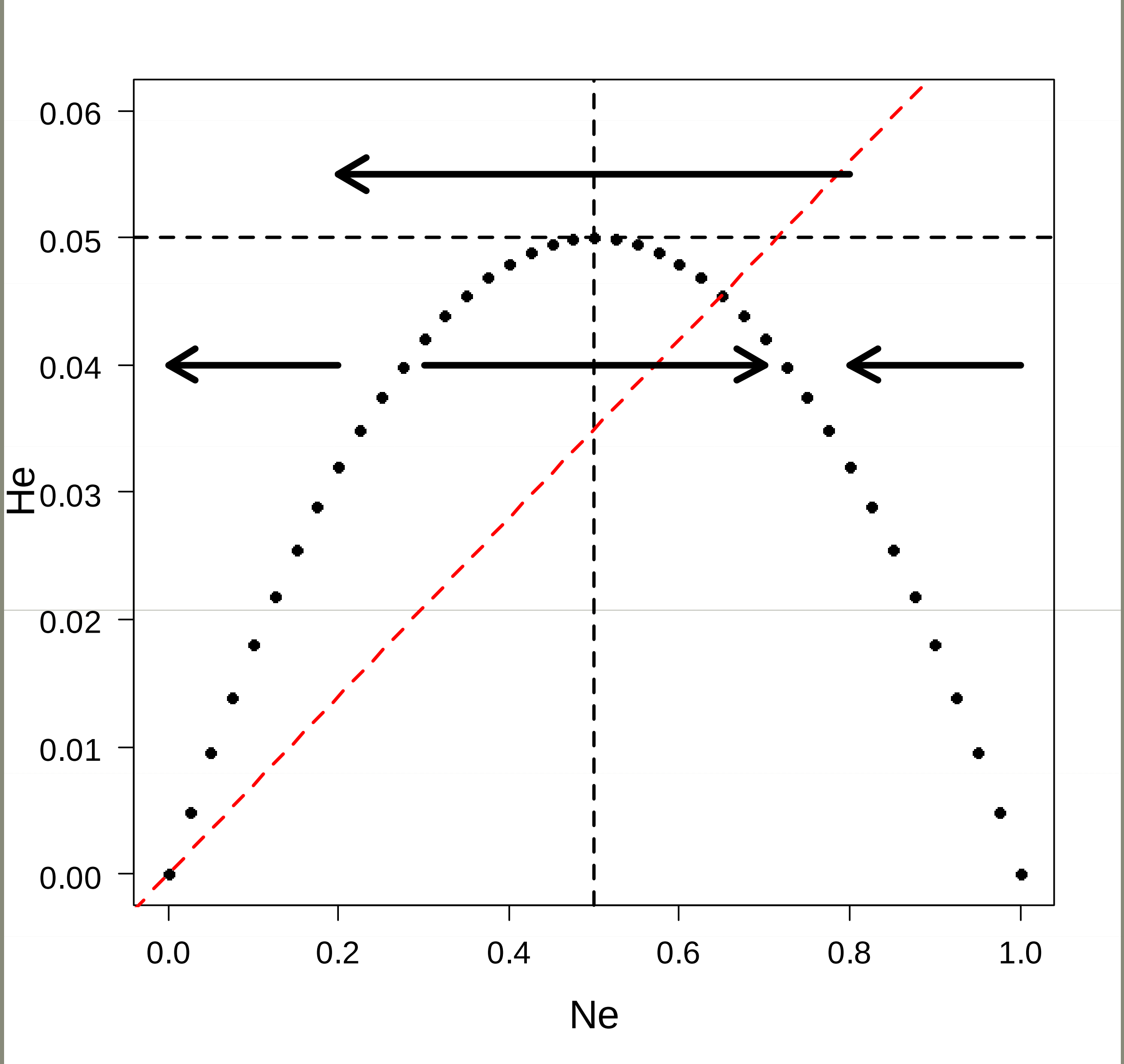
- $\lambda = 0.84$
- Halving time = 4 years
- Projected population size in 2013 = 31k

A first look at taiga bean geese



- λ most sensitive to variation in survival rates of breeding-age birds
- Survival rates of birds aged 2+ would have to be increased to 0.9 (similar to pink-feet) to stabilize the population

Harvest theory fundamentals



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Is harvest sustainable?

