Ontologies and Spatial Decision Support

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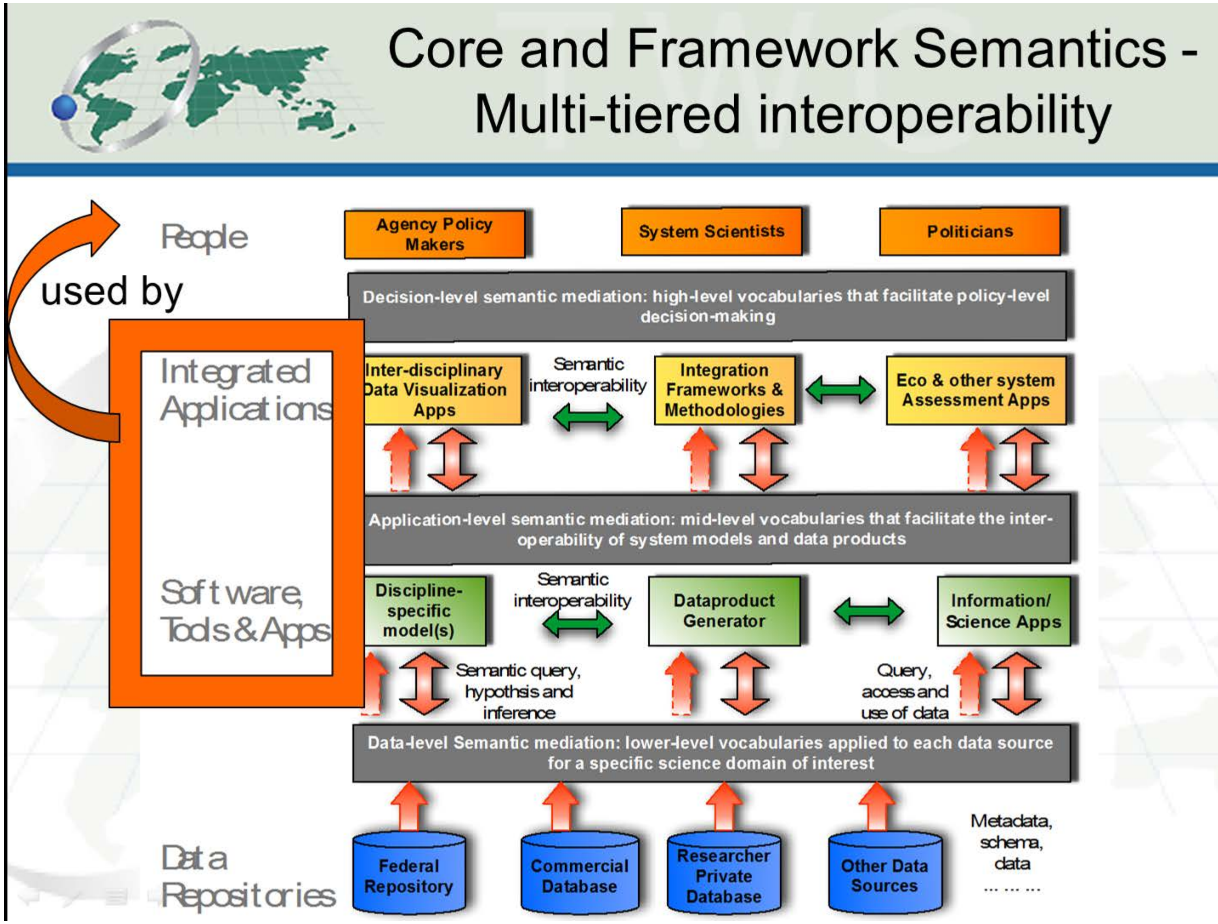
Earth Science-Ontolog mini series, Session 2
September 6, 2012

Spatial Decision Support Consortium

The Redlands Institute
Tough Challenges. Smart Decisions

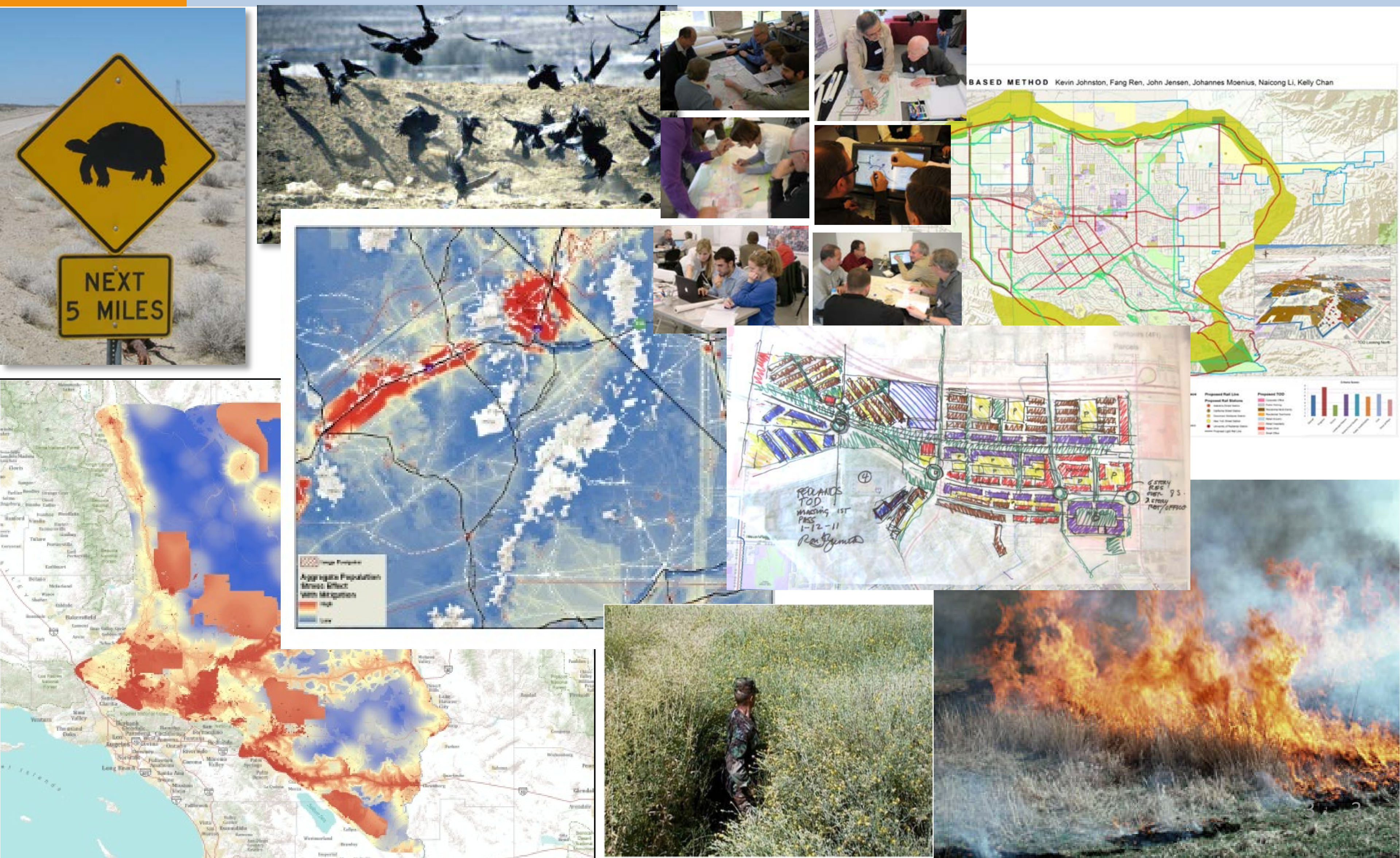
Earth sciences and decision making

- Down stream application for earth science data and models – informing decsion making
- Data and models will have added value when easily discovered and accessed as useful resources for informing large-scale planning and decision making.
- Need for decision level semantics



Peter Fox, Earth science-Ontolog mini series, 2012

Large-scale planning and decision problems



Large-scale planning and decision problems

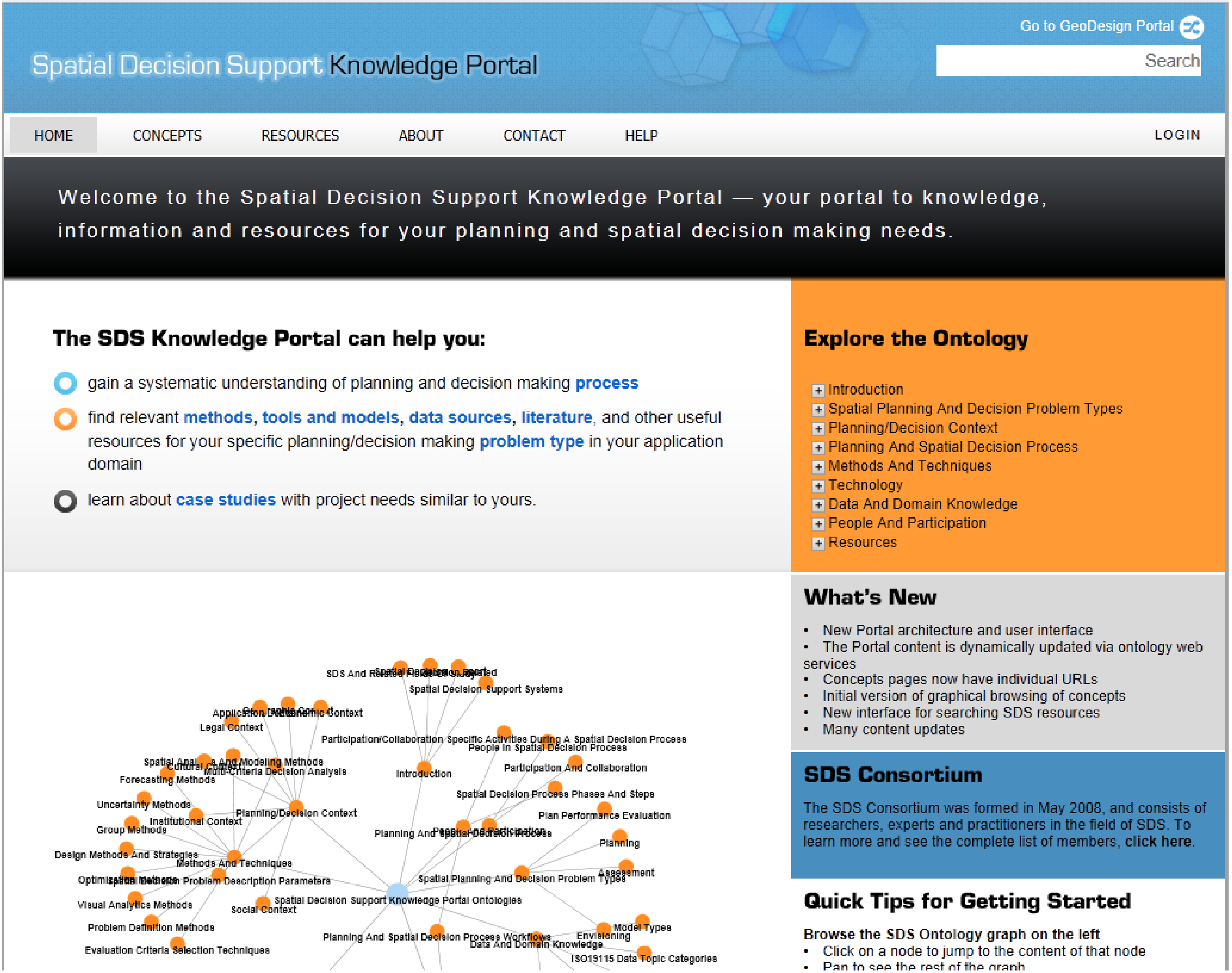
Characteristics of large scale planning and spatial decision problems

