Open Decision Support

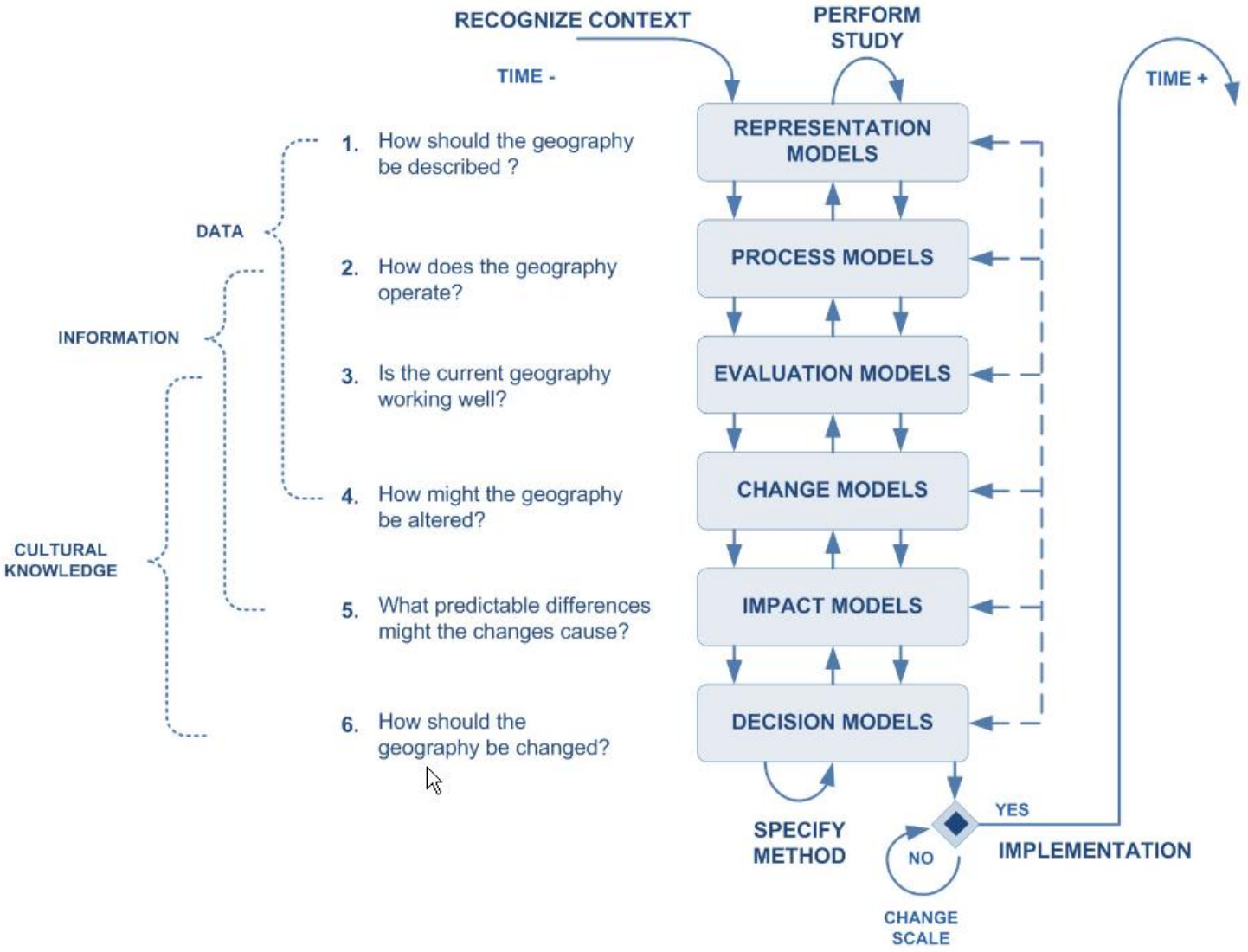
eScience: Open Data for Open Science

(Spatial) Decision Support

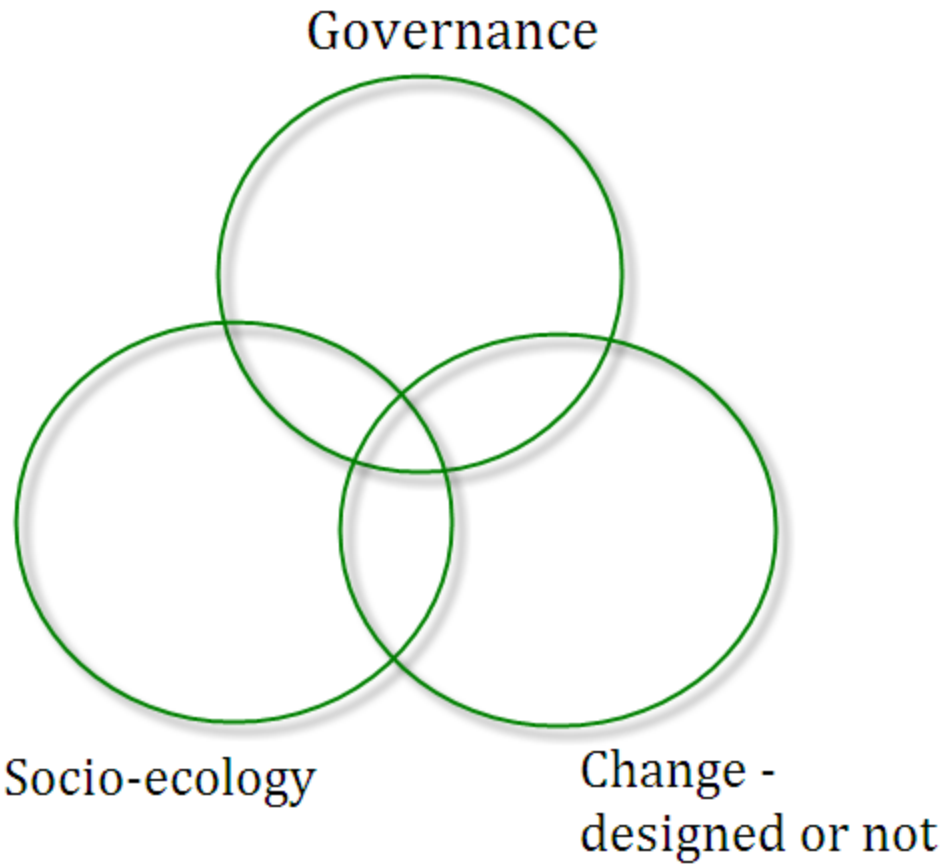
Using best available science to support decisions that will change the landscape.

http://www.spatial.redlands.edu/sds

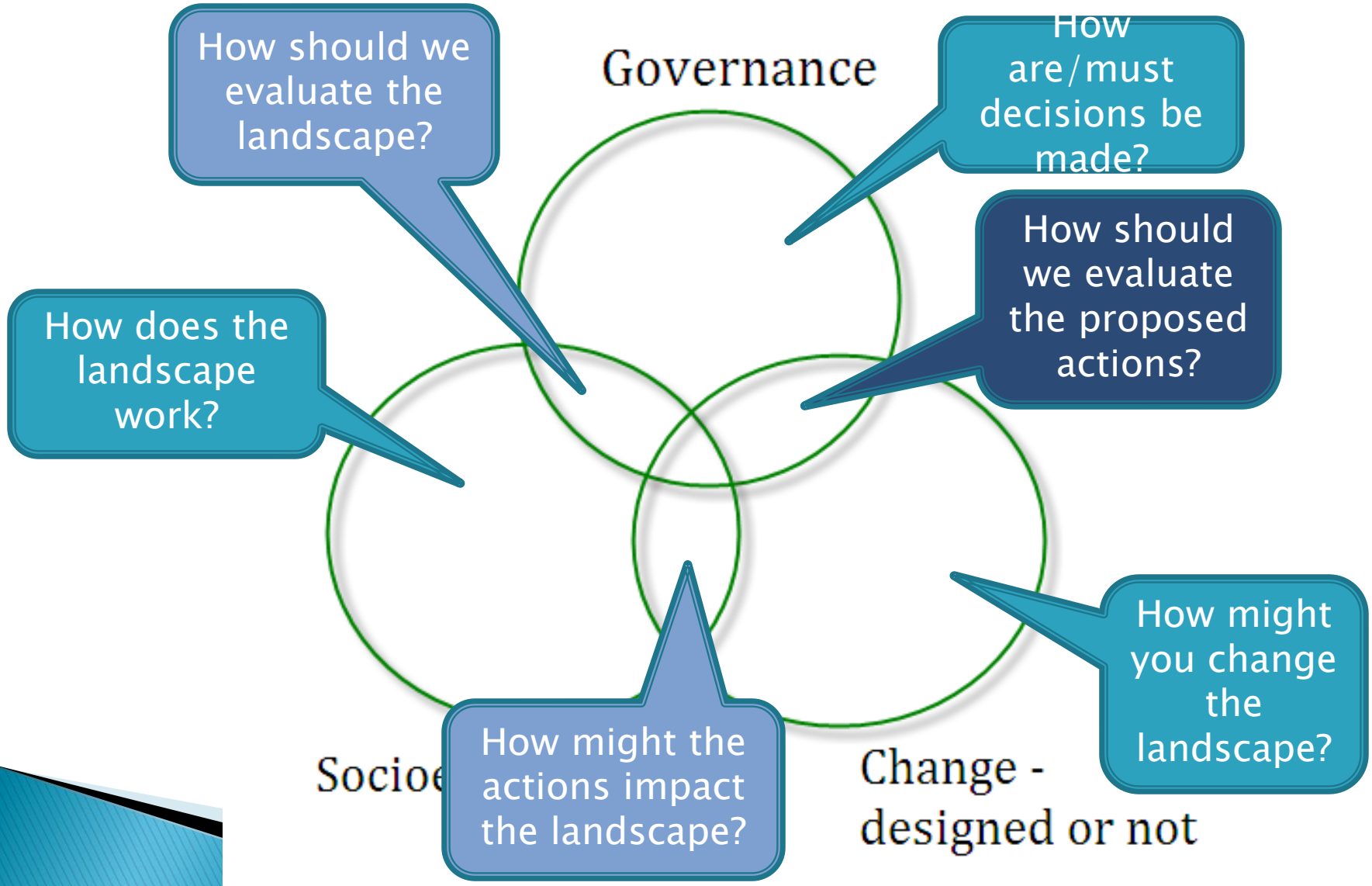
Steinitz Process/Workflow



Planning Support Venn view



Planning Venn/Steinitz



How does SDS synthesize w. eScience?

