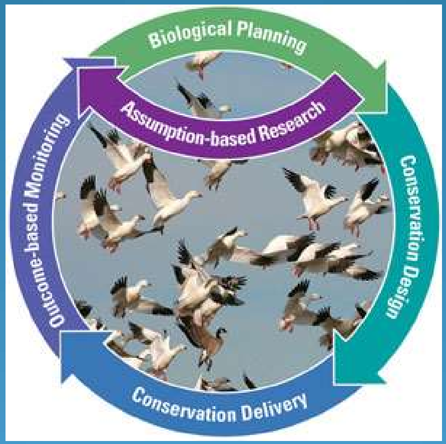
Monitoring & Decision Making in Adaptive Management



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Outline

- Flavors of monitoring in conservation
- Dynamic decision making and adaptive management
- Using Integrated Population Models to inform decisions and to evaluate monitoring protocols

Flavors of monitoring

- Surveillance or omnibus monitoring
  - To provide information potentially useful for science or conservation decision-making
- Science-focused monitoring
  - To discriminate among competing hypotheses (learn)
- Decision-focused monitoring
  - To inform state-dependent decisions and track performance
- Adaptive management
  - To inform state-dependent decisions and track performance
  - To discriminate among competing hypotheses (learn)

A critique of surveillance monitoring

- Typically used as part of a 2-step process
  - Detect a problem (e.g., population decline)
  - Followed by remedial action or more study
- Often justified as needed to detect “unknown unknowns” or “black swans” (unforeseen changes in ecological systems)
- Issues:
  - Detection dependent on precision of monitoring; focus often on Type I rather than Type II error
  - Often ineffective at identifying the cause(s) of the problem
  - Time lag between detection of problem and action (inefficient)
  - Little guidance concerning how limited monitoring resources are best allocated
  - Not necessarily better at detecting black swans than more targeted monitoring

Science-focused monitoring

- Goal: to discriminate among alternative hypotheses; e.g.,
  - Agricultural damage is related to population size in geese
  - Survival rate differs between males and females

- Performance reflects study design
  - Power analysis: probability of rejecting H_o when it is false

- In ecology, often involve retrospective or observational studies
  - A reliance on natural variation to provide sufficient contrast
  - Experimental designs more powerful

