Outline of the Presentation

• Provide a context for adaptive decision making
• Describe the practice of adaptive management
• Imbed AM in a larger decision framework that incorporates ecosystem services
• Offer a few closing remarks
Adaptive Management

Learning by doing, and adapting based on what is learned

- Dual goals: to reduce uncertainty and thereby improve management
- Accounts for future consequences of present actions
- General approach: iterative structured decision making
Adaptive Management Situation

- Management actions are taken through time
- Resource behavior is influenced by environmental conditions and management actions
- There is uncertainty (or disagreement) about the expected impacts of management
Adaptive Management Situation

management action
resource system
environmental conditions

management action
resource system
environmental conditions

management action
resource system
environmental conditions

...
Adaptive Management Situation

- Management action
- Resource system
- Environmental conditions
  - Partial control
  - Structural uncertainty
  - Partial observability

- Time
  - \textit{t-1}
  - \textit{t}
  - \textit{t+1}
When is AM Appropriate?

- When a real management choice must be made
- When there is uncertainty about management outcomes
- When uncertainty can be expressed in terms of testable hypotheses
- When monitoring can be established to reduce uncertainty
- When there is an opportunity to apply what is learned
Adaptive Decision Making

... → decisionₜ → decisionₜ₊₁ → ...

monitoring → assessment

- Decisions are guided by management objectives at each time
- Monitoring is used to track system responses to management
- New information from monitoring is combined with previously collected information to produce improved understanding
- Decisions are adjusted in the next time period based on that improved understanding

Two key outcomes: improved understanding, and improved management based on that understanding
AM Process in Two Phases

**Deliberative phase**
- Management framework
  - Stakeholder involvement
  - Objective(s)
  - Potential management alternatives
  - Predictive models
  - Monitoring protocols and plans

**Iterative phase**
- Feedback sequence (technical learning)
  - Decision making
  - Monitoring
  - Assessment

Institutional Learning
Adaptive Management Cycle

- Assess problem
- Design
- Implement
- Monitor
- Evaluate
- Adjust

deliberative phase
Adaptive Management Cycle

- **Assess problem**
  - iterative phase
  - Learning about decision architecture, and reformulating the problem based on what is learned

- **Design**
  - deliberative phase
  - double loop
  - Learning about the resource, and adjusting decisions based on what is learned

- **Implement**

- **Monitor**

- **Evaluate**

- **Adjust**
Framework for Science-based Decision Making
Framework for Science-based Decision Making
Framework for Science-based Decision Making

- **drivers**
  - climate, land use, disturbance factors

- **natural system**
  - structures
  - functions
  - processes
  - distribution
  - dynamics
  - scale
  - resilience
Framework for Science-based Decision Making

Drivers:
- Climate, land use, disturbance factors

Natural system:
- Structures
- Functions
- Processes
- Distribution
- Dynamics
- Scale
- Resilience

Resource management

Species/habitat management, monitoring, etc
Framework for Science-based Decision Making

- **Sustainability, ecological condition, economic yield**
- **Goals and objectives**
  - **Drivers**
    - Climate, land use, disturbance factors
  - **Natural system**
    - Structures, functions, processes, dynamics, scale, resilience
  - **Resource management**
    - Species/habitat management, monitoring, etc.
Framework for Science-based Decision Making

goals and objectives

sustainability, ecological condition, economic yield

resource management

natural system

drivers

species/habitat management, monitoring, etc

climatic, land use, disturbance factors

ecosystem services

structures functions processes distribution dynamics scale resilience

goods services attributes metrics
Framework for Science-based Decision Making

- Goals and objectives
  - Sustainability, ecological condition, economic yield

- Drivers
  - Climate, land use, disturbance factors

- Natural system
  - Structures, functions, processes, distribution, dynamics, scale, resilience

- Resource management

- Ecosystem services
  - Goods, services, attributes, metrics

- Valuation
  - Utilities, discounting, uncertainty, risk
Framework for Science-based Decision Making

- **goals and objectives**
- **resource management**
  - species/habitat management, monitoring, etc
- **natural system**
  - climate, land use, disturbance factors
  - structures, functions, processes, distribution, dynamics, scale, resilience
- **ecosystem services**
  - goods, services, attributes, metrics
- **valuation**
  - utilities, discounting, uncertainty, risk

**drivers**

**sustainability, ecological condition, economic yield**

**decision analysis**
Framework for Science-based Decision Making

- **goals and objectives**
- **resource management**
- **natural system**
- **ecosystem services**
- **valuation**
- **decision analysis**

**drivers**
- climate, land use, disturbance factors

**species/habitat management, monitoring, etc**

**sustainability, ecological condition, economic yield**

**Adaptive management cycle**

**structures**
- functions
- processes
- distribution
- dynamics
- scale
- resilience

**goods**
- services
- attributes
- metrics

**utilities**
- discounting
- uncertainty
- risk
Key Attributes of the Framework

- The system is influenced by environmental fluctuations and management interventions through time.
- There is limited understanding about how the system works.
- Ecosystem services arise naturally in the framework, with values that inform, and are informed by, the decision making process.
- Learning about ecoservices production and valuation coincides with learning about the system and how to manage it.
Influences of Ecosystem Services

• Informing objectives
• System identification
• Monitoring
• Identification of mgmt strategies
• Engagement of stakeholders
What’s Needed for Ecosystem Services To Be Useful in Decision Making?

- Identification of ecosystem services
- Production of ecosystem services
- Measurement of ecosystem services
- Valuation of ecosystem services