# Addressing Increasing Invasive Species due to Climate Change through Structured Decision Analysis

# Outline

- Climate change
- Direct & Indirect Interactions
  - climate and plants
- Exotic species
- Case study
  - Climate change
  - Garlic mustard
  - Decision analysis
- Summary

Photo: Ryan Brady

# Interactions – Direct Effects

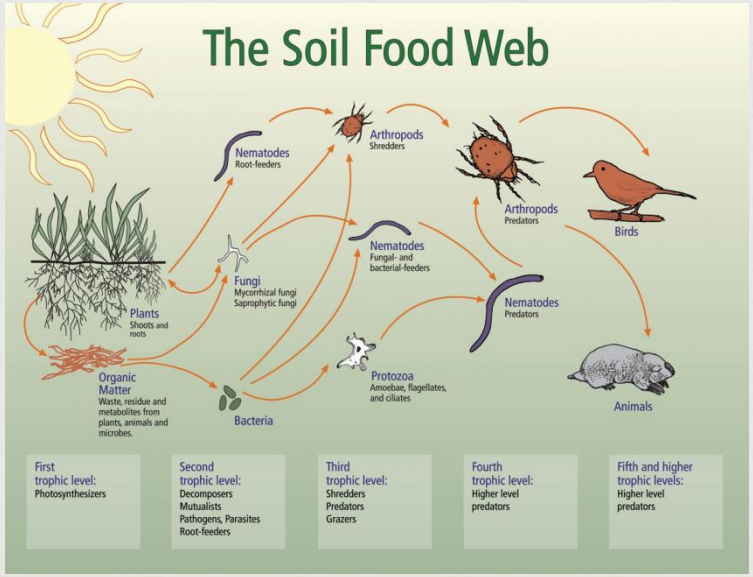
- Plants respond to many aspects of climate including:
  - Means –
    - Temperature
    - Precipitation
  - Timing –
    - Frost free period length
    - Temperature regimes during critical life history stages
  - Variability-
    - Magnitude of climate extremes
    - Duration of climate extremes

# Interactions – Indirect Effects

- Indirect effects
  - Altering ecosystem processes
    - Natural disturbance regimes
      - Wind
      - Fire
      - Storms

# Interactions – Indirect Effects

- Effects to soil moisture and nutrients
  - Exotics often consume greater amounts of water
  - Soil nutrient availability is one of the most important factors determining ecosystem stability and productivity



# Exotic Species

- More tolerant of new climates
- Broad environmental tolerances
- Better ability to keep up with changing climate
- Disproportionately rapid evolutionary change and/or high phenotypic plasticity
- Species with traits facilitating long range dispersal; outcompete those less adapted to new climate

# Case Study

- Potential of garlic mustard to:
  - Move north due to climate change
  - Invade forests of the Apostle Islands National Lakeshore

# Structured Decision Analysis

- Problem definition
- Determining objectives
- Developing alternatives
- Consequences
- Making decisions under risk
- Making decisions under uncertainty: monitoring and adaptive management

# Problem Definition
# key parts to a good decision

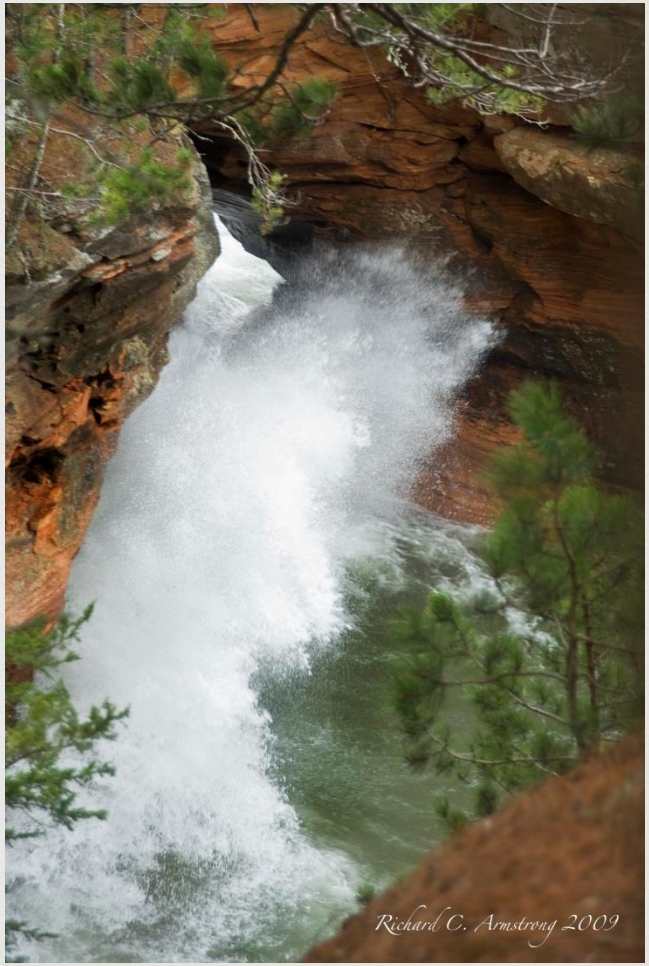
- **Trigger**
- **Action Frequency & Timing**
- **Scope**
  - Complexity
- **Constraints**
  - Legal
  - Knowledge
  - Potential scale
  - Financial
- **Uncertainty**
- **Problem Class**