- Population is increasing
  - Harvest is sustainable
  - Additional harvest available unless current population size deemed too low
- Population is stable
  - Harvest is sustainable
  - Population size is either acceptable or not

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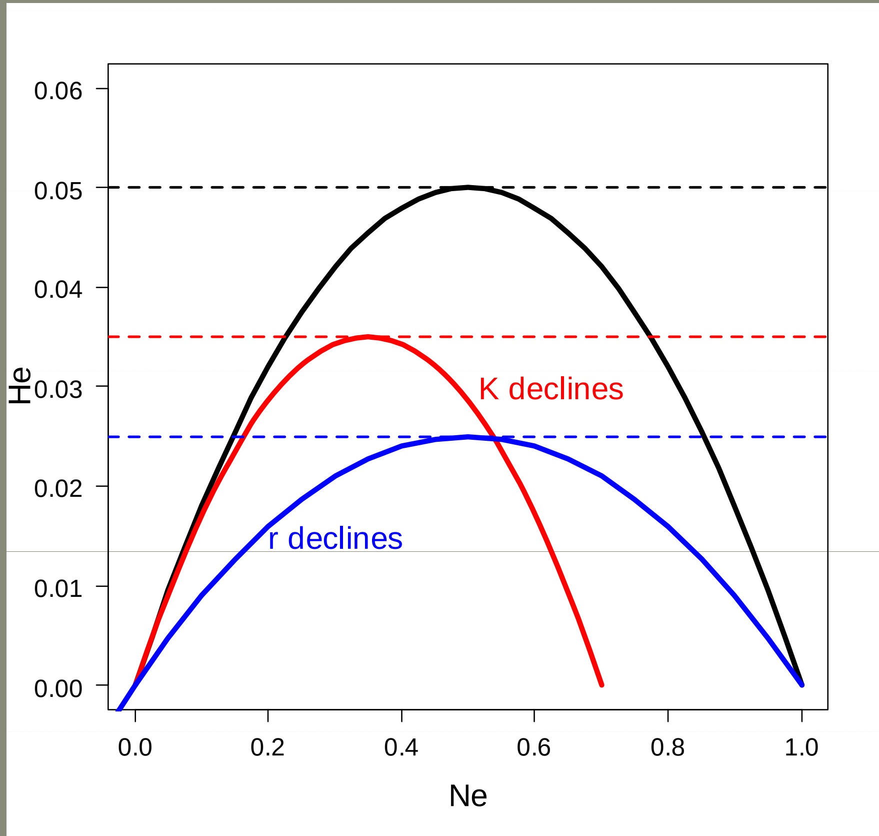
Is harvest sustainable?

- Population is declining
  - Harvest is <u>not</u> sustainable; $N_t \rightarrow 0$, ***or***
  - Harvest is sustainable; *N* moving to a lower equilibrium (which may or may not be desirable), ***or***
  - Carrying capacity or intrinsic rate of growth is declining; harvest may or may not be sustainable depending on level of harvest and degree of decline in *K* and *r*



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Going forward

1) What are breeding stocks and harvest management units?

2) What is the status of each breeding stock?

3) For each stock, what is the desired combination of population size and harvest opportunity?

4) For each harvest management unit, how will the size and allocation of the harvest be controlled and how often will those decisions be made?

5) What population models will we use to predict the consequences of harvest and what are key sources of uncertainty in making those predictions?

6) How will monitoring be organized? Is additional monitoring warranted?

