EMDS 4.0

a modeling framework for coping with complexity in ecosystem assessment and environmental planning

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Version history

- Version 1, ArcView 3
  - ✓ 1997, USFS Research, Northwest Forest Plan
- Version 2, ArcView 3
  - ✓ 1998, USFS Research, EPA OR&D, USFS EMC (WO)
- Version 3, ArcMap 8 through 9.1
  - ✓ 2002, v3.02, Natural Resource Information System (WO)
  - ✓ 2004, v3.1, EMDS consortium (Redlands Institute)
  - ✓ 2007, v3.2, EMDS consortium (Redlands Institute)
- Version 4, ArcEngine and ArcMap
  - ✓ January 2009, EMDS consortium (Redlands Institute)

Development consortium

- PNW Station
  - ✓ System design & project oversight
- Redlands Institute
  - ✓ ArcGIS implementation
- Rules of Thumb, Inc.
  - ✓ NetWeaver logic engine and OCX
- InfoHarvest, Inc.
  - ✓ Priority Analyst engine and OCX

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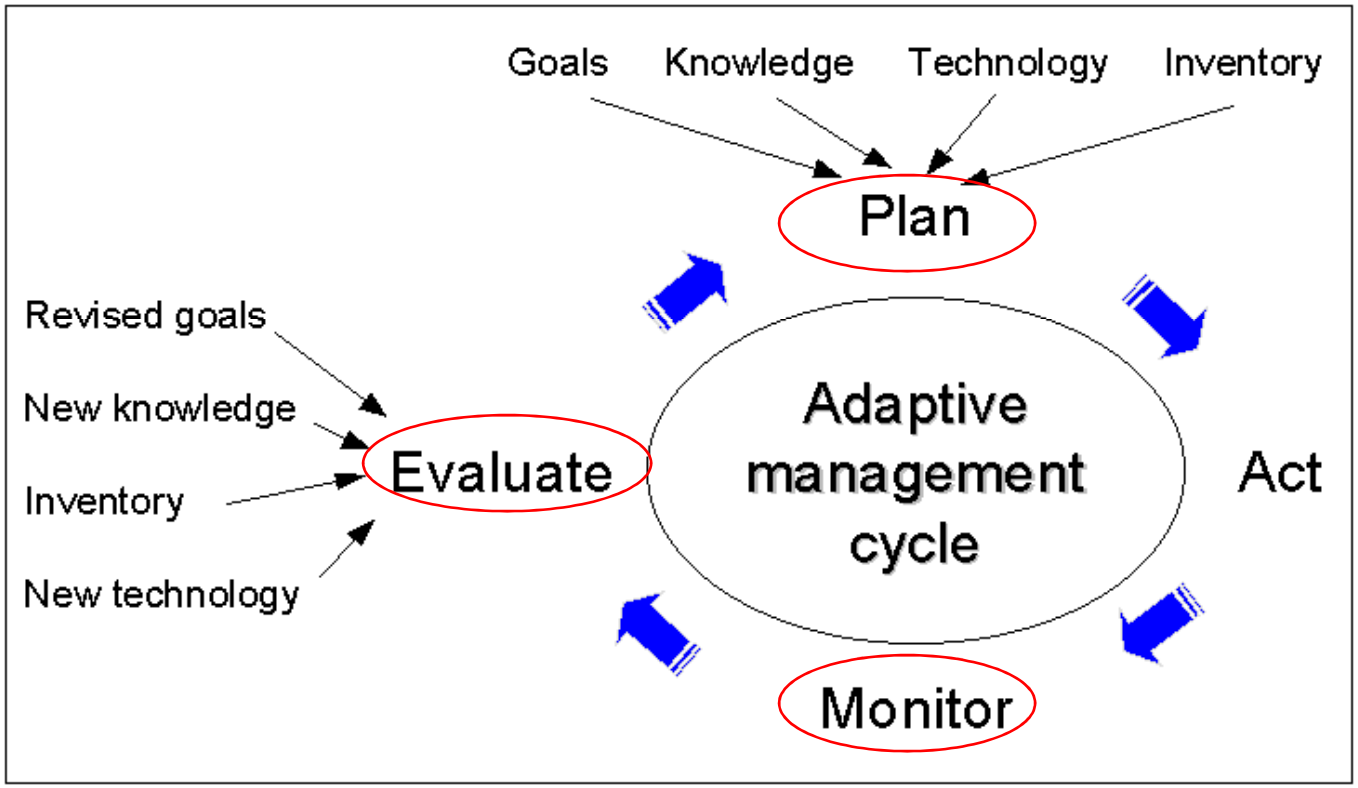
Design objectives

1. Improve the efficiency with which landscape evaluation is conducted
   a) Optimize use of information
2. Improve the quality of evaluation products
   a) More comprehensive analysis
   b) Better integration of diverse topics
3. Integrated support for planning