- Complex
- Involving spatial and temporal dimensions
- Computationally demanding
- Inherently cross domain
- Involving interaction between natural and human systems
- Finding spatial decision support (SDS) resources often faces Big Data problem
    - Where are the good datasets, tools and models
    - Which ones are most appropriate for the problem at hand
- Interoperability problem among SDS resources

Need for formalizing the knowledge in SDS

- Registration, automatic discovery and access of SDS resources (e.g. workflow templates, methods and algorithms, models and tools, data, cases studies)
- Encourage modular, reusable models and tools development
- Facilitate interoperability among models and tools
- Automatic workflow composition and orchestration
- Provide a common vocabulary for the user community
- Facilitate learning in SDS

One solution – SDS ontology



… and the **SDS Knowledge Portal** driven by the SDS ontology

The SDS Consortium

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Forest Research	Stephen Bathgate & Duncan Ray	Forest Research		Karen Kemp	The Kohala Center
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The University of Georgia	Susan Crow	University of Georgia	PlaceMatters	Jason Lally & Ken Snyder	PlaceMatters
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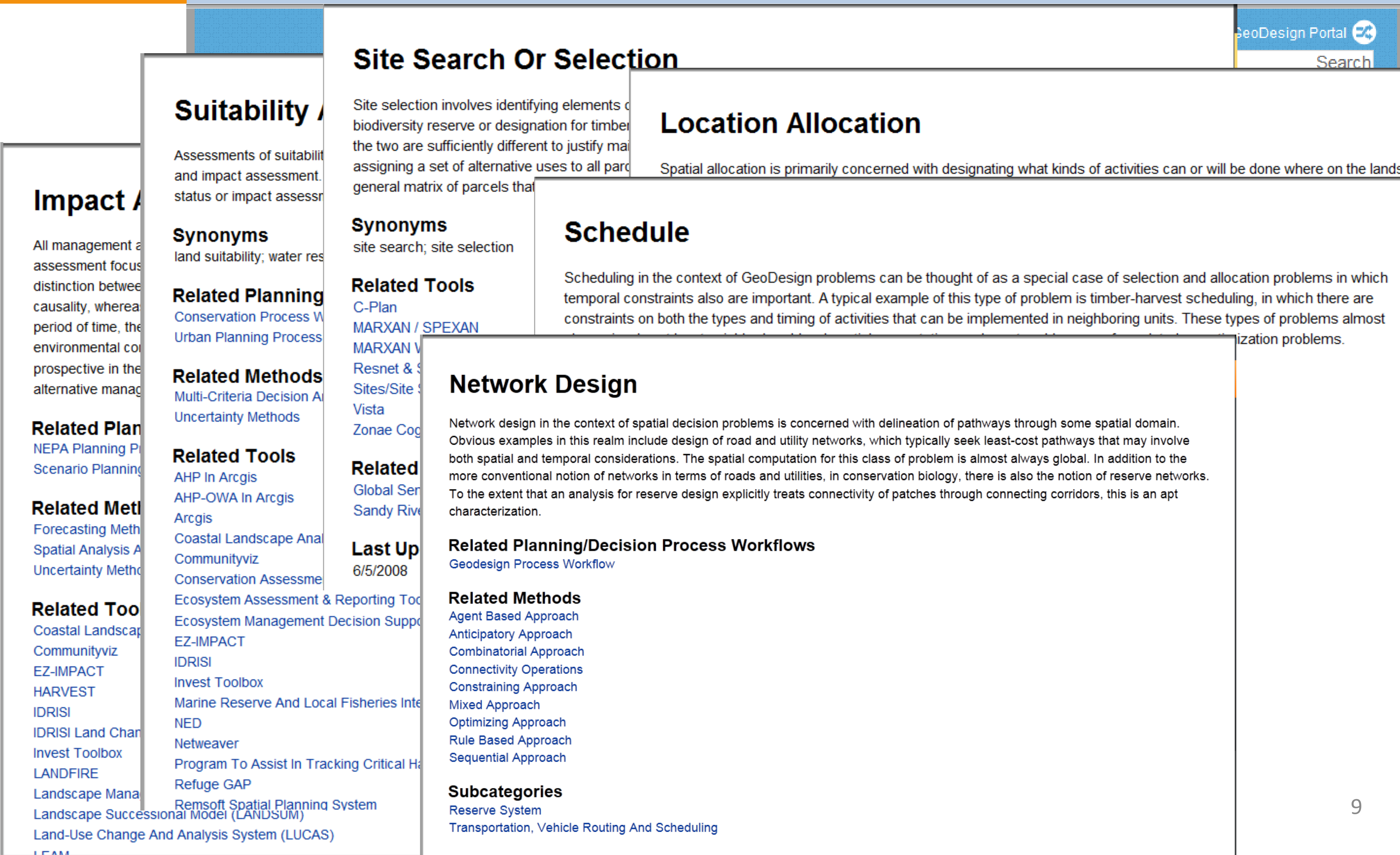
UCSB	Michael Goodchild	University of California, Santa Barbara	Harvard University	Carl Steinitz	Harvard University
Interforest LLC	Sean Gordon	Interforest LLC	Missouri S&T	Mingzhen Wei	Missouri University of Science and Technology
University of Otago	Brent Hall	University of Otago	Oregon State University	Dawn J. Wright	Oregon State University
University of Wyoming	Jeffrey D. Hamerlinck	University of Wyoming	CRD BGSU	Xinyue Ye	Bowling Green State University
San Diego State University	Piotr Jankowski	San Diego State University	University of Florida	Paul Zwick	University of Florida

