Aspen Monitoring Project

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- “Managing ecosystems {forested ecosystems for example} is not as complex as we think, it is more complex than we can think.”
    - F.E. Egler
- “Forest management is not rocket science – it is far more complex.”
    - J.W. Thomas and F. Bunnell
- “If we only consider careful management at the stand level, we will sacrifice the integrity of the forest landscape.”
    - H. Hammond

What is Monitoring?

- Measurement of environmental characteristics over time

Purpose oriented

- Detect long-term change
- Early warning that change is coming
- Provides insight into consequences
- Corrections to management practices

Indefinite temporal span

What is Monitoring?

- Measured attributes are referred to as “indicators”

Assumption:

Value of the indicator indicates

Quality

Health

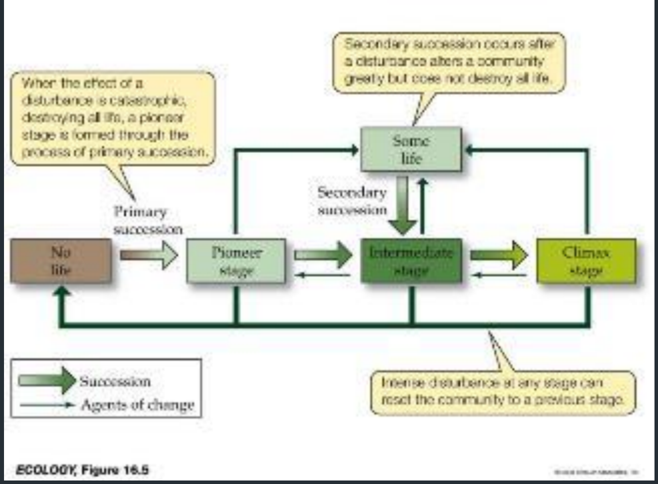
Integrity

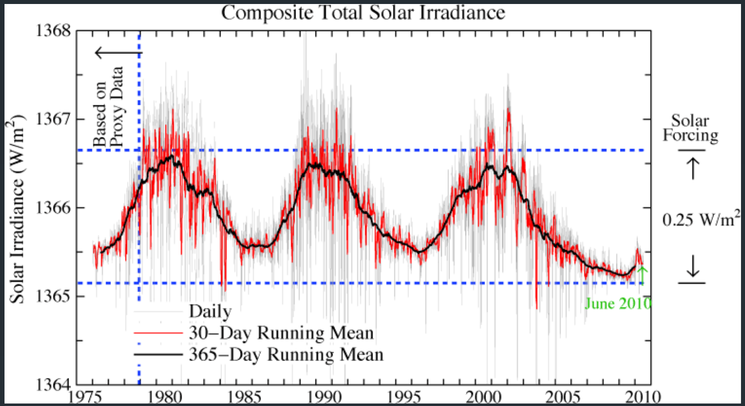
Of the larger ecosystem of which it is a part

Meaningful Change

- Task of detecting and recognizing meaningful change is complex
- Natural systems are inherently dynamic and spatially heterogeneous
- Changes may not be human caused or amenable to management action

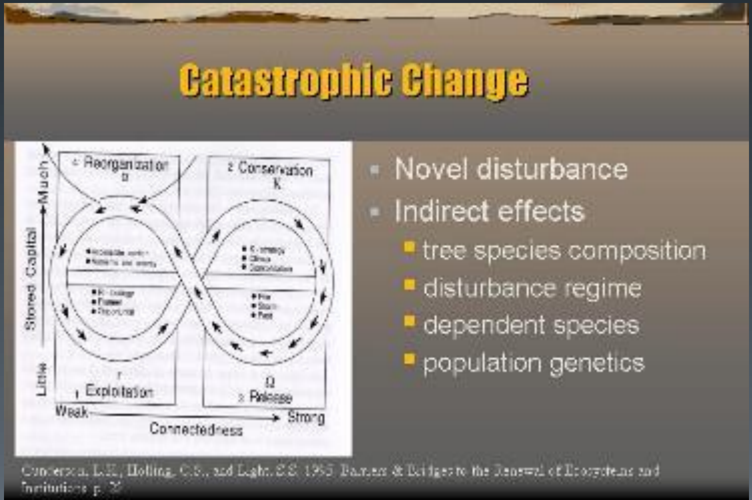
Change





Four kinds of change:

