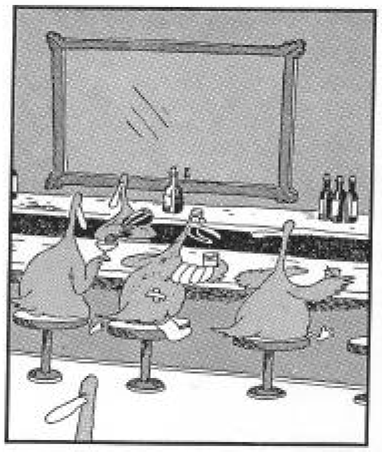
WLF 419 – Waterfowl and Wetland Ecology and Management
Lecture 19 – Adaptive Harvest Management
Next Time – Summary



"Well, hell no, I can't tell Harriet! ... First thing she's gonna ask me is what was I doin' checkin' out a decoy!"

Conceptual Framework:

Concern	**Solution**
Resource State	Monitor
Learning	Research
Management	Decision Theory
All of the Above	Adaptive Management

In the history of waterfowl harvest management 3 things were missing:

- Management Objective(s) - NAWMP
- Logical process of making decisions
    - Who can shout the loudest
- Quantitative models of the effects of management decisions
    - Harvest is an experiment

We already had information about:

- State of the system
- Research
- Enter decision theory (1975)

Decision Theory
Components

- **Explicit management objectives**
- **Alternative management actions**
- **Model of system**

Goal: Select management option to maximize objective(s) given current state of system

Example: Harvest of Mallards:

- **Objective:** Long-term harvest of mallards
- **Management Alternatives:** # to harvest
- **Model:** Population dynamics as a functions of ponds, population size, and harvest

What was missing?

- Acknowledgement, incorporation, and reduction of uncertainty

1995 – present: Adaptive Harvest Management

Goal: "AHM describes the ability to make a sequence of decisions in the face of uncertainty, that is optimal with respect to a stated objective, recognizing some constraints"

D.R. Anderson

- Managing in the face of uncertainty, with the focus on its reduction

Sources of Uncertainty

- Environmental Stochasticity
  - Weather, habitat
- Partial Observability
  - Uncertainty about population status
- Partial Controllability
  - Decisions only partially control actual magnitude of actions
- Structural Uncertainty
  - Relationship between management and population status
    - Additive vs. Compensatory Mortality
    - Density Dependent vs. Density Independent Reproduction

How do we reduce Structural Uncertainty in the face of other sources of variation?

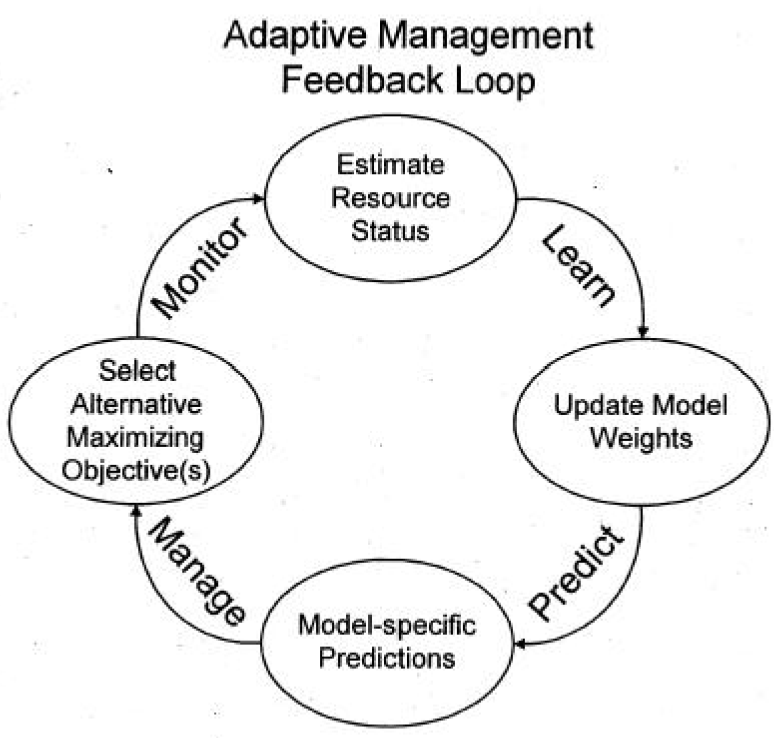
- Pursuit of information through management
  - Harvest is an experiment

Components of Adaptive Management

- Explicit Objective(s)
    - Means to gauge effects of management actions
    - Opportunity to harvest is less important than maintenance of population
- Alternative Management Actions
- Competing Models of System
    - Hypotheses of how system works
    - Acknowledgement of uncertainty
- Models Weights
    - Credibility of Different Models
- Monitor Effects of Management

The AHM Cycle:

- Monitor
    - What is the current state of the system?
- Learn – Reduce Structural Uncertainty
    - Compare Predictions to Estimate
    - Update Model Weights
    - Passive vs. Active
- Predict
    - Model-specific predictions of effects of management given resource status
- Manage
    - Implement management alternative maximizing objective(s) based on resource status and model weights



Example: AHM of Mallards

- Objective: Long-term harvest of Mallards, Pop > 8.7 million
- Management Alternatives: Harvest Regulations
- 4 Models of population dynamics:
    - o Mortality: Additive vs. Compensatory
    - o Reproduction: Strong vs. Weak Density Dependence

Table 5. Model-specific predictions of mallard population size in 1996 based on observed population size, pond numbers, and harvest rates in 1995.