# Effects of Climate Change in Great Lakes

- Temperatures:
  - Air:
    - ***Warmer, drier summers****
    - ***Warmer winters***
    - Shorter cold season
  - Water
    - ***Warmer water***
    - ***Less ice***
    - ***Lower lake levels***
    - Later freeze-up, earlier ice-out
    - More evaporation from lakes

- Precipitation
  - ***Irregular, higher intensity storms***
  - More winter precipitation as rain
  - More flooding, esp. in spring

*Italics indicates effects already experienced.



# Garlic Mustard

- Ability to invade forest habitats – park is over 95% forested
- Transported by people and wildlife
- Capable of disrupting plant-microbe interactions and reducing tree growth

# Problem Definition
# Problem Class

| | No Uncertainty | With Uncertainty |
|---|---|---|
| Single Objective | | |
| Multiple Objective | | X |

# Problem Statement

- One way to meet our mission and protect Apostle Islands National Lakeshore forest communities is to prevent garlic mustard (*Allaria petiolata*) from entering the park. This effort is confounded by climate change impacts already evident which include increased temperatures, believed to benefit exotic species. In addition, garlic mustard was recently identified in nearby Washburn, Wisconsin. National Park Service policy requires management of exotic species and this species is also 'restricted' on the Wisconsin state NR-40 list. Natural resource management staff need to develop and implement a strategy to prevent garlic mustard from entering park lands prior to next summer. While the decision to prevent this species from entering park lands is simple, implementation of any strategies will be complicated. Garlic mustard is transported by wildlife and people. In addition, there are numerous ways visitors enter the park to access the 21 islands which prohibits educational and mitigation efforts at a single entrance. Finally, funding can be a limiting factor at times.

# Determining objectives

- Identify concerns – garlic mustard will invade the parks forests and reduce health & resilience
- Convert to objectives – minimize the number of acres and islands infested with garlic mustard
- Identify measurable attributes:
  - Number of acres infested
  - Number of islands/locations infested

# Developing Alternatives

- Early detection & rapid response on park lands
- Work with local weed cooperative to eliminate threat on adjacent lands
- Targeted education effort with local community residents
- Increase educational efforts with visitors

# Comparison Table

| Consequence Matrix | | Alternatives | | | |
|---|---|---|---|---|---|
| Objectives | Goal & units | Status Quo (no action) | EDRR | Work on Targeted Adjacent Lands | Education |
| Garlic Mustard Infestation | Min (acres & locations) | Won't meet objective | Most likely to meet objective | Moderate effective-ness | May help meet objective |
| Costs | Min ($) | No Cost | Highest Cost due to acreage | Moderate cost | Low to Moderate cost |

# Comparison

| Consequence Matrix | | Alternatives | | | |
|---|---|---|---|---|---|
| Objectives | Goal & units | Status Quo (no action) | EDRR | Work on Targeted Adjacent Lands | Education |
| Garlic Mustard Infestation | Min (acres & locations) | Won't meet objective | Most likely to meet objective | Moderate effective-ness | May help meet objective |
| Costs | Min ($) | No Cost | Highest Cost due to acreage | Moderate cost | Low to Moderate cost |

# Consequences

| Consequence Matrix | | Alternatives | | |
|---|---|---|---|---|
| **Objectives** | **Goal & Units** | **EDRR** | **Work on Targeted Adjacent Lands** | **Education** |
| **Garlic Mustard Infestation** | Minimize (Units: acres & locations) 0-10 | Most likely to meet objective<br>2 | Moderate effective-ness<br>3 | May help meet objective<br>5 |
| **Costs** | Minimize (Units: $) | Highest Cost due to acreage of park<br>15 | Moderate cost due to fewer acres but more coordination<br>10 | Low to Moderate cost<br>7 |