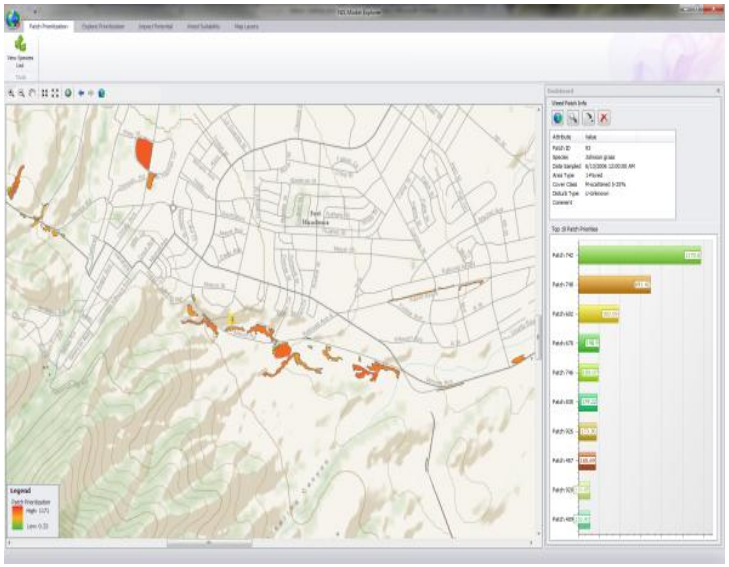
- Can't work without eScience describing the processes and state of the socio-ecology**
- Very focused on decisions about intentional actions (but has to accommodate external actions)
- Change models/representation must be integratable with socio-ecology system models
- Both need to be validated & uncertainty estimated
- Computation is key

How does SDS differ from eScience?

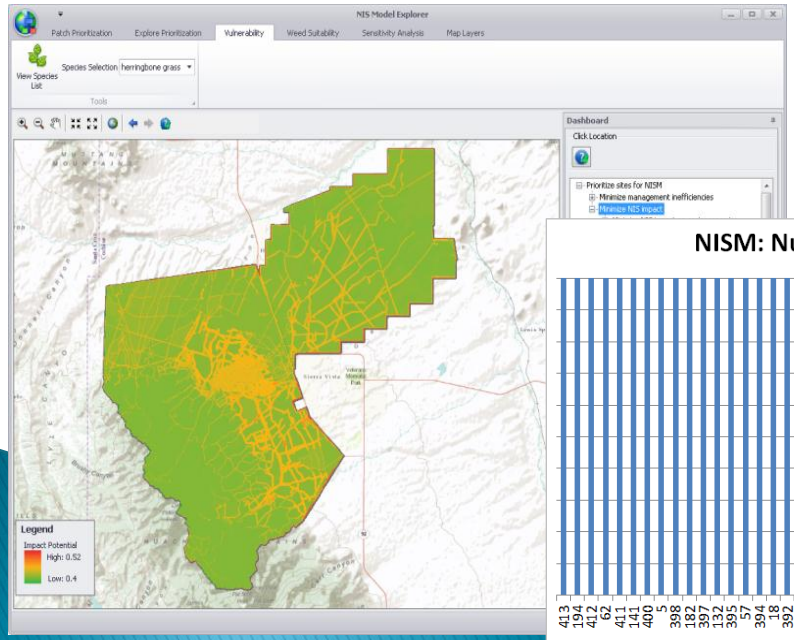
- Governance (Cultural) Models explicit: Evaluation and Action Decision models
- Type II errors often less acceptable than Type I errors – the need to act while still time
- SDS even more likely to be X-discipline
- Can be more directly experimental >> adaptive management, but…
- Can require even longer timescales to validate
- Decision Efforts are often episodic

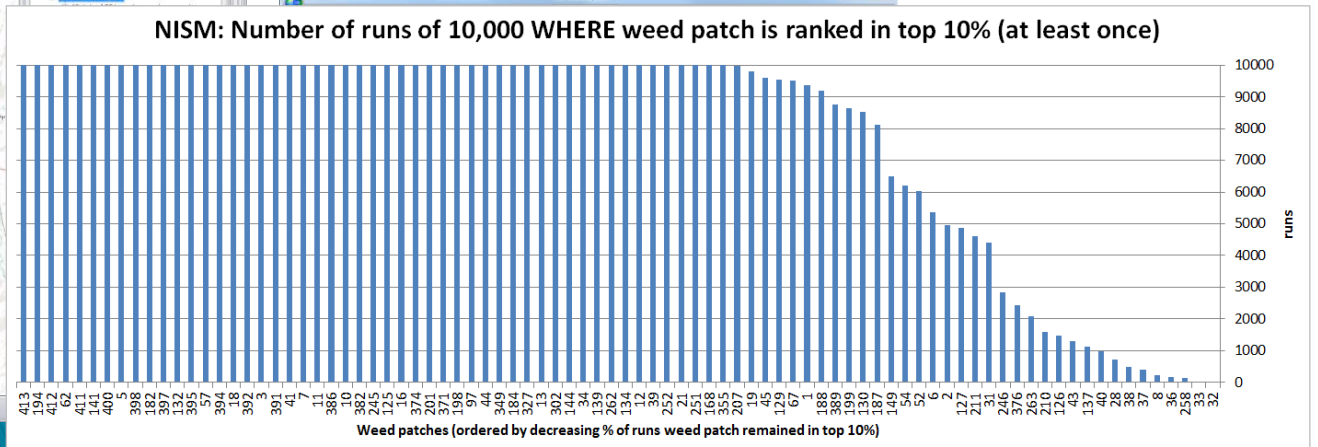
II. Examples of SDSs

1: Non-native Invasive Species Management

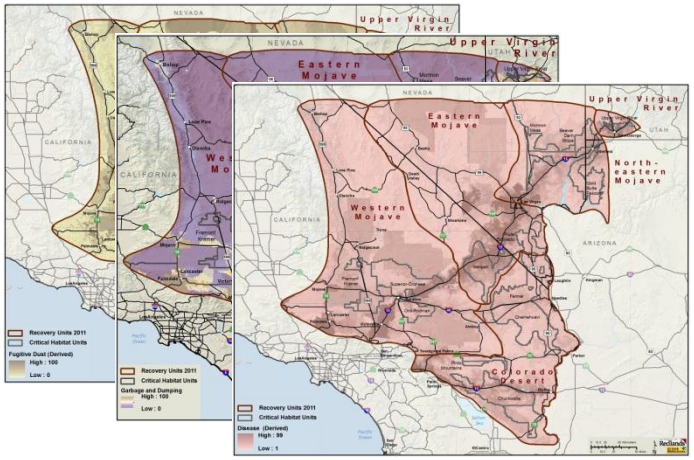


- Data: Curated from Installation datasets
- Model = Threat & Vulnerability & Importance
  - Geo processing of standard weed models
  - Expert Assessment of Resource Vulnerability
  - Operational Expert Evaluation of Resource Importance Key Features
  - Weed propagation forecasting
  - Dashboard like rendering
  - (Spatial) Drill down



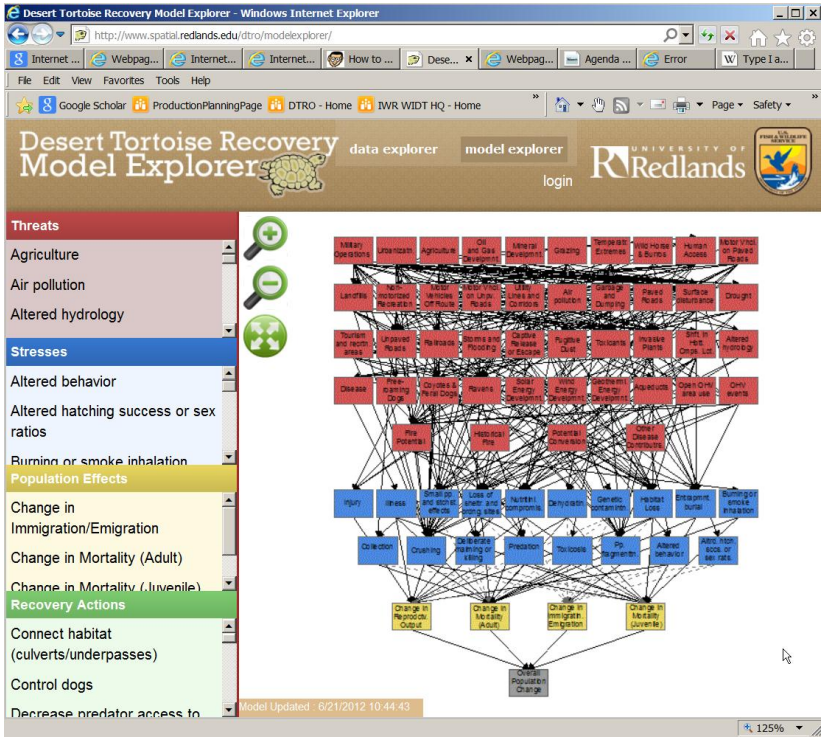


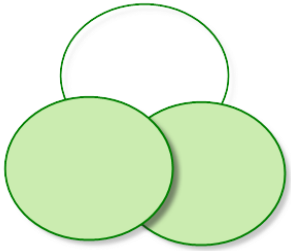
2: Desert Tortoise Recovery Action Prioritization