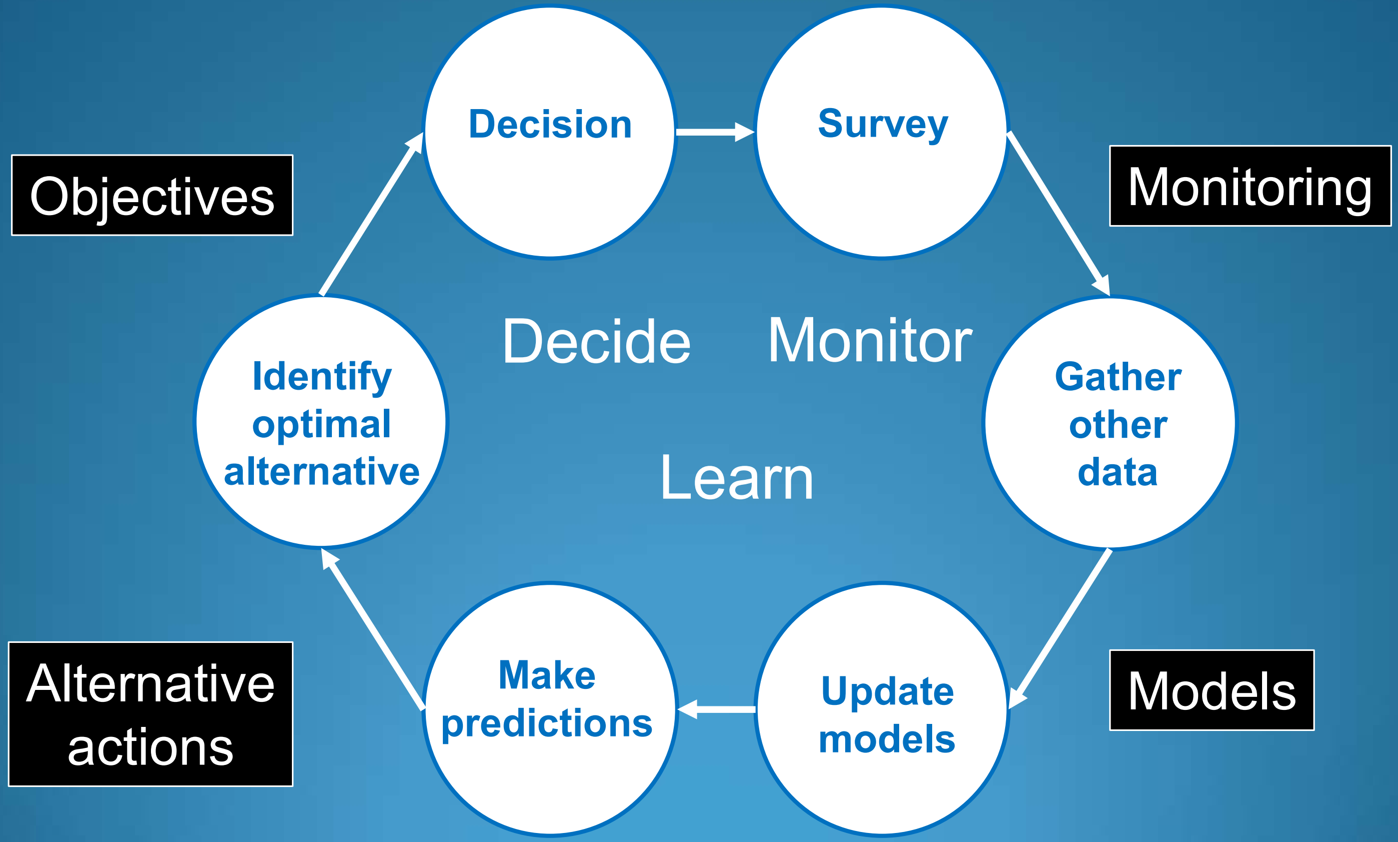
Decision-focused monitoring

- Goal: to achieve conservation objectives

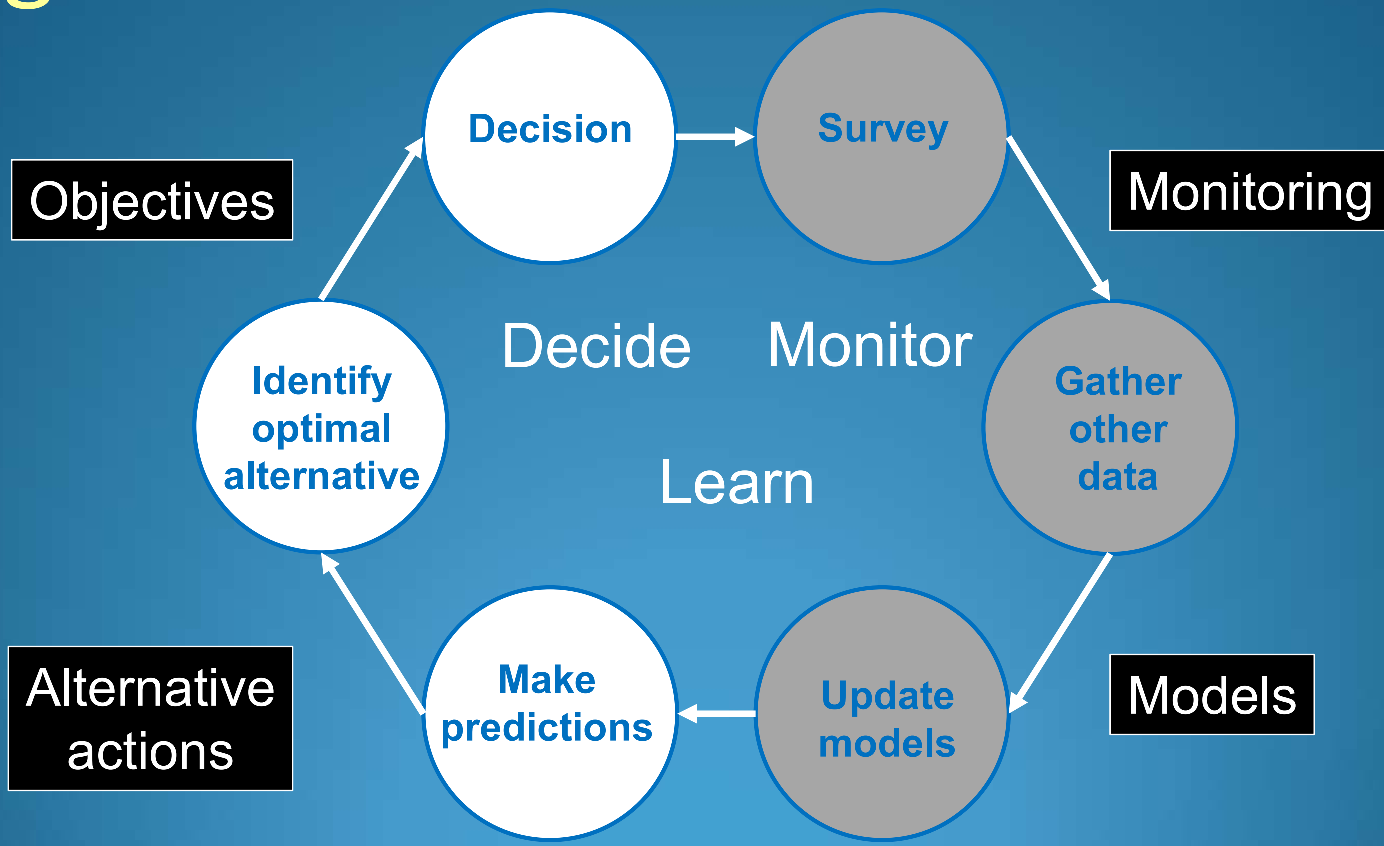
- Relies on specification of:
  - Unambiguous conservation objectives
  - A set of alternative conservation actions
  - A model that predicts the effects of those actions in terms that are relevant to the objectives (i.e., models must be tailored to the decision context)

- Monitoring permits state-dependent decisions, tracking of performance, and learning

