
Multi-Criteria Decision-Making
Using the Analytic Hierarchy
Process for Wicked Risk
Problems

Introduction

It has become more and more difficult to see the world around us in a uni-dimensional way and to use only a single criterion when judging what we see

Zeleny, M. 1982. Multiple Criteria Decision Making, McGraw-Hill, New York.

Introduction

Many regulatory problems involve multiple objectives and goals. For example:

chemical eradication measures for an exotic invasive species involves concerns such as:

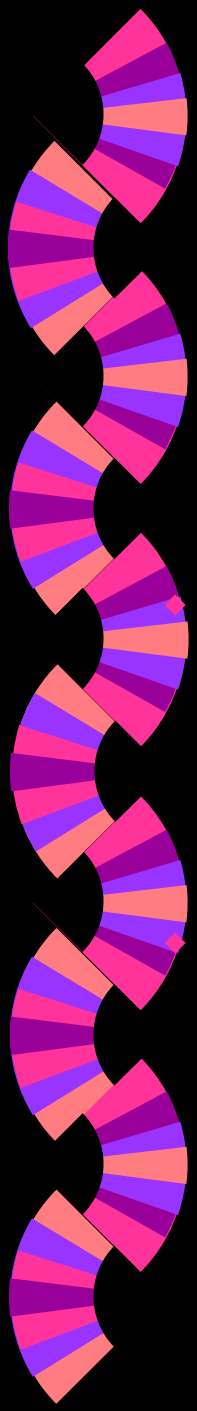
- Safety
- Health
- Environment
- Cost

Introduction

Another example:

How to prioritize the selection of organisms as the focus of:

- Survey activities, *e.g.*, CAPS
- Response documents, *e.g.*, NPRGs
- Recovery documents, *e.g.*, NPDRS



There is a potential problem with these endeavors:

How do you provide a means of

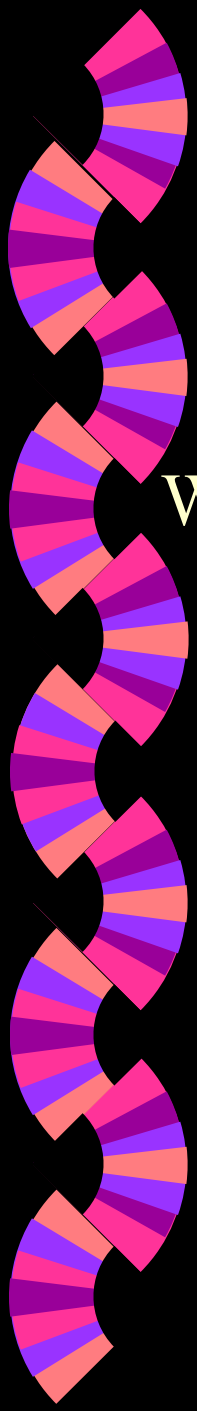
integrating/comparing performance measures and decision criteria with stakeholder and decision-maker values?

AND

Provide a means of communicating and comparing trade-offs for planning and further understanding?

***There are a number of multi-criteria methods that can be utilized to facilitate individual or group decision-making*:**

1. Analytic Hierarchy Process (AHP)
2. AHP Combined Method
3. Fuzzy AHP
4. Fuzzy AHP Combined
5. Fuzzy AHP Group
6. Group Evaluation Method
7. Weighted Sum Method (WSM)
8. Weighted Product Method (WPM)



We’ll focus on the Analytic Hierarchy Process (AHP)

AHP

AHP was first introduced by Thomas Saaty in 1970s.

The approach is to structure a problem as a hierarchy, or a set of integrated levels.

Problems are structured in at least three levels:

The goal: what will AHP measure, *e.g.*, prioritize organisms for survey activities

The criteria: elements integral to attaining the goal, *e.g.*, biological effects, economic effects, *etc*.