# Consequences

| Consequence Matrix | | Normalized Alternatives | | |
|---|---|---|---|---|
| **Objectives** | **Goal & units** | **EDRR** | **Work on Targeted Adjacent Lands** | **Education** |
| **Garlic Mustard Infestation** | Minimize (Units: acres & locations) 0-10 | Most likely to meet objective 1.000 | Moderate effective-ness 0.667 | May help meet objective 0.000 |
| **Costs** | Minimize (Units: $) | Highest Cost due to acreage of park 0.000 | Moderate cost due to fewer acres but more coordination 0.333 | Low to Moderate cost 1.000 |

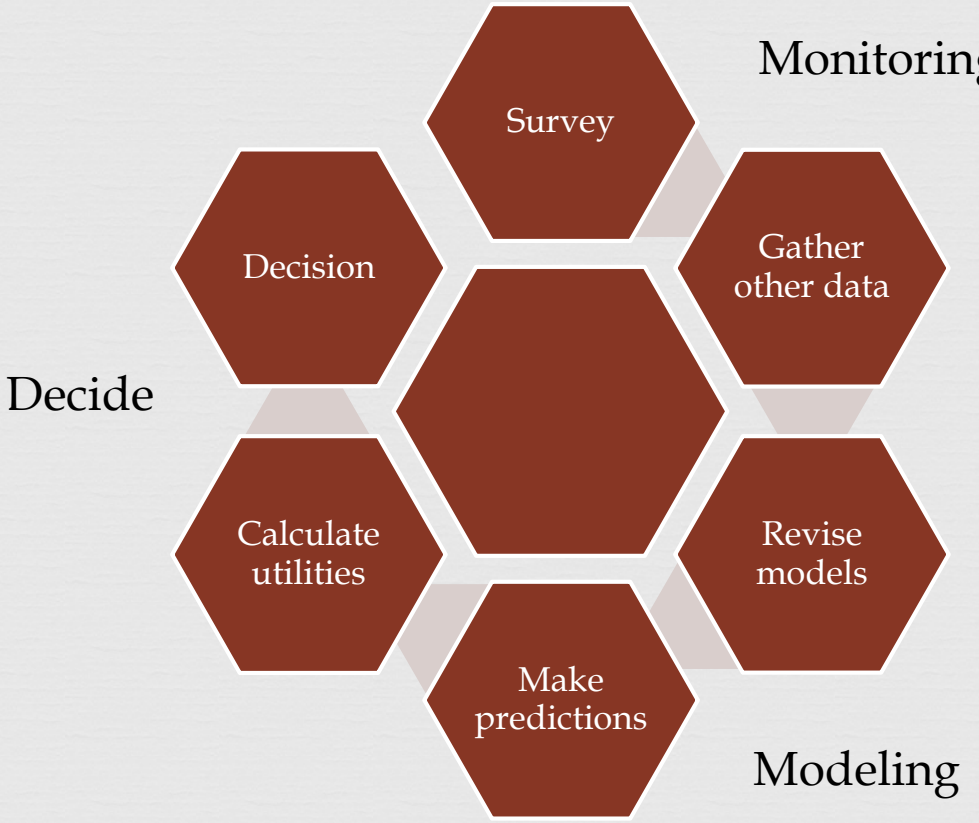
# Consequences

| Consequence Matrix | | Normalized & Weighted Alternatives | | |
|---|---|---|---|---|
| **Objectives** | **Goal & units** | **EDRR** | **Work on Targeted Adjacent Lands** | **Education** |
| **Garlic Mustard Infestation**<br><br>**Weight: 0.50** | Minimize (Units: acres & locations) | Most likely to meet objective | Moderate effectiveness | May help meet objective |
| **Costs**<br><br>**Weight: 0.25** | Minimize (Units: $)<br><br>Totals: | Highest Cost due to acreage of park<br><br>0.67 | Moderate cost due to fewer acres but more coordination<br><br>0.56 | Low to Moderate cost<br><br>0.33 |

# Making decisions under risk

- Important to understand decision maker's risk attitude:
  - Risk-adverse
  - Risk-seeking
- Can address uncertainty by converting phrases (quite likely) to numerical probabilities (90% chance)
- Assign probabilities to commonly used phrases such as "…in danger of extinction…"
- Probabilities & odds

# Making decisions under uncertainty: monitoring and adaptive management



# Summary

- Decision analysis
- Climate change
- Garlic mustard

# Questions?