Integrated evaluation and planning

- Evaluation within scale
  - ✓ Concurrent evaluation of possibly numerous states and processes within a single analysis
- Across scale
  - ✓ Explicit linkage of evaluations across spatial scales
  - ✓ Comparing evaluations over time
- Across phases of adaptive management
  - ✓ Going from landscape evaluation to planning

EMDS in adaptive management



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Version 4.0 implementation

- ArcGIS 9.2 and 9.3 (Environmental Systems Research Institute)
  - ✓ Standalone interface to ArcEngine
  - ✓ ArcMap extension
- Microsoft Windows XP and Vista
  - ✓ Microsoft .Net
- Major components
  - ✓ Project environment (core)
  - ✓ Logic engine (logic-based evaluation)
  - ✓ Hotlink tool (intuitive graphic explanation)
  - ✓ Data Influence and Priority Manager (priority of missing data)
  - ✓ Priority Analyst (priority setting in planning)

Logic models

- A form of meta database
- A formal logical representation of how to evaluate information
- Networks of interrelated topics
- Mental map

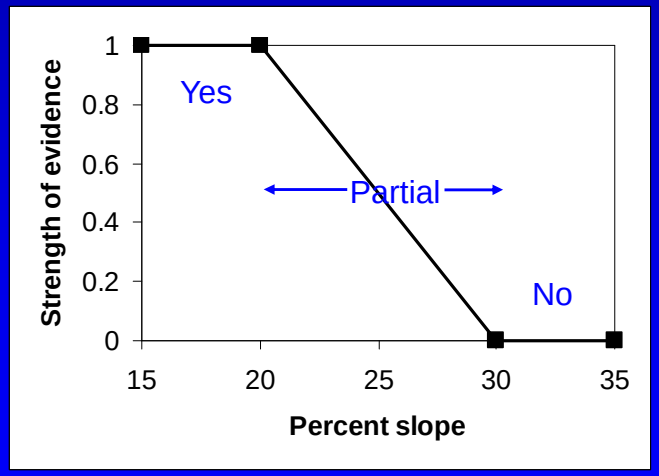
Logic models: forms of uncertainty

- Probabilistic uncertainty
  - ✓ Uncertainty of events
- Linguistic uncertainty
  - ✓ Uncertainty about the definition of events
    - Vagueness or imprecision
  - ✓ A proposition is the smallest unit of thought to which one can assign a measure of truth (strength of evidence)
  - ✓ SE: a measure that quantifies the degree of support for a proposition provided by its premises

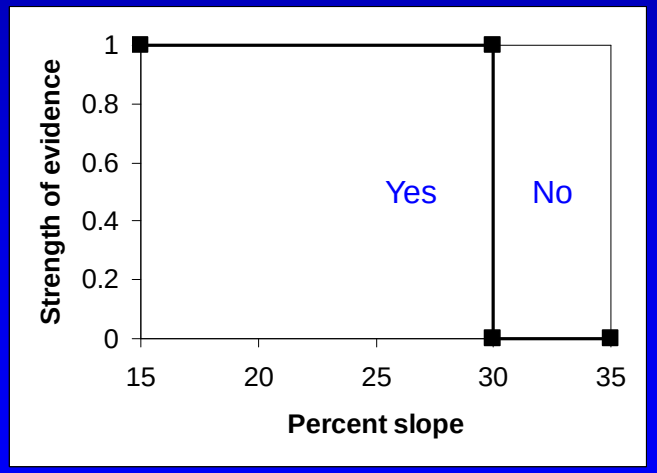
Logic models: strength of evidence

An example: strength of evidence for suitable slope for tractor logging.

Degrees of support



Bivalent reasoning



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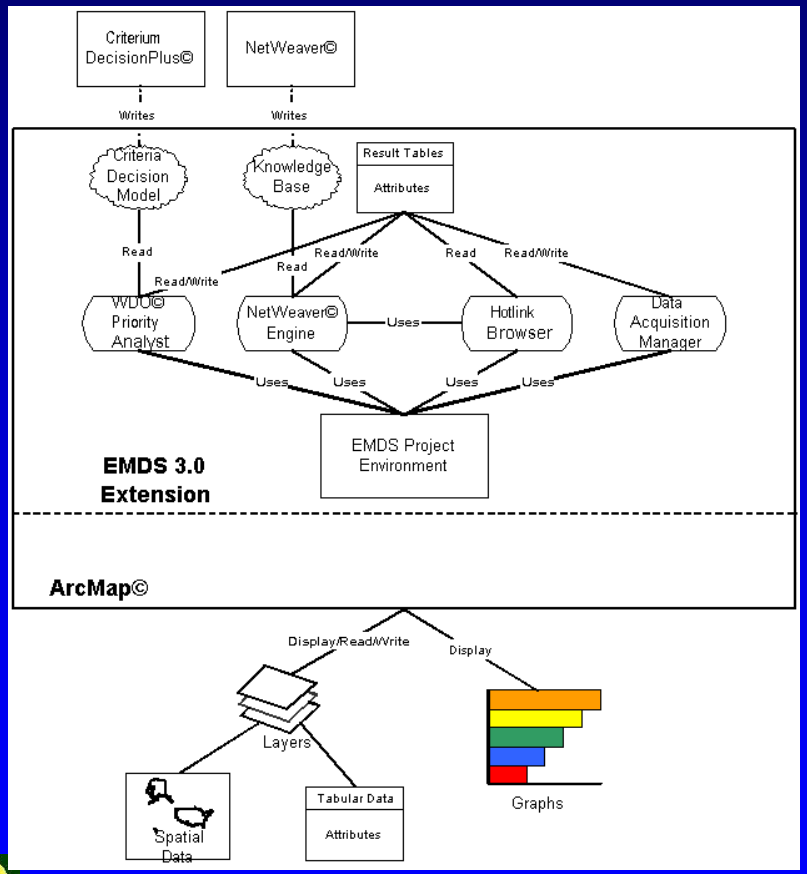
Project environment