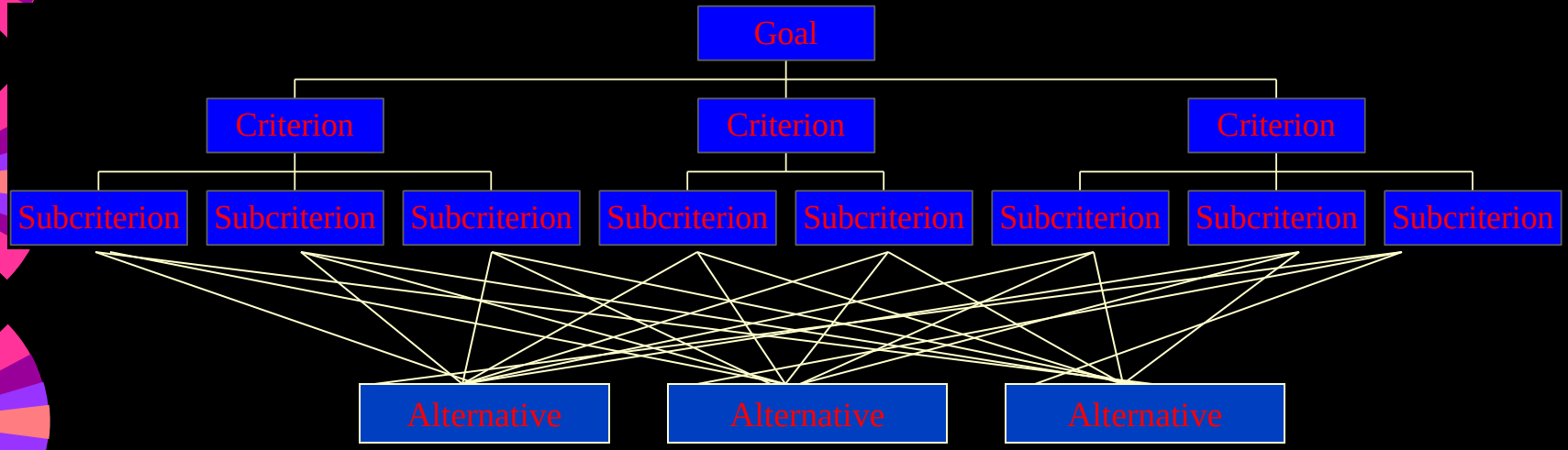
The alternatives: the organisms of concern

requires individual or group to provide judgments about relative importance of each criterion;

then specify a preference for each alternative on each criterion.

AHP Step 1: Forming the Hierarchy

- The first step in the AHP is to develop a graphical representation of the problem in terms of a goal, criteria, and alternatives.



Pairwise Comparison

- The next step is to make pair-wise comparisons, *i.e.*, compare the elements in pairs against a given sub-criterion or criterion.
- To compare elements, ask: how much more (less) strongly is this element preferred than the element with which it is being compared?
- The AHP employs a scale with values from 1 to 9 to designate the relative preference of one element over another.

Criterion 1, 2, . . .	Alternative 1	Alternative 2	…	Alternative n
Alternative 1	A_1/A_1	A_1/A_2	…	A_1/A_n
Alternative 2	A_2/A_1	A_2/A_2	…	A_2/A_n
…	…	…	…	…
Alternative n	A_n/A_1	A_n/A_2	…	A_n/A_n

Pairwise Comparisons

Preference Scale	Numerical Rating
Equally preferred	1
Equally to Moderately preferred	2
Moderately preferred	3
Moderately to Strongly preferred	4
Strongly preferred	5
Strongly to Very Strongly preferred	6
Very Strongly preferred	7
Very Strongly to Extremely preferred	8
Extremely preferred	9

The 9-point pair-wise comparison scale:

- X to Y = 1 Equal importance
- X to Y = 3 X moderately favored
- X to Y = 5 X strongly favored
- X to Y = 7 X clearly dominant
- X to Y = 9 X super dominant

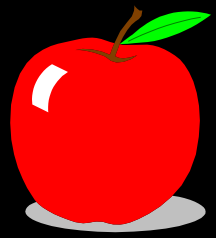
Note: X to Y = 3 implies Y to X = 1/3

Use reciprocals for inverse comparisons; Weights can be used instead of 1-9 scale.

