Incorporating Weighted Hierarchical Criteria and Uncertainty into Invasive Plant Prioritization Schemes: A Case Study from the National Park Service Klamath Network

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But First…Many Thanks

- Whiskeytown NRA Staff
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- Klamath Network Staff
  - Dan Sarr, Sarah McCulloch, Susan O’ Neil
- Clare Aslan, Mike Bowers, Dennis Odion
Project Background

• NPS need for system-wide prioritization scheme
• Buzz words, buzz words, buzz words…
  – “Early Detection”
    • Of what?
  – “Prediction”
    • How accurate?
  – “Prioritization”
    • Of what?
    • What scale?
    • What objectives?
Considerations – First Set

• Numerous prioritization procedures have been developed
  – Vary in:
    • Objectives
    • Scale
    • Inputs

• Not all criteria used in setting priorities are created equally
Considerations – Second Set

• Missing ecological aspects of invasions
  – Invasion process
• Uncertainty in ranking and relative importance of different ranking criteria not addressed
  – Variation in management priorities, phase of invasion, and data quality
• Invasion process implies different priorities for different species
  – Scale
Invasion Process

Different Management Goals

Colonization

Establishment

Spread

Prevention

Control or Eradicate

Control (reduce population size)
Goals & Requirements

• Develop a *practical* procedure for prioritizing *different* management actions

• Flexibility & generality
  – Applicable at different scales and in range of wildlands

• Uncertainty incorporated in rankings
Options

• Create another system
  – Re-inventing the wheel…
  – Or recognizing specific needs
• Use an existing system
  – Easy…
  – But may not be appropriate
• Synthesize existing systems
  – Evaluate utility of each existing system
  – Take most useful components
  – Add missing components

And the winner was…
Synthesis of Existing Systems

• Integration of Two Existing Systems
  – Cal IPC Inventory of Invasive Wildland Weeds
    • Excellent information source
    • Screening system for potential invaders
  – Randall et al. in prep
    • Usable at network and site scales
    • Criteria divided into four primary sections
    • Scores for individual sections and composite score
Approach

• Link system to stages of invasion process
• Data-based
  – Use pre-existing data on distribution and abundance patterns, invasion potential
• Develop and test in phases
• Provide more than just a list
  – Alternatives
• Incorporate Uncertainty and Different Weighting Criteria
  – Analytical Hierarchy Process (AHP)
    • Mathematical foundation
    • Widely used outside of conservation field
    • Well-studied
The Analytical Hierarchy Process In A Nutshell

- Hierarchical multiobjective-multicriteria decision technique
  - Appropriate for problems with significant data uncertainty
  - Reduces subjectivity
- Pairwise application of quantitative measurement scale to obtain vectors of normalized weights or priorities
- Matrix based
  - Eigenvectors associated with dominant eigenvalue of matrix used to weight multiple criteria at different levels
- Output is adjusted rankings of non-native species
Measurement Scale

1 = Equally important
2
3 = Weak importance of one criteria over another
4
5 = Moderate importance of one criteria over another
6
7 = Strong importance of one criteria over another
8
9 = Absolute importance of one criteria over another
Importance of AHP in Prioritization

- Explicitly recognizes greater importance of some criteria over others
- Reduces subjectivity
- Uncertainty calculated at two levels
  - Sub-criteria (model)
  - Scores (data)
Test Case: Klamath Network (NPS)

- Six Sites ranging in size 2-740 km²
- Elevation range sea level to > 10,500
- Temperate rain forests to Great Basin desert
Step 1: Data Analysis

• Three Goals
  – Determine distribution, abundance, trend
    • Pre-existing data
  – Determine similarity in invasive plant species composition among and within NPS sites
    • Cluster analysis
    • Analysis of similarity (ANOSIM)
  – Evaluate likelihood of invasion from surrounding lands by non-natives not on NPS lands
    • Species-accumulation and extrapolation curves
Network Patterns
Species Richness

Number of Species

CRLA  |  LABE  |  LAVO  |  ORCA  |  REDW  |  WHIS  
-----|-------|-------|-------|-------|-------
   0  |   0   |   0   |   0   | 250   | 180   

Graph showing the number of species for different locations.
Dissimilarity Among Sites
Dissimilarity Within Sites

WNRA
Network Patterns
Species Accumulation Curves

Number of Sites vs. Number of Species

- Chao
- Observed
Data Analysis Evaluation

• Three levels of prioritization required
  – Individual sites
    • Within sites?
  – Within Klamath Network but not in sites (yet)
  – Not yet in network
Step 2. Develop Structure

- Randall et al. criteria
  - Impacts
    - Ecosystems, communities, composition, etc.
  - Biological characteristics
    - Reproduction, dispersal, etc.
  - Ecological characteristics
    - Distribution, abundance, and trend
  - Management potential
## Main Criteria Matrix

### Establishment Phase

<table>
<thead>
<tr>
<th></th>
<th>Management</th>
<th>Biology</th>
<th>Impacts</th>
<th>Ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>1</td>
<td>1/4</td>
<td>1/6</td>
<td>1/5</td>
</tr>
<tr>
<td>Biology</td>
<td>4</td>
<td>1</td>
<td>1/2</td>
<td>1/2</td>
</tr>
<tr>
<td>Impacts</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Ecology</td>
<td>5</td>
<td>2</td>
<td>1/2</td>
<td>1</td>
</tr>
</tbody>
</table>
## Sub-criteria Matrix

### Management Potential

<table>
<thead>
<tr>
<th>Sub-criteria</th>
<th>Information Quality</th>
<th>Control Feasibility</th>
<th>Infestation Area</th>
</tr>
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<tbody>
<tr>
<td>Information Quality</td>
<td>1</td>
<td>1/4</td>
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<td>Infestation Area</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
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</table>
Link of Hierarchy to Invasion Stage
Weights (dominant eigenvalues)

- **Establishment Phase**
  - Impacts (0.442)
  - Ecology (0.299)
  - Biology (0.199)
  - Management (0.060)

- **Spread Phase**
  - Management (0.493)
  - Ecology (0.303)
  - Impacts (0.116)
  - Biology (0.088)
Establishment Phase Hierarchy
Lava Beds National Monument
Establishment Phase Hierarchy
Whiskeytown National Recreation Area
Step 3: Evaluate Rankings

- Ranking
- Uncertainty
- Sensitivity
- Contributions
Uncertainty
LABE
Sensitivity – Biology

WNRA – Spread Phase Species

Note: The most critical 5 alternatives are shown.
Challenges & Caveats

- Challenges
  - Data access
  - Direct incorporation of site characteristics as criteria difficult
  - Prioritizing species not yet in Klamath Network may be more suited for other approaches

- Caveats
  - The method is not a “solution”, but a “justification”
  - Determining “optimal” prioritization problematic
  - Lag effects!!
  - Limitations to chances of control and/or eradication success