NetWeaver Developer (Rules of Thumb) and Criterium DecisionPlus (InfoHarvest) are external development tools needed to create logic models and decision models, respectively.

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Project environment interface

- Create and manage EMDS projects.
- View and edit EMDS projects notes (meta data).
- Select GIS layers to include in an assessment
- Define a Study Area.
- Select a logic model.
- Select topics for evaluation.
- Evaluate an analysis or scenario.
- Review results of an analysis or scenario in maps, tables, and graphs.
- Launch Data Influence and Priorities Manager, Hotlink Browser, and Priority Analyst.

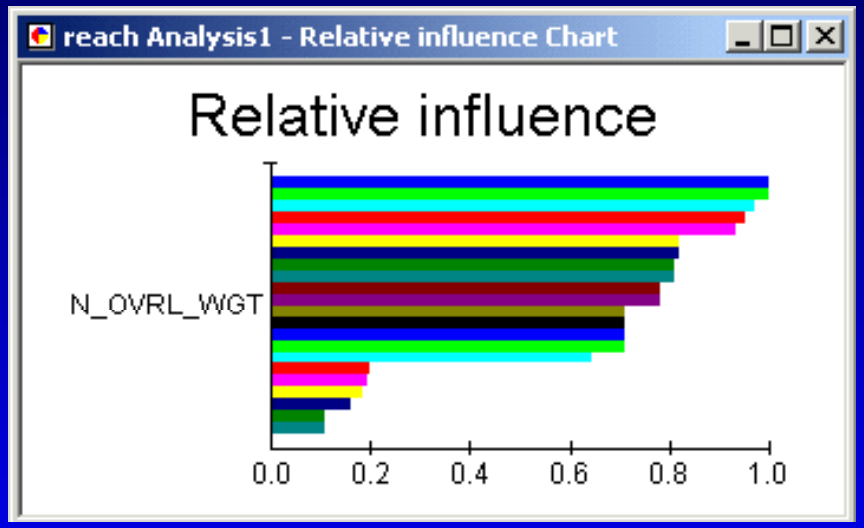
Project structure

- Project hierarchy
  - ✓ Multiple scales of assessment
  - ✓ Multiple analyses within assessments
  - ✓ Multiple scenarios within analyses

NetWeaver logic engine

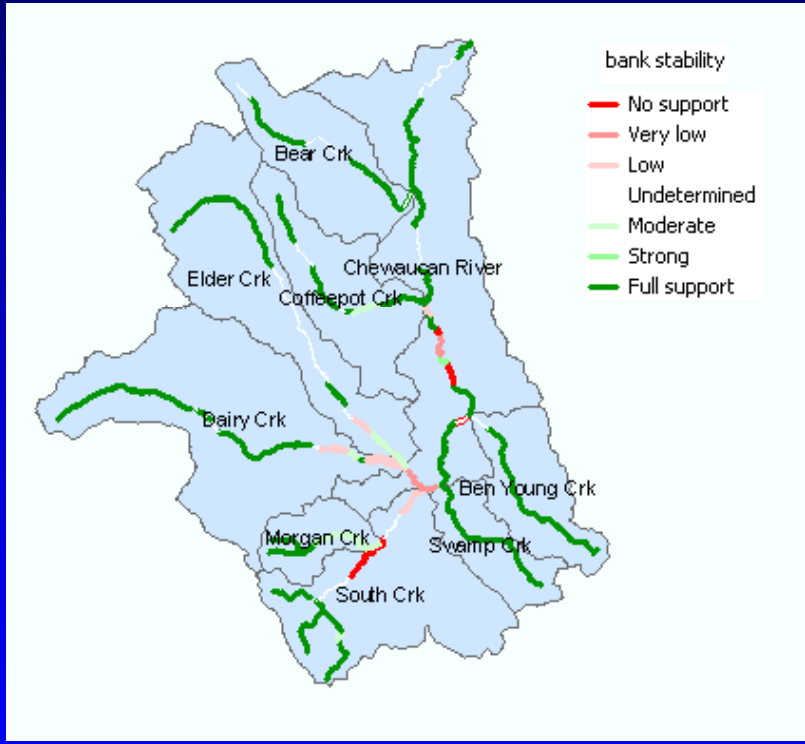
- Evaluations of landscape condition performed with this engine.
- Data input to the engine is mediated by the EMDS Project Environment.
- The engine
  - ✓ supports design of logic specifications for the types of large, complex, and abstract problems typically posed by ecosystem management,
  - ✓ evaluates data against a knowledge base that provides a formal specification for interpretation of data, and
  - ✓ allows partial evaluations of ecosystem states and processes based on available information.
    - Ideal for use in landscape evaluation where data are often incomplete.