Mortality hypothesis	Reproduction hypothesis	Population prediction[a]	SE[a]	1996 model weight
Additive	Strong density-dependence	8.47	0.30	0.7024
Additive	Weak density-dependence	8.75	0.35	0.2965
Compensatory	Strong density-dependence	9.60	0.34	0.0009
Compensatory	Weak density-dependence	9.92	0.39	0.0002

[a] In millions.

- Implement optimal regulatory choice given:
    - o Current State of System
    - o Current Model Weights

Table 7. Optimal regulatory choices[a] for mallards during the 1996 season, conditioned on the proposed objective to maximize long-term harvest and achieve a population goal of 8.1 million, with unequal probabilities for four alternative models of population dynamics (see Table 5).

	Ponds[b]									
Mallards[c]	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
4.5										
5.0							R	R	R	R
5.5		R	R	R	R	R	R	R	R	M
6.0	R	R	R	R	R	R	M	M	L	L
6.5	R	R	M	M	M	M	L	L	L	L
7.0	M	M	M	L	L	L	L	L	L	L
7.5	L	L	L	L	L	L	L	L	L	L
8.0	L	L	L	L	L	L	L	L	L	L
8.5	L	L	L	L	L	L	L	L	L	L
9.0	L	L	L	L	L	L	L	L	L	L

[a] R = restrictive, M = moderate, and L = liberal.
[b] Estimated number of ponds in Prairie Canada in May, in millions.
[c] Estimated number of mid-continent mallards during May, in millions.

- Model Predictions

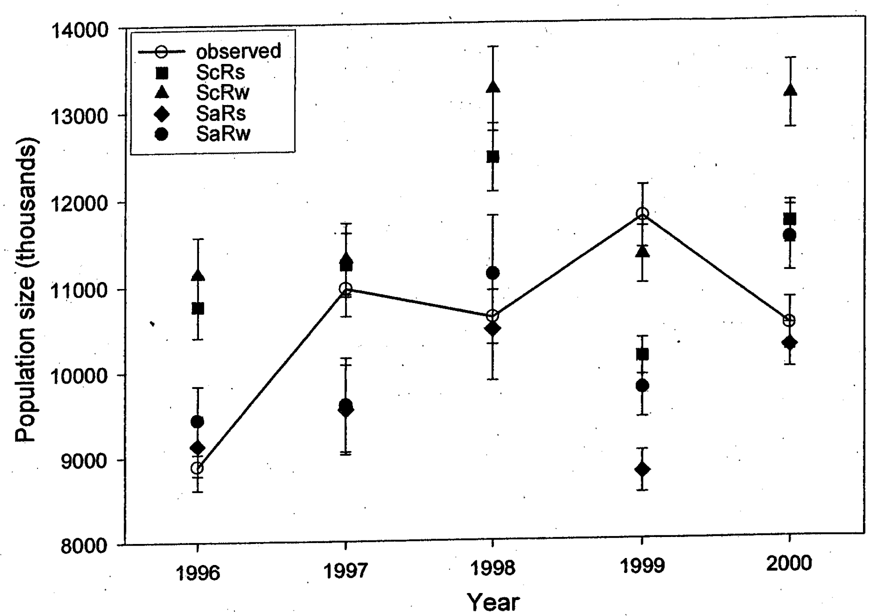


Fig. 2. Estimates of observed mallard population size (line with open circles) compared with predictions from four alternative models of population dynamics (ScRs = compensatory mortality and strongly density-dependent reproduction; ScRw = compensatory mortality and weakly density-dependent reproduction; SaRs = additive mortality and strongly density-dependent reproduction; SaRw = additive mortality and weakly density-dependent reproduction). Vertical bars represent one standard deviation on either side of the estimated population size.

- Monitor Response
- Learn

Table 2. Temporal changes in probabilities ("weights") for alternative hypotheses of midcontinent mallard population dynamics.

		Model weights					
Mortality hypothesis	Reproductive hypothesis	1995	1996	1997	1998	1999	2000
Additive	Strong density dependence	0.25000	0.65479	0.53015	0.61311	0.60883	0.92176
Additive	Weak density dependence	0.25000	0.34514	0.46872	0.38687	0.38416	0.07822
Compensatory	Strong density dependence	0.25000	0.00006	0.00112	0.00001	0.00001	0.00001
Compensatory	Weak density dependence	0.25000	0.00001	0.00001	0.00001	0.00700	0.00001

Table 9. Optimal regulatory choices[a] in the three western Flyways during the 2000 hunting season. This strategy is based on current regulatory alternatives, on current midcontinent-mallard models and weights, and on the dual objectives of maximizing long-term cumulative harvest and achieving a population goal of 8.7 million midcontinent mallards.

	Ponds[b]									
Mallards[c]	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
<4.5										
4.5										VR
5.0						VR	VR	VR	R	R
5.5	VR	VR	VR	VR	VR	R	R	R	M	M
6.0	VR	R	R	R	R	M	M	M	L	L
6.5	R	R	M	M	M	M	L	L	L	L
7.0	M	M	M	M	L	L	L	L	L	L
7.5	M	M	L	L	L	L	L	L	L	L
8.0	L	L	L	L	L	L	L	L	L	L
>8.0	L	L	L	L	L	L	L	L	L	L

[a] VR = very restrictive, R = restrictive, M = moderate, and L = liberal.
[b] Estimated number of ponds in Prairie Canada in May, in millions.
[c] Estimated number of midcontinent mallards during May, in millions.

Note Change from 1996 – more conservative

Benefits of AHM

- Objective, quantitative decision making
- Balance of management and learning

Limitation of AHM

- Only as good as set of models
- Relies on accurate information
  - Precise
    - Learn faster
    - Reduce other sources of uncertainty
  - Bias
    - May lead to inappropriate decisions