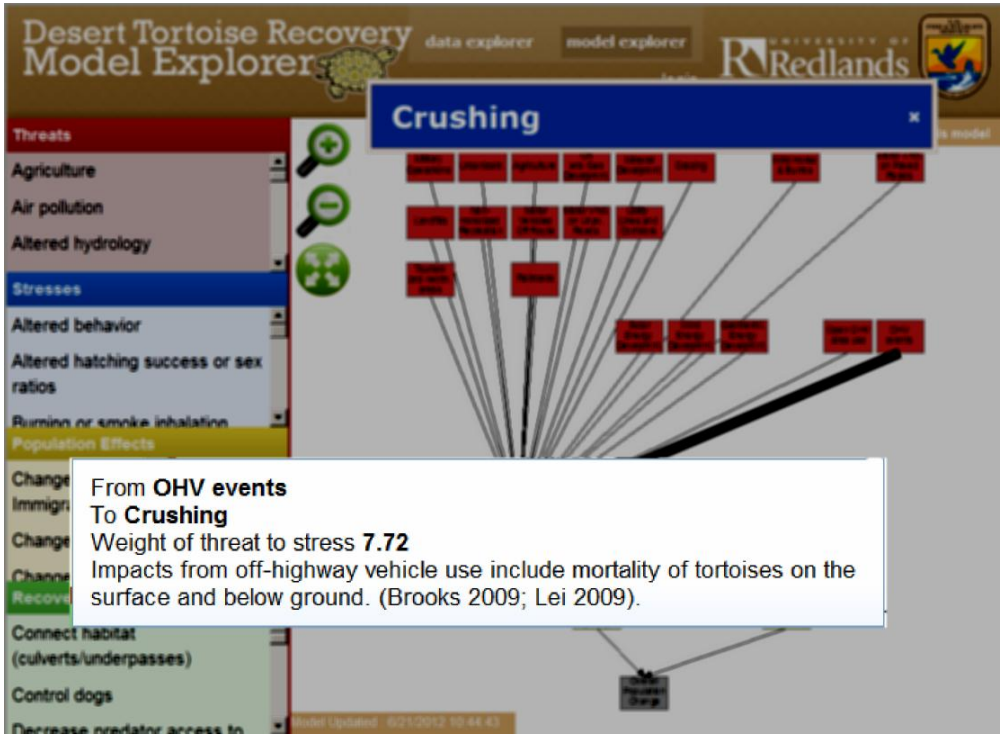


- Data Curated from multiple sources, published to web as web services
- Model: Risk to DT Recovery = Pop Change Risk x Population Density
  - Threat > Stress > Demographic weights > Pop Chang
  - Threats can also drive other threats – calculated
- Recovery Actions suppress (Threats > Stresses) links
  - Reduction of threat effects > Reduction in Pop Change Risk
- Key Features
  - Recovery Actions explicitly target Threat-Stress mechanisms
  - Sensitivity Analysis + Uncertainty in Data and Expert Opinion > Error Bars

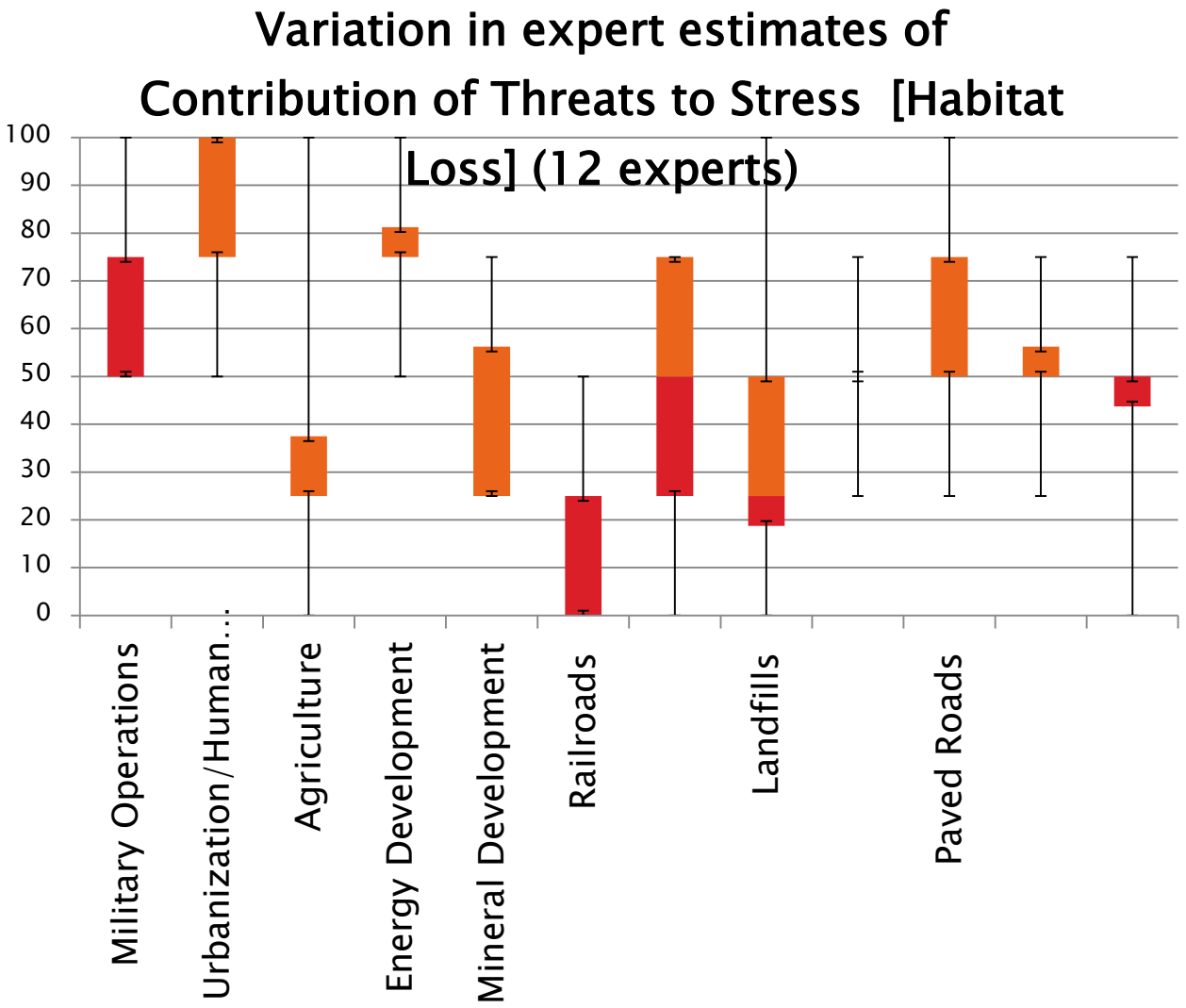
2: Desert Tortoise Recovery Action Prioritization