- Stochastic
- Successional trend
- Cyclic variation
- Catastrophic



Meaningful Change

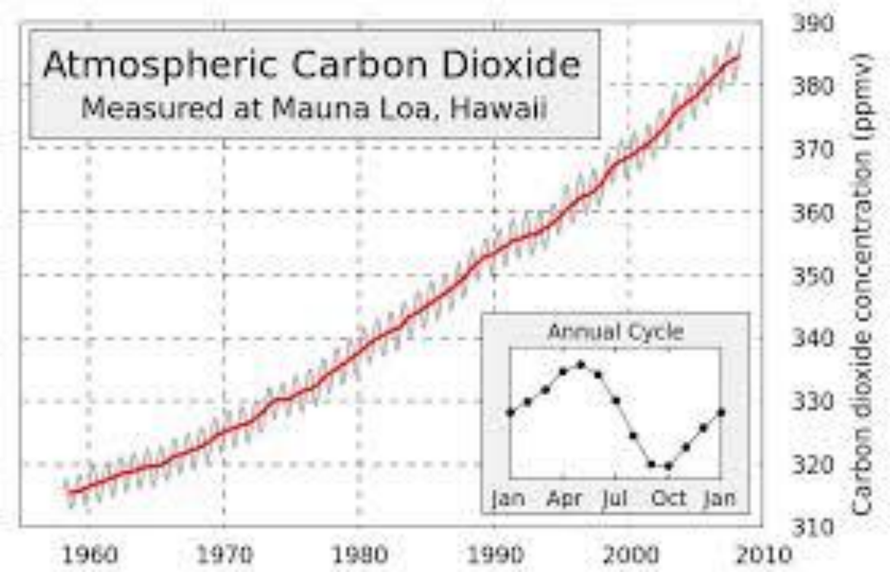
- Management intervention may be appropriate even if disturbance is not man made
- Value of observed indicator variables that appear 'out-of-range' could trigger management intervention
- Extrinsic driver change is of most interest

Meaningful Change

- Concern – when extrinsic factors singly or in combination with intrinsic factors drive ecosystems outside the bounds of 'sustainable' variation.

Key goal – discriminate between extrinsic and intrinsic drivers of change

- Expected intrinsic change – noise
- Human induced pattern of change - signal



Value of Monitoring

- Principle Value: Illuminates Decision Making
- How
  - Assesses status
  - Provides an early warning of change
  - Validates management decisions
    - Correct interpretation
    - Correctly implemented
    - Achieved desired consequences
  - Insight into how systems work

Value of Monitoring

- Determine if guidelines and/or regulations have been implemented

Value of Monitoring

- Determine the effectiveness of current practices
  - Develop a predictive understanding in terms of hypotheses of why an indicator is changing
  - Decide if more active management intervention is required


Value of Monitoring

- Early Warning:
  - Success depends on the indicator(s)
  - Knowledge of how much change in the signals represents a significant biological change

Types of Monitoring

- Inventory
- Surveillance
- Implementation
- Effectiveness
- Validation

Take Home Messages

- Differentiate between natural and acceptable or desired variation
- Uncertainty around ecosystem dynamics
  - Non-linear
  - Thresholds
- Most monitoring is surveillance

Take Home Messages

- Without an INTEGRATED STRATEGY for processing monitoring information, the multiple indicators deliver a cacophony of signals with no clear message
- Effective environmental monitoring remains an unanswered challenge

Challenges to Effective Monitoring

- "Managing ecosystems is not as complex as we think, it is more complex than we can think."
  - F.E. Egler
- "Forest management is not rocket science – it is way more complicated."
  - J.W. Thomas and F. Bunnell

Project Origins

- Fall of 2013
  - Presentation to Management Team on Effectiveness Monitoring and the Need
- January of 2014
  - Climate Adaptation Workshop in Sault Ste. Marie
- March of 2014
  - Need and Approval for a Pilot Project

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A Pilot of What?

