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

Rob Klinger & Matt Brooks
USGS-BRD

John Randall
The Nature Conservancy

But First…Many Thanks

- Whiskeytown NRA Staff
  - **Jen Gibson, Windy Bunn, Mike Commons, Tim Bradley**
- 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

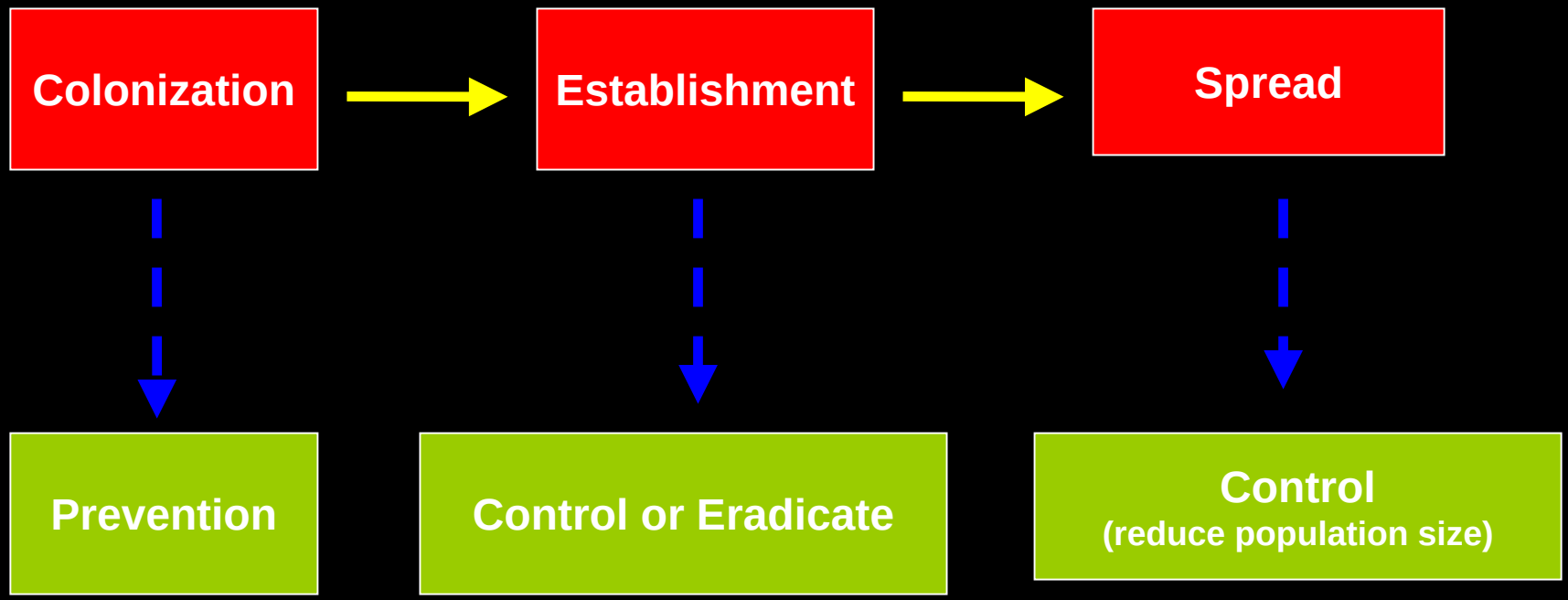
- Numerous prioritization procedures have been developed
  - Vary in:
    - **Objectives**
    - **Scale**
    - **Inputs**
- Not all criteria used in setting priorities are created equally

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



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

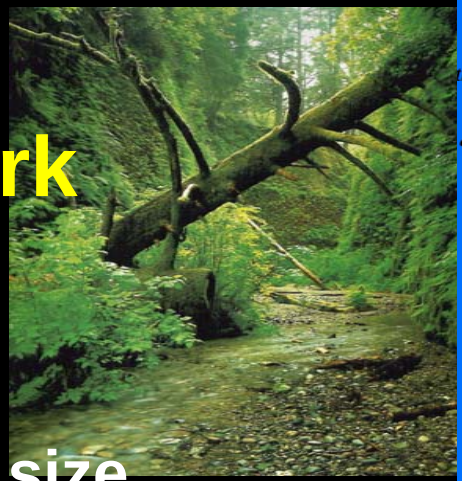
8

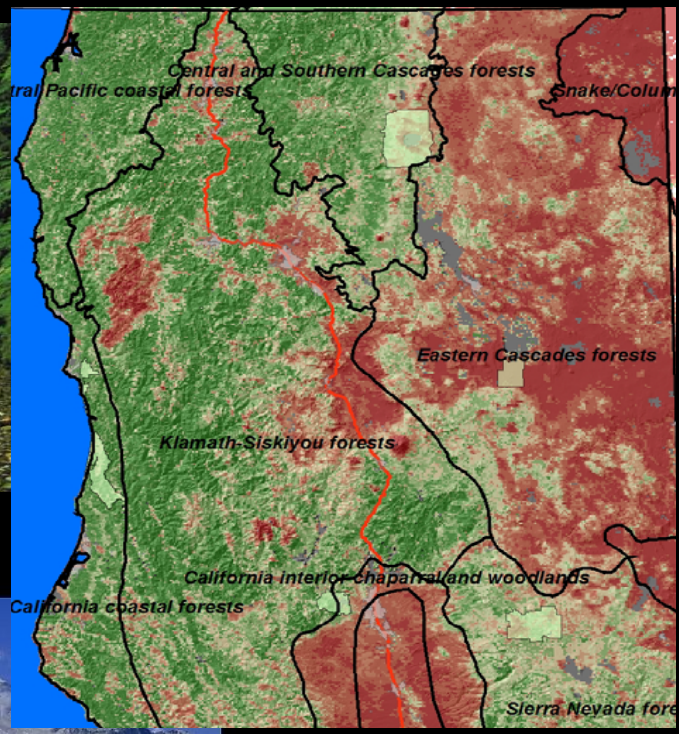
9 = Absolute importance of one criteria over another

