

Ecosystem Services centered adaptation strategies

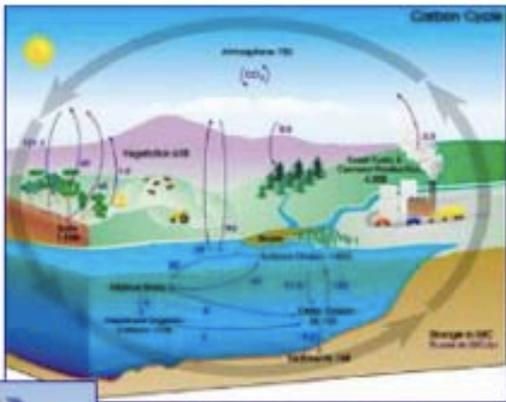
Ferdinando Villa, BC3

SUMMARY

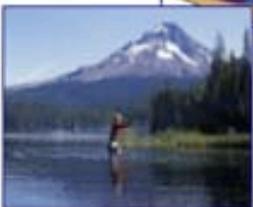
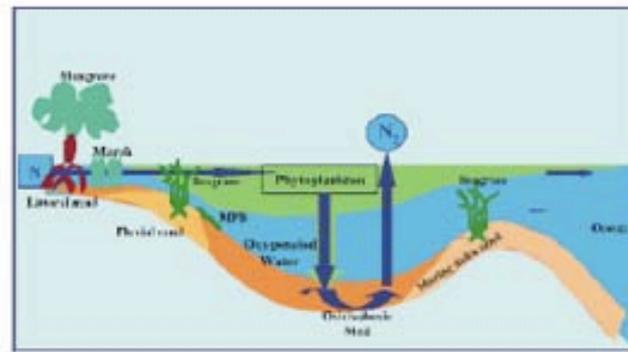
Improving the efficiency of ecosystem services transfer from Nature to humans can be an effective adaptation strategy, as opposed to reducing consumption or finding new ways for production

This lecture focuses on the developing science of ecosystem services that can allow us to quantify, model and manage that efficiency