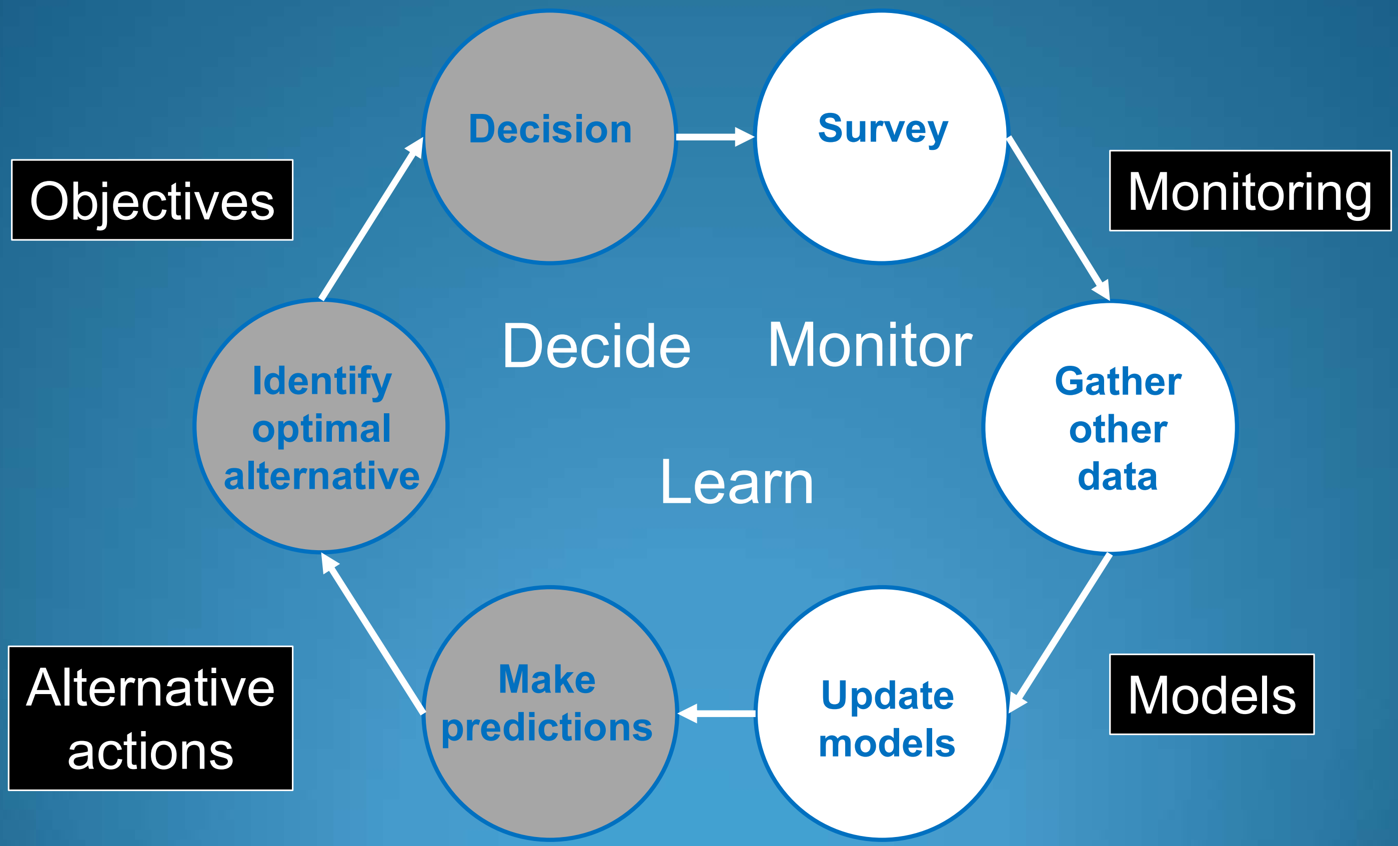
Adaptive Management



Management


Decision
Survey
Objectives
Monitoring
Decide
Monitor
Identify optimal alternative
Gather other data
Learn
Make predictions
Update models
Alternative actions
Models

Adaptation


Objectives
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Monitor
Gather other data
Learn
Make predictions
Update models
Models

Integrated Population Models (IPMs)

- Use of multiple data sources to *simultaneously* estimate trajectories of population size and demographic parameters

- Leverages population counts to inform demographic parameters and demographic information to inform population trajectories

- A synthetic approach to modeling that:
  - Provides better precision of estimates
  - Properly propagates sources of sampling error
  - Provides estimates of latent (unobserved) parameters of interest