Dealing with missing data



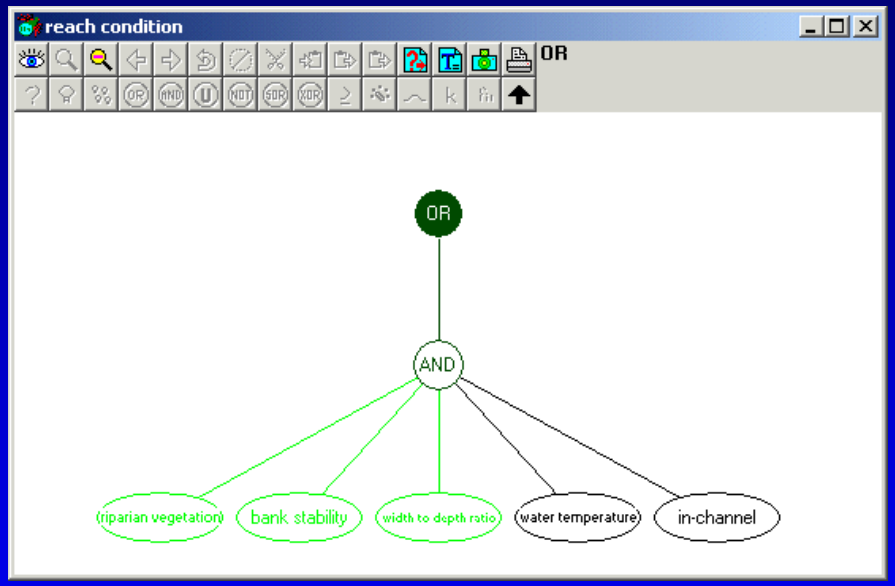
- Data are treated as evidence.
  - ✓ Missing data are treated as lack of evidence.
- The logic engine can evaluate the influence of missing information on the logical completeness of an analysis.
  - ✓ One component for determining priority of missing data.

Map products



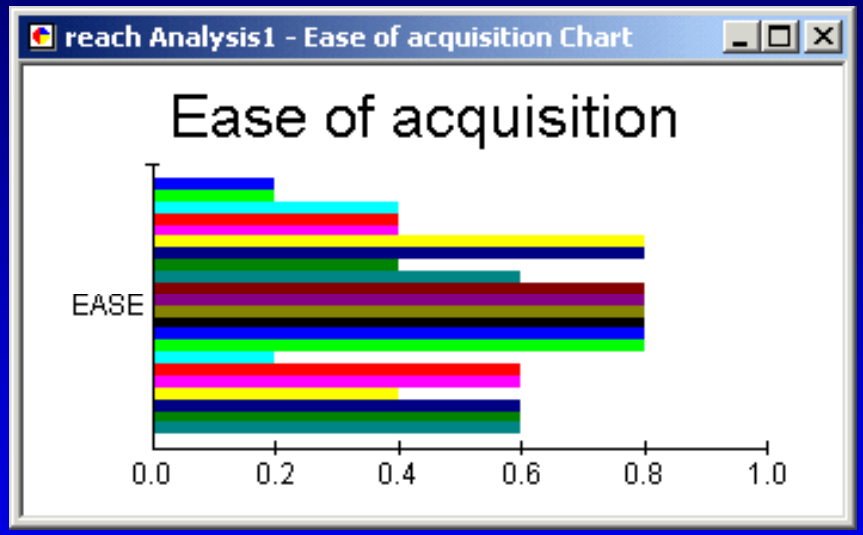
- Basic EMDS output is maps.
- Symbology displays strength of evidence for a conclusion.
- Advantage of a logic-based solution.
  - ✓ **Not** a "black box."