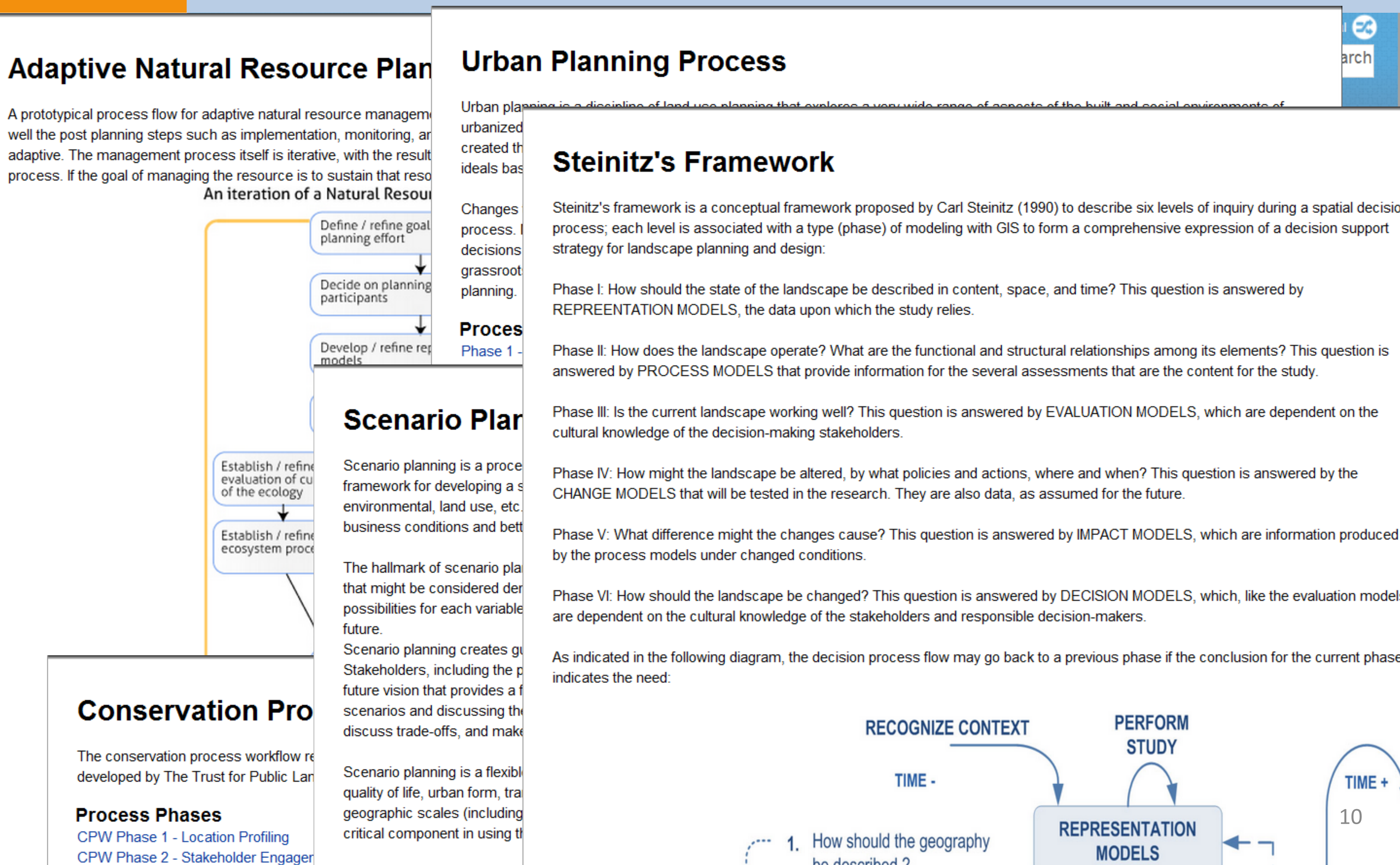
Content of the SDS ontology

- Planning/decision problem types
- Planning process workflows and steps
- Strategies, methods and techniques that are commonly associated with different workflow steps
- Models and tools supporting spatial planning
- Data sources supporting spatial planning
- Spatial planning/decision support case studies
- Related concepts supporting the descriptions of the above

Spatial planning and decision problem types



Spatial planning workflows



Adaptive Natural Resource Plan

A prototypical process flow for adaptive natural resource managem
well the post planning steps such as implementation, monitoring, ar
adaptive. The management process itself is iterative, with the result
process. If the goal of managing the resource is to sustain that reso

Urban Planning Process

Urban planning is a discipline of land use planning that explores a very wide range of aspects of the built and social environments of
urbanized
created th
ideals bas

Changes
process. I
decisions
grassroot
planning.

Proces
Phase 1 -

Scenario Plan

Scenario planning is a proce
framework for developing a s
environmental, land use, etc.
business conditions and bett

The hallmark of scenario pla
that might be considered der
possibilities for each variable
future.
Scenario planning creates gu
Stakeholders, including the p
future vision that provides a f
scenarios and discussing th
discuss trade-offs, and make

Scenario planning is a flexibl
quality of life, urban form, tra
geographic scales (including
critical component in using th

Conservation Pro

The conservation process workflow re
developed by The Trust for Public Lan

Process Phases
CPW Phase 1 - Location Profiling
CPW Phase 2 - Stakeholder Engager

Steinitz's Framework

Steinitz's framework is a conceptual framework proposed by Carl Steinitz (1990) to describe six levels of inquiry during a spatial decisio process; each level is associated with a type (phase) of modeling with GIS to form a comprehensive expression of a decision support strategy for landscape planning and design:

Phase I: How should the state of the landscape be described in content, space, and time? This question is answered by REPREENTATION MODELS, the data upon which the study relies.

Phase II: How does the landscape operate? What are the functional and structural relationships among its elements? This question is answered by PROCESS MODELS that provide information for the several assessments that are the content for the study.

Phase III: Is the current landscape working well? This question is answered by EVALUATION MODELS, which are dependent on the cultural knowledge of the decision-making stakeholders.

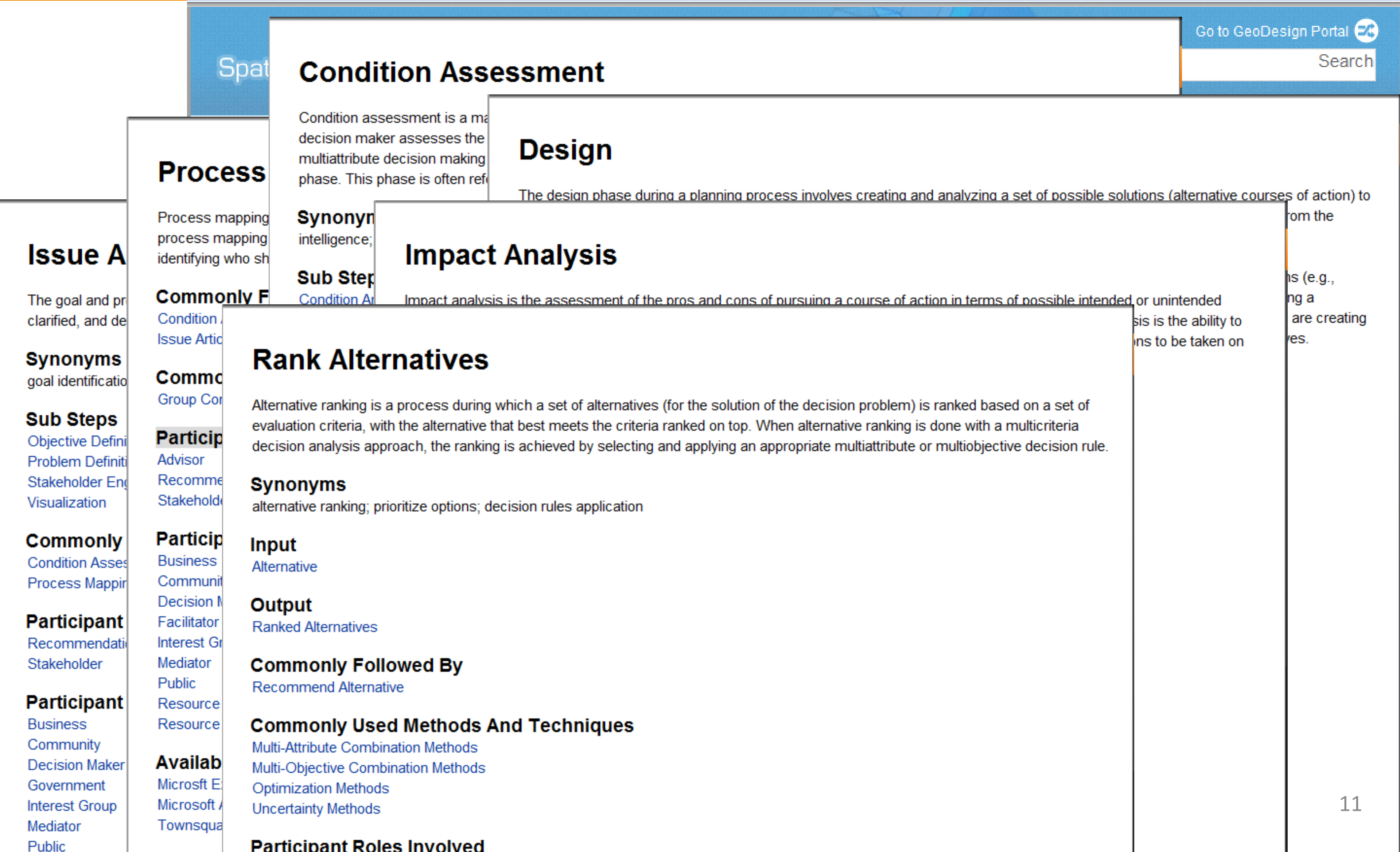
Phase IV: How might the landscape be altered, by what policies and actions, where and when? This question is answered by the CHANGE MODELS that will be tested in the research. They are also data, as assumed for the future.

Phase V: What difference might the changes cause? This question is answered by IMPACT MODELS, which are information produced by the process models under changed conditions.

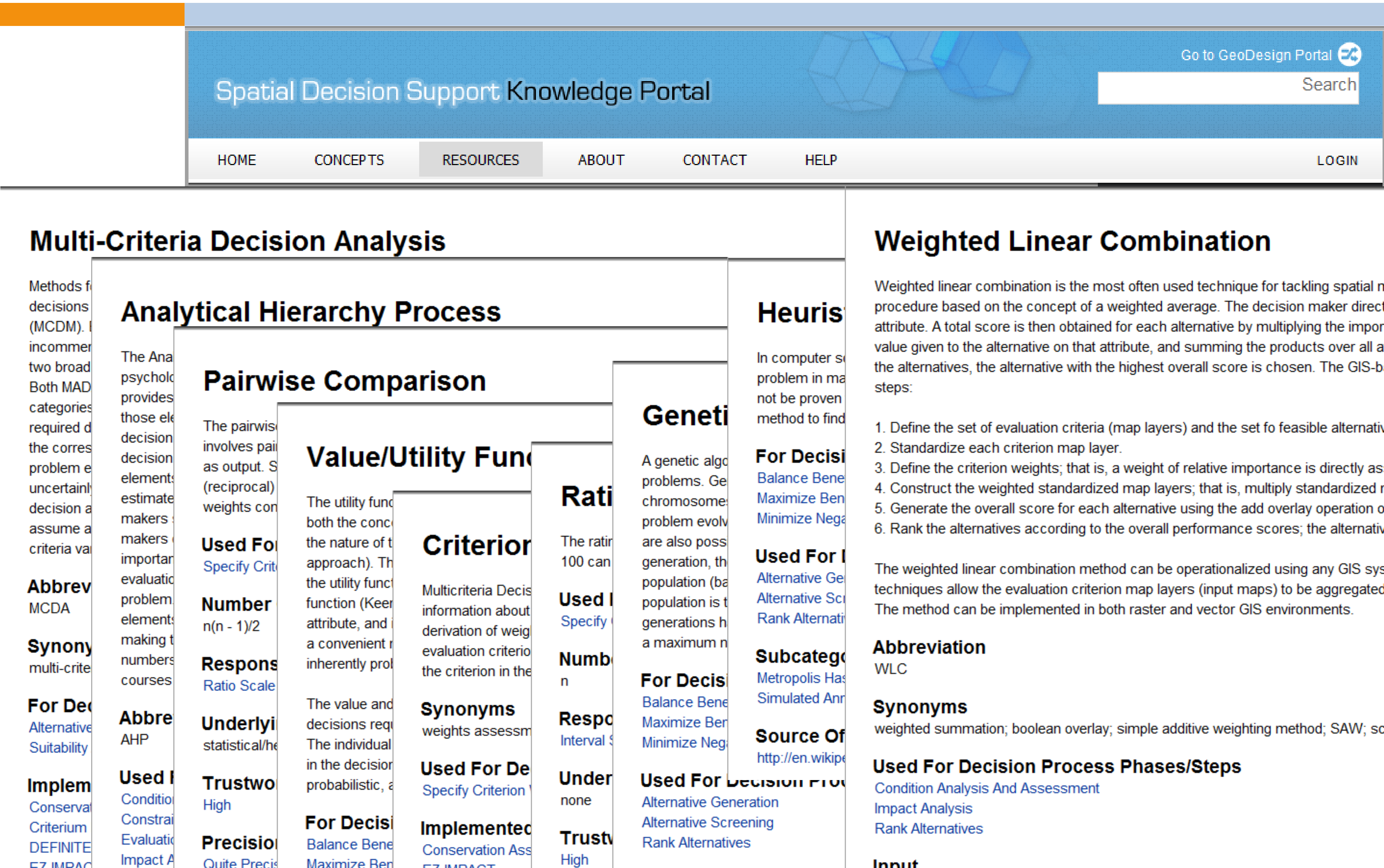
Phase VI: How should the landscape be changed? This question is answered by DECISION MODELS, which, like the evaluation model are dependent on the cultural knowledge of the stakeholders and responsible decision-makers.