- Challenges:
  - Effectiveness Monitoring
    - Legal requirement
    - Ethical need
    - Lack of understanding
  - Climate Change
    - High degree of uncertainty
    - Need to confront and reduce uncertainty
  - Integration of Science
    - Crisis management

Addressing the Challenges

- Use a Sequential List of Design Steps:
  1. Clearly defined goals and objectives
  2. Characterize stressors and disturbances
  3. Develop conceptual models that outline the pathways from stressors to their ecological expression
  4. Clearly explain logic & rationale for selection of indicators
  5. Outline the sample design, measurement methods and detection limits
  6. Establish “trigger points” for management intervention
  7. Connect monitoring results to decisions

Pilot Project

- Pilot Project Outcomes:
  - Demonstration of:
    - an approach to dealing with ongoing issues with the traditional approach
    - how to develop an effectiveness monitoring application
    - how to reduce uncertainty with respect to the impacts of climate change on trembling aspen
    - how to integrate science
  - Can we do this without collecting new data?

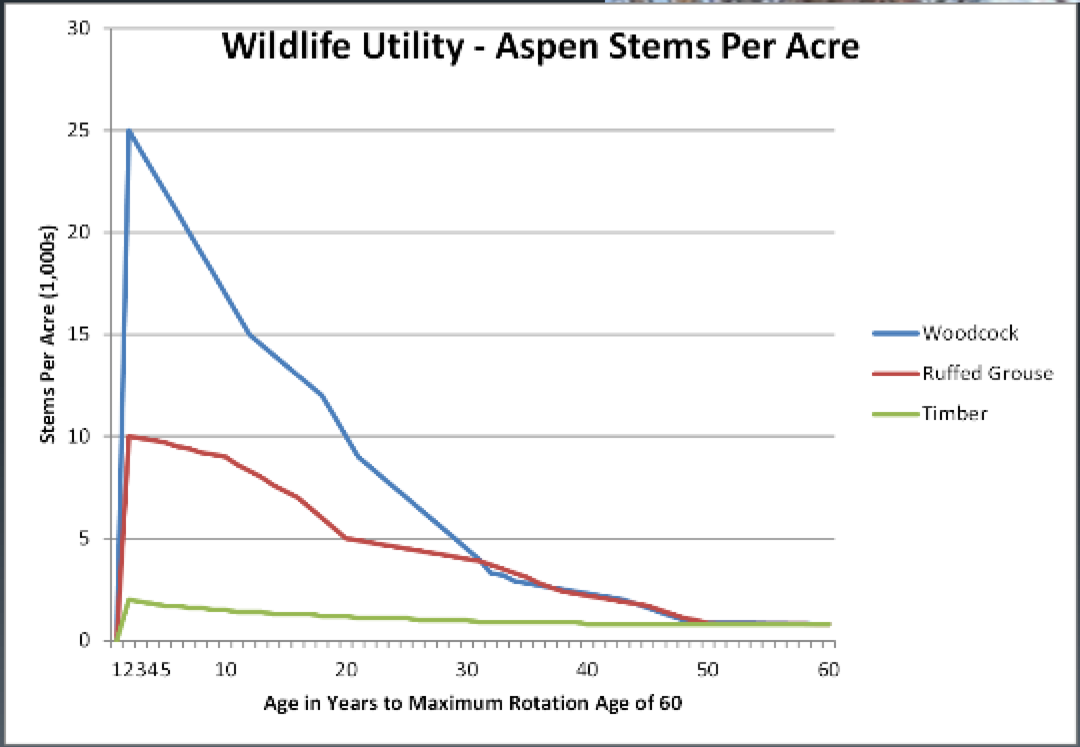
General Assumptions

- Project Foundation:
  - Trembling aspen is a climate change loser
  - Worst case scenario: a stand collapses just before it reaches maturity
  - Need for an early warning to impending change
  - Need to know when to convert to another species (reduce uncertainty)