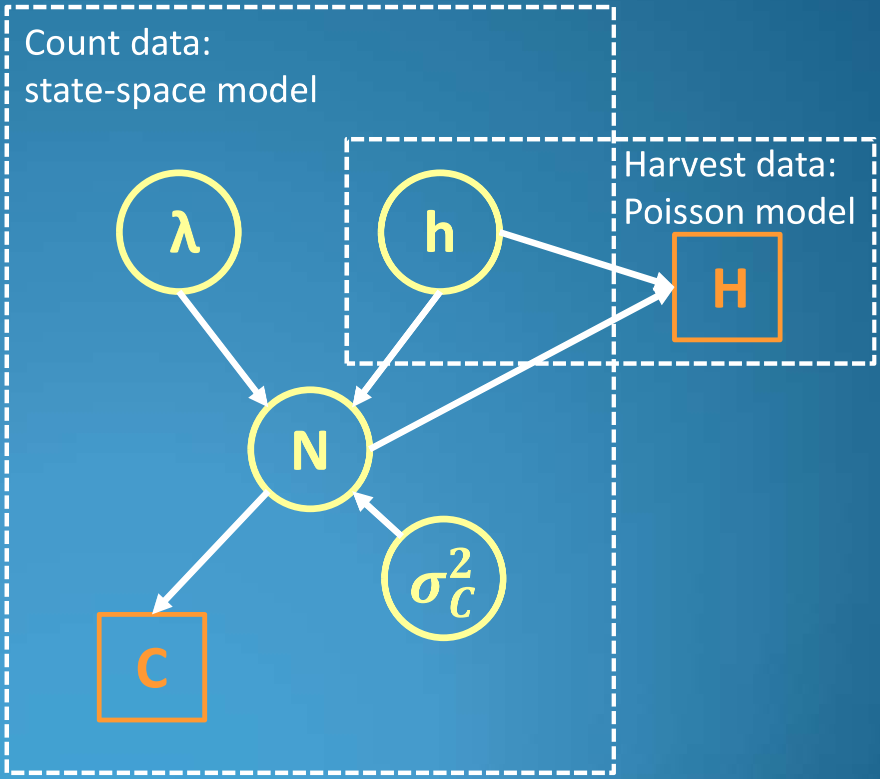
IPMs

- Usually constructed in a Bayesian framework, which:
  - Is less restrictive than a maximum likelihood approach
  - Permits the use of prior knowledge about model parameters (e.g., from similar species)
  - Provides a natural platform for adaptation as monitoring data are accumulated

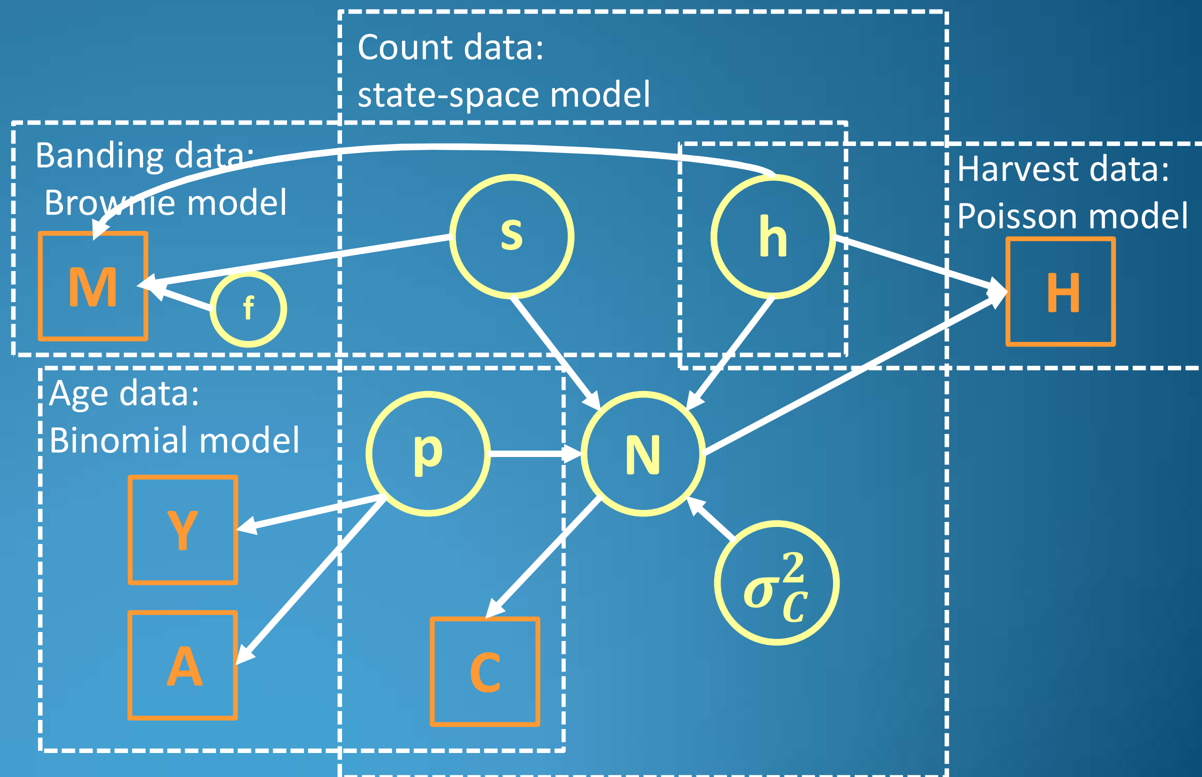
- Necessary components
  - At least one set of population counts (or estimates) and one source of demographic information
  - A hypothesized model of population dynamics (e.g., a logistic model)
  - The likelihood of each data set given that model
  - Prior distributions for all unknown model parameters