As indicated in the following diagram, the decision process flow may go back to a previous phase if the conclusion for the current phase indicates the need:

Steps in a spatial planning workflow



Methods, techniques, algorithms



Software models, tools, services

Case studies

Spatial Decision Support Knowledge Portal

Go to GeoDesign Portal

Search

HOME CONCEPTS RESOURCES ABOUT CONTACT HELP LOGIN

Ontology Hierarchy

Case Studies

Filter By

show all

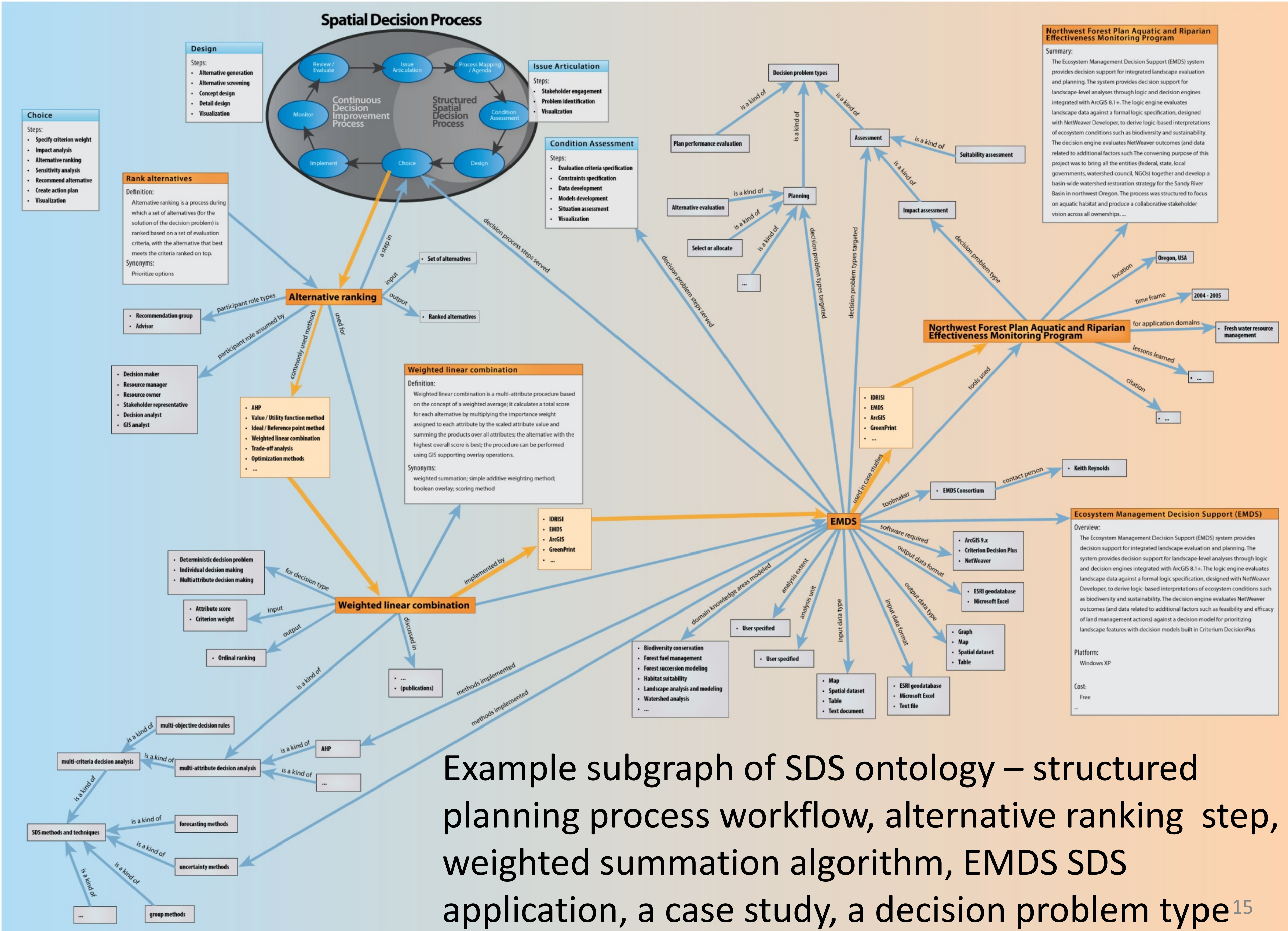
decision problem type	tools and models used
application domain	location
planning/decision process workflow adopted	start year
planning/decision process steps involved	end year

Baltimore reservoirs forest conservation plan

The city of Baltimore, Maryland, used a combination of computer-based tools, primarily the ArcView geographic information system (GIS) and the NED-1 system, to analyze risks to the long-term sustainability of their reservoir lands and to develop and evaluate alternative scenarios for management of the lands. While maintaining water quality was the primary goal, the second and third goals were maintaining and enhancing the forest habitat as a contribution towards regional biodiversity. NED-1 inventories incorporated data needed to evaluate wildlife habitat composition and structure and the quality of habitat along first- and second-order streams. While providing a platform for the management and analysis of data on numerous key abiotic and biotic forest characteristics, the NED-1 decision support software did not provide a mechanism for evaluating the relationships of these landscape elements. The need to understand how landscape context and current ecological processes were shaping the forest required a synthesis of tools and often required stepping outside the decision support mechanism for critical answers to conservation problems.

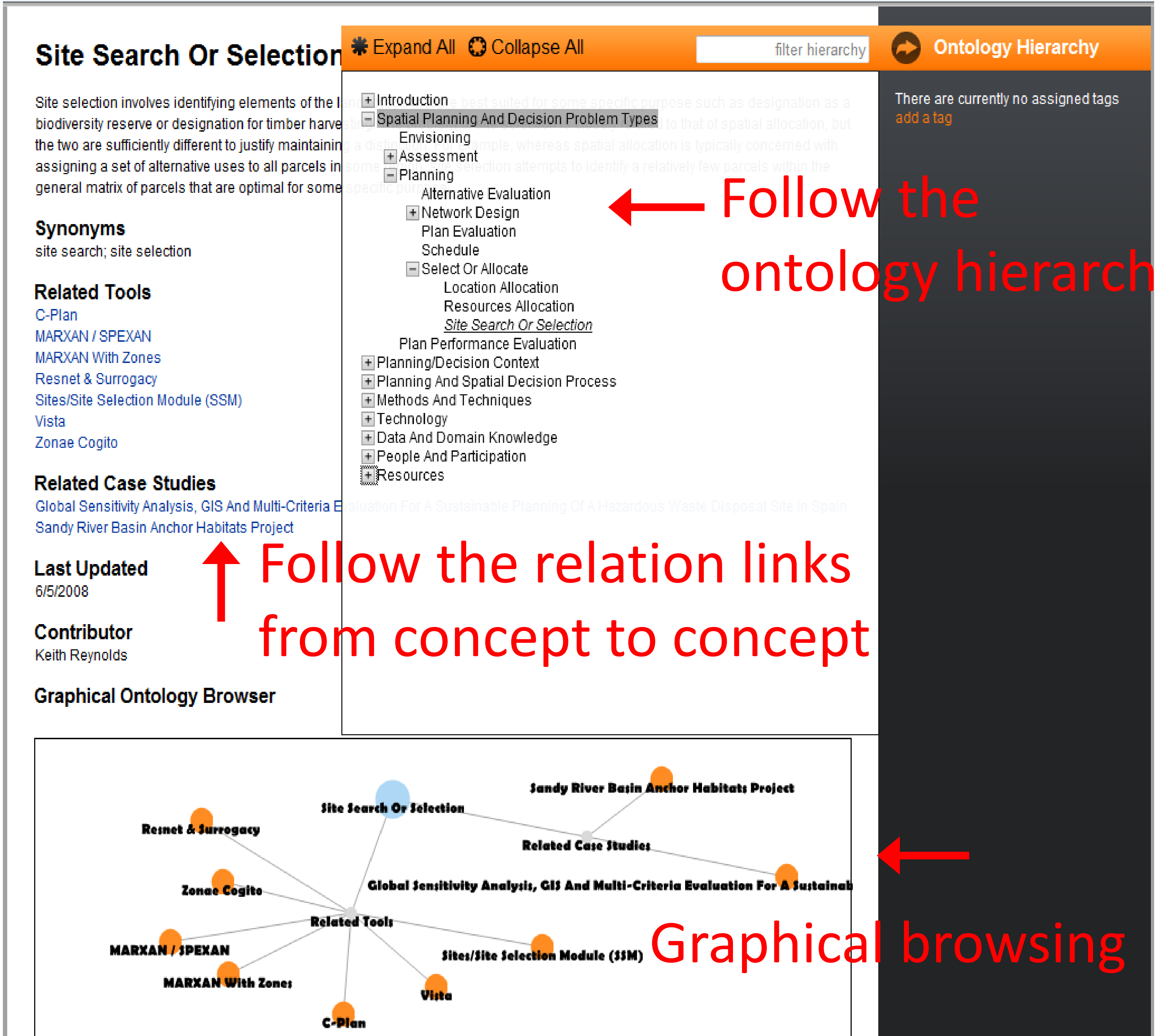
Boise-Payette-Sawtooth National Forest Plan