Hotlink browser: explaining results



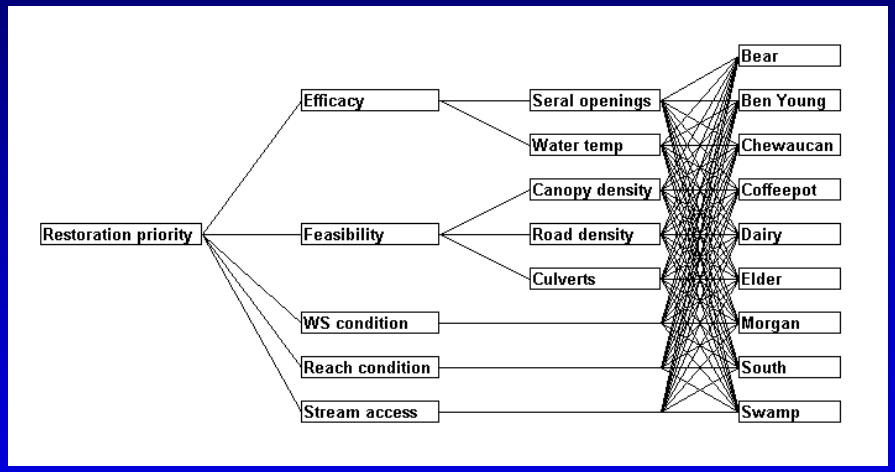
- Used to view the evaluated state of a logic model for a selected map feature.
- The graphic display of the evaluated state of a knowledge base is relatively intuitive.
- Provides a detailed explanation of the derivation of conclusions.
  - Valuable to EMDS developers, users, and the general public

Data Influence and Priorities



- Data gaps are common in early stages of landscape evaluation.
- Influence of missing information is very dynamic.
- The DIP
  - ✓ summarizes the influence of missing information, given the information that is currently available, and
  - ✓ assists with establishing priorities for obtaining missing data to improve the logical completeness of an analysis in the most efficient way.

Priority Analyst (PA)



- PA is a Multi-Criteria Decision Analysis (MCDA) component
  - ✓ Assists in ranking landscape elements, based on how well each rates against a set of decision criteria.
- Uses output from the landscape evaluation and a decision model.
- Rates landscape elements with respect to
  - ✓ their condition, and
  - ✓ factors related to the feasibility and efficacy of management.

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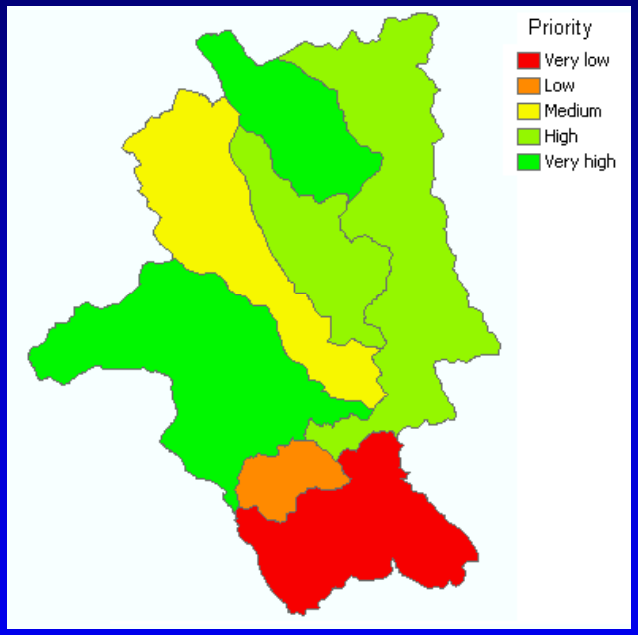
Priority analyst output

Decision: Restoration priority

Alternatives	Value	Decision Scores
Dairy	0.45	
Bear	0.42	
Elder	0.39	
Ben Young	0.34	
Swamp	0.30	
Morgan	0.25	
South	0.22	
Chewaucan	0.21	
Coffeepot	0.20	

0.00 Decision Score 0.53

Aspatial output



Spatial output

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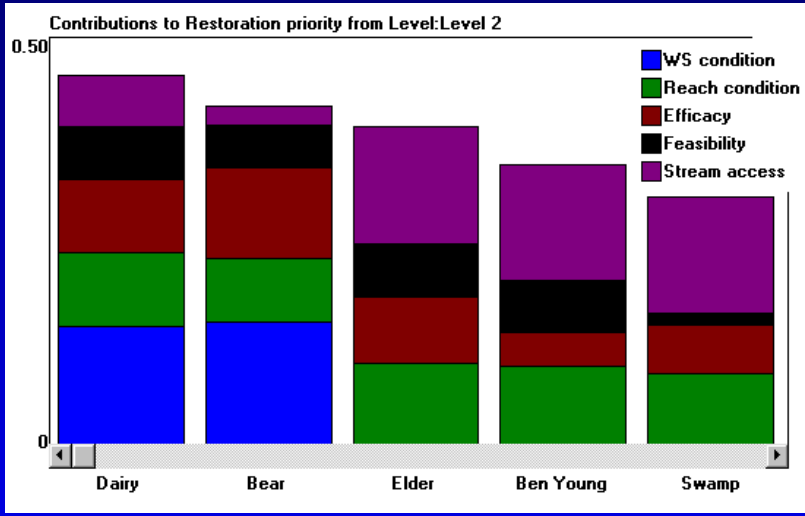
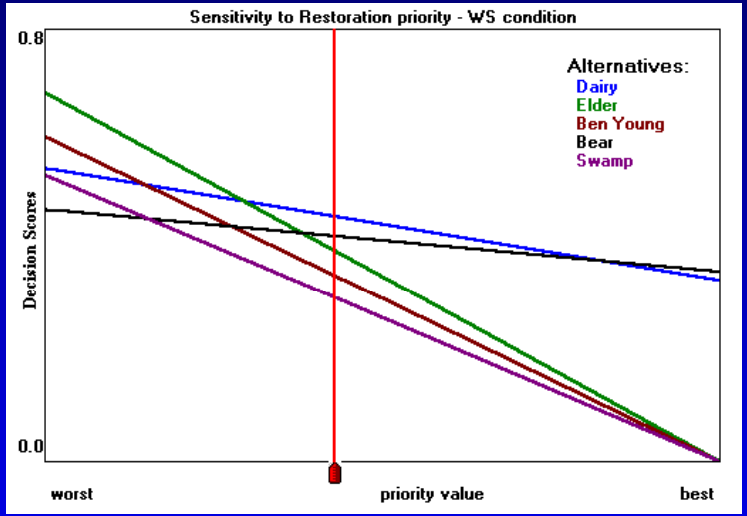
Priority analyst diagnostics