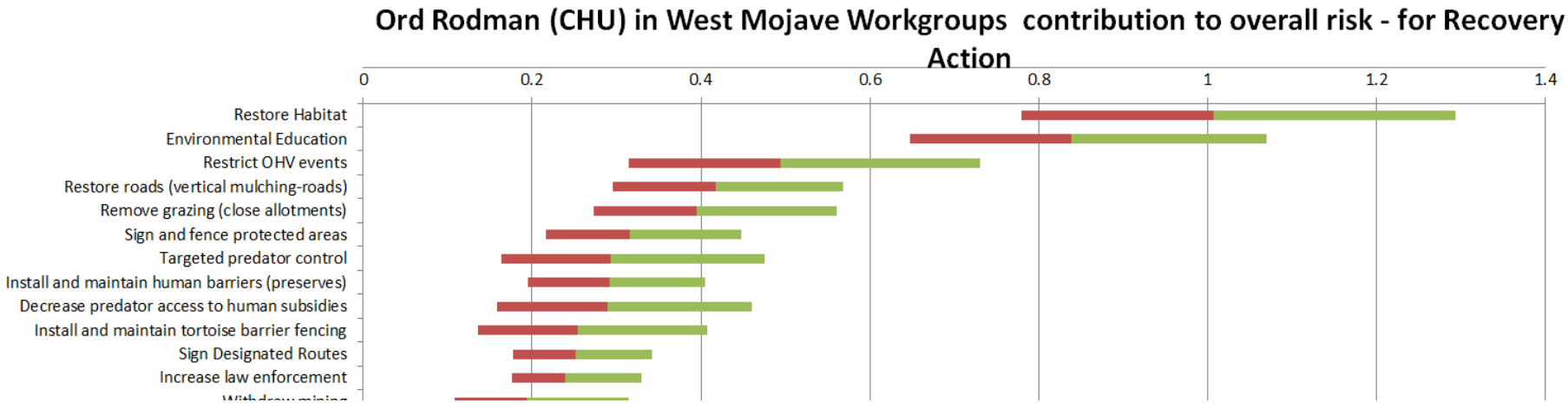


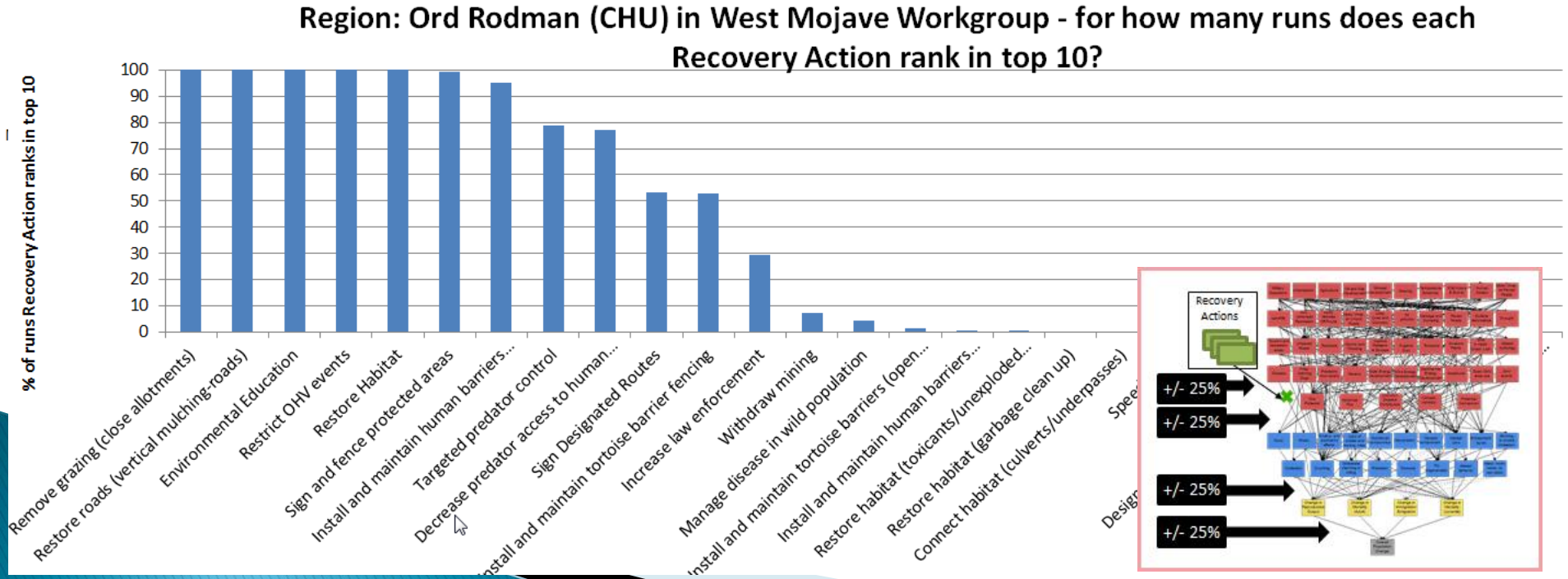
Characterization of Uncertainty



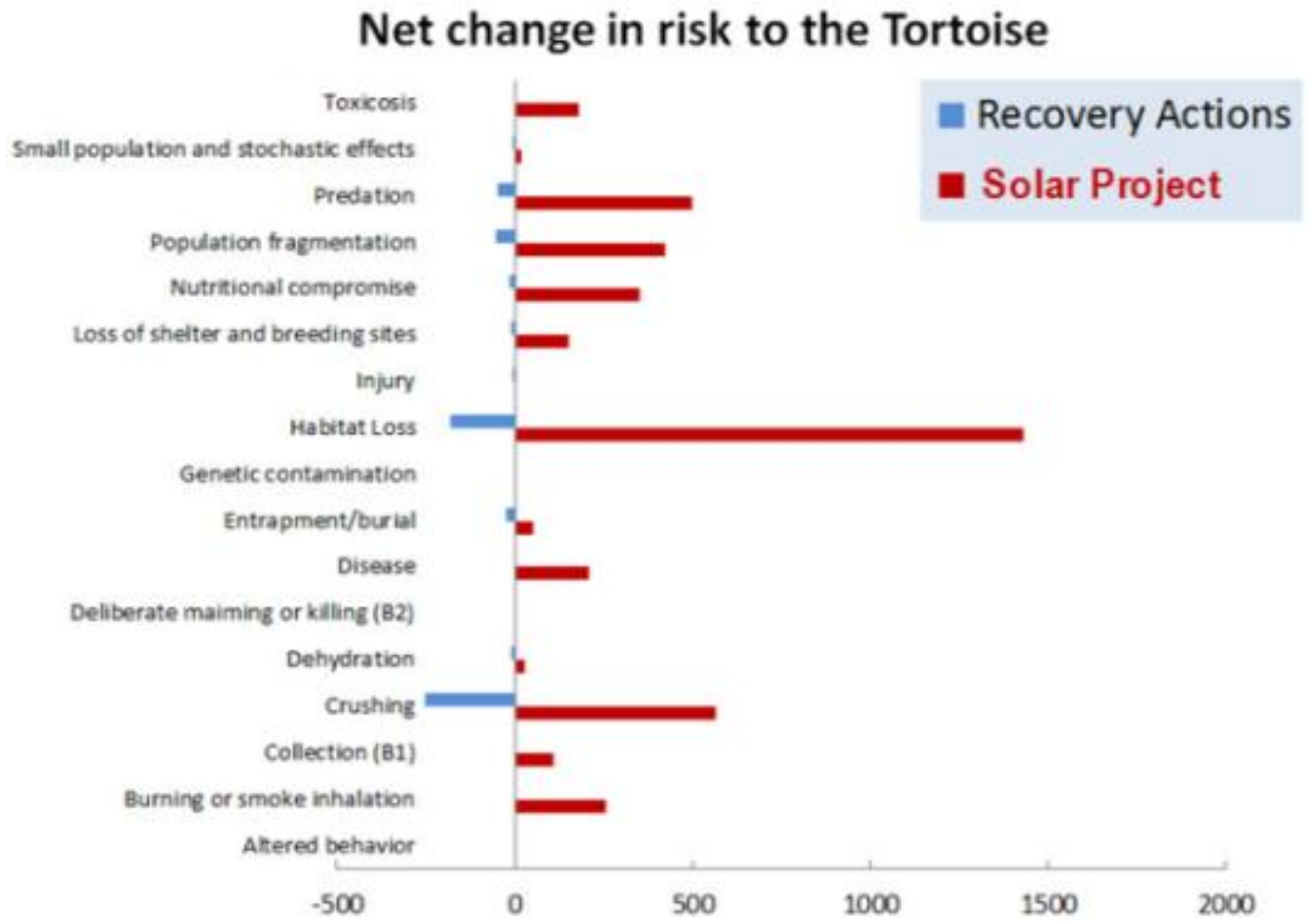
2: Desert Tortoise Recovery Action Prioritization

WEMO TCA: Ord Rodman – RAs

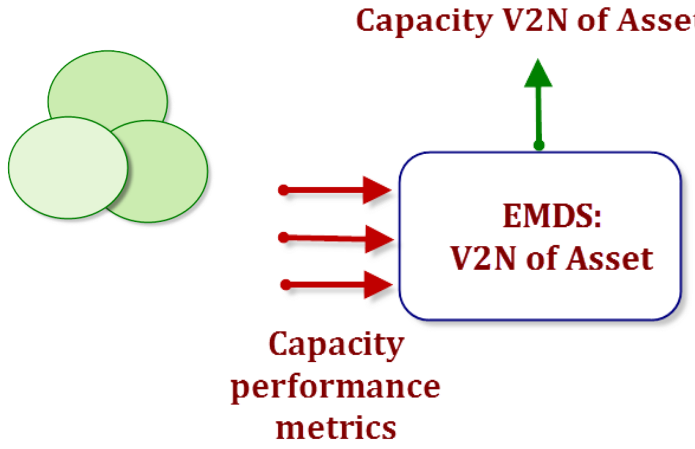


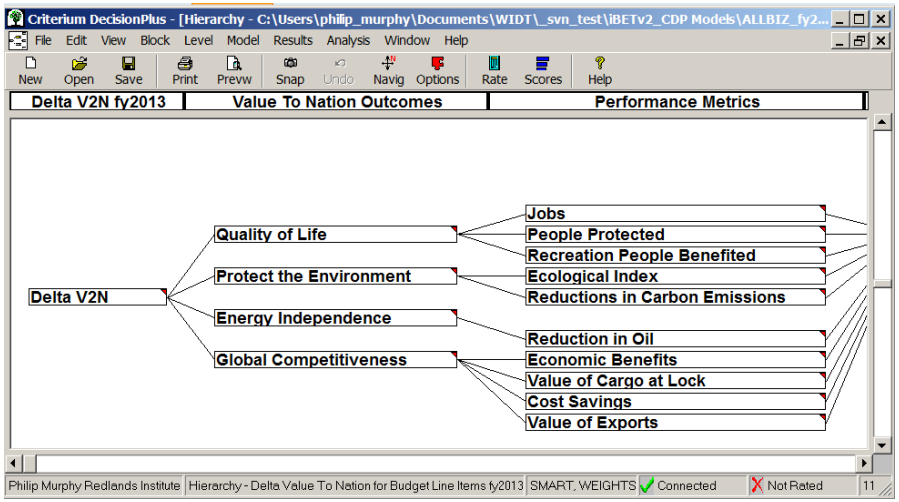


2.5: Desert Tortoise Solar Project Offsets

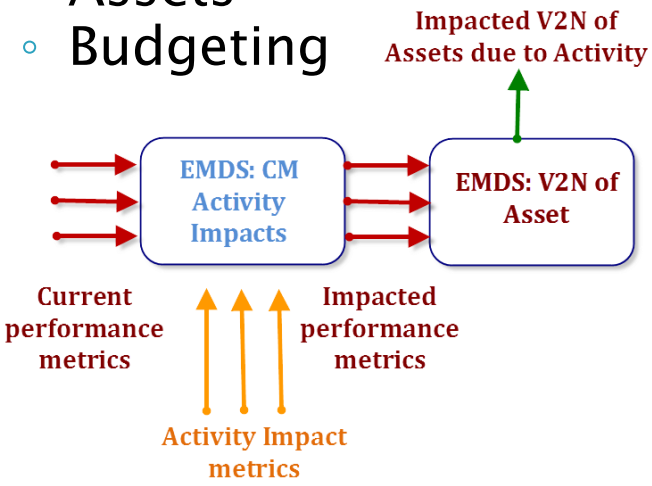


3: National Infrastructure Investment





- Data: Internal to Corps
- Asset Value to Nation
  - Processes > Performance metrics > Value
- Action Delta Value to Nation
  - How access changes processes
  - Changed processes > Changed Value
- Key Features
  - Actions impact processes of Assets
  - Budgeting