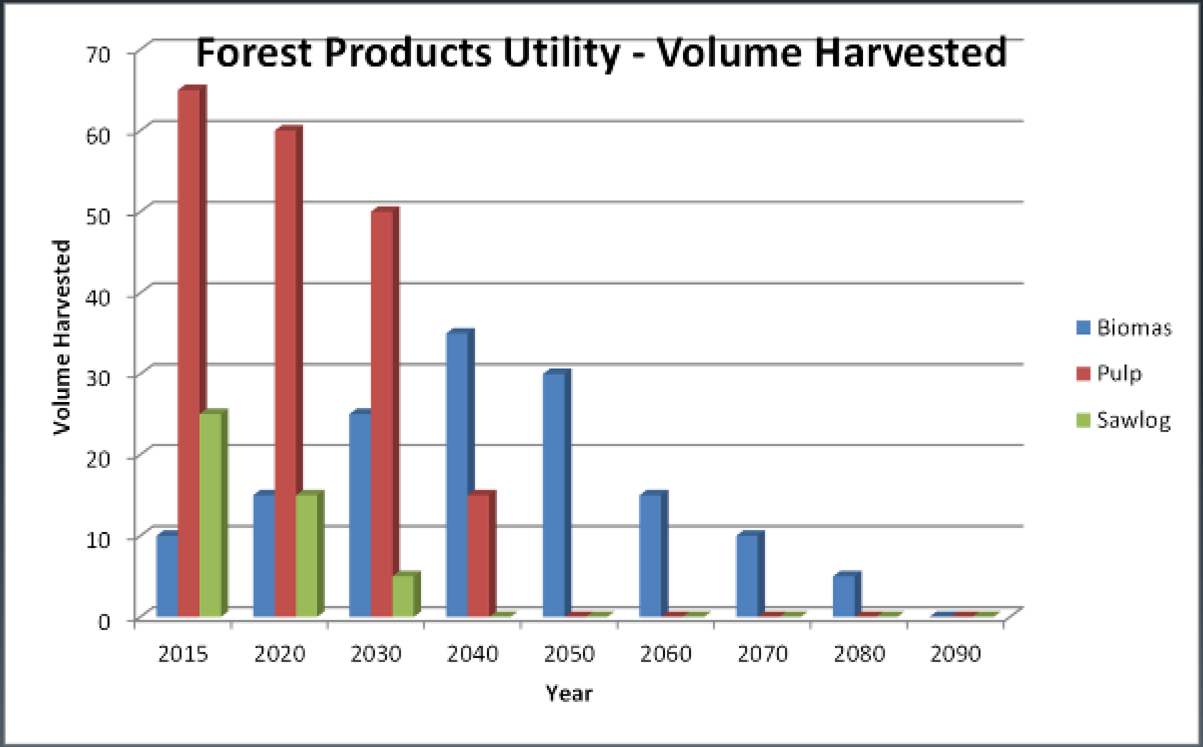
Consequences

- Aspen has biological, social and economic value in Michigan
  - Wildlife utility
    - Habitat
      - Deer
      - Ruffed Grouse
      - Woodcock
  - Forest Products utility
    - Sawlogs
    - Pulp
    - Biomass

Wildlife Utility



Forest Products Utility



Uncertainty

- Climate
- Climate impacts
- Regenerating stem density
- Product volume
- Insect impacts
- Disease impacts
- Uncertainty => Probability

Introduction to Thinking About Probability

- When we say that something will "probably" happen, we usually mean that the chance of that happening is greater than 50% or the odds are greater than 50:50
- How can we better quantify uncertainty in terms of probability?
- Bayes' Theorem and Bayesian statistics

Bayesian Networks

- Characteristics:
  - Models that graphically and probabilistically represent correlative and causal relationships among variables
  - Directed acyclic graphs
  - They can work with missing data
  - They can be run backwards
  - They learn over time
  - They can work with expert opinion
  - They can be used for sensitivity testing
  - They can test for outcomes of different decisions

Bayesian Networks

- Strengths:
  1. Representing and combining empirical data with expert opinion on ecological systems;
  2. Addressing uncertainties that plague attempts to solve resource management problems in a structured way;
  3. Structuring and evaluating alternative decisions within a risk assessment framework to determine the best decision;
  4. There is no such thing as “too little data”
  5. As information accumulates, knowledge of the true value of the variable usually increases – the uncertainty of the value diminishes

Bayesian Networks

- Weaknesses:
    1. Data and parameters often have continuous values; but Bayesian networks can deal with continuous variables in only a limited manner
    2. Collecting and structuring expert knowledge can prove difficult to acquire
    3. No support for feedback loops

Converting Inference Diagram to a Bayesian Network

- *Netica* Software:
  - https://www.norsys.com/netica.html
  - Free download that will handle up to 15 nodes – fully functional
  - Users manual
  - Excellent tutorial at: http://www.norsys.com/tutorials/netica/nt_toc_A.htm
  - Net Library:
  - http://www.norsys.com/netlibrary/index.htm
    - Chest Clinic: http://www.norsys.com/netlibrary/index.htm
      - Choose "Medical " in the top left box
      - Choose "ChestClinic" from the Medical menu – lower left box