How primary criteria in a decision model contribute to the total priority score for a watershed.



In this example, a 13.4% change in the weight on the WS condition criterion would lead to a change in ordering of priorities.

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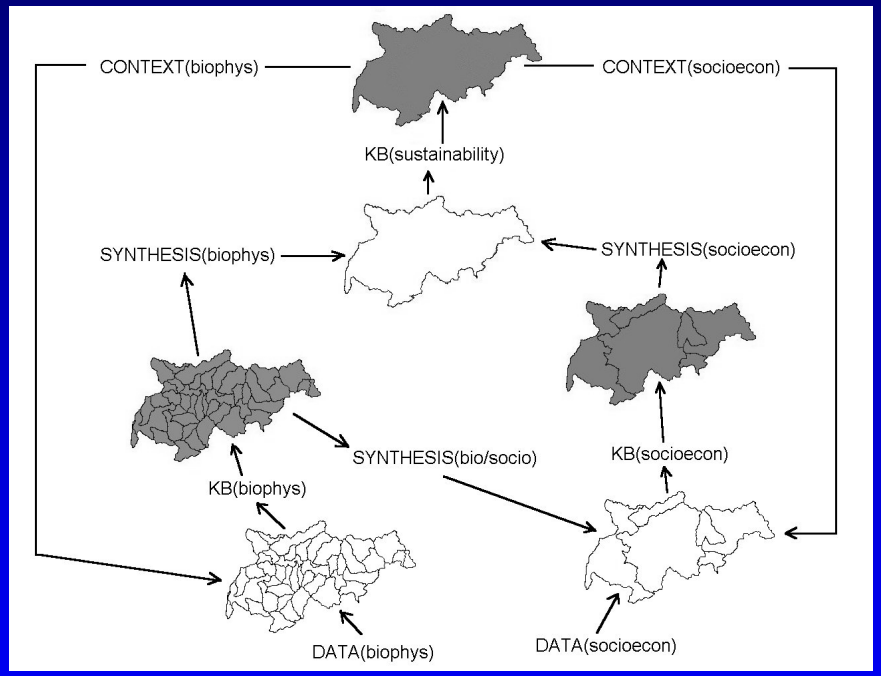
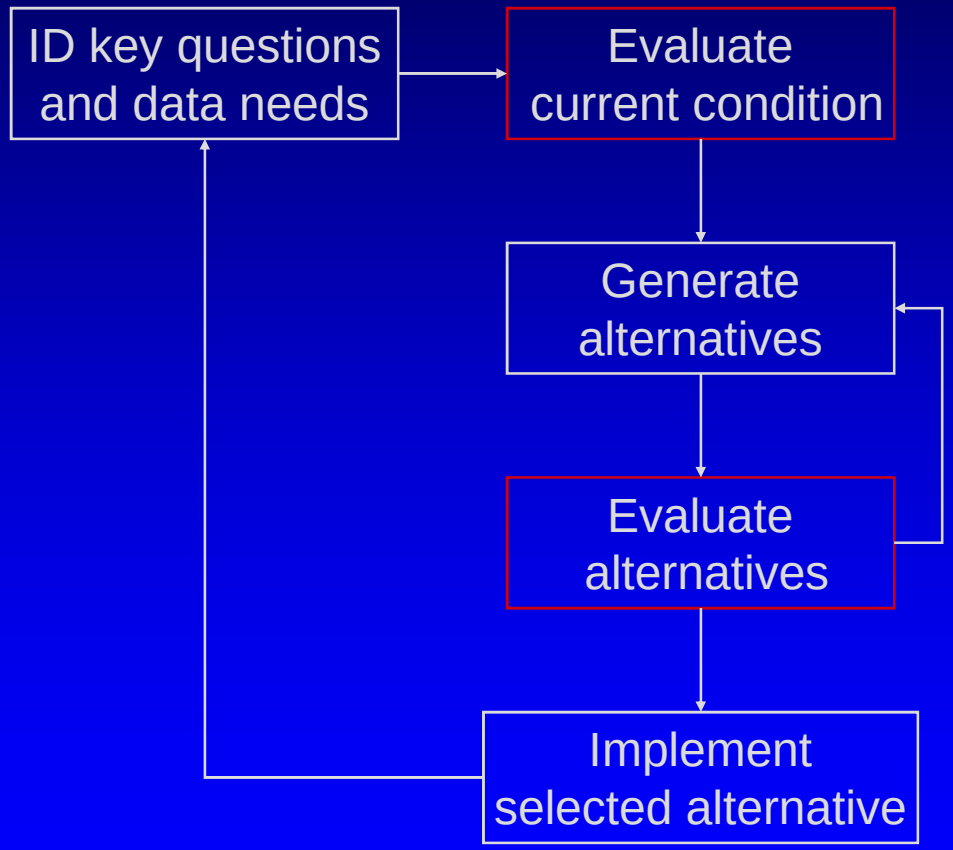
Linking multiple spatial scales