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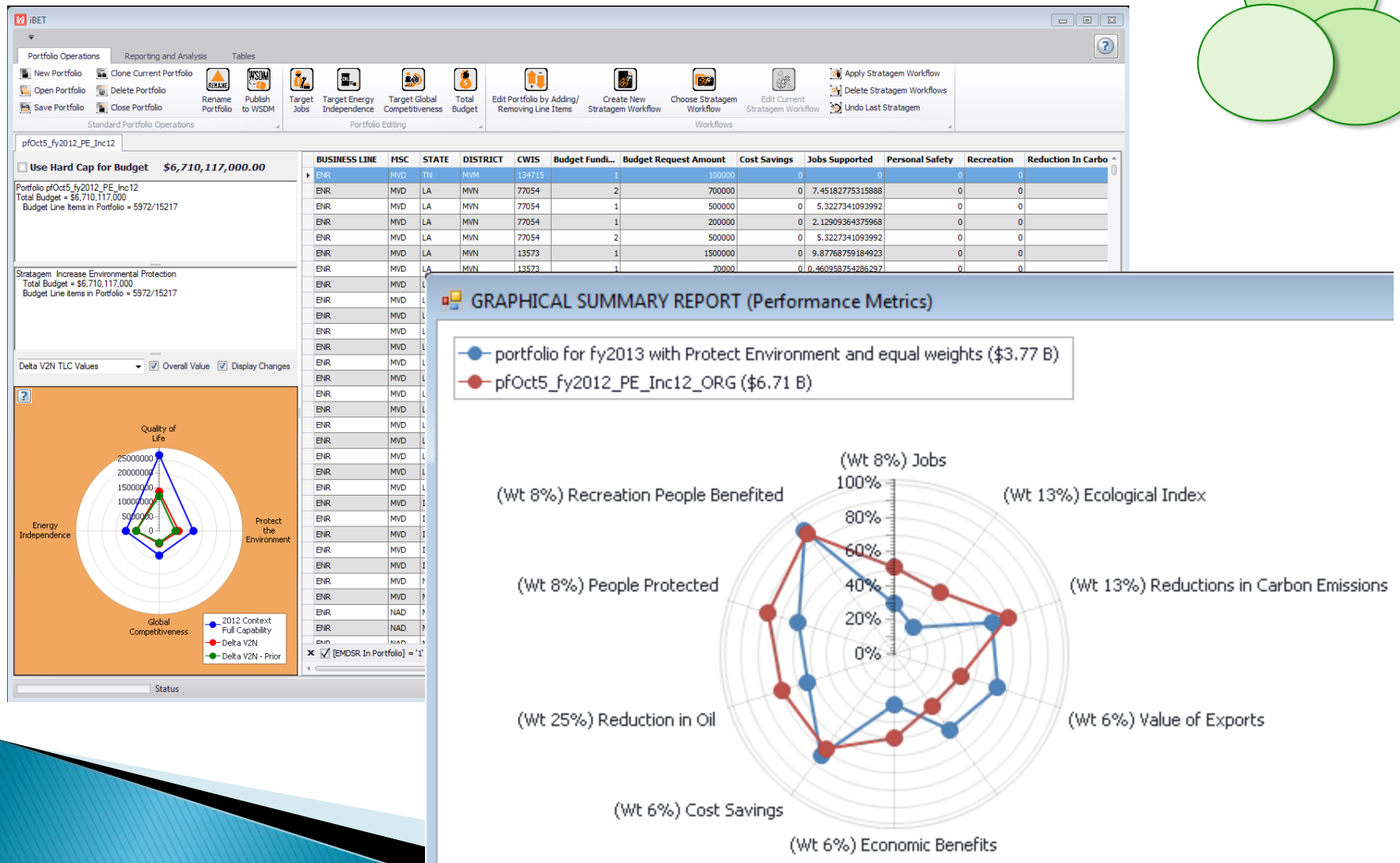
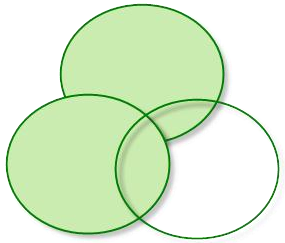


Summary of Examples

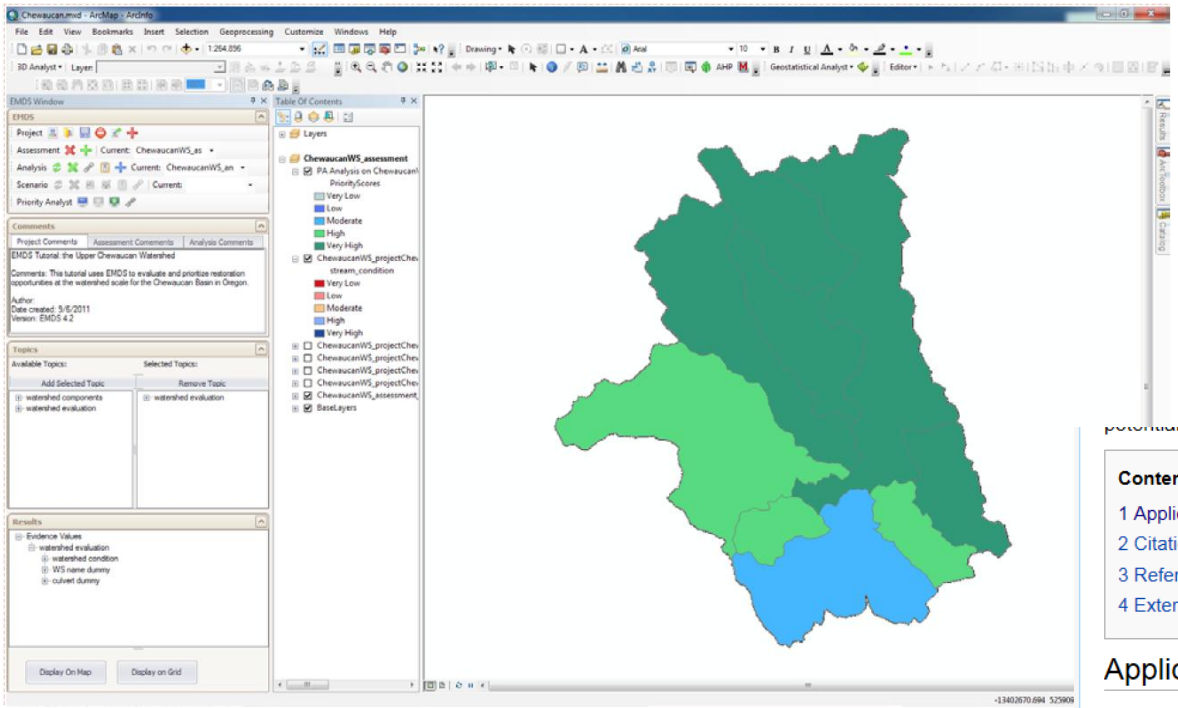
- All are examples of planning workflow
- All have very different End User Interfaces
- User Types: Analysts, Decision Makers, Stakeholders
- All had underlying process, change and governance models – each created in its own authoring application
- All should have had
  - Drill down
  - Parameter editing
  - Sensitivity & Uncertainty handling
  - Provenance

III: Ecological Management Decision Support (EMDS)



- Open modeling system
- Spatial System Evaluation
- Fixed Workflow:
  1. Spatial Identity – data representation
  2. Set Study Area
  3. Run authored fuzzy logic models
  4. Generate map outputs – state of system
  5. Run prioritization models
  6. Generate map outputs – evaluation of state

EMDS "Classic"



http://www.spatial.redlands.edu/emds/

1. Fixed Workflow for landscape evaluation
2. Desktop
3. Single Thread
4. Data – ESRI geodatabase
5. Max ~ 1,000,000 features

GOOD:

1. Freely available
2. User Community
3. No-CODE Process/governance models
   1. Spatial (ESRI)
   2. Fuzzy Logic (Net Weaver)
   3. MCDA (Criterium DecisionPlus)

Contents [hide]

Applications [edit]

1. Carbon sequestration[8]
2. Conservation[9][10][11][12]
3. Design and siting of ecological reserves[13][14]
4. Ecosystem sustainability[15][16][17][18]
5. Land classification[19][20][21]
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7. Soil impacts[25]
8. Urban growth and development[26][27]
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10. Wetlands management[35]
11. Wildlife habitat management[36][37][38][39][40]
12. Wildland fire danger[41][42][43][44]

Citations [edit]

IV: EMDS 5 – Open Decision Support

- Data: Catalog Search & Publishing
- Ontology: Connect to SDS Ontology via Domain Ontologies (e.g Salfasky's Species Recovery lexicon)
- Re-architect EMDS into:
  - EMDS Back-end Web Services
  - Infrastructure for wrapping 3rd party engines
    - Adding inference, optimization, geoprocessing, ..
  - Workflow Architecture
    - Windows Workflow
    - Trident Workbench: Workflow Composer, provenance, ..
  - Analysis GUI: Specific data and modeling visualization
  - Decision Manger GUI (decision visualization)??

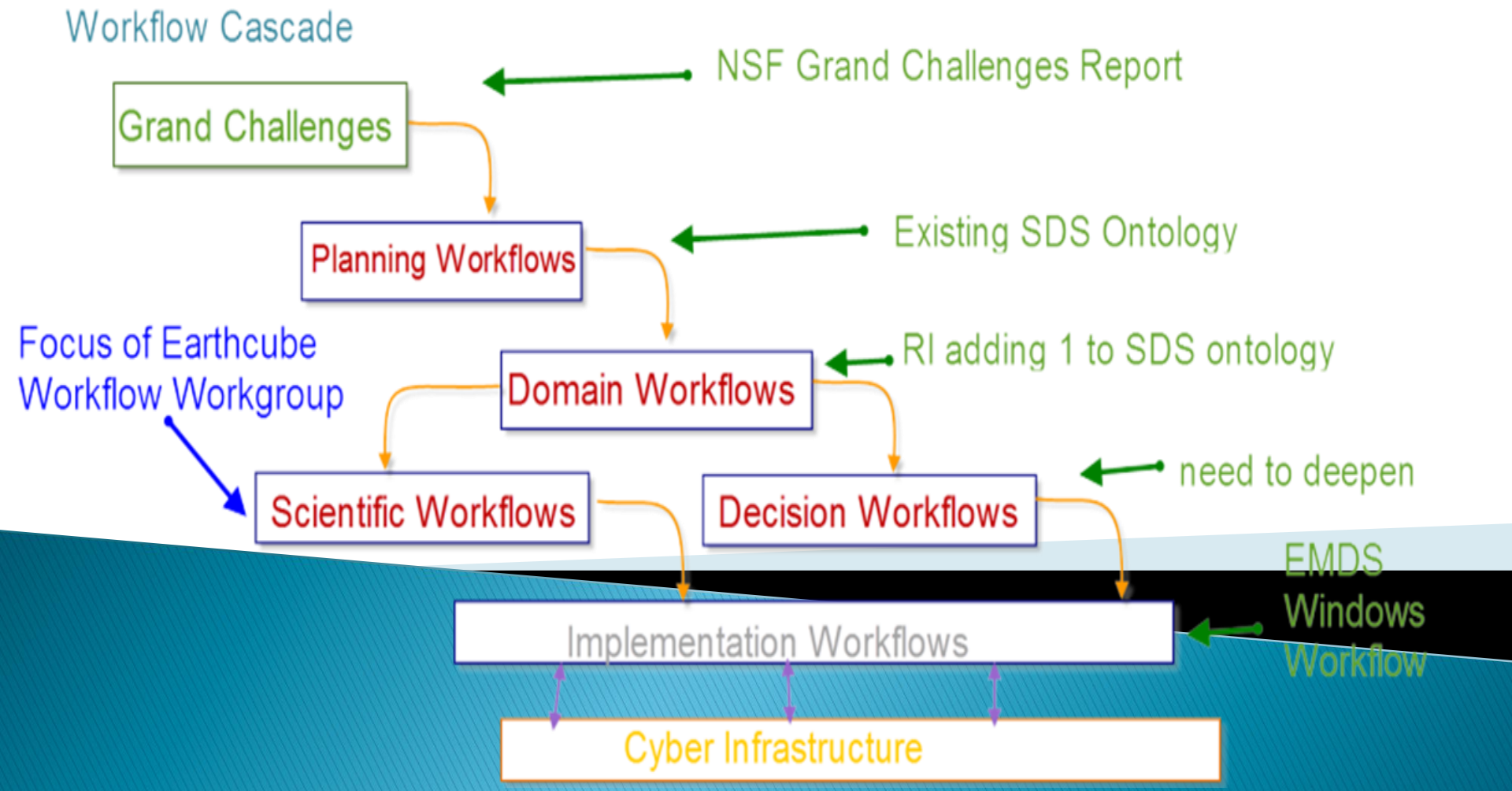
What Does EMDS get from Trident?