Importance of AHP in Prioritization

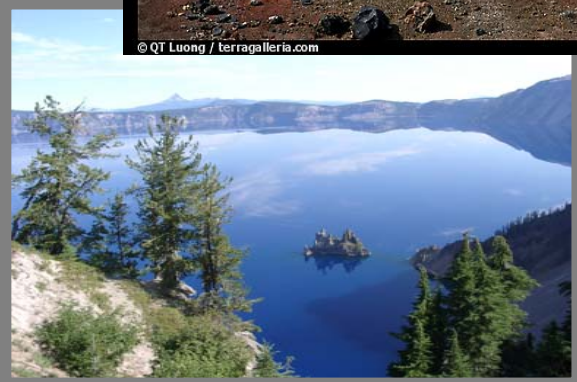
- Explicitly recognizes greater importance of some criteria over others
- Reduces subjectivity
- Uncertainty calculated at two levels
  - **Sub-criteria (model)**
  - **Scores (data)**

Test Case: Klamath Network (NPS)





- Six Sites ranging in size 2-740 km^2
- Elevation range sea level to > 10,500
- Temperate rain forests to Great Basin desert

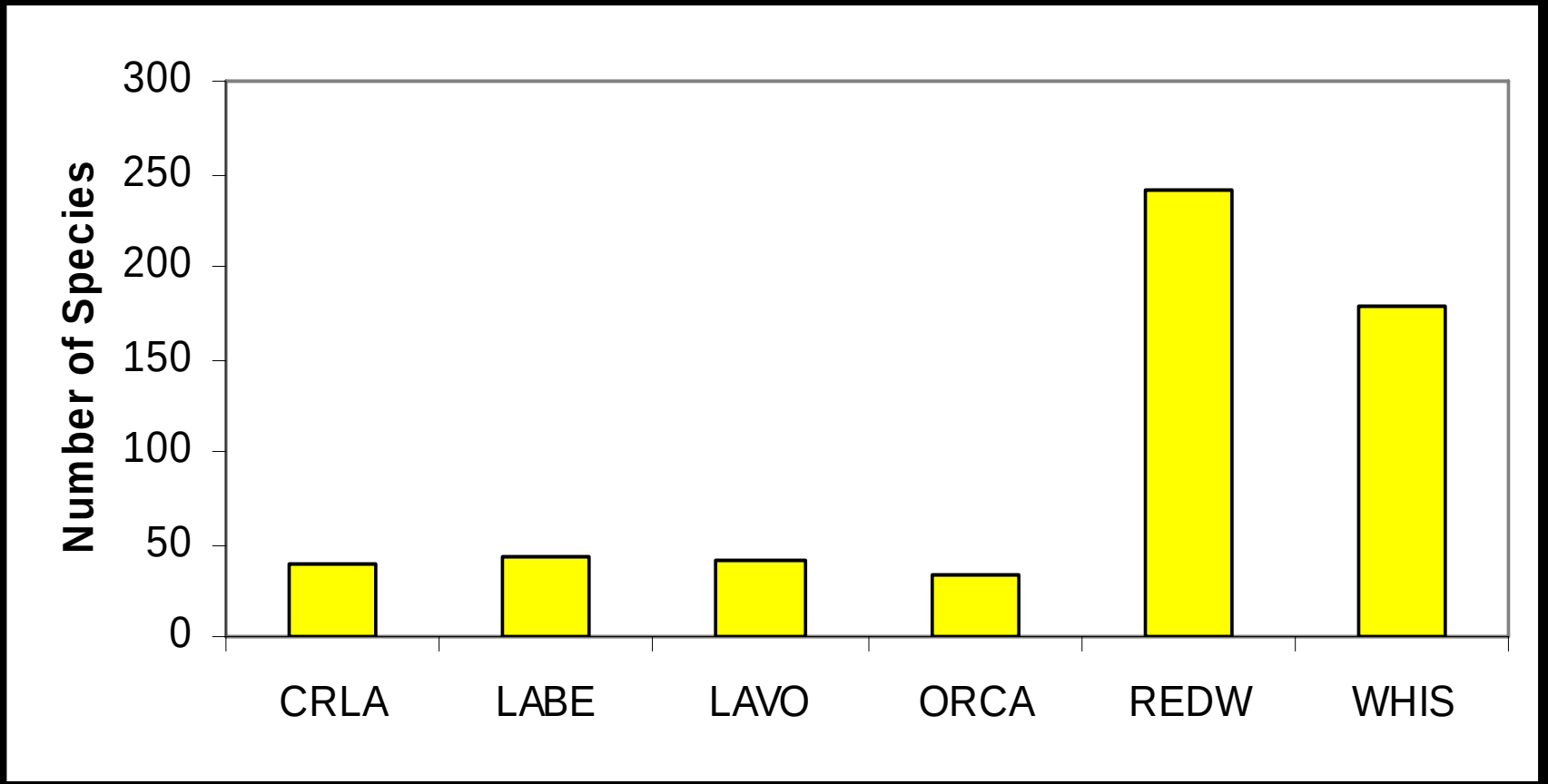


Step 1: Data Analysis

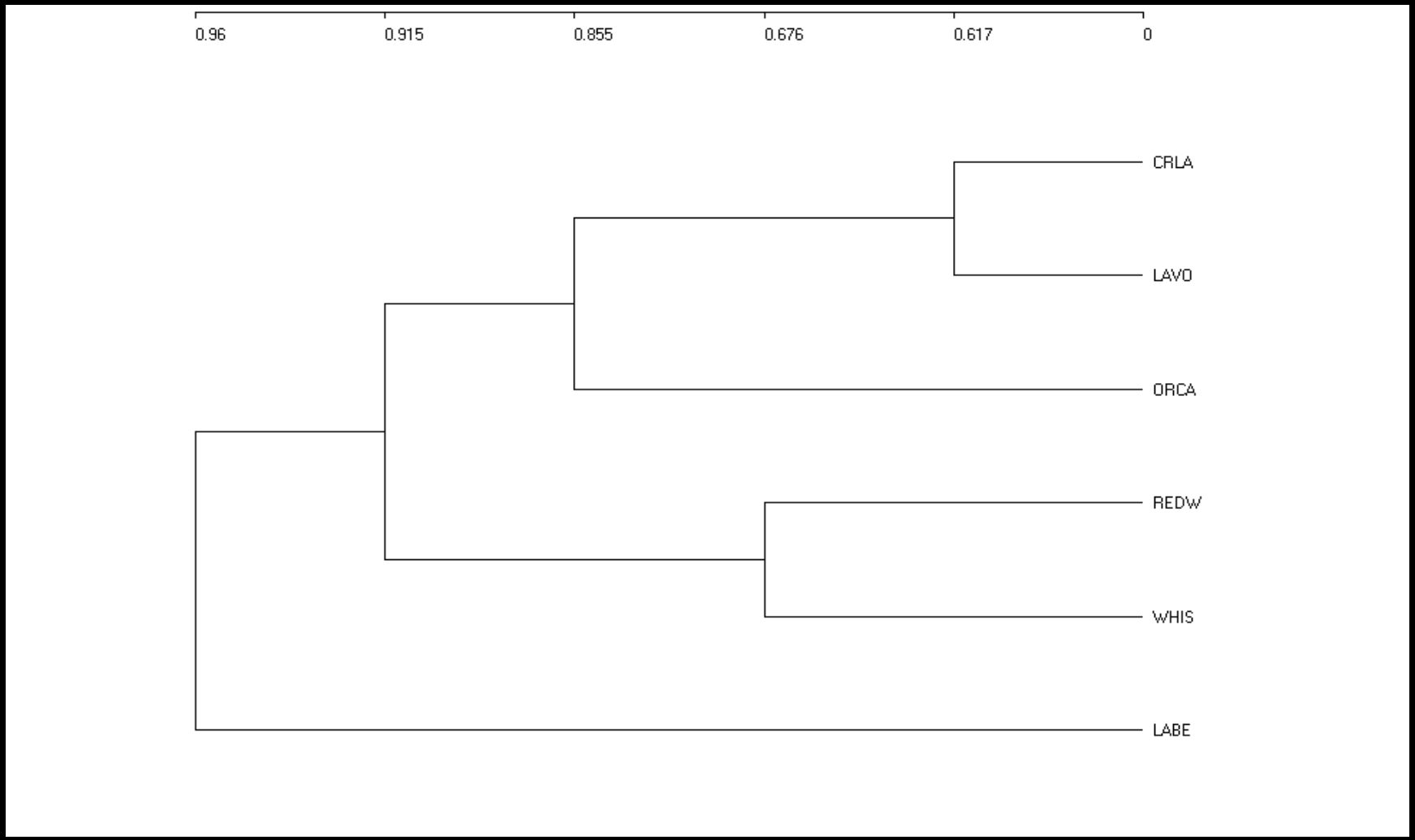
- Three Goals
  - Determine distribution, abundance, trend
    - **Pre-existing data**
  - Determine similarity in invasive plant species composition among and within NPS sites
    - **Cluster analysis**
    - **Analysis of similarity (ANOSIM)**
  - Evaluate likelihood of invasion from surrounding lands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

Network Patterns

Species Richness

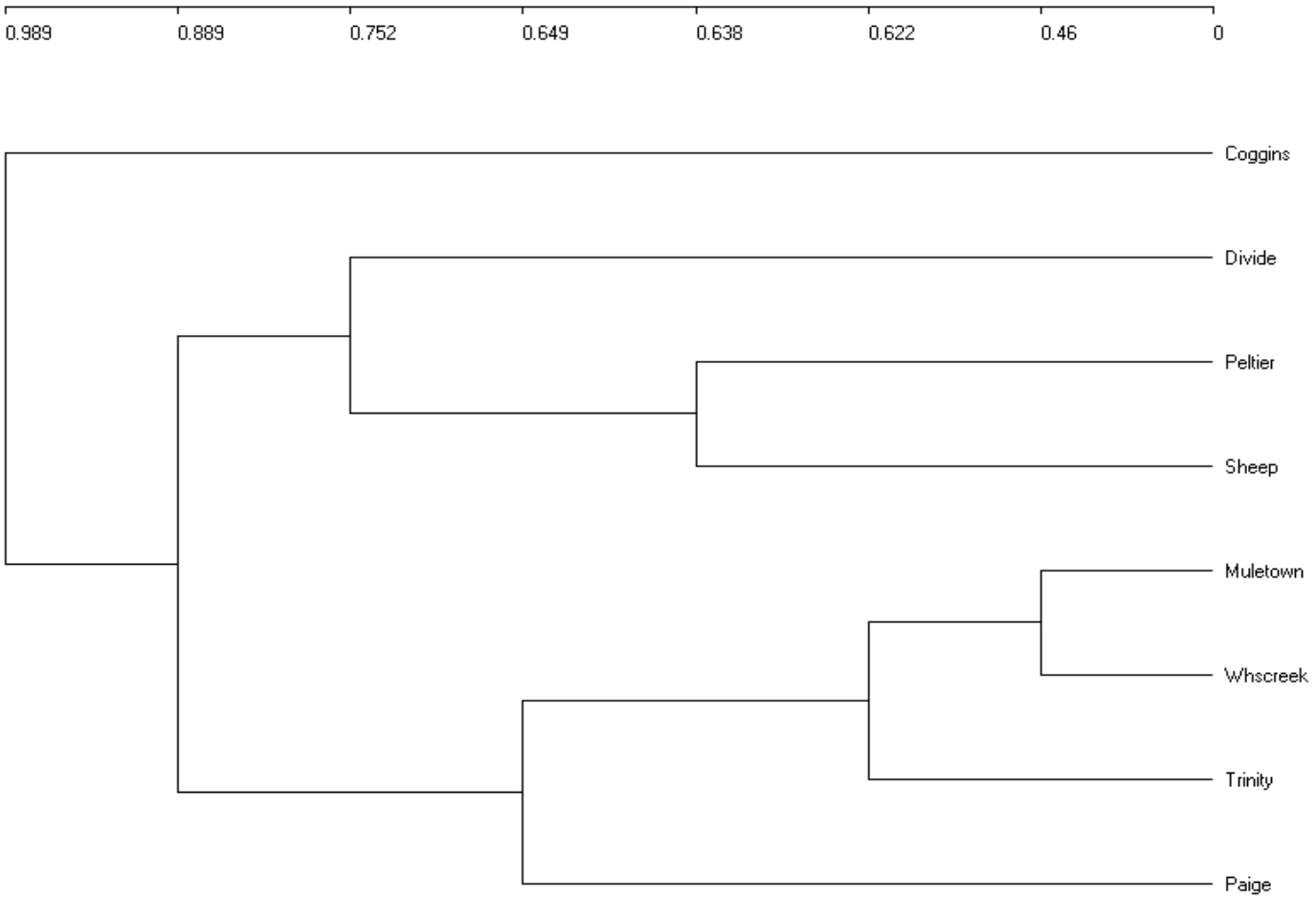


Dissimilarity Among Sites



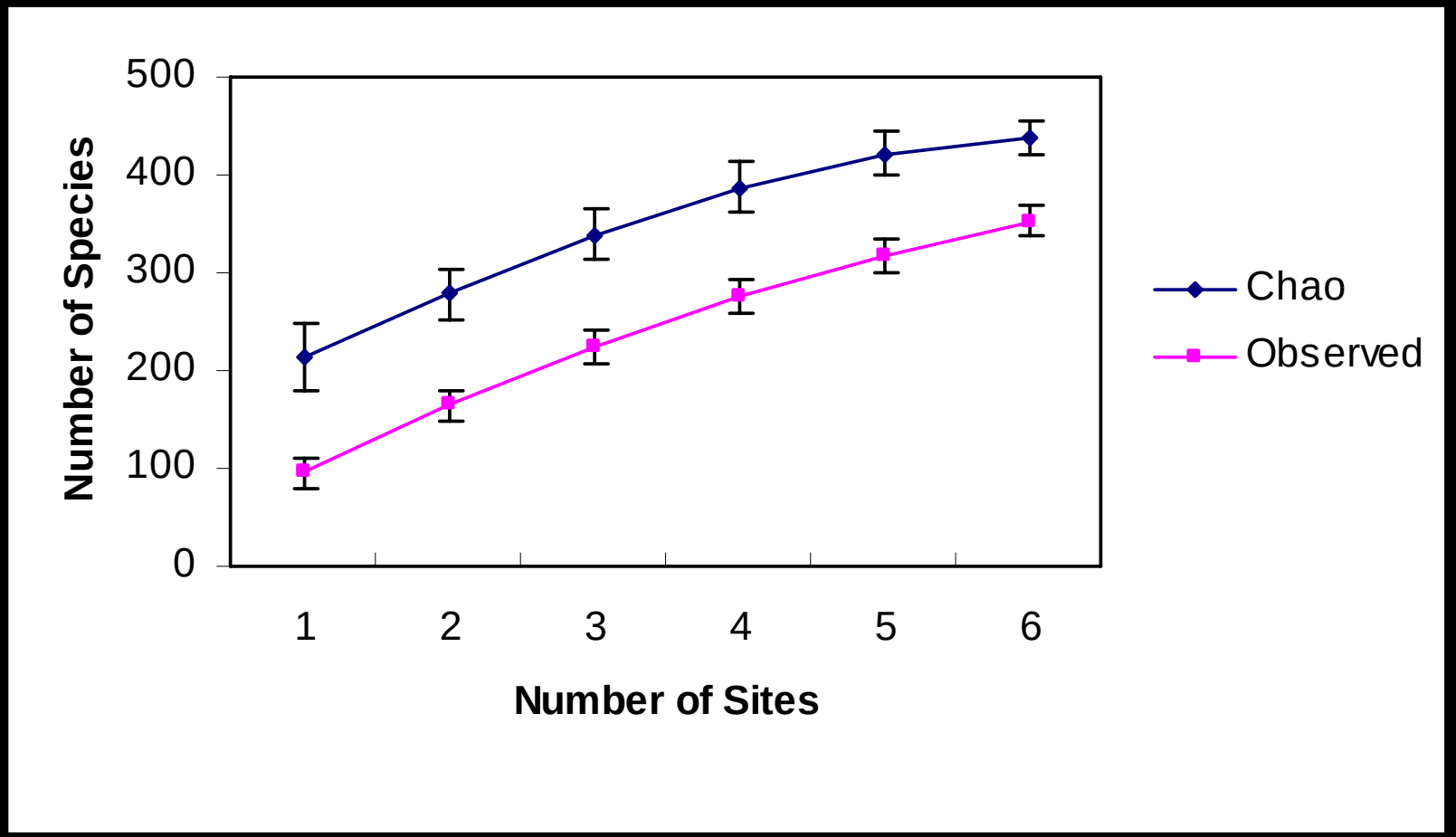
Dissimilarity Within Sites

WNRA



Network Patterns

Species Accumulation Curves



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

	Management	Biology	Impacts	Ecology
Management	**1**	**1/4**	**1/6**	**1/5**
Biology	**4**	**1**	**1/2**	**1/2**
Impacts	**6**	**2**	**1**	**2**
Ecology	**5**	**2**	**1/2**	**1**

Sub-criteria Matrix

Management Potential

	Information Quality	Control Feasibility	Infestation Area
Information Quality	**1**	**1/4**	**1/5**
Control Feasibility	**4**	**1**	**1/2**
Infestation Area	**5**	**2**	**1**

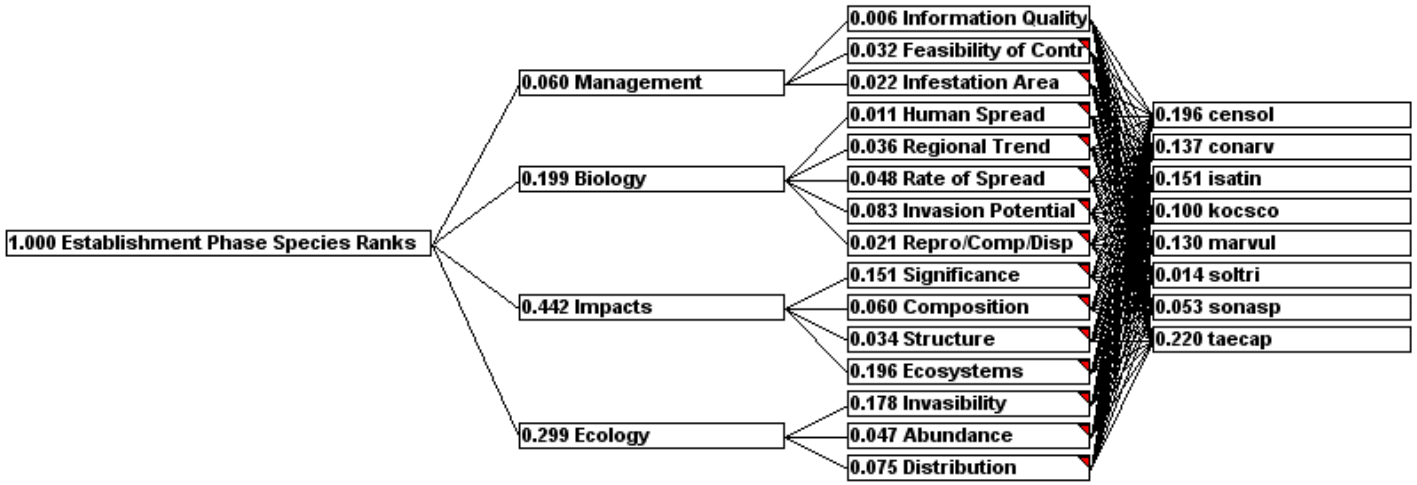
Link of Hierarchy to Invasion Stage

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)