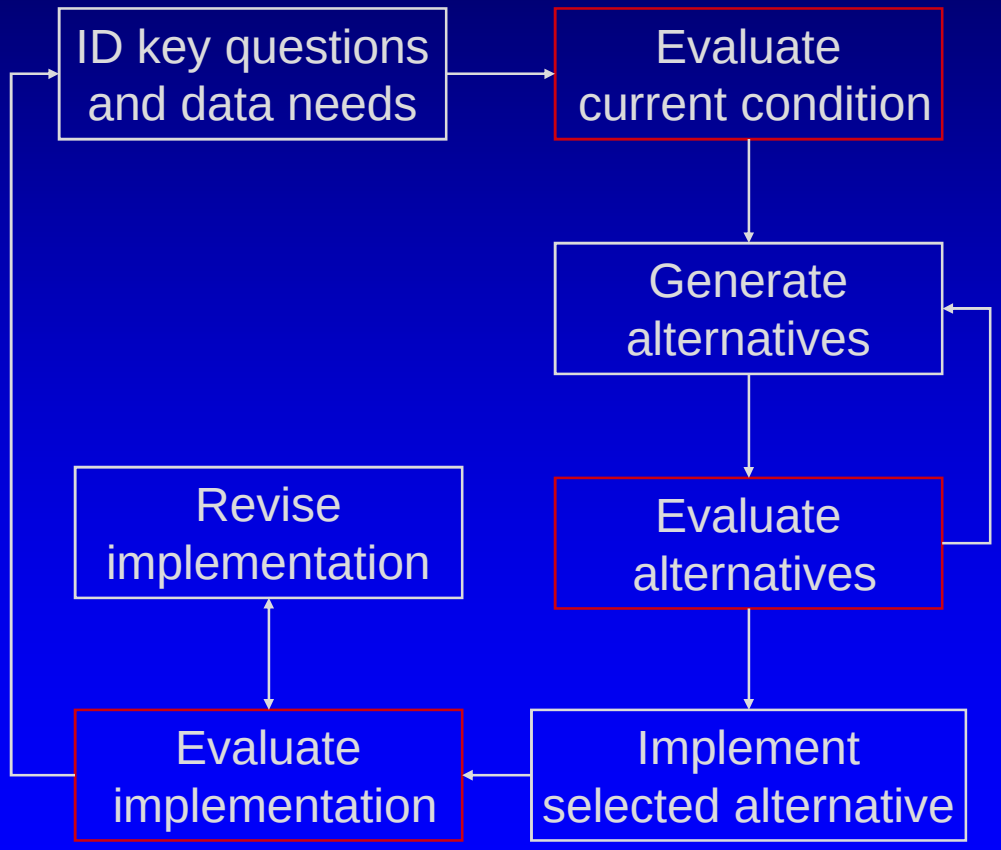
- Basic approach: summarize information from one scale in a manner that makes the information applicable at another scale.
- In general, some type of transformation of information is needed when moving information from one scale of evaluation to the next.

Classic planning process



Each planning cycle is more or less independent of the previous one.

Adaptive planning



Plan is evaluated at shorter intervals than in classic model, allowing incremental adjustments that may extend life of plan.