A simple IPM

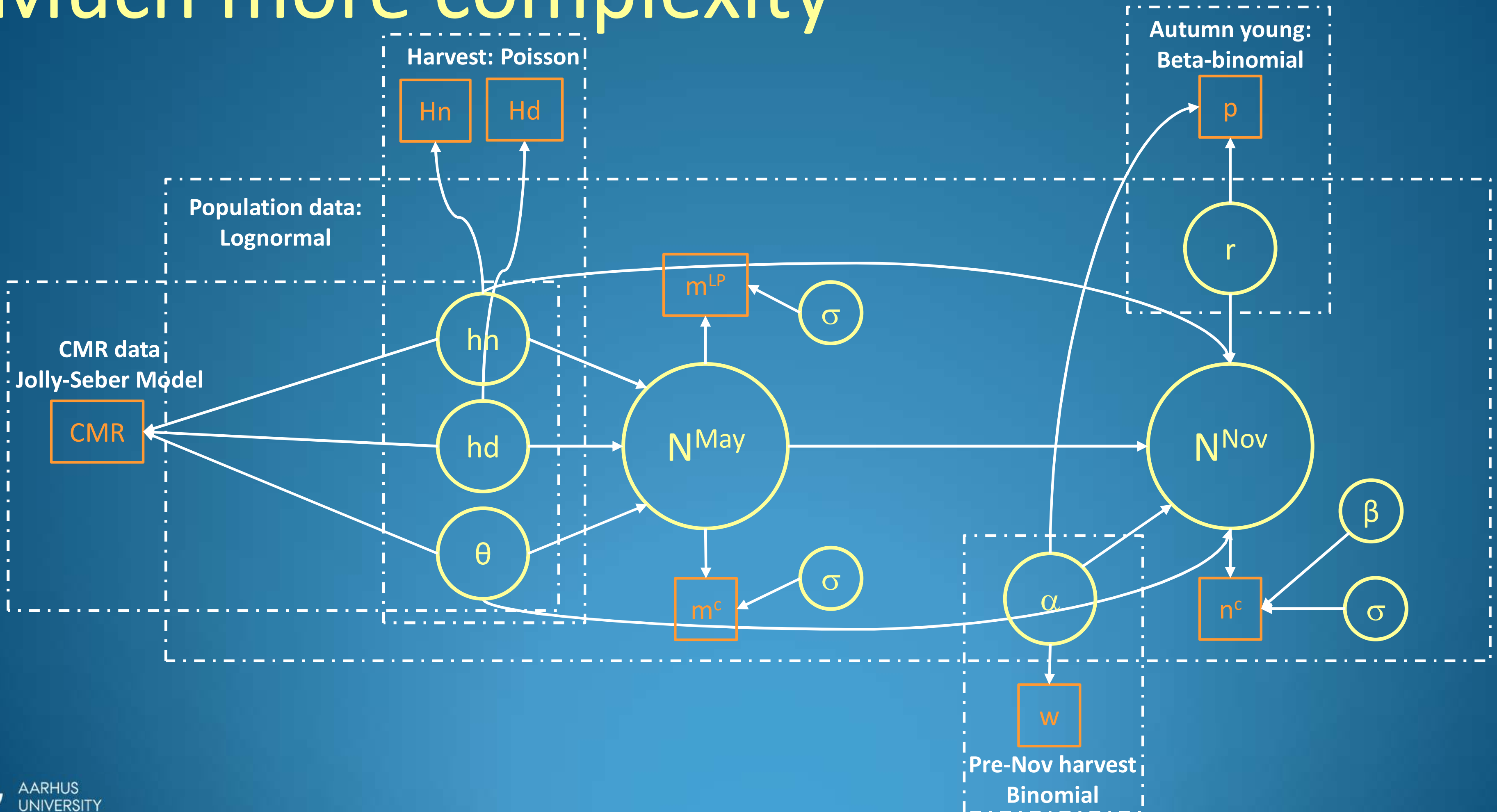

N
λ(1-h)


Count data:
state-space model
Harvest data:
Poisson model
λ
h
H
N
C
σ_C^2

More complexity