- Work flow composer
- Workflow orchestration
- Fault Tolerance
- HPC
- Utilizes Windows Platform

EMDS5 and SDS Ontology

- Populate Analytic models from domain Ontologies
- Augment Workflow Composition using SDS Ontology
  - Workflows, steps, tools, methods

SDS ontology as integration framework



SDS for Tortoise Recovery – Conceptual Model

Conceptual Models

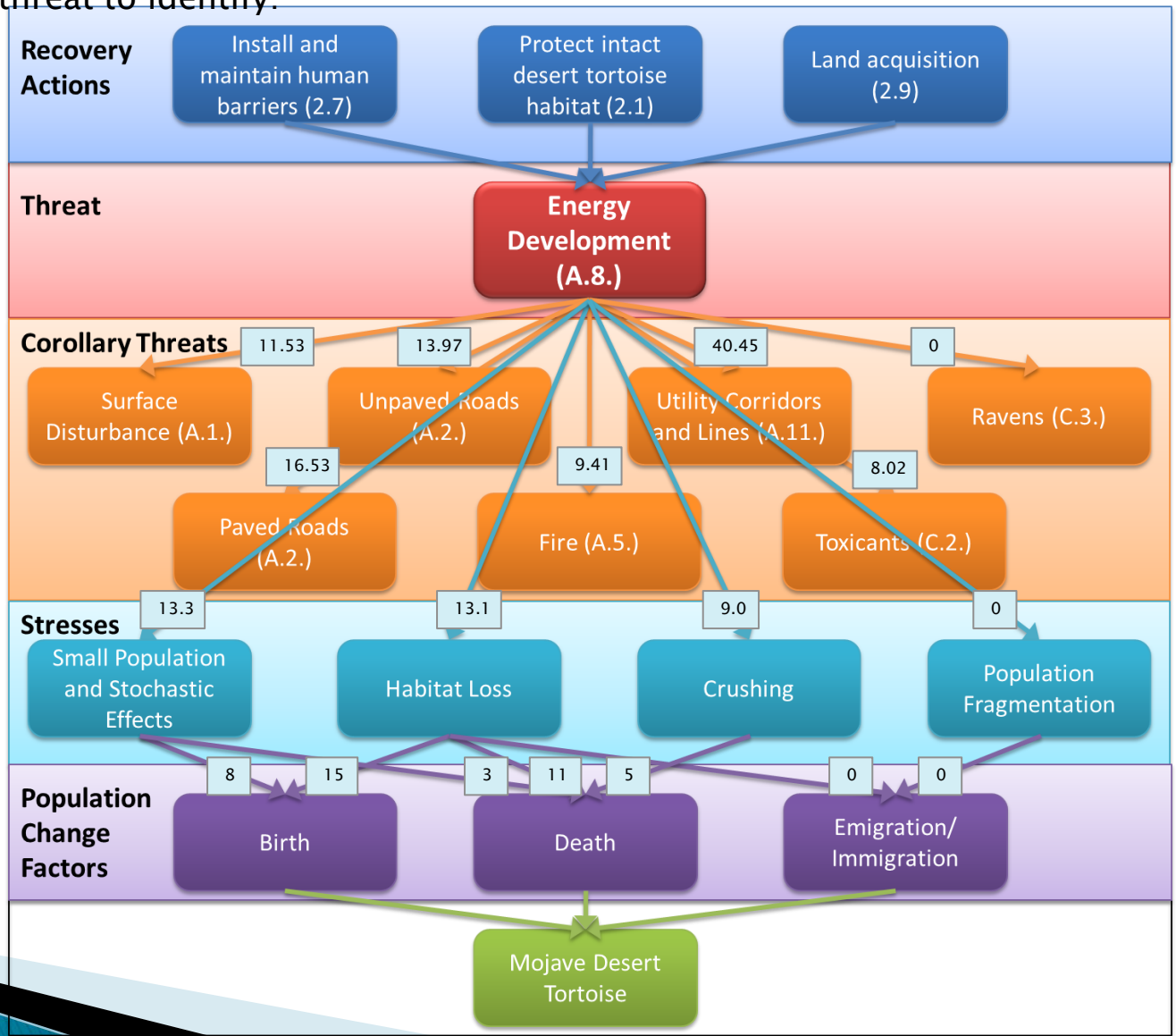
The DTRO worked threat-by-threat to identify:

Which *Recovery Actions* can be introduced to abate the threat

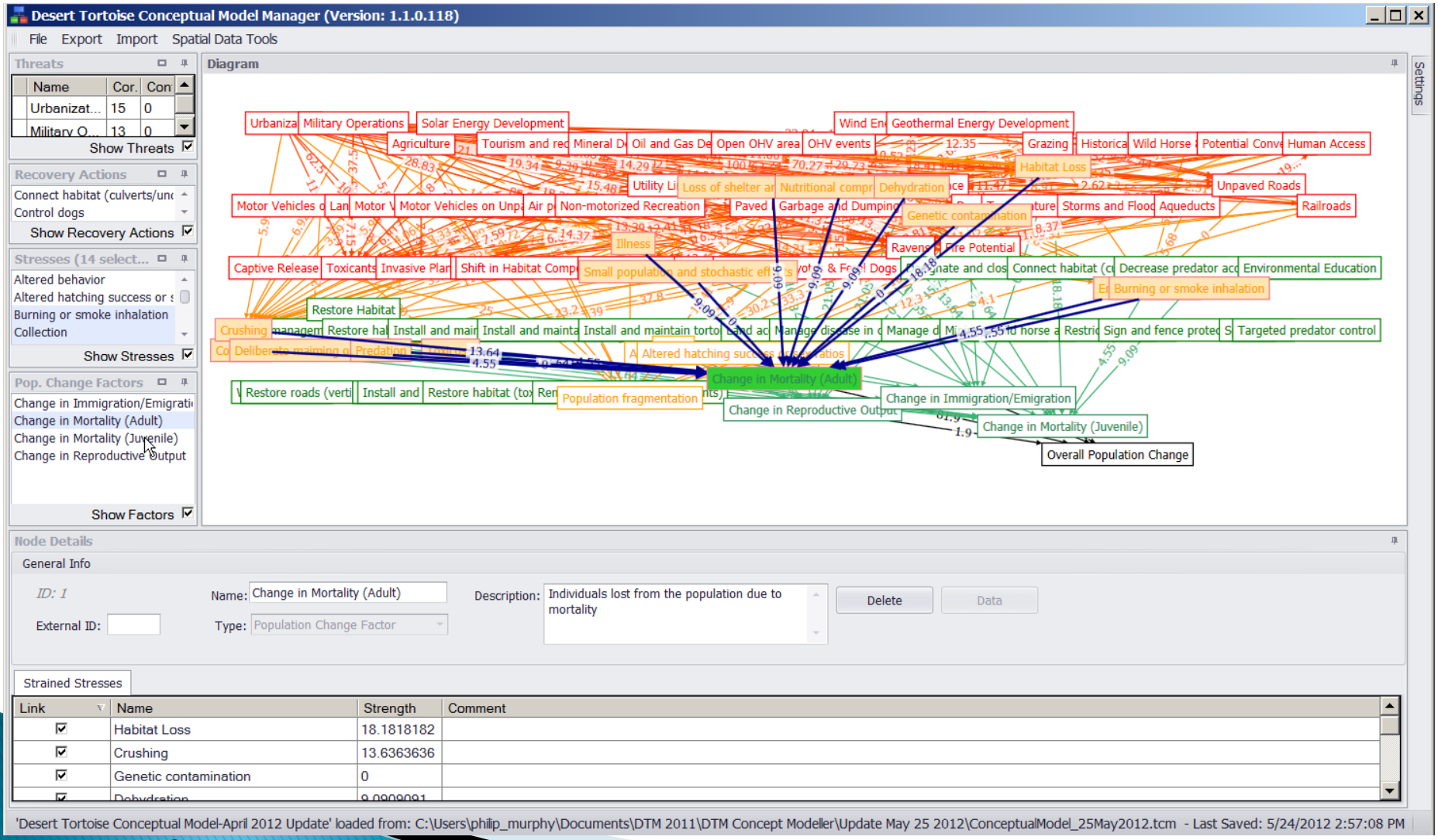
The *threats* caused by each threat

The *stresses* caused by each threat

Which *factors* each stress causes to *overall population change*

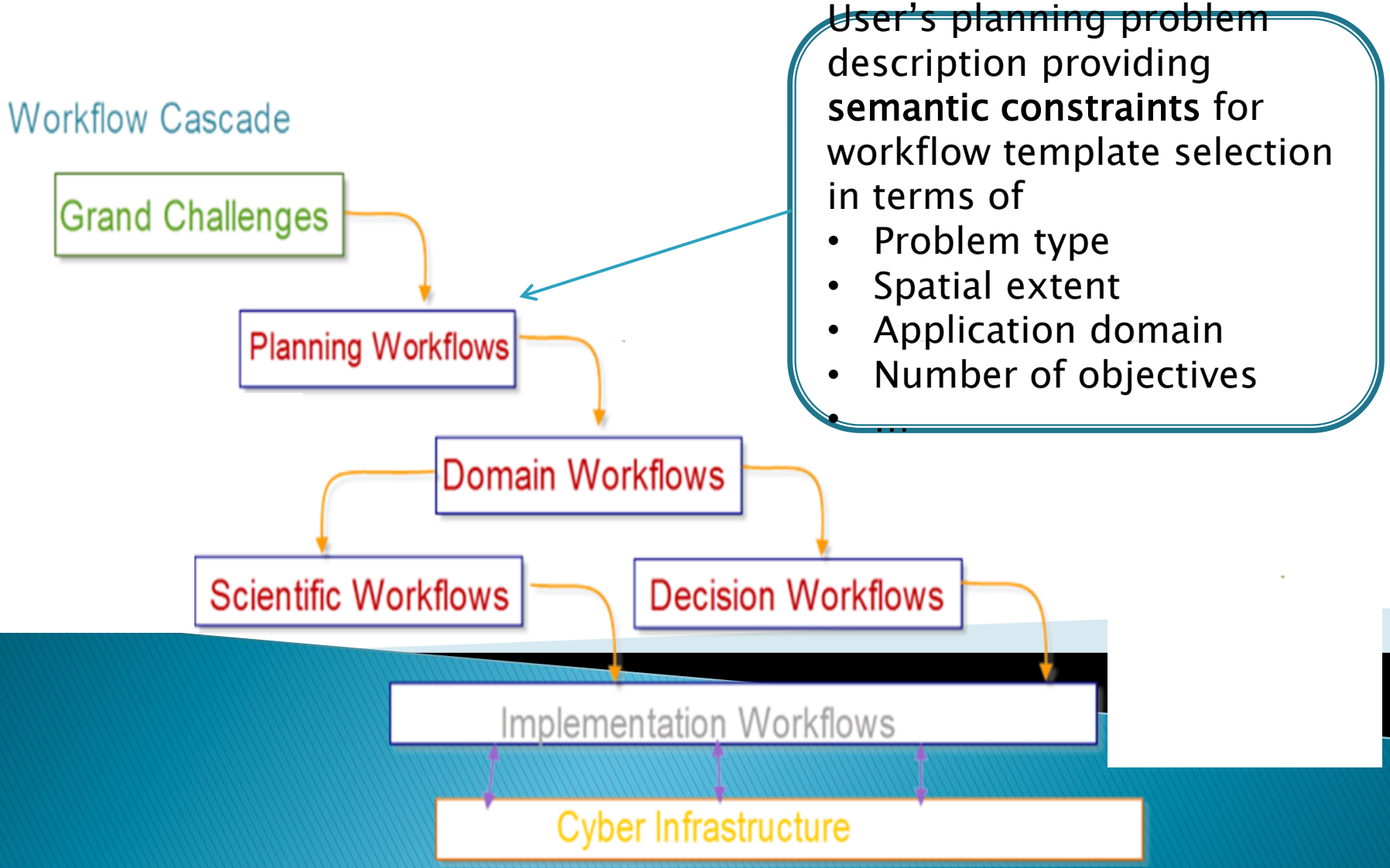


SDS for Tortoise Recovery > Conceptual Model



created for basic

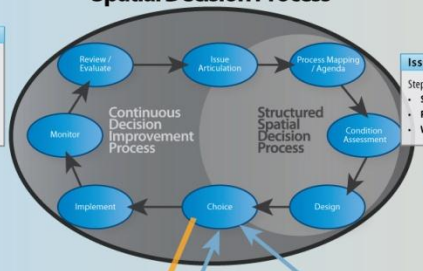
SDS ontology as Composer support



User's planning problem description providing **semantic constraints** for workflow template selection in terms of

- Problem type
- Spatial extent
- Application domain
- Number of objectives
- ...

Spatial Decision Process



Design

Steps:
- Alternative generation
- Alternative screening
- Concept design
- Detail design
- Visualization

Issue Articulation

Steps:
- Stakeholder engagement
- Problem identification
- Visualization

Choice

Steps:
- Specify criterion weight
- Impact analysis
- Alternative ranking
- Sensitivity analysis
- Recommend alternative
- Create action plan
- Visualization

Condition Assessment

Steps:
- Evaluation criteria specification
- Constraints specification
- Data development
- Models development
- Situation assessment
- Visualization

Rank alternatives

Definition:
Alternative ranking is a process during which a set of alternatives (for the solution of the decision problem) is ranked based on a set of evaluation criteria, with the alternative that best meets the criteria ranked on top.

Synonyms:
Prioritize options

Alternative ranking

- a step in
- input: Set of alternatives
- output: Ranked alternatives
- participant role types: Recommendation group, Advisor
- participant role assumed by: Decision maker, Resource manager, Resource owner, Stakeholder representative, Decision analyst, GIS analyst
- commonly used methods: AHP, Value / Utility function method, Ideal / Reference point method, Weighted linear combination, Trade-off analysis, Optimization methods, ...
- used for
- decision process steps served

Weighted linear combination

Definition:
Weighted linear combination is a multi-attribute procedure based on the concept of a weighted average; it calculates a total score for each alternative by multiplying the importance weight assigned to each attribute by the scaled attribute value and summing the products over all attributes; the alternative with the highest overall score is best; the procedure can be performed using GIS supporting overlay operations.

Synonyms:
weighted summation; simple additive weighting method; boolean overlay; scoring method

- for decision type: Deterministic decision problem, Individual decision making, Multiattribute decision making
- input: Attribute score, Criterion weight
- output: Ordinal ranking
- discussed in: ..., (publications)
- implemented by: IDRISI, EMDS, ArcGIS, GreenPrint, ...
- is a kind of: multi-objective decision rules; multi-criteria decision analysis; multi-attribute decision analysis; AHP; ...
- methods implemented

SDS methods and techniques

- is a kind of: forecasting methods
- is a kind of: uncertainty methods
- is a kind of: group methods
- is a kind of: ...

Decision problem types

- is a kind of: Plan performance evaluation
- is a kind of: Assessment
- is a kind of: Suitability assessment
- is a kind of: Impact assessment
- is a kind of: Planning
- is a kind of: Alternative evaluation
- is a kind of: Select or allocate
- is a kind of: ...
- decision problem types targeted
- decision problem type

EMDS

- used in case studies: IDRISI, EMDS, ArcGIS, GreenPrint, ...
- toolmaker: EMDS Consortium
- contact person: Keith Reynolds
- software required: ArcGIS 9.x, Criterion Decision Plus, NetWeaver
- output data format: ESRI geodatabase, Microsoft Excel
- output data type: Graph, Map, Spatial dataset, Table
- input data format: ESRI geodatabase, Microsoft Excel, Text file
- input data type: Map, Spatial dataset, Table, Text document
- analysis unit: User specified
- analysis extent: User specified
- domain knowledge areas modeled: Biodiversity conservation, Forest fuel management, Forest succession modeling, Habitat suitability, Landscape analysis and modeling, Watershed analysis, ...

Northwest Forest Plan Aquatic and Riparian Effectiveness Monitoring Program

Summary:
The Ecosystem Management Decision Support (EMDS) system provides decision support for integrated landscape evaluation and planning. The system provides decision support for landscape-level analyses through logic and decision engines integrated with ArcGIS 8.1+. The logic engine evaluates landscape data against a formal logic specification, designed with NetWeaver Developer, to derive logic-based interpretations of ecosystem conditions such as biodiversity and sustainability. The decision engine evaluates NetWeaver outcomes (and data related to additional factors such The convening purpose of this project was to bring all the entities (federal, state, local governments, watershed council, NGOs) together and develop a basin-wide watershed restoration strategy for the Sandy River Basin in northwest Oregon. The process was structured to focus on aquatic habitat and produce a collaborative stakeholder vision across all ownerships. ...

- location: Oregon, USA
- time frame: 2004 - 2005
- for application domains: Fresh water resource management
- lessons learned: ...
- citation: ...
- tools used: IDRISI, EMDS, ArcGIS, GreenPrint, ...

Ecosystem Management Decision Support (EMDS)

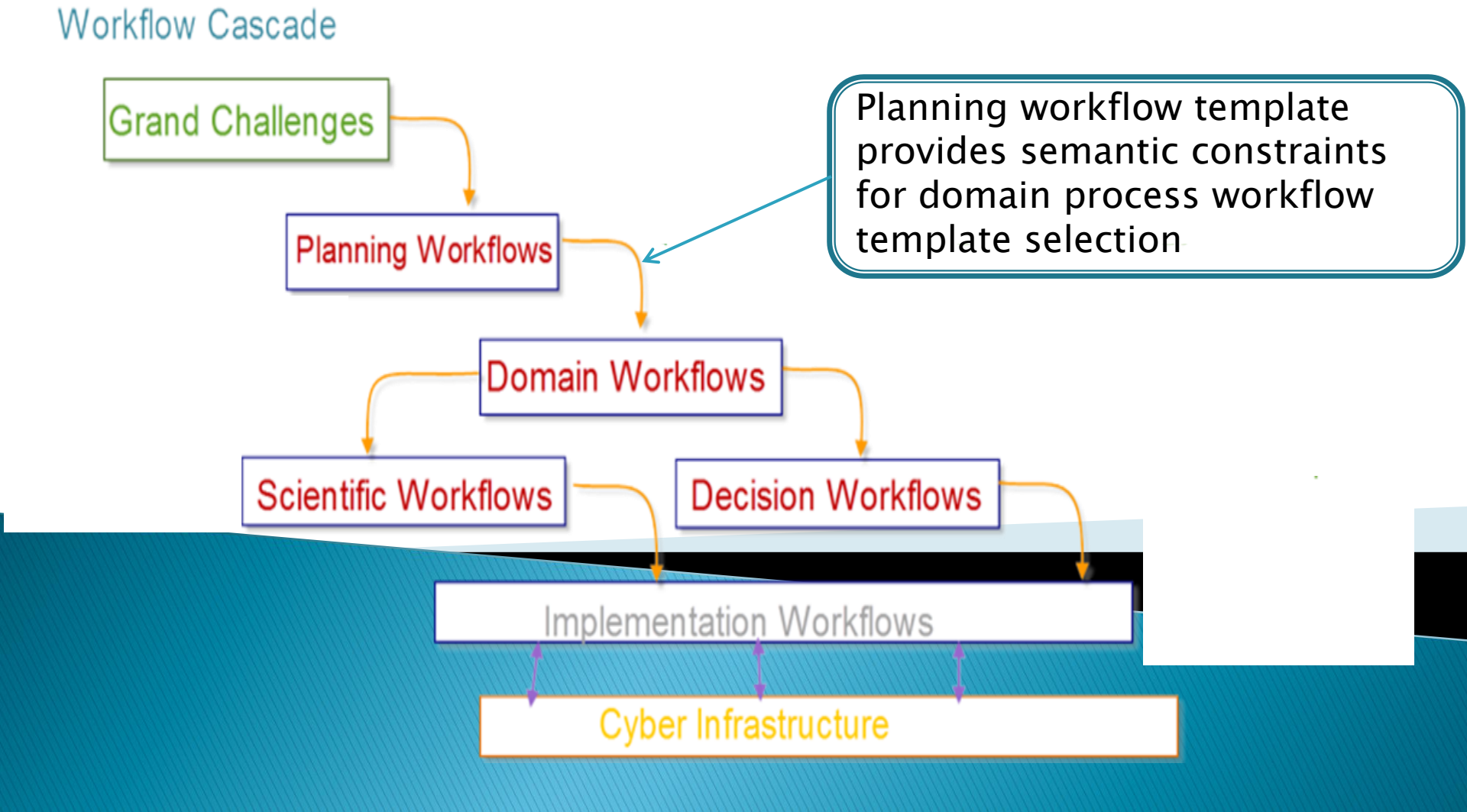
Overview:
The Ecosystem Management Decision Support (EMDS) system provides decision support for integrated landscape evaluation and planning. The system provides decision support for landscape-level analyses through logic and decision engines integrated with ArcGIS 8.1+. The logic engine evaluates landscape data against a formal logic specification, designed with NetWeaver Developer, to derive logic-based interpretations of ecosystem conditions such as biodiversity and sustainability. The decision engine evaluates NetWeaver outcomes (and data related to additional factors such as feasibility and efficacy of land management actions) against a decision model for prioritizing landscape features with decision models built in Criterium DecisionPlus