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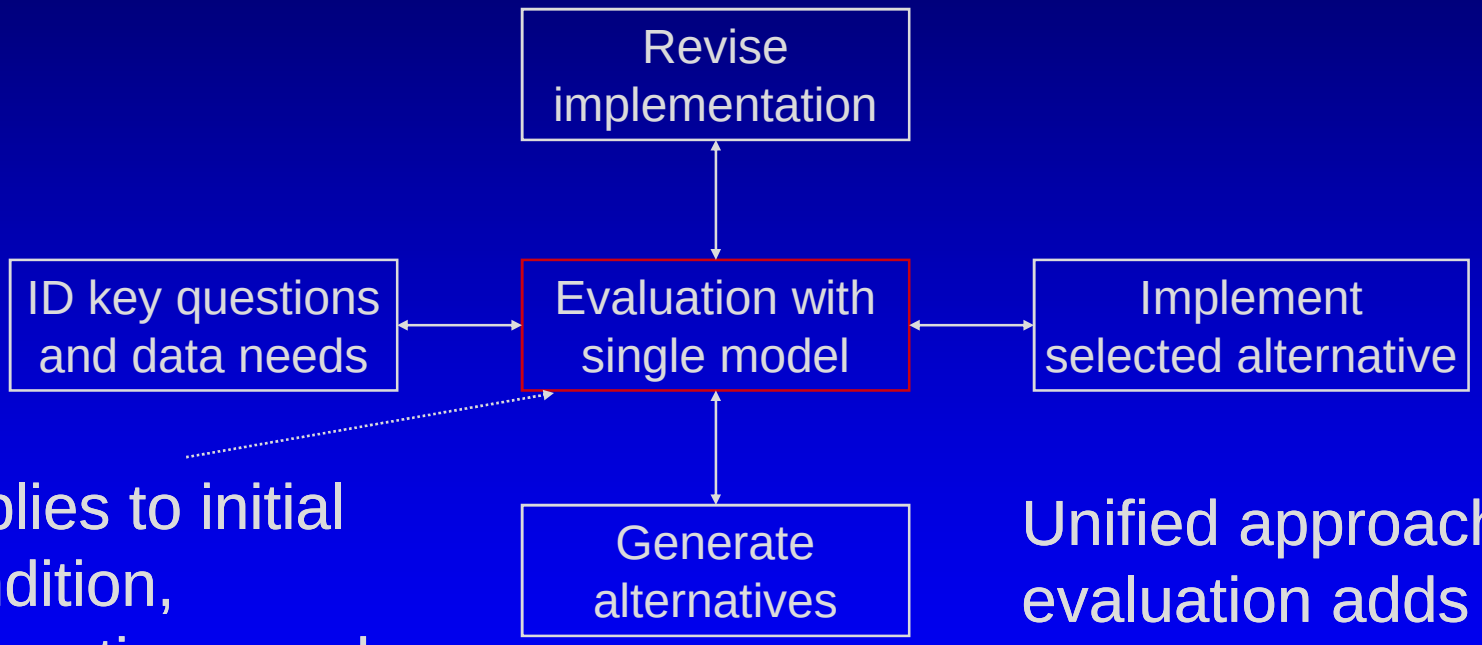
Adaptive, coherent planning (EMS, ISO 14001)



Applies to initial condition, alternatives, and plan performance.

Unified approach to evaluation adds coherence through institutional memory.

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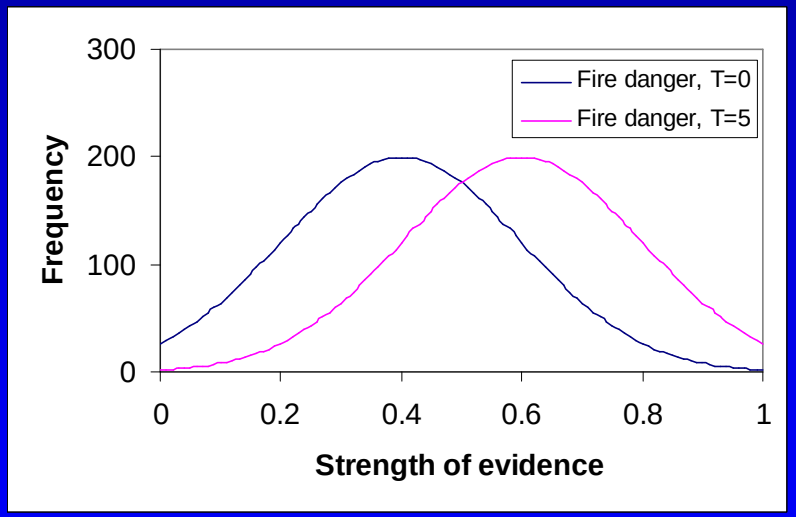
A single unified model for planning

1. Assess current condition
   - ✓ Context for planning (where are we starting from?)
2. Evaluate alternative strategies
   - ✓ A framework for synthesizing results of projections
   - ✓ Harvest scheduling, vegetation modeling, etc.
3. Priority Analyst for more tactical decisions
   - ➢ Which activities to do where?
4. Evaluate plan implementation
   - ➢ How well is the plan working?

Outputs versus outcomes

- Change in performance standards of federal agencies
  - ✓ Old (outputs): acres treated per year
  - ✓ New (outcomes): acres of reduced fire danger per year
- New planning rule and EMS
- Adaptive management (ISO 14001)
  - ✓ Hypothesis testing
  - ✓ Shift in distribution of outcomes?



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