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

1. How should the geography be described?
2. How does the geography operate?
3. Is the current geography working well?
4. How might the geography be altered?
5. What predictable differences might the changes cause?
6. How should the geography be changed?

- RECOGNIZE CONTEXT
  - Time -
  - DATA
    - INFORMATION
    - CULTURAL KNOWLEDGE
  - How should the geography be described?
  - How does the geography operate?
  - Is the current geography working well?
  - How might the geography be altered?
  - What predictable differences might the changes cause?
  - How should the geography be changed?

- PERFORM STUDY
  - Time +
  - REPRESENTATION MODELS
  - PROCESS MODELS
  - EVALUATION MODELS
  - CHANGE MODELS
  - IMPACT MODELS
  - DECISION MODELS
  - SPECIFY METHOD
    - Yes
      - IMPLEMENTATION
    - No
      - CHANGE SCALE
Planning Support Venn view

- Governance
- Socio-ecology
- Change - designed or not
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

![GIS Map](image_url)

**NISM: Number of runs of 10,000 WHERE weed patch is ranked in top 10% (at least once)**

Weed patches (ordered by decreasing % of runs weed patch remained in top 10%)
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

Diagram showing various threats and stresses affecting desert tortoises, with arrows indicating the relationship between different factors. The diagram includes categories such as Threats, Stresses, Recovery Actions, and Population Effects. A specific section highlights the impact of OHV events leading to crushing, with a weight of threat to stress of 7.72. Impacts from off-highway vehicle use include mortality of tortoises on the surface and below ground. (Brooks 2009; Lei 2009).
Characterization of Uncertainty

Variation in expert estimates of Contribution of Threats to Stress [Habitat Loss] (12 experts)
2: Desert Tortoise Recovery Action Prioritization

WEMO TCA: Ord Rodman – RAs

Ord Rodman (CHU) in West Mojave Workgroups contribution to overall risk - for Recovery Action

Region: Ord Rodman (CHU) in West Mojave Workgroup - for how many runs does each Recovery Action rank in top 10?
2.5: Desert Tortoise Solar Project Offsets

Net change in risk to the Tortoise

- Toxicosis
- Small population and stochastic effects
- Predation
- Population fragmentation
- Nutritional compromise
- Loss of shelter and breeding sites
- Injury
- Habitat Loss
- Genetic contamination
- Entrapment/burial
- Disease
- Deliberate maiming or killing (B2)
- Dehydration
- Crushing
- Collection (B1)
- Burning or smoke inhalation
- Altered behavior

[Bar chart showing recovery actions and solar project effects for each risk factor with x-axis indicating risk level from -500 to 2000]
3: National Infrastructure Investment

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

EMDS: V2N of Asset

Impact V2N of Assets due to Activity

Current performance metrics

Impacted performance metrics

Activity Impact metrics
3: National Infrastructure Investment

[Diagram showing various metrics and performance indicators related to national infrastructure investment, including charts and graphs demonstrating impact on areas such as quality of life, recreation, people protected, reductions in carbon emissions, cost savings, and economic benefits.]
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)
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 Manager 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

Workflow Cascade

Grand Challenges

Planning Workflows

Domain Workflows

Scientific Workflows

Decision Workflows

Implementation Workflows

Cyber Infrastructure

Focus of Earthcube Workflow Workgroup

NSF Grand Challenges Report

Existing SDS Ontology

RI adding 1 to SDS ontology

need to deepen

EMDS Windows Workflow
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

<table>
<thead>
<tr>
<th>Threat</th>
<th>Energy Development (A.8.)</th>
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</thead>
<tbody>
<tr>
<td>Install and maintain human barriers (2.7)</td>
<td></td>
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<tr>
<td>Protect intact desert tortoise habitat (2.1)</td>
<td></td>
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<tr>
<td>Land acquisition (2.9)</td>
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</tbody>
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### Corollary Threats

- Surface Disturbance (A.1.)
  - 11.53
- Unpaved Roads (A.2.)
  - 13.97
- Utility Corridors and Lines (A.11.)
  - 40.45
- Ravens (C.3.)
  - 0

### Stresses

- Small Population and Stochastic Effects
  - 13.3
- Habitat Loss
  - 13.1
- Crushing
  - 9.0
- Population Fragmentation
  - 0

### Population Change Factors

- Birth
  - 8
- Death
  - 15
- Emigration/Immigration
  - 0

Mojave Desert Tortoise
Conceptual Models: "The Spider Diagram" stored & managed as a custom XML-based format with APIs for query, analysis, & reporting developed by the Univ. of Redlands.

Model web services have also been created for basic query and analysis.
User’s planning problem description providing **semantic constraints** for workflow template selection in terms of

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

SDS ontology as Composer support
SDS ontology as integration framework
SDS ontology as a bridging framework

Planning workflow template provides semantic constraints for domain process workflow template selection
SDS ontology as a bridging framework

Workflow Cascade

- Grand Challenges
- Planning Workflows
- Domain Workflows
- Scientific Workflows
- Decision Workflows
- Implementation Workflows

semantic constraints for scientific workflow template selection and data selection
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
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