WEIGHTS

- The AHP uses eigenvalues and eigenvectors to compute criteria, sub-criteria, and alternative weights for each factor based on the pairwise comparisons.

- Final alternative weights are determined using a simple weighted average computation.



Apple A

Apple B

Apple C

Three apples of different (but known) sizes*. Assess their relative sizes by forming ratios.

Size Comparison*	Apple A	Apple B	Apple C
Apple A	S_A/S_A	S_A/S_B	S_A/S_C
Apple B	S_B / S_A	S_B / S_B	S_B / S_C
Apple C	S_C / S_A	S_C / S	S_C / S_C

* A is 2x larger than B, and 6x larger than 3

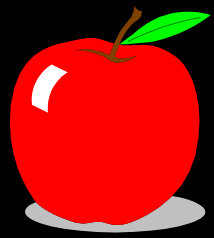
Size

Apple A | Apple B | Apple C

Size Comparison	Apple A	Apple B	Apple C	Relative Priority	Relative Size of Apple
Apple A	1	2	6	0.6	A
Apple B	1/2	1	6/2	0.3	B
Apple C	1/6	2/6	1	0.1	C

CONSISTENCY

Consistency of judgments can also be measured (important when three or more items are being compared).



We saw previously that Apple A was 2x larger than Apple B, and 6x larger than Apple C.

To be perfectly consistent, Apple B must be 3x larger than Apple C.

AHP does not require perfect consistency. However, it does provide a measure of consistency.

AHP Software

Decision Lens

Expert Choice

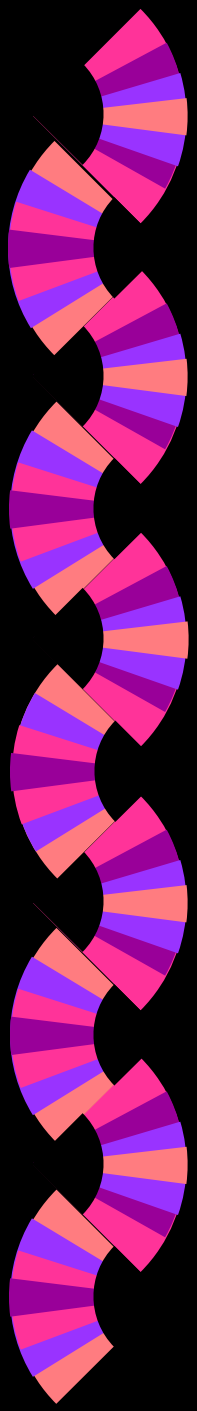
As decision support tools, these programs help with the creation of the hierarchy, synthesis of priorities, and checking consistency. Also have the capability of conducting sensitivity analysis (measuring the impact that changes to the criteria weights have on the final alternative weights).

AHP Advantages

- Unity – can construct single, easily understood, flexible models for a broad range of unstructured problems.
- Complexity - integrates deductive and inductive reasoning in solving complex problems.
- Interdependence – elements can be interdependent.
- Hierarchic Structuring – utilizes the natural tendency of people to sort elements of a system into different levels and to group like elements.
- Measurement – can utilize a scale for measuring intangible elements; provides a method for establishing priorities.

AHP Advantages (cont.)

- Consistency - does not require judgments to be consistent.
- Synthesis – determines the relative importance of the criteria in meeting a goal.
- Trade-offs – considers the relative priorities of factors in a system; enables decision-makers to select the best alternative based on their goals.
- Judgment and Consensus - does not require consensus; synthesizes a representative outcome from diverse judgments.
- Process Repetition - enables the refinement of the definition of a problem; improves judgment and understanding through repetition.



Using AHP, you can actually compare apples and oranges. . .

Thank you.

Questions