National forests are required to update their management plans every 10–15 years. The adjacent Boise, Payette, and Sawtooth National Forests in southern Idaho and northern Utah decided to update their plans together in order to better understand larger landscape issues and to address their many common concerns more efficiently. National forest plans do



Example subgraph of SDS ontology – structured planning process workflow, alternative ranking step, weighted summation algorithm, EMDS SDS application, a case study, a decision problem type

Browsing on SDS Knowledge Portal

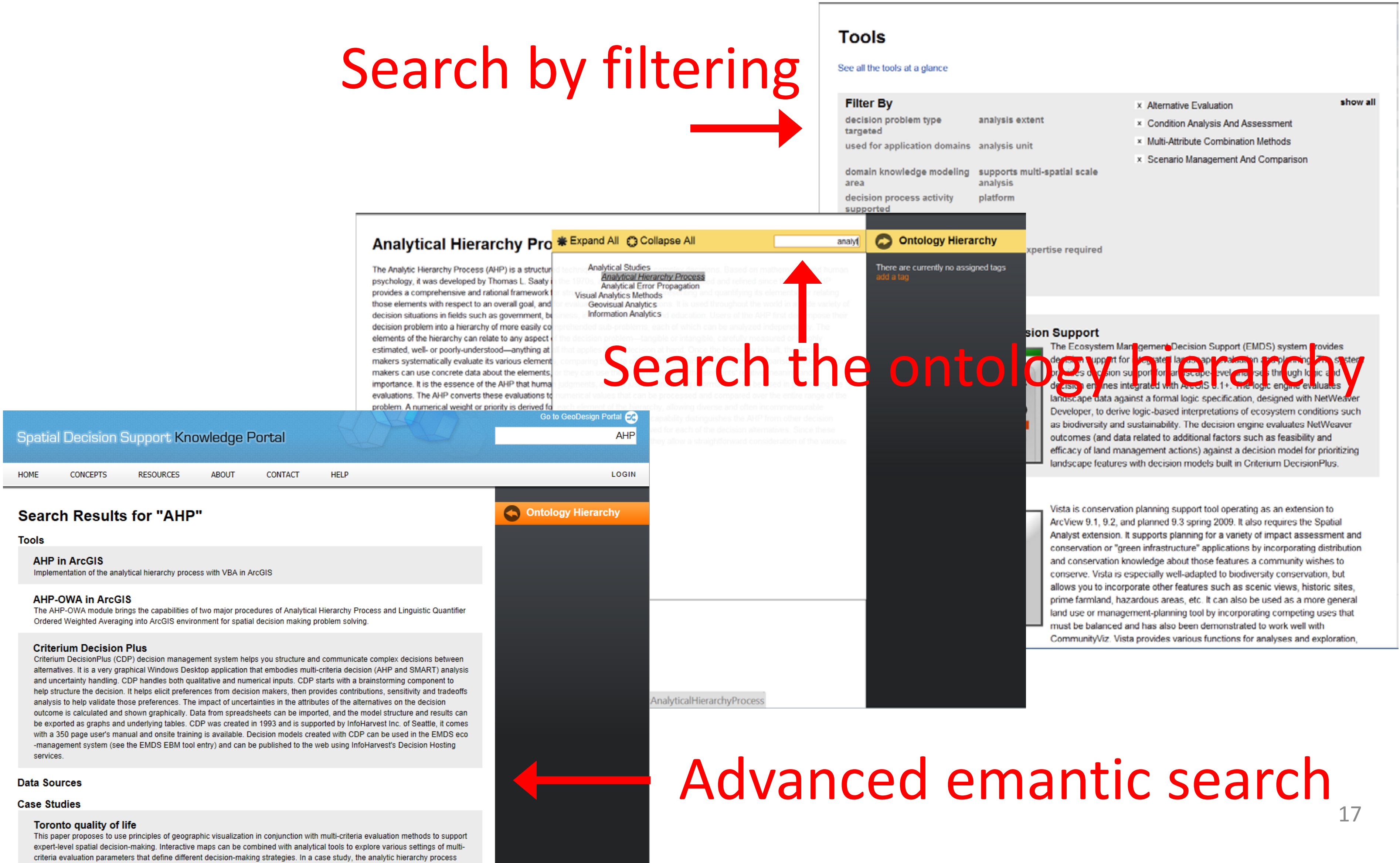


Follow the ontology hierarchy

Follow the relation links from concept to concept

Graphical browsing

Searching on SDS Knowledge Portal

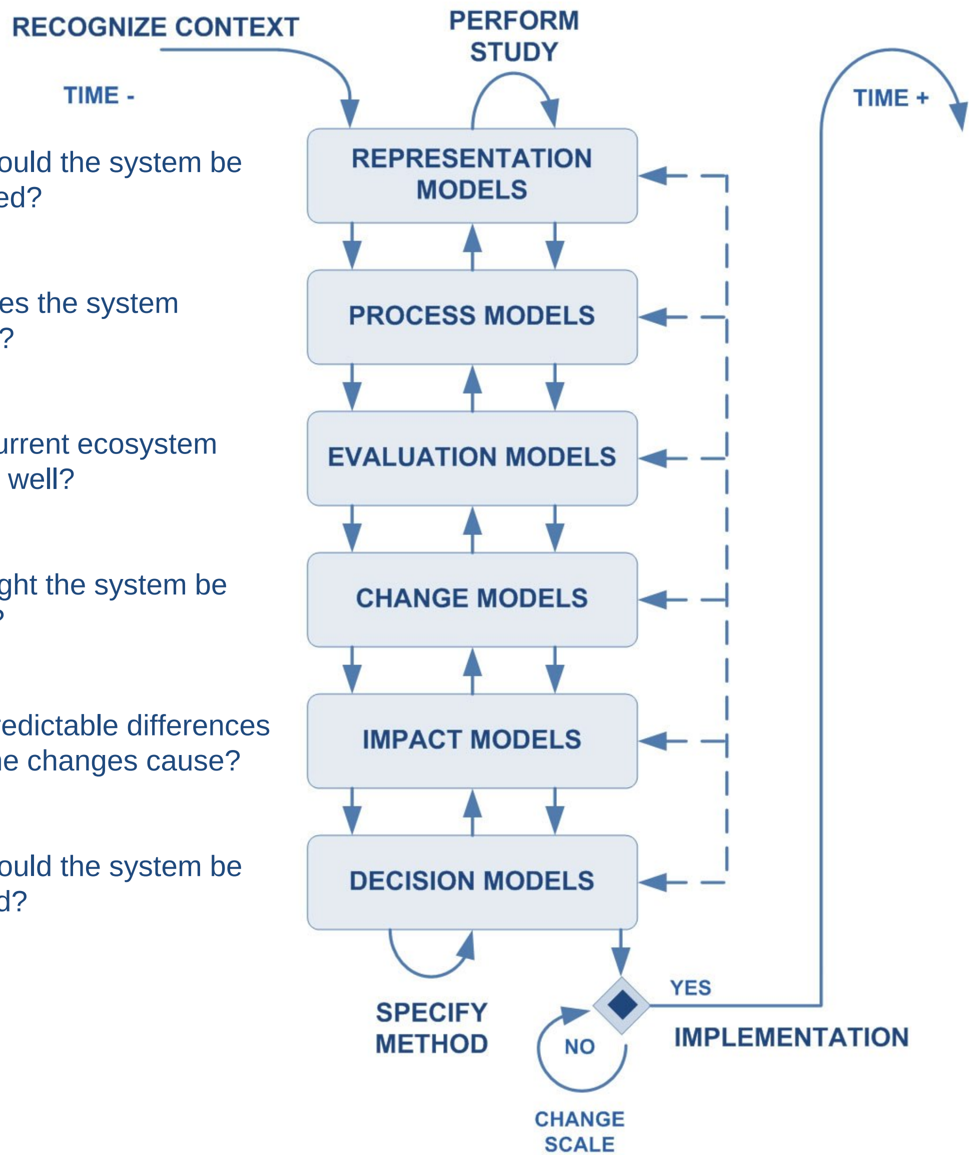


From Ontologies (directly) to Computational Workflows

- Ontologies are not just for conceptual clarity (though we love that!) and for organizing things
- Decision support researchers and practitioners need them to create interoperable computational applications that deliver decision support for solving Grand Challenge planning and decision problems.