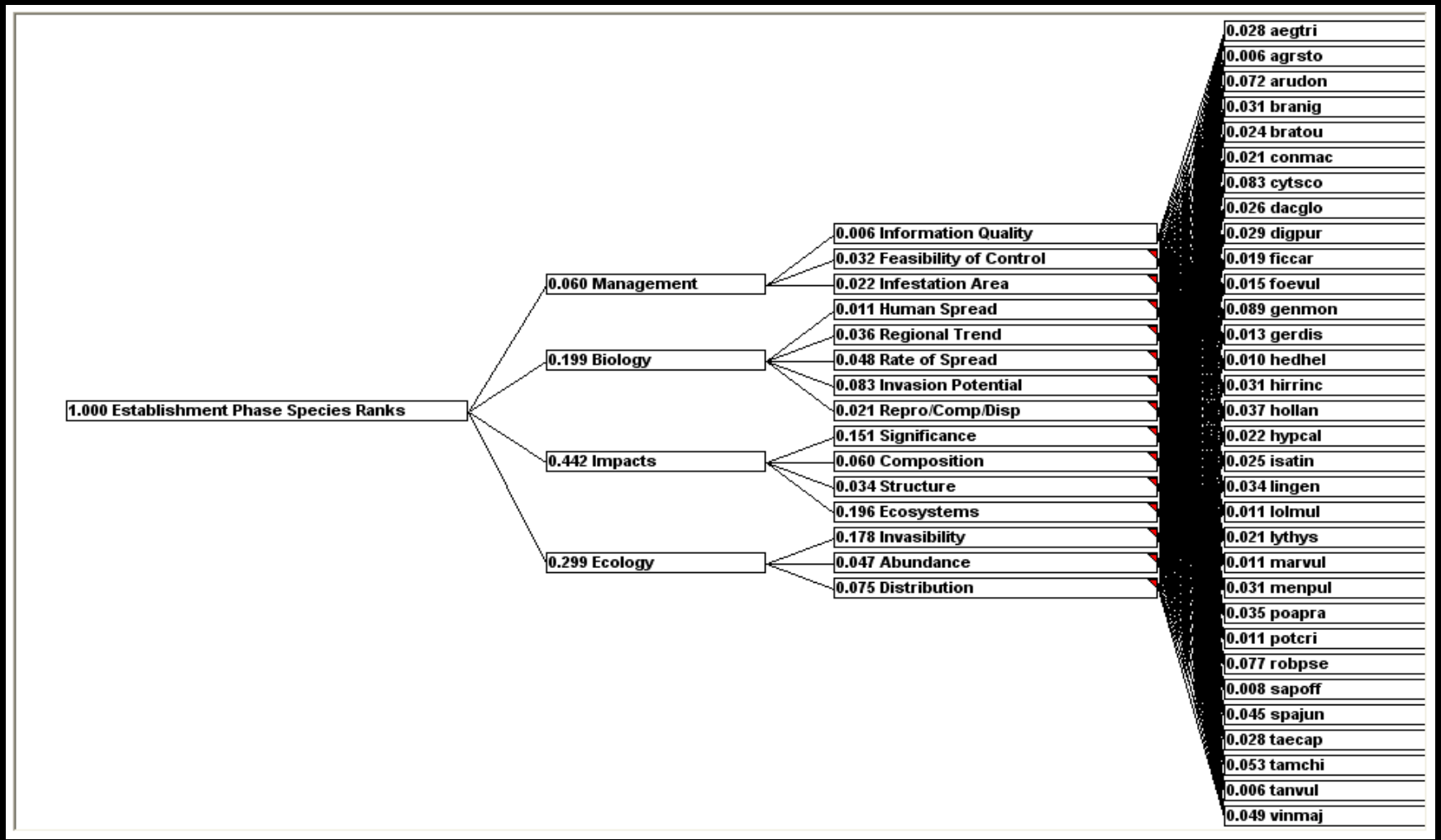
Establishment Phase Hierarchy

Lava Beds National Monument



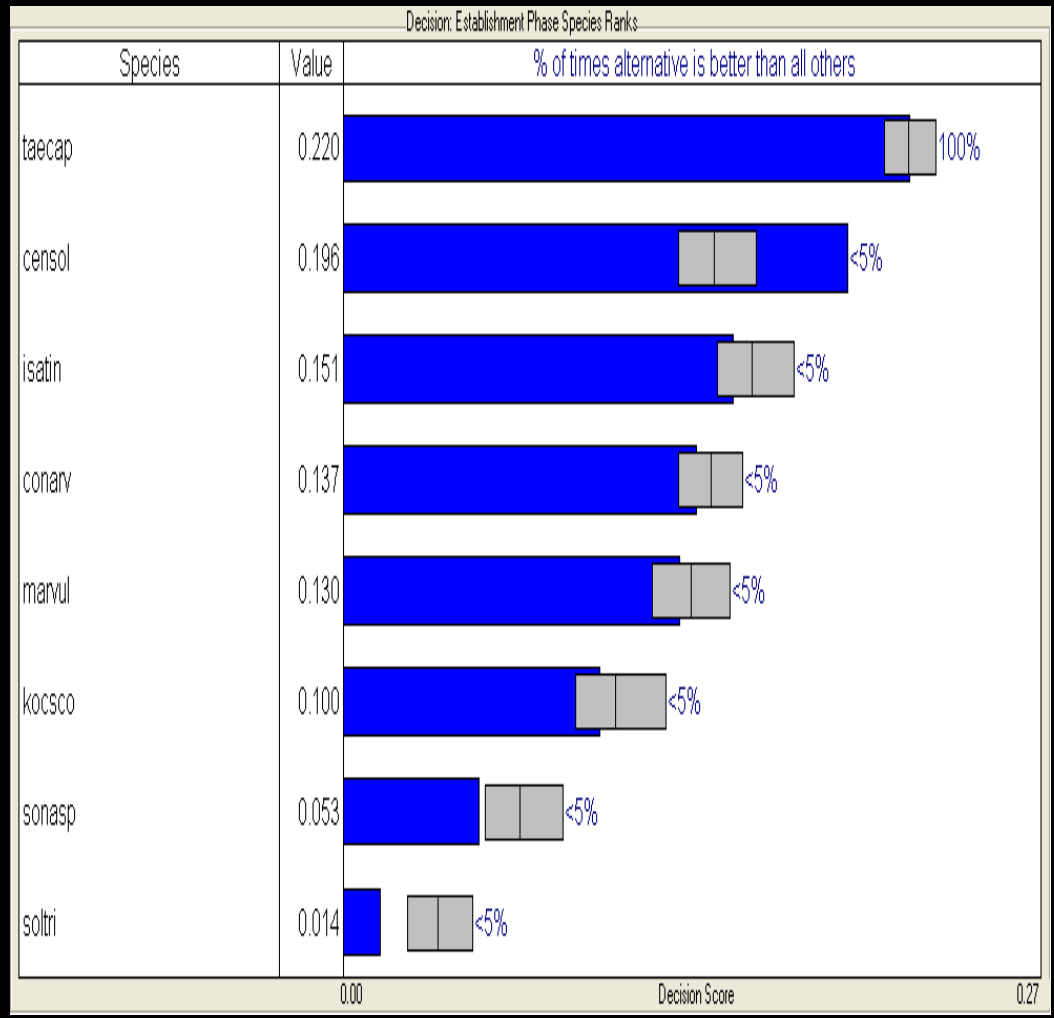
Establishment Phase Hierarchy