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Going forward

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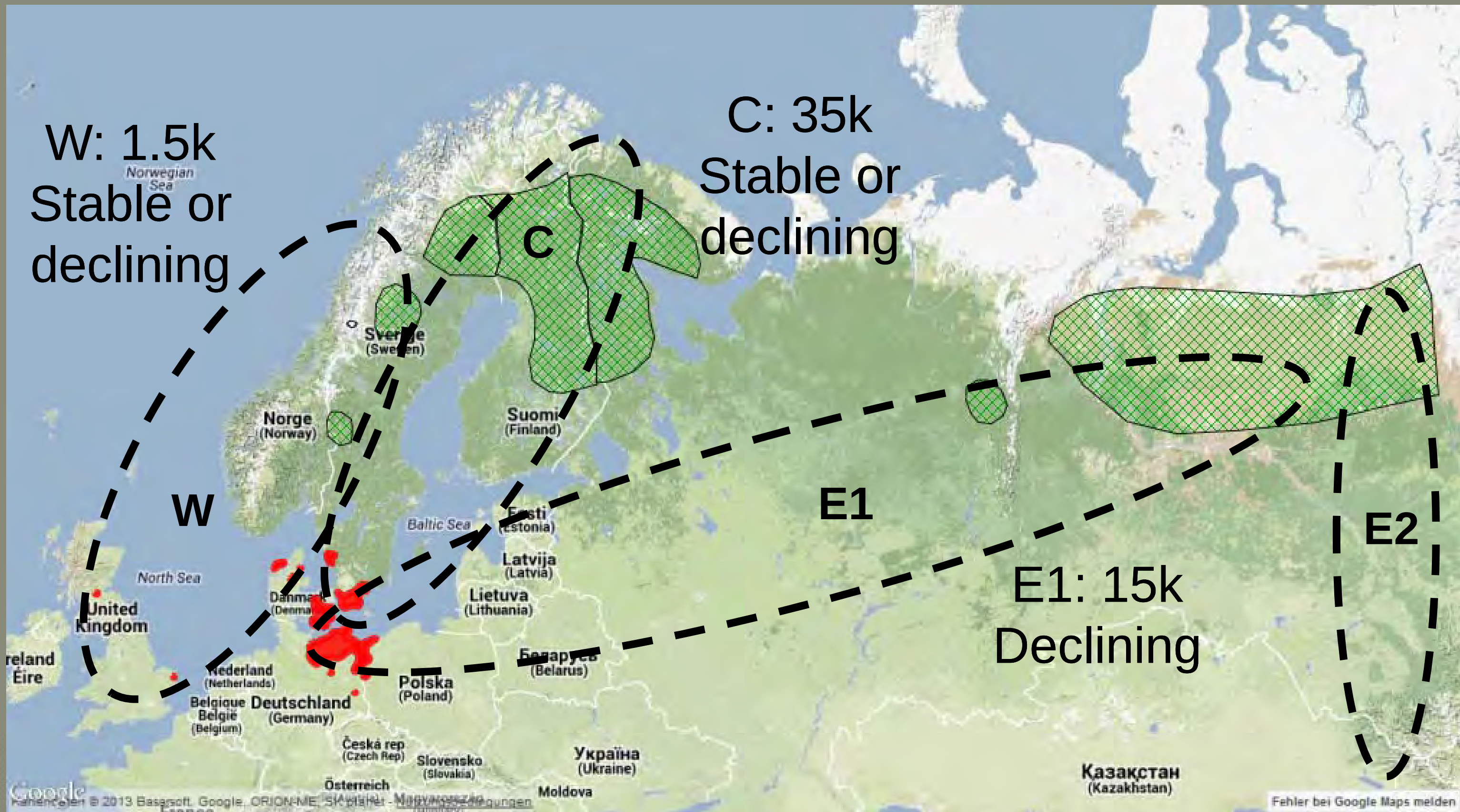

Going forward

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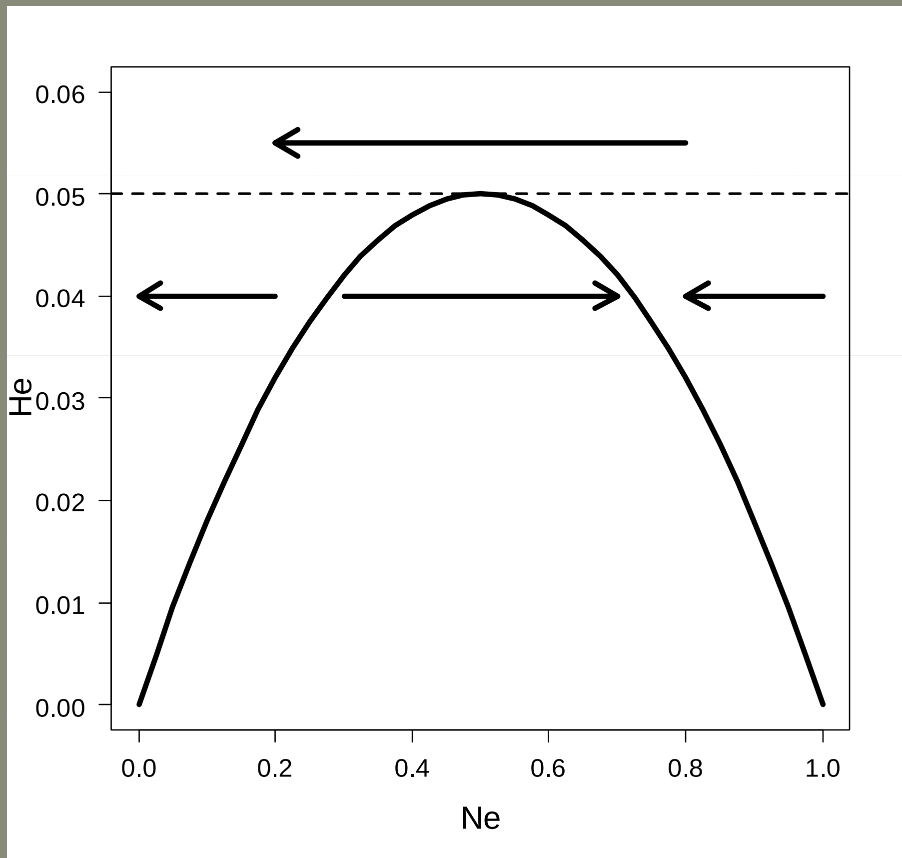