Much more complexity



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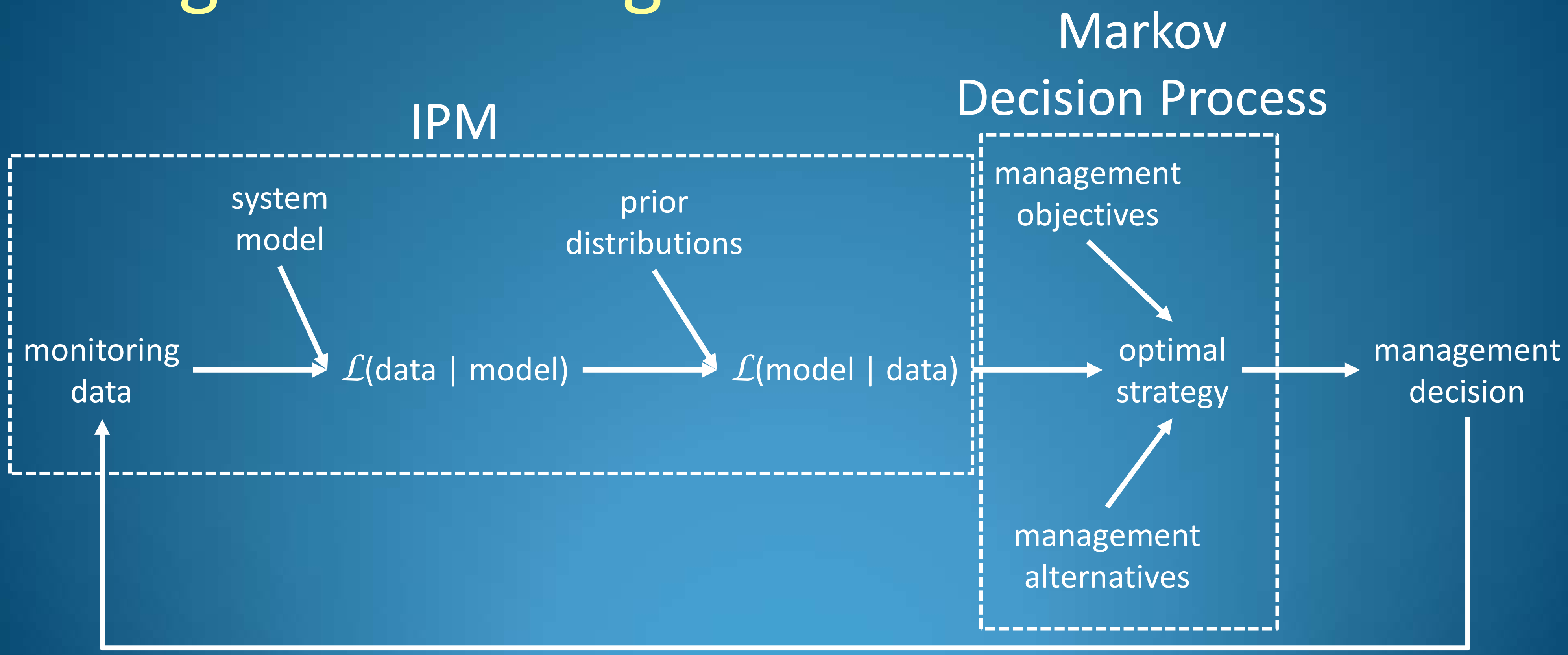
Integrated management