Whiskeytown National Recreation Area



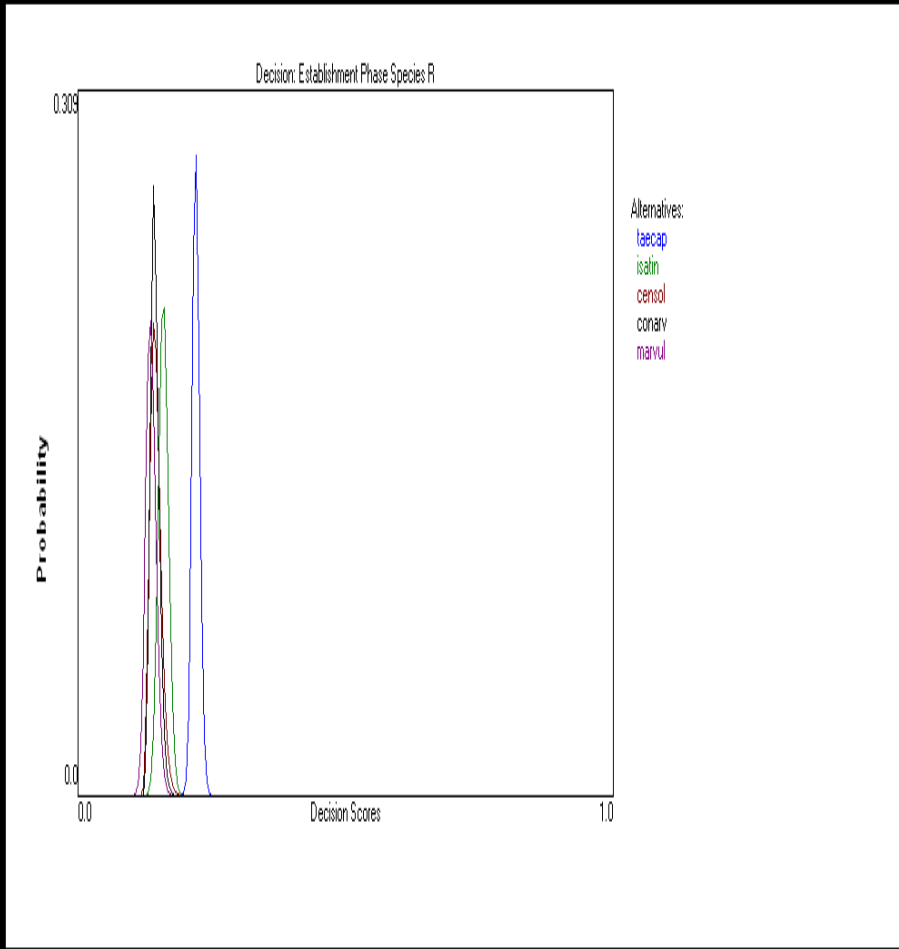
Step 3: Evaluate Rankings

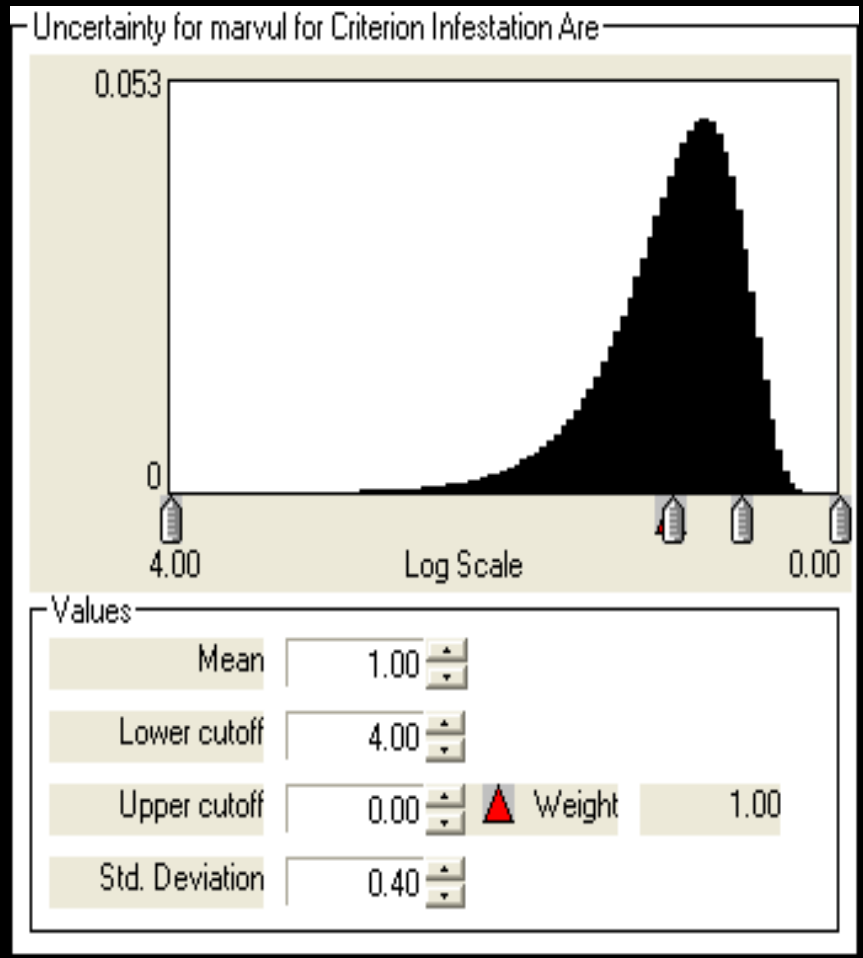
- Ranking
- Uncertainty
- Sensitivity
- Contributions