A planning process workflow

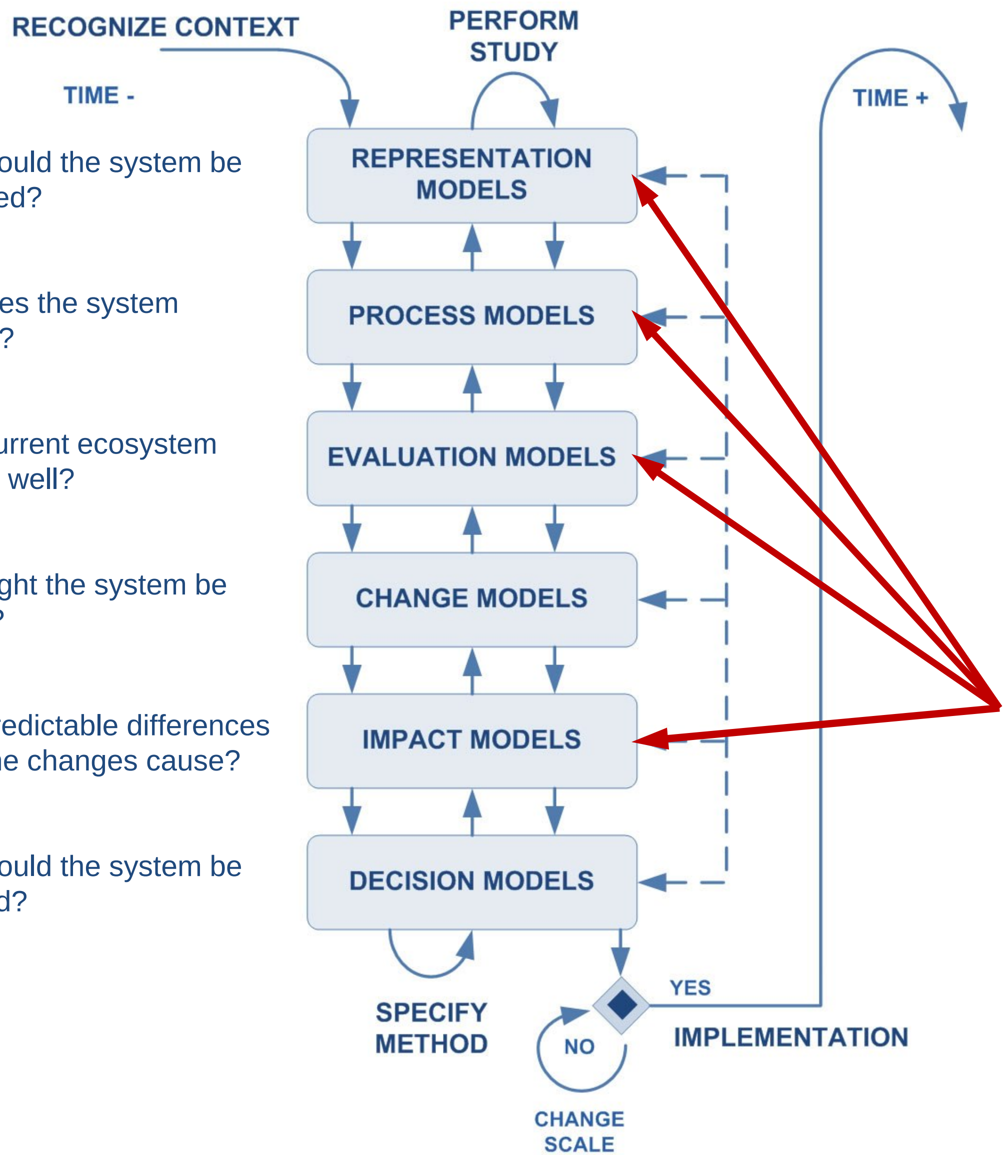
1. How should the system be described?
2. How does the system operate?
3. Is the current ecosystem working well?
4. How might the system be altered?
5. What predictable differences might the changes cause?
6. How should the system be changed?



Steinitz's framework for planning workflow

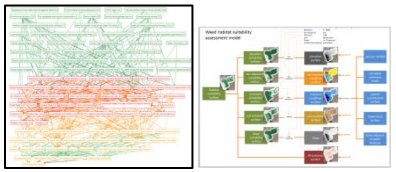
Earth sciences data and modes in planning workflow

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



Steinitz's framework for planning workflow

Earth science data, process models, assessment models



Example of Earth Science models

-- Process model used in Desert Tortoise Recovery (DTRO) SDS, driving tortoise population change assessment calculation

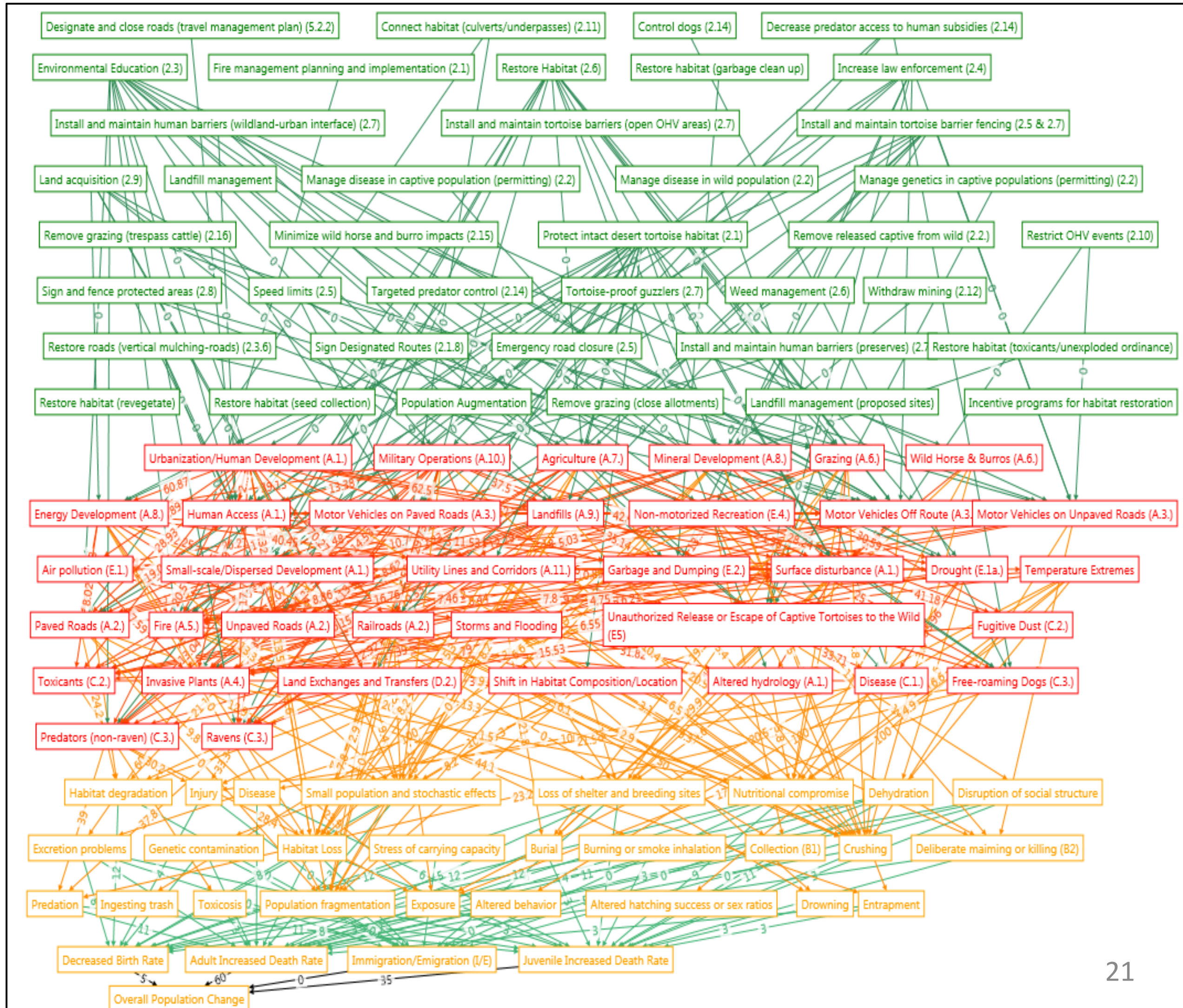
The Fish and Wildlife Service (FWS) DTRO office identified:

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*

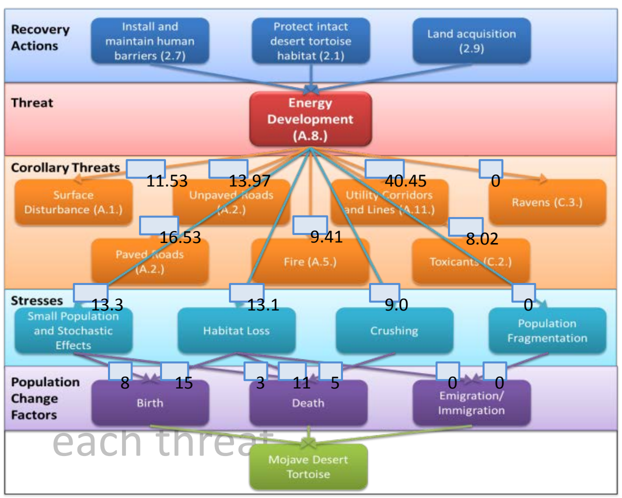


Example of Earth Science models
-- Process model used in Desert Tortoise Recovery SDS

The FWS DTRO created this process model by creating Threat “tiles”