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Going forward

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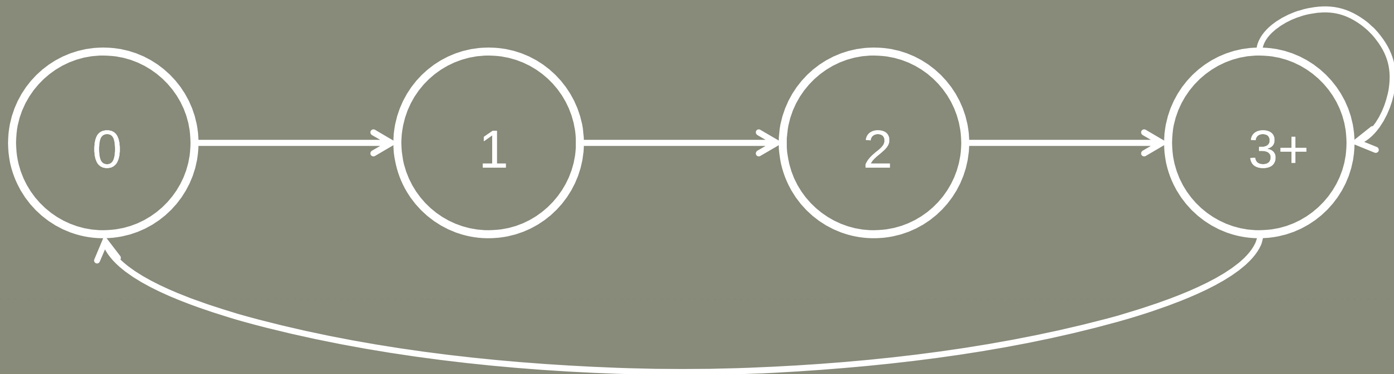
Going forward

5) What population models will we use to predict the consequences of harvest and what are key sources of uncertainty in making those predictions?

$$N_{t+1} = N_t + N_t r\left(1 - \frac{N_t}{K}\right) - N_t h_t$$



Going forward

6) How will monitoring be organized?

- To permit state-dependent harvest actions
- To allow learning and knowledge-based adaptation

Will new monitoring efforts be considered and how can we determine whether they are worth the cost?

Expected value of perfect information

- EVPI: the increase in value (in terms of the management objective) that you could *expect* if you were to resolve the source of uncertainty
- Analytical technique
  - That is simple to apply (at least in concept)
  - Can help you decide if it's worth the cost of gathering additional information
- Pink-footed geese
  - Nine alternative models with varying degrees of density dependence
  - EVPI = +3%
  - State-dependency probably more important than distinguishing among models

  (Johnson et al. 2013, Uncertainty, robustness, and the value of information in managing an expanding Arctic goose population. Ecological Modelling:In press.)

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What to remember

- An effective, adaptive approach
  - Is transparent, deliberative, rational, reproducible
  - Provides a clear connection between actions and objectives
  - Provides an efficient use of management resources and information
  - Facilitates communication among stakeholders
- Separate values and outcomes
  - Values are the purview of stakeholders/managers Outcomes are the purview of scientists
  - Decision analyst serves as an "honest broker" (i.e., has no stake in the decision)
- Get the problem framing right
  - Better to have a fuzzy decision for the correct problem than an optimal decision for the wrong problem
  - Frame the problem within your capacity to address it (uncertainties, budgets, institutional capacity)

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