Parting thoughts

- Monitoring supports management decision-making by:
  - providing for state-dependent actions
  - tracking performance
  - reducing uncertainty about population dynamics

- IPMs are currently the gold standard of population modeling, with many advantages over analyzing various data sources independently

IPMs can also help evaluate monitoring programs; more on this later…

Contents lists available at ScienceDirect
Ecological Modelling
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Using integrated population models for insights into monitoring programs: An application using pink-footed geese

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ABSTRACT

Development of integrated population models (IPMs) assume the absence of systematic bias in monitoring programs, yet many potential sources of systematic bias in monitoring data exist (e.g., under-counts of abundance). By integrating multiple sources of data, we can assess whether various sources of monitoring data provide consistent inferences about changes in population size and, thus, whether monitoring programs appear unbiased. For the purposes of understanding how IPMs could provide insights for monitoring programs, we used the Svalbard breeding population of pink-footed goose (Anser brachyrhynchus) as a case study. The Svalbard pink-footed goose is a well-studied species, the focus of the first adaptive-harvest-management program in Europe, and the subject of a variety of long-term monitoring programs. We examined two formulations of an IPM, but ultimately relied on the one that provided a satisfactory fit to all the available data as based on Chi-squared goodness of fit tests. Our analyses suggest a negative bias in November counts (-20 %), a negative bias in capture-mark-recapture estimates of survival (-3 %), and a negative bias in indices of productivity (-23 %). We offer possible explanations for these biases, whether the degree of bias seems reasonable considering those explanations, and how bias might be investigated directly and ultimately avoided or corrected. Finally, we discuss implications of our work for developing IPMs and associated monitoring programs for managing pink-footed geese and other waterbird species.

RESEARCH ARTICLE
Journal of Applied Ecology

Assessing the value of monitoring to biological inference and expected management performance for a European goose population

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Abstract

1. Informed conservation and management of wildlife require sufficient monitoring to understand population dynamics and to direct conservation actions. Because resources available for monitoring are limited, conservation practitioners must strive to make monitoring as cost-effective as possible.
2. Our focus was on assessing the value of monitoring to the adaptive harvest management (AHM) programme for pink-footed geese *Anser brachyrhynchus*. We conducted a retrospective analysis to assess the costs and benefits of a capture–mark–resight (CMR) programme, a productivity survey and biannual population censuses. Using all available data, we fit an integrated population model (IPM) and assumed that inference derived from it represented the benchmark against which reduced monitoring was to be judged. We then fit IPMs to reduced sets of monitoring data and compared their estimates of demographic parameters and expected management performance against the benchmark IPM.

RESEARCH ARTICLE
Ecological Solutions and Evidence

Sources of variation in estimating breeding success of migratory birds from autumn counts

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Abstract

1. Understanding drivers of change in population sizes requires estimation of demographic rates such as survival and productivity. In migratory geese, productivity or breeding success is typically assessed at the autumn staging and wintering grounds by observing the number of young versus adults in flocks of geese—also called age counts. Such age counts are, however, likely to be affected by a number of factors as we are compelled to sample from an open population, in which the temporal and spatial age composition can vary due to differential migration, mortality and flocking behaviour.
2. In this study we seek to provide guidance for the design of age counts, by identifying which factors need to be taken into account when collecting data. Identification of these factors will facilitate a more targeted data collection and enable better conservation and management recommendations. We use the long-term age count dataset for the Svalbard population of the pink-footed goose and focus on the following factors: May thaw days on Svalbard, region of sampling, flock size, time and cumulative harvest, calculated as the amount of shot individuals up to each observation of juveniles.

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