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

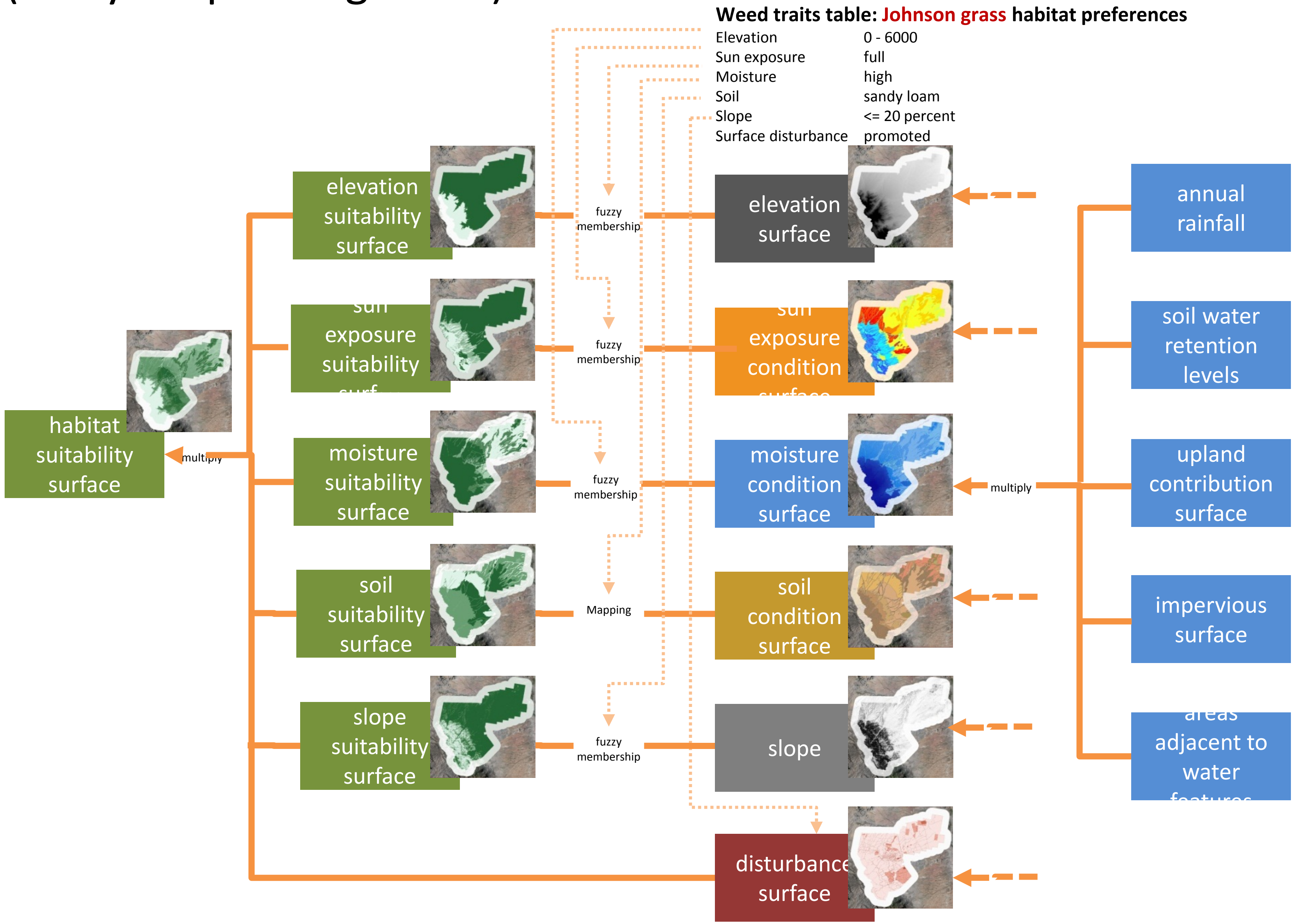
A threat description based on the Threat design pattern



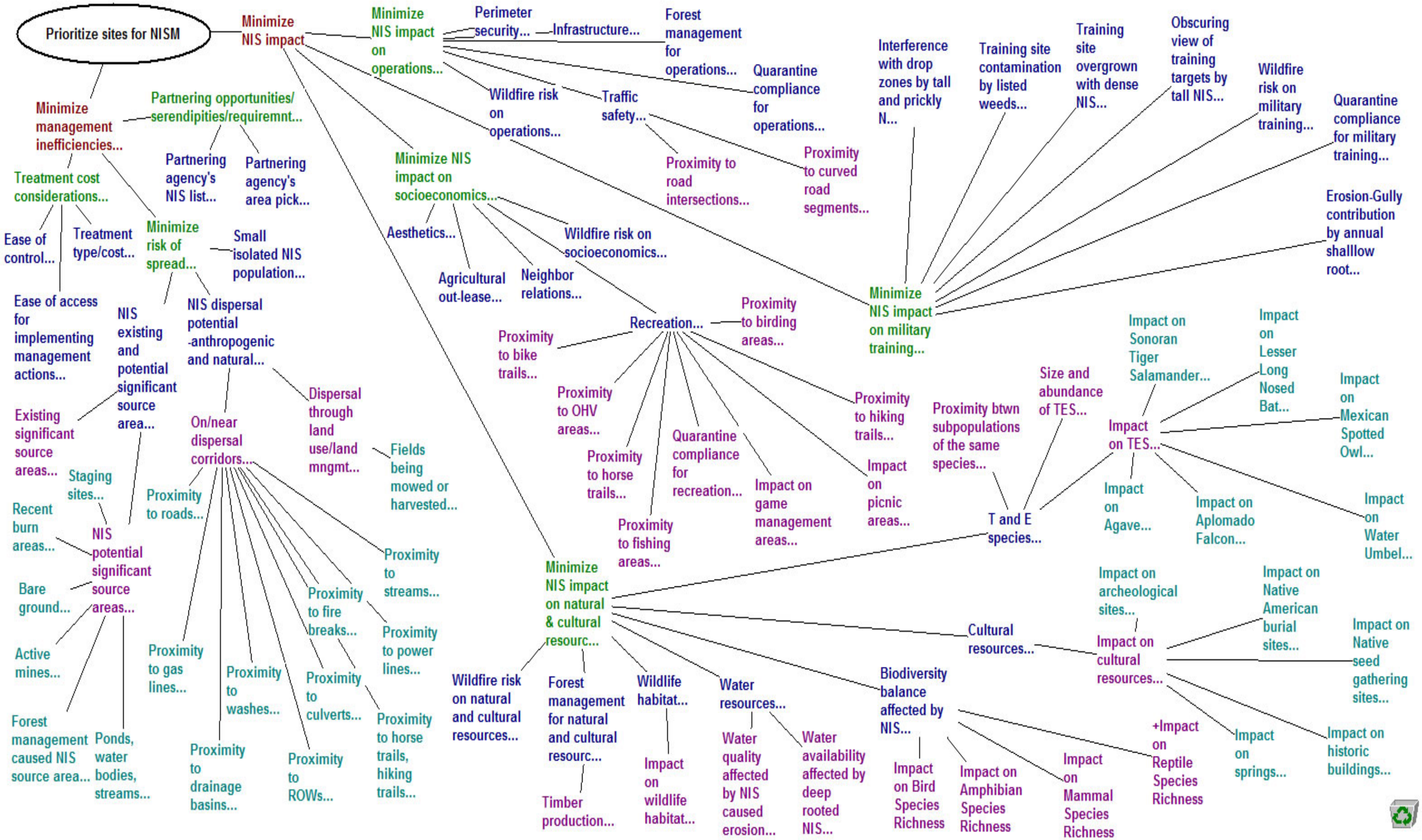
each threat

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

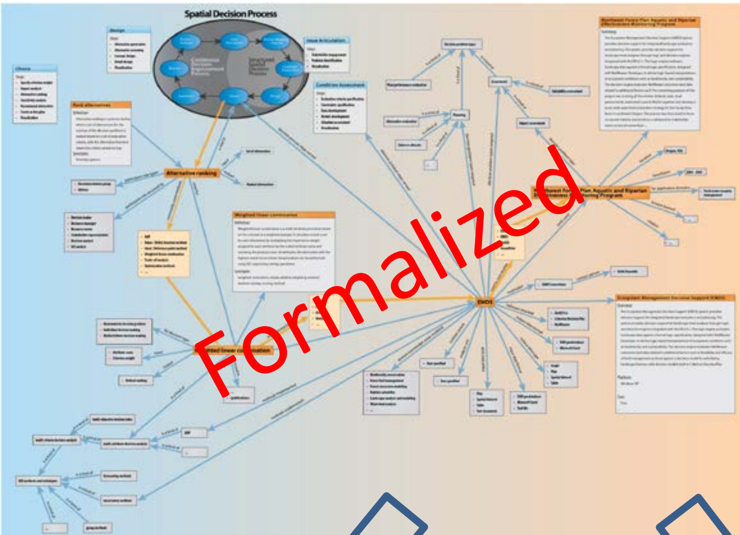
Example of Earth Science models
-- Non-native invasive species habitat suitability assessment model (Army Corp of Engineers)



Example of decision models
-- Non-native invasive species management on military installations

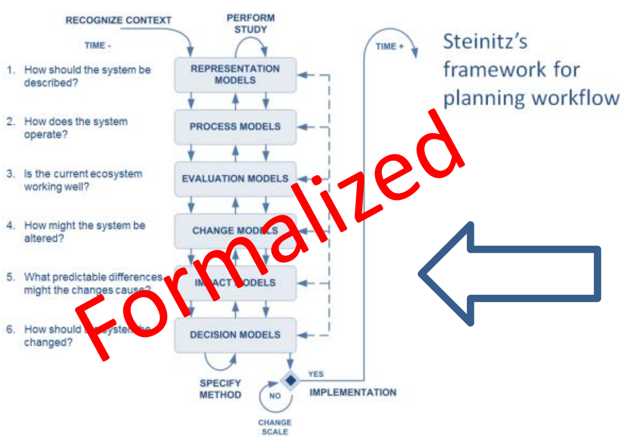


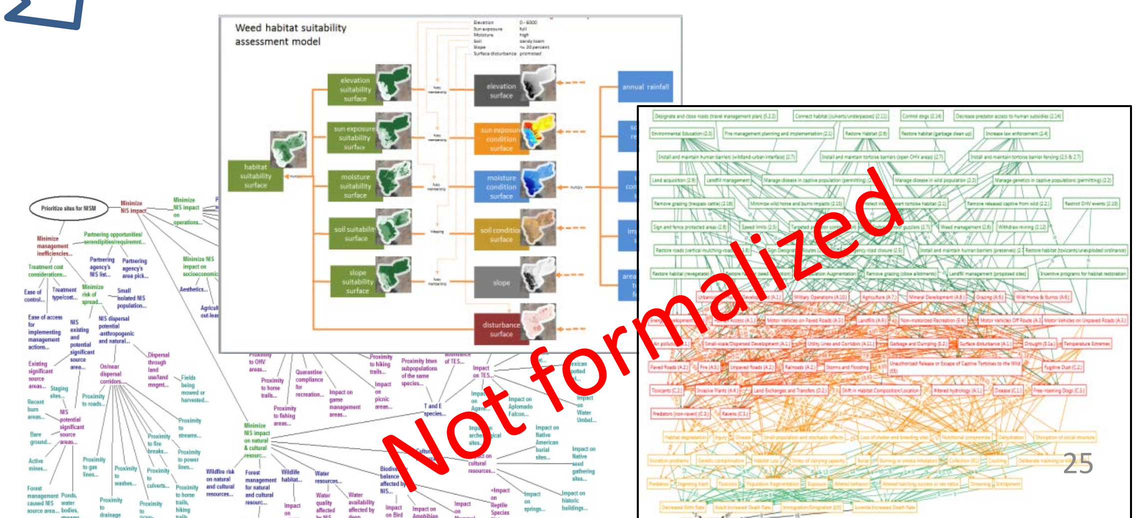
Earth science ontologies and SDS ontology