Uncertainty

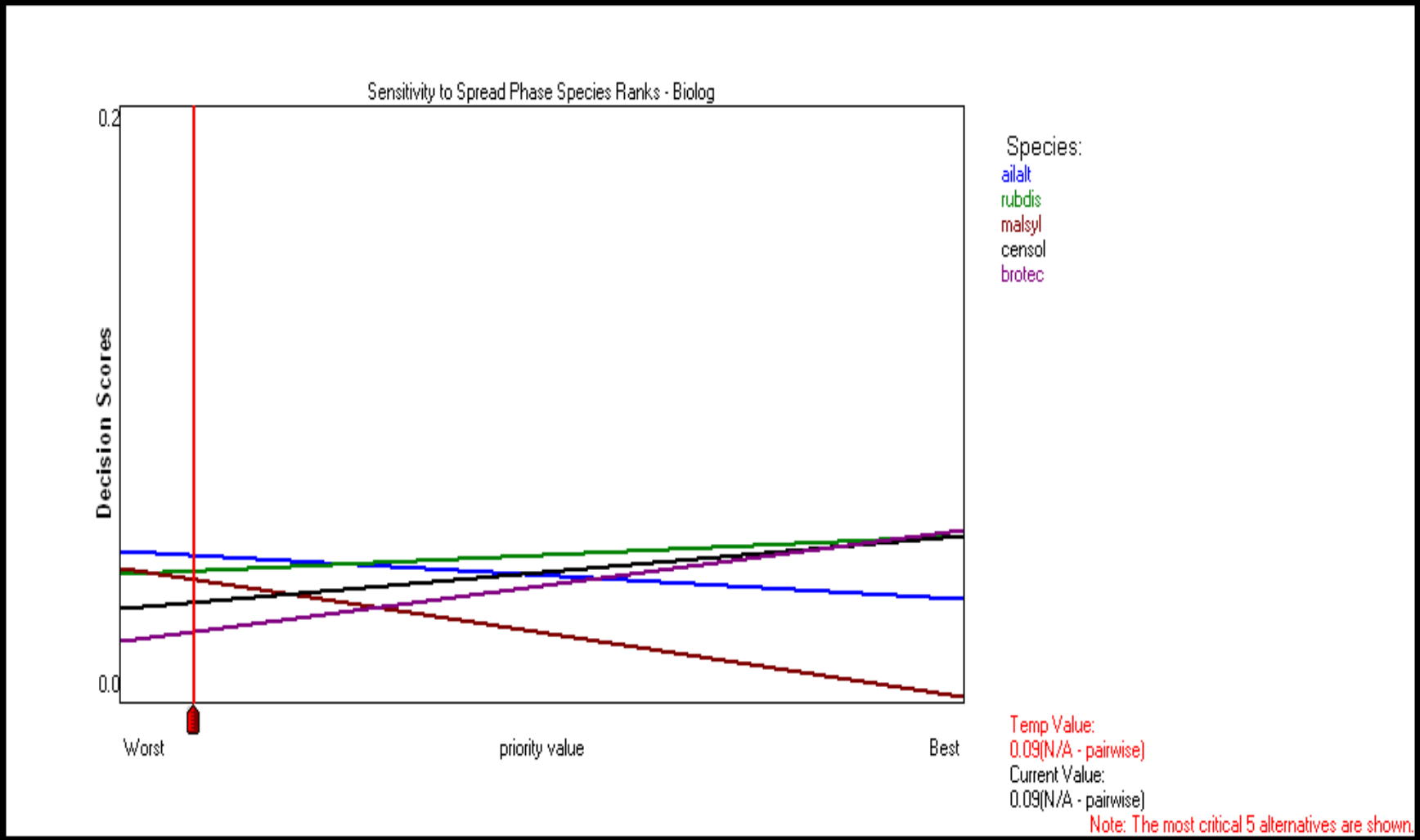
LABE





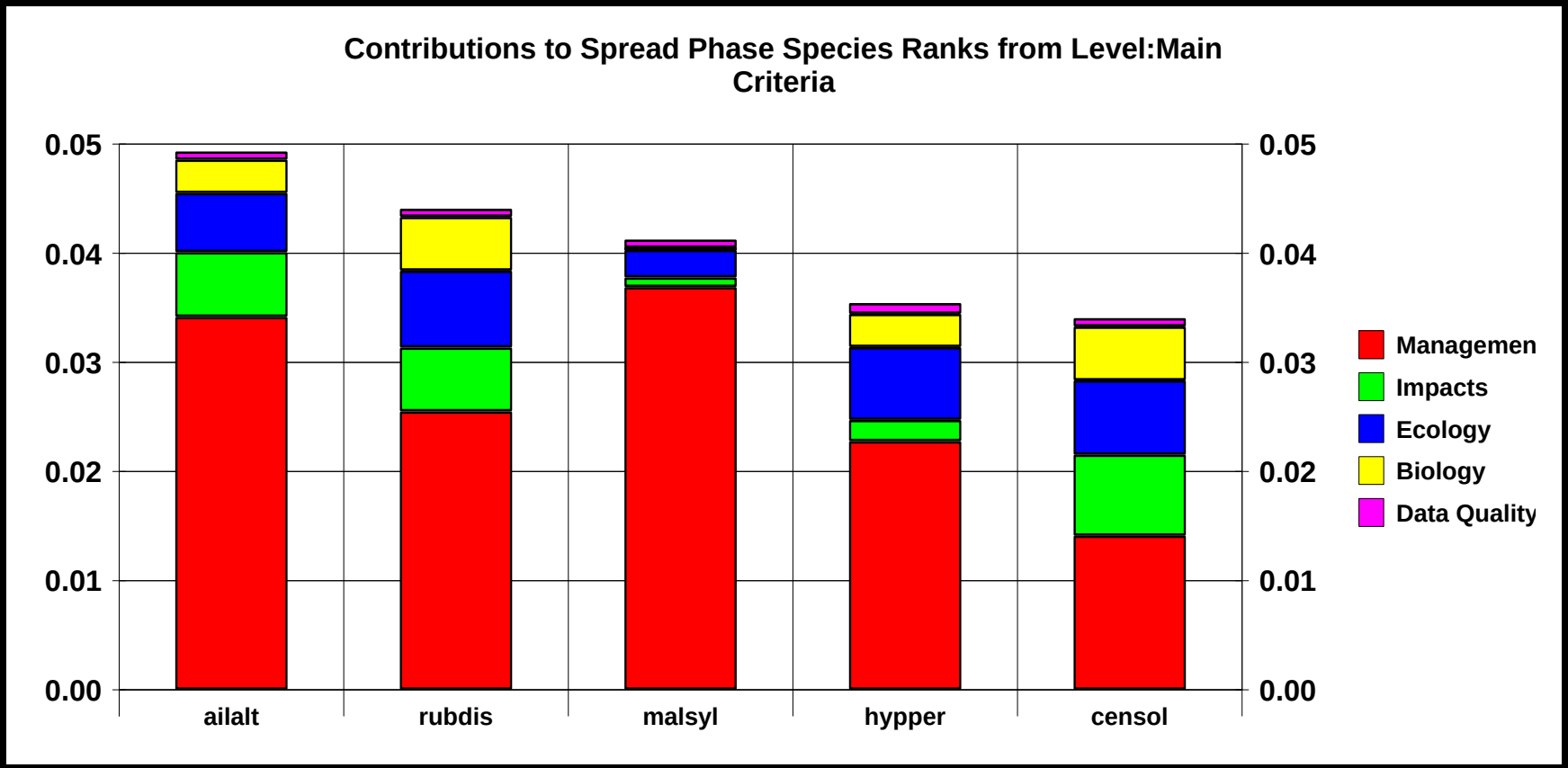
Sensitivity – Biology

WNRA – Spread Phase Species



Contributions to Scores

WNRA – Spread Phase Species



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