Platform:
Windows XP

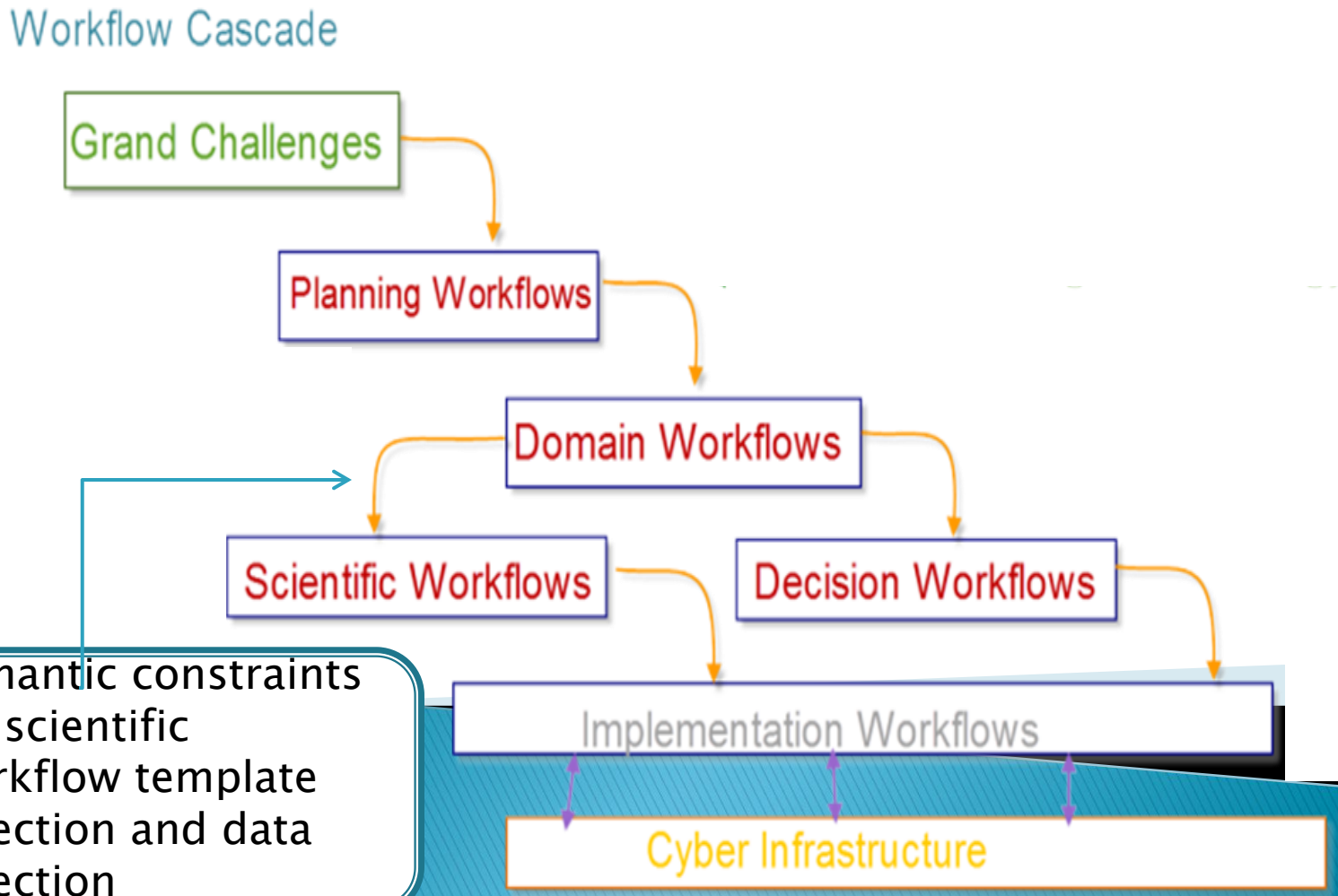
Cost:
Free

...

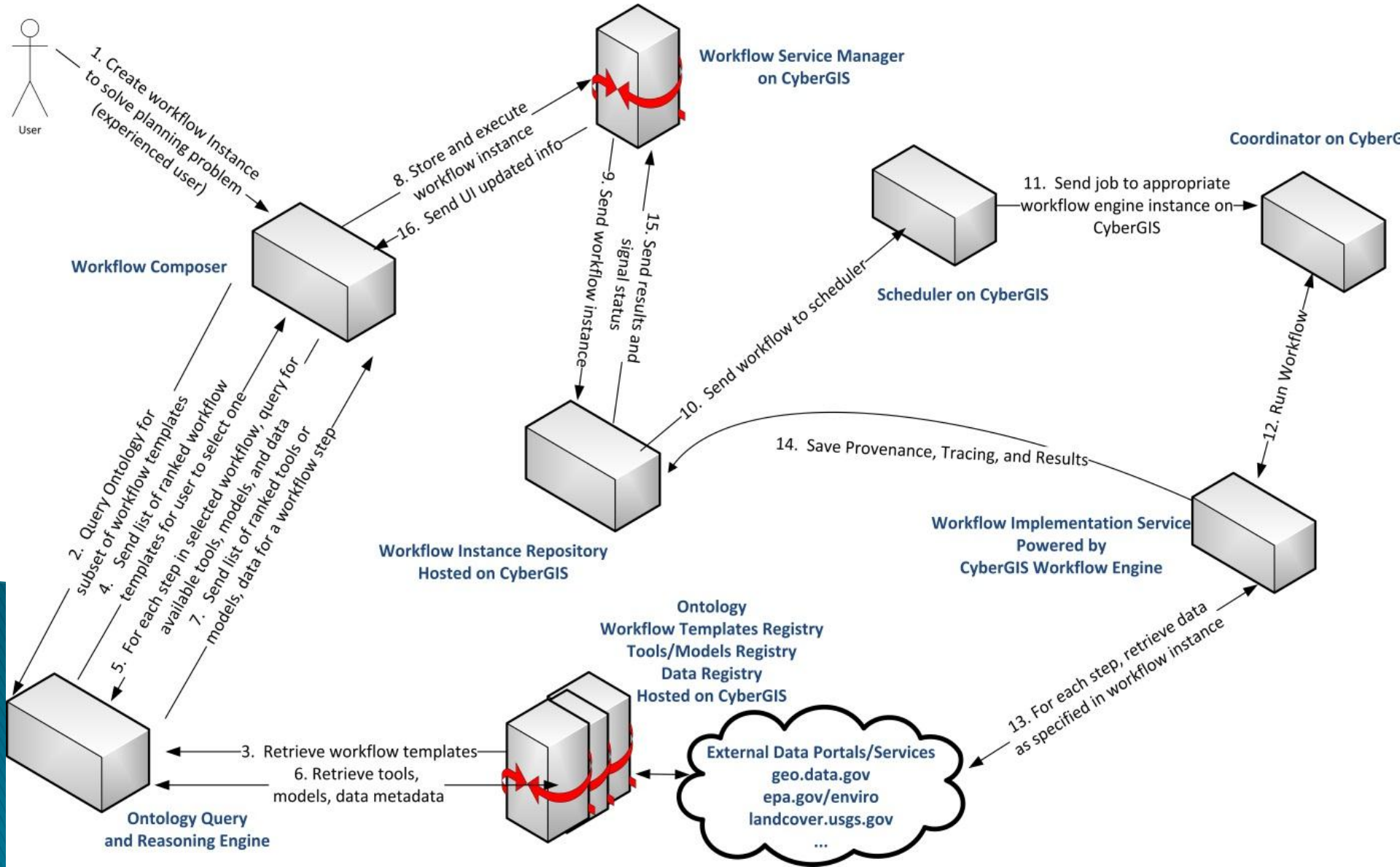
SDS ontology as a bridging framework



SDS ontology as a bridging framework



Ontology-driven SDS workflow orchestration



Work for us

- Have EMDS back end running on Windows Workflow
- Have Persistence Layer in place
- Have wrapped 3 engine**
- Starting design for Trident integration
- Extending SDS Ontology to Species Recovery domain ontology

Questions (for you)

- How far to go with auto-composed GUI for Decision Makers?
- What Modeling standards will work well for mapping process/change/governance engines?
- How to implement sensitivity and uncertainty analysis along the analysis workflow?
- How to practically achieve Conceptual Interoperability?
- How to handle Activity Scales in Trident?
- How to test our emerging system on Interop Testbed?

Thank You

The Redlands Institute	University of Redlands		Krzysztof Janowicz	Pennsylvania State University
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Brenda Faber	Fore Site Consulting, Inc.		Timothy L. Nyerges	University of Washington
Max Flaxman	MIT		Rob Raskin	NASA / Jet Propulsion Laboratory
Stan Geertman	Utrecht University		Keith Reynolds	USDA Forest Service
Michael Goodchild	University of California, Santa Barbara		Carl Steinitz	Harvard University
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