The SDS ontology needs to reference the concepts and parameters defined in the Earth science ontologies to Identify the right datasets and models that are

- appropriate for a specfic decision problem
- Interoperable





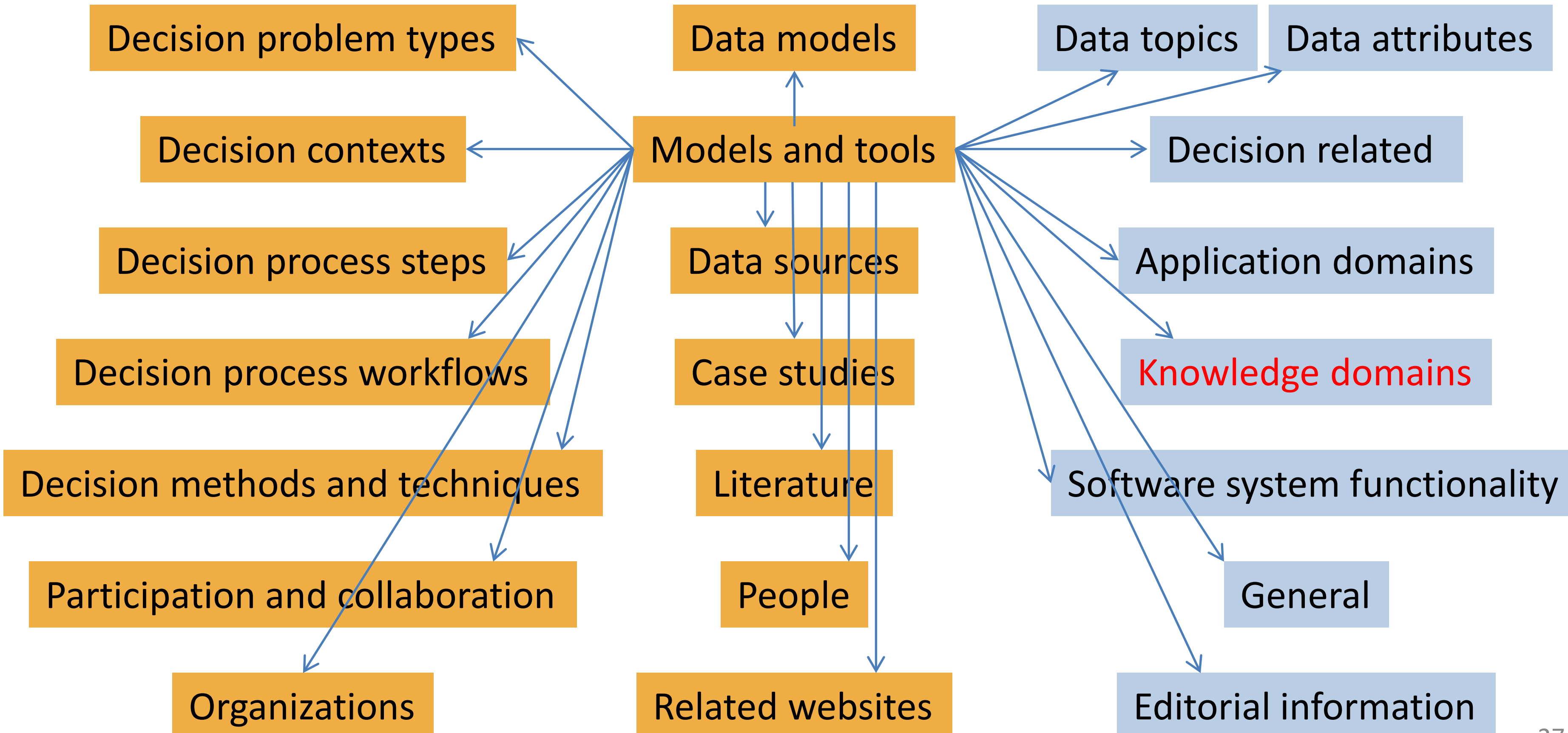
Earth science ontologies and SDS ontology

The SDS ontology currently refers to ISO 19115 for data topic concepts (not granular enough)

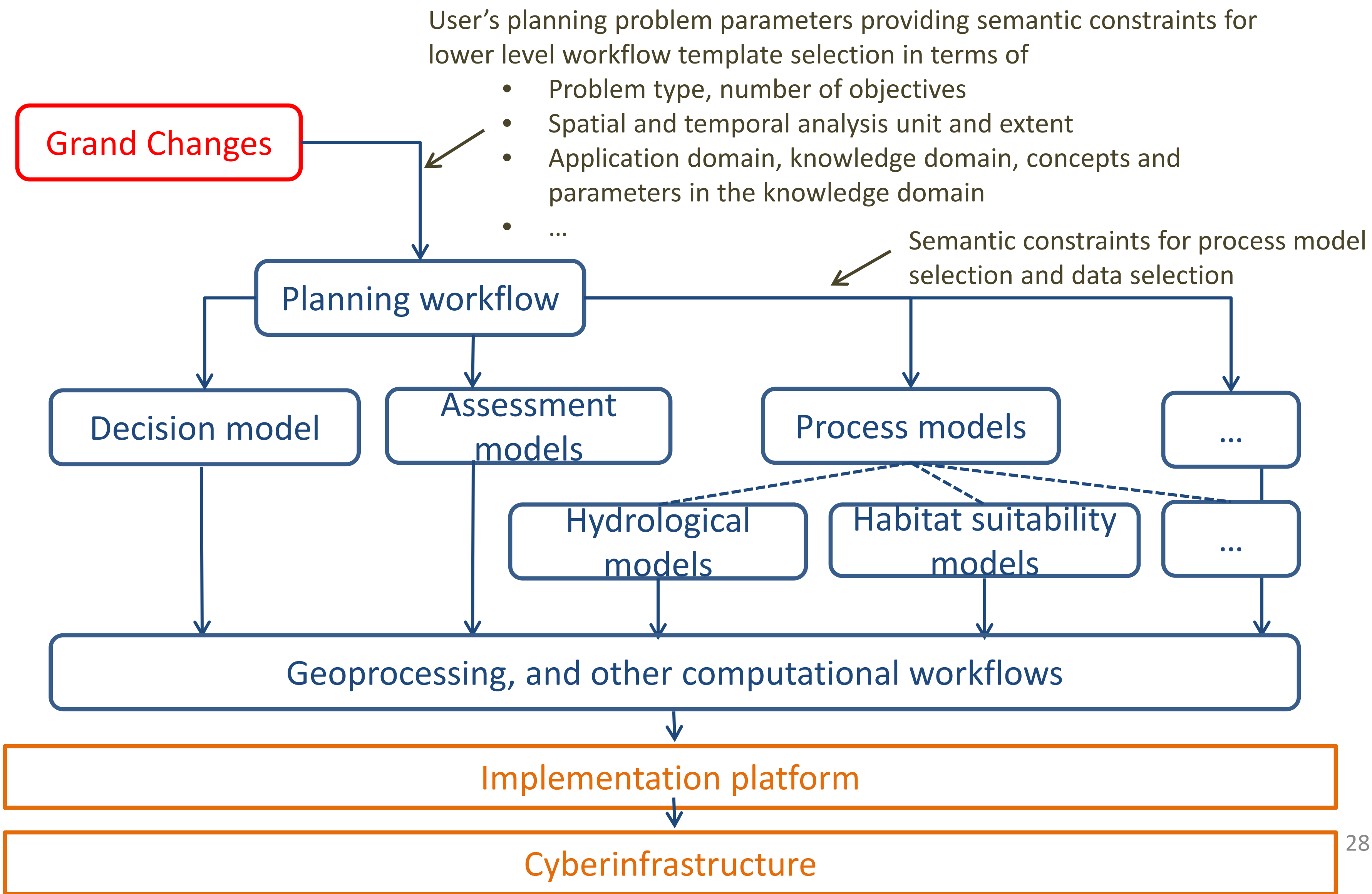
Decision problem types	Data models	ISO 19115	Data attributes
Decision contexts	Models and tools	Decision related	
Decision process steps	Data sources	Application domains	
Decision process workflows	Case studies	Knowledge domains	
Decision methods and techniques	Literature	Software system functionality	
Participation and collaboration	People	General	
Organizations	Related websites	Editorial information	

Earth science ontologies and SDS ontology

The models sub ontology in SDS ontology only refers to knowledge domains taxonomy, but not specific concepts within Earth science domains – need to connect to earth science ontologies



Workflow composition guided by SDS ontology and Earth science ontologies



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See also:

- www.spatial.redlands.edu/sds
- Li, N., Raskin, R., Goodchild, M. and Janowicz K. (2012) An Ontology-Driven Framework and Web Portal for Spatial Decision Support. *Transactions in GIS* 16(3): 313-329.