Flood Attenuation/
Storm Surge Protection

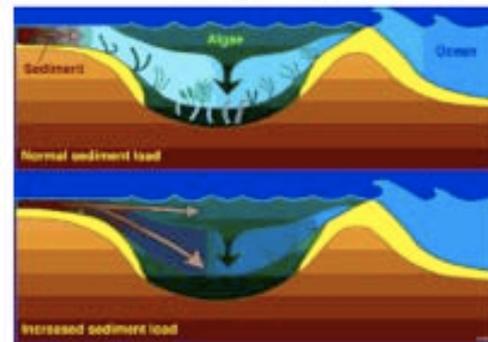


Atmospheric and Climate
Regulation

Recreation / Aesthetic



Food and Fiber



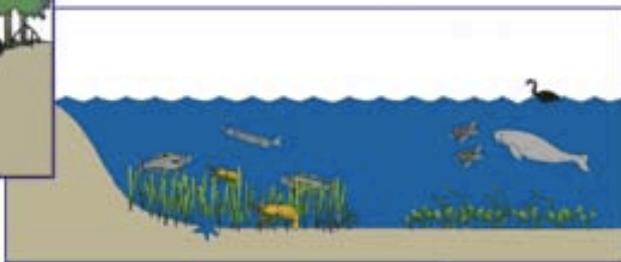
Soil and Sediment Regulation



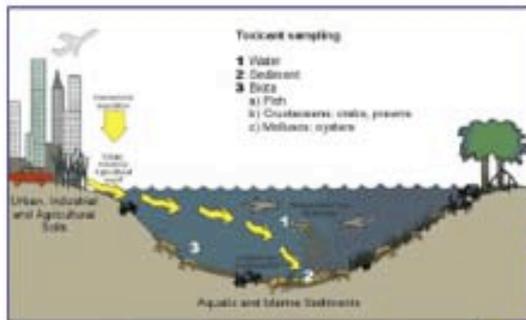
Water Quality and Supply



Pest and Disease
Regulation



Habitat/Fisheries



Waste Regulation

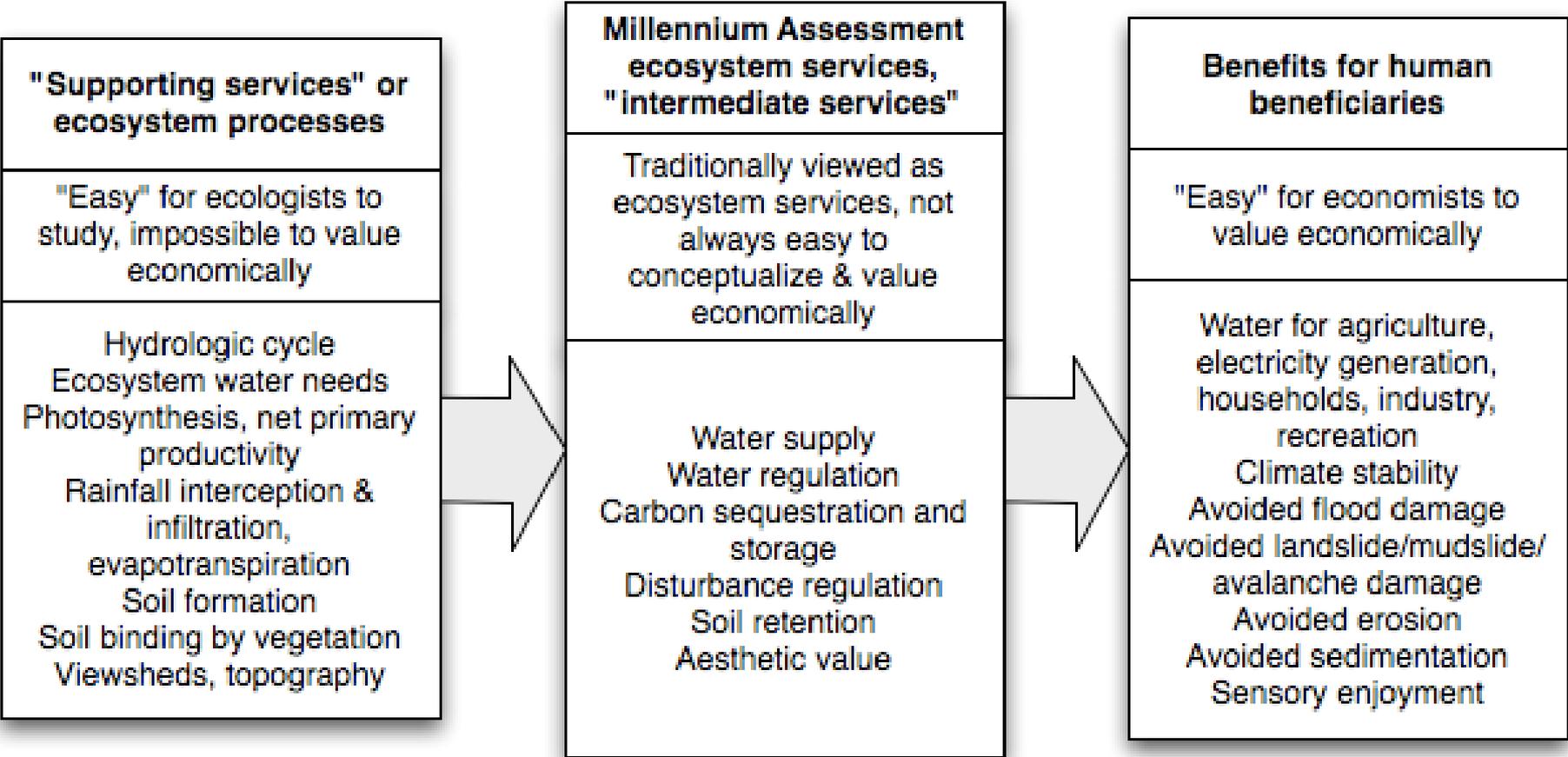
ECOSYSTEM SERVICES in the MILLENNIUM ASSESSMENT

Optimal for communication, raising awareness

| | |
|---|--|
| Supporting services <ul style="list-style-type: none">-Nutrient cycling-Net primary production-Pollination & seed dispersal-Hydrologic cycle... | Regulating services <ul style="list-style-type: none">-Climate regulation-Disturbance regulation-Water regulation-Nutrient regulation... |
| Provisioning services <ul style="list-style-type: none">-Water supply-Food-Raw materials... | Cultural services <ul style="list-style-type: none">-Recreation-Aesthetic-Spiritual & historic... |

Ecosystem Services are a multiple-scale problem where provision and use have different modes and scales, and flow across the landscape in different manners. Quantitative, spatially explicit assessment and valuation require more systematic and less general definitions.

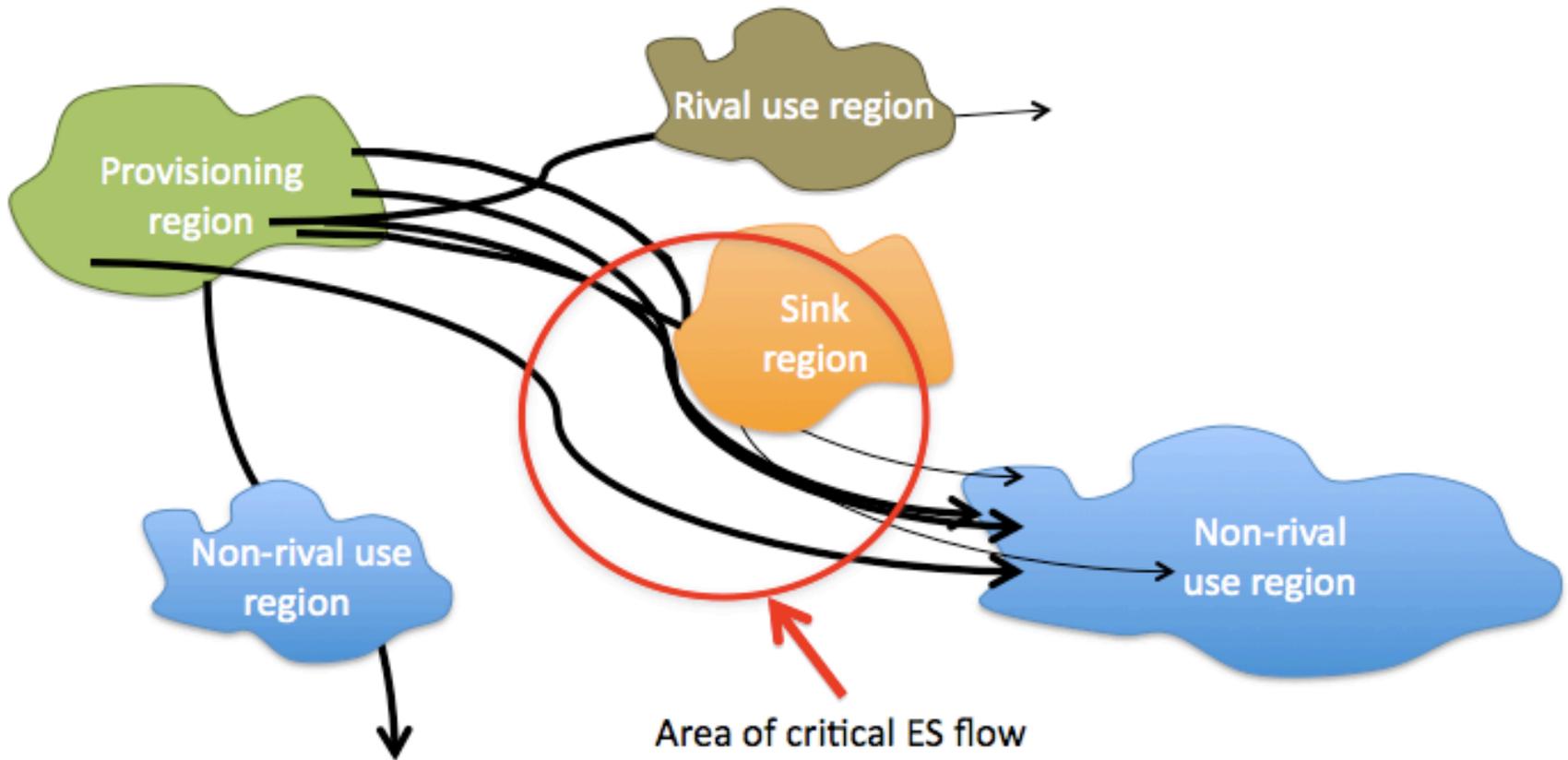
A quantitatively based framework for ES



Four challenges

- RAPID ASSESSMENT of ecosystem services and their values; not a single model but an intelligent system that customizes models to user goals.
- Demonstrate a MAPPING PROCESS for ecosystem service provision, use, and flow where most ES assessments only look at provision.
- “Honest” probabilistic models should inform decision-makers of the UNCERTAINTY of all possible outcomes; **should operate in conditions of data scarcity.**
- USABILITY: web based, customizable for specific user groups, geographic areas and policy goals; custom tools implement specific “bottom line”

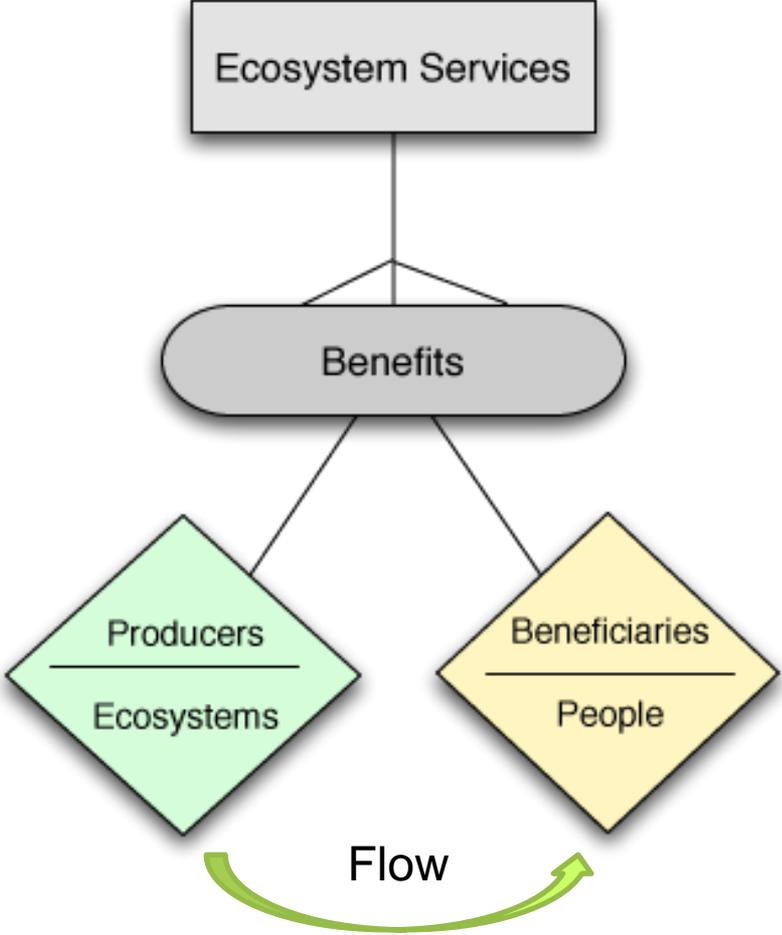
Conceptual Ecosystem Service framework



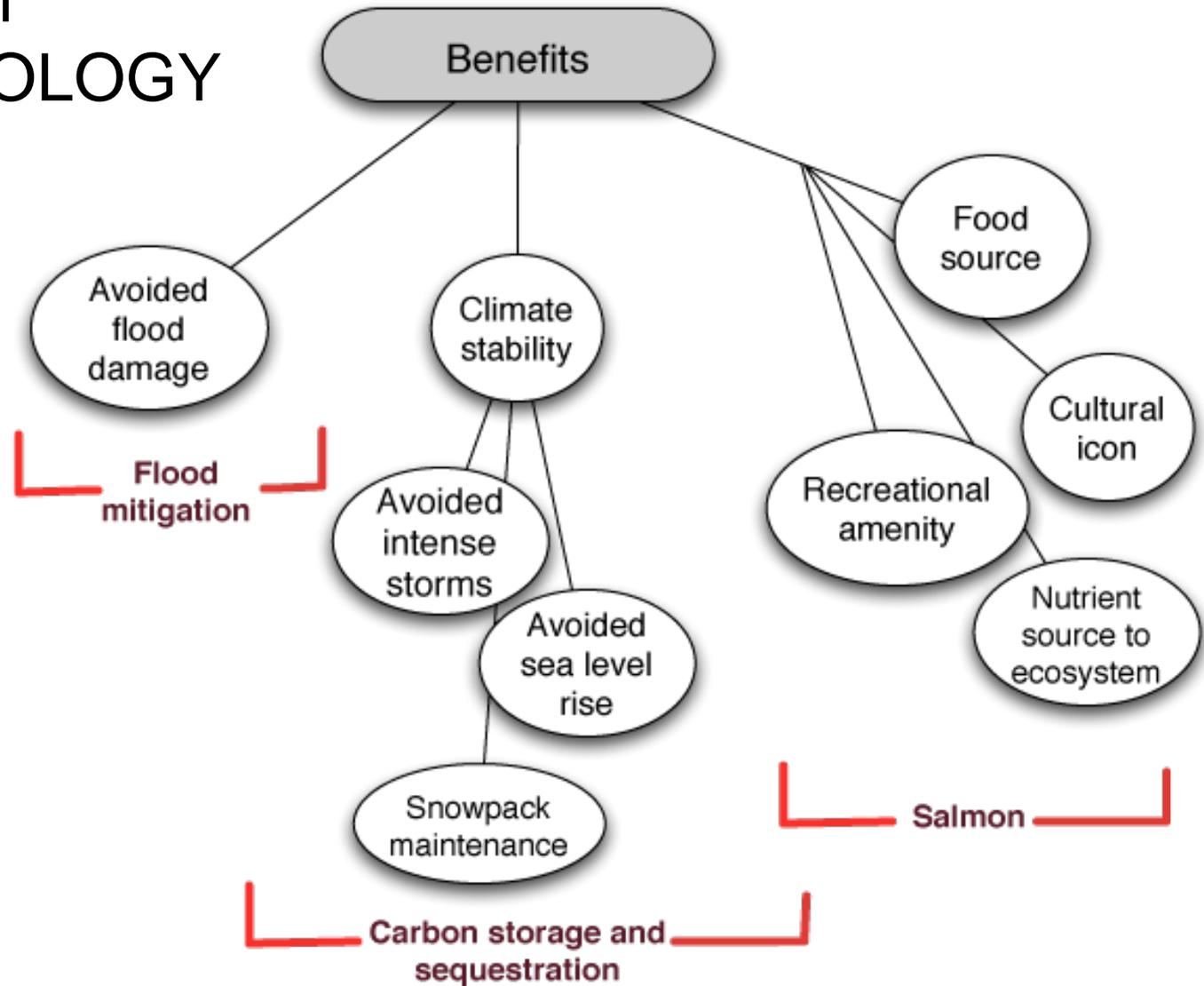
ECOSYSTEM SERVICES

Improving the definition to operationalize the notion

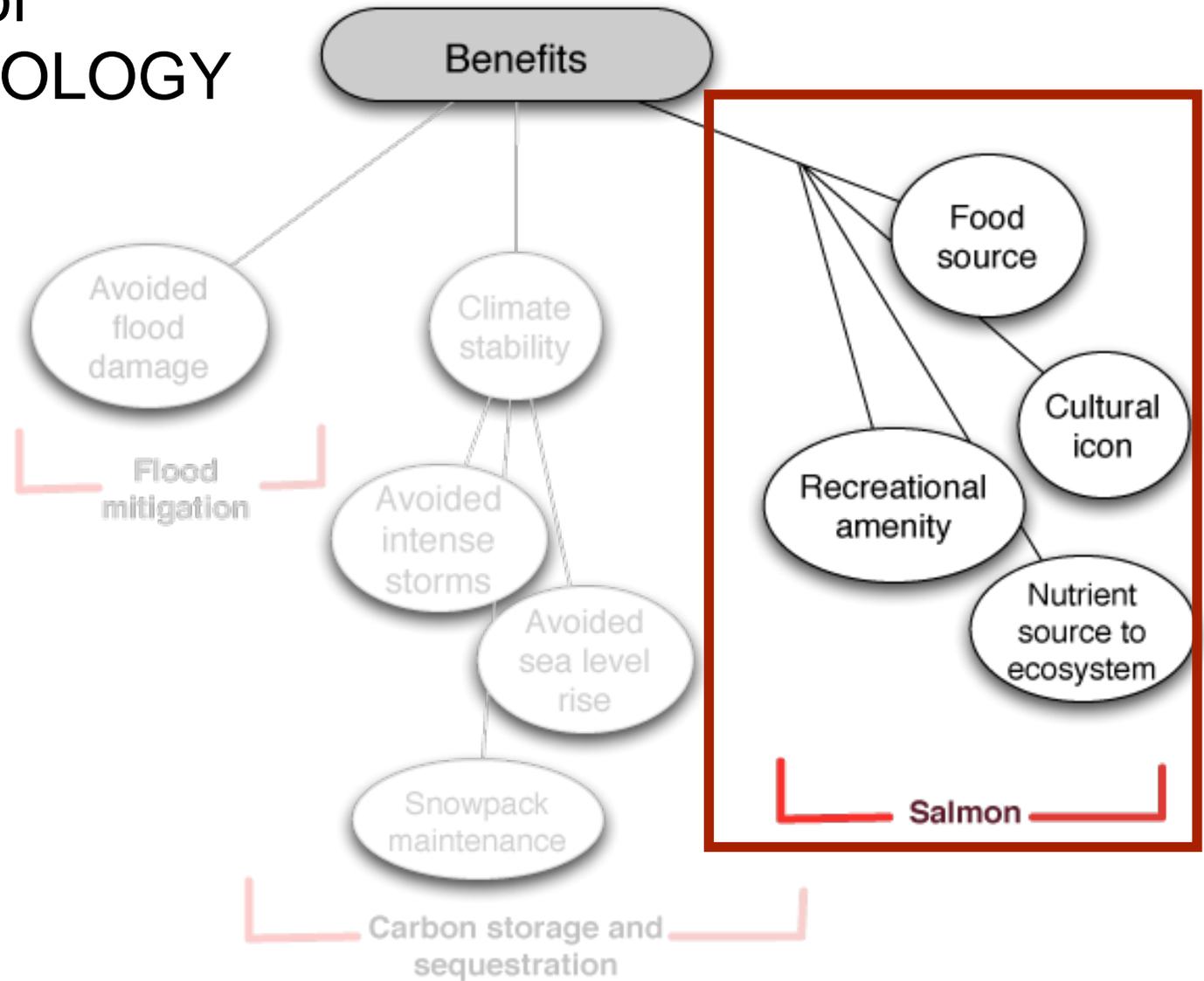
Ecosystem Services:
the effects on human well-being of the flow of benefits from an ecosystem endpoint to a human endpoint at given extents of space and time



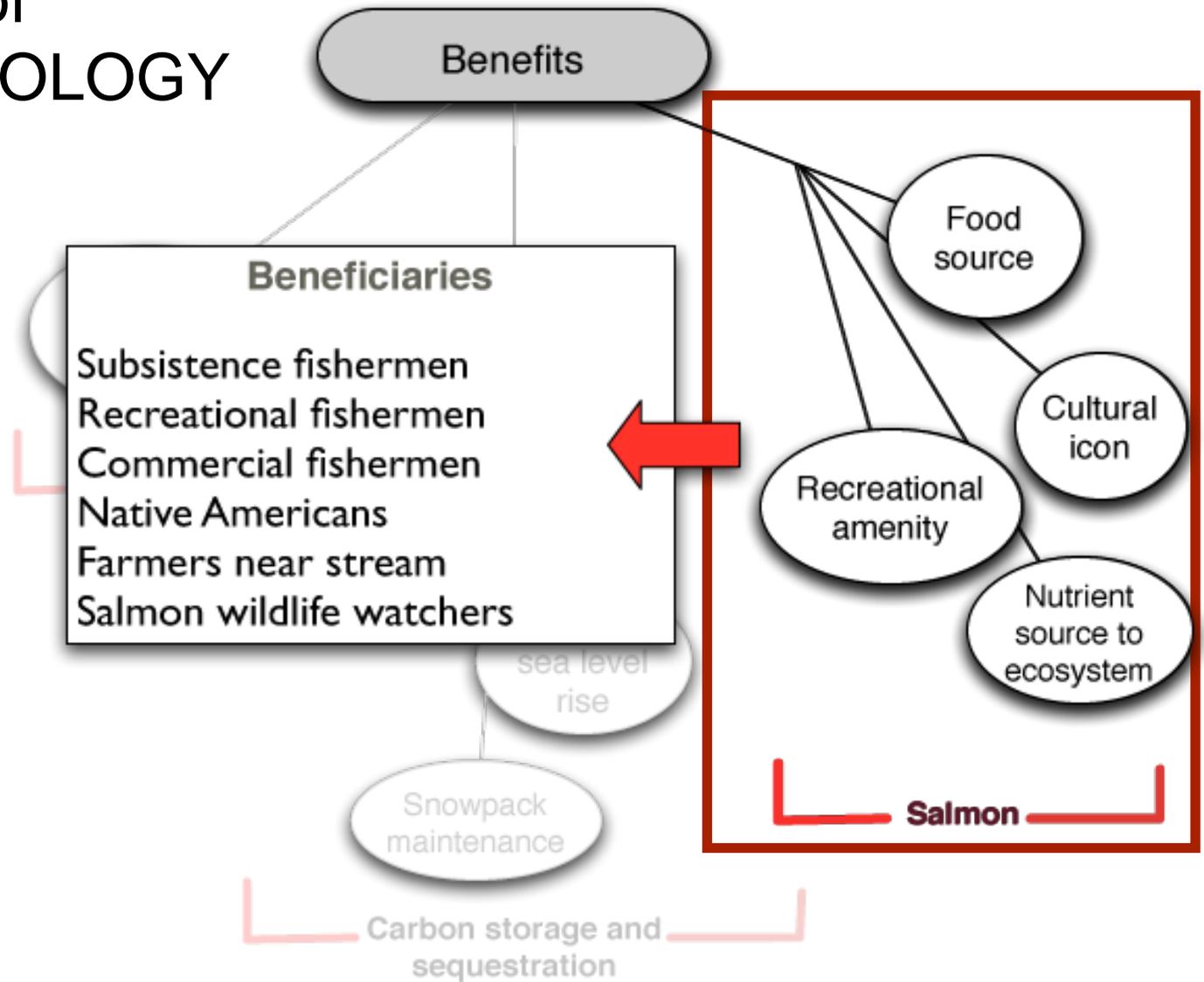
EXAMPLE of ARIES ONTOLOGY



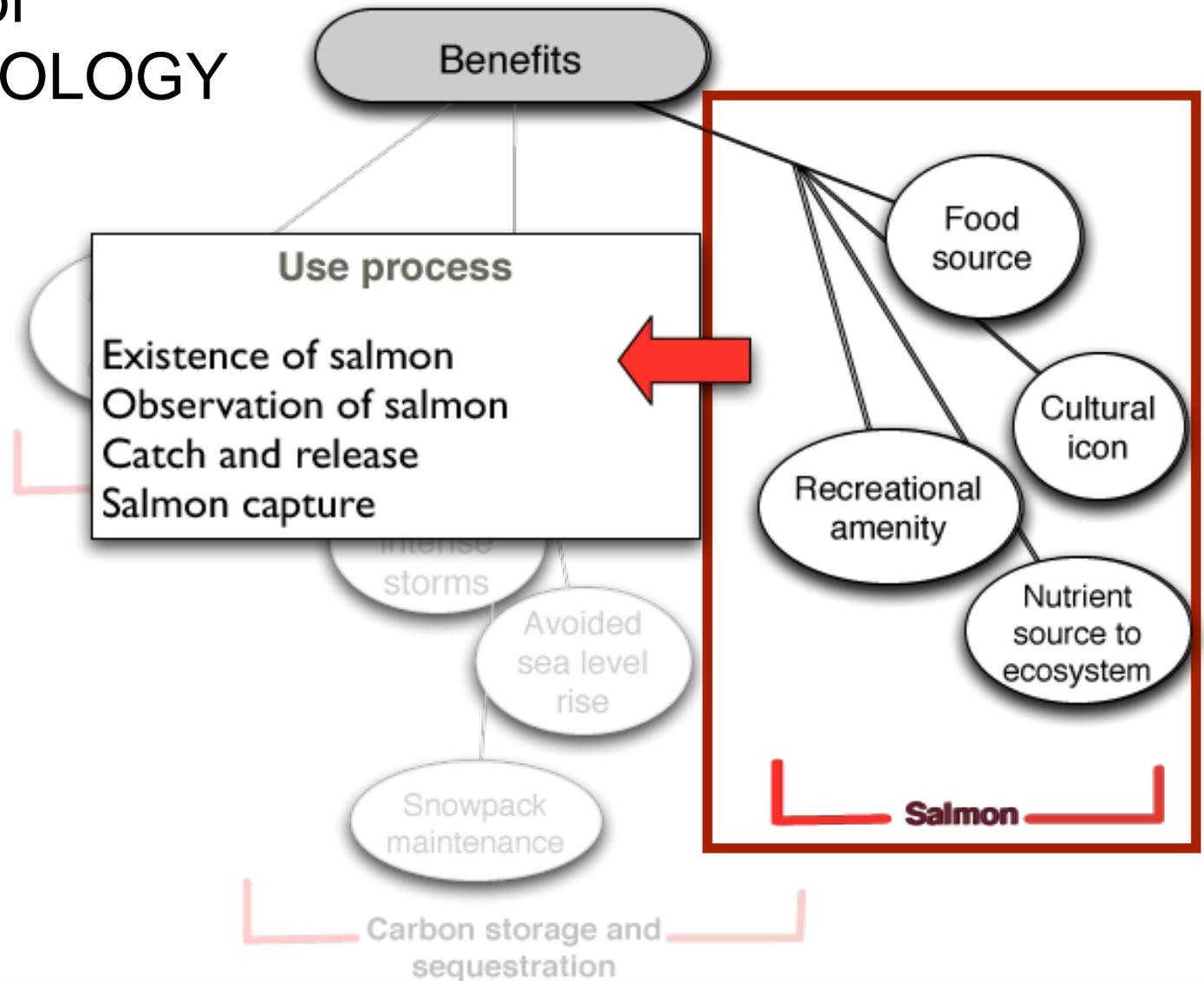
EXAMPLE of ARIES ONTOLOGY



EXAMPLE of ARIES ONTOLOGY



EXAMPLE of ARIES ONTOLOGY



The three elements of ES modeling in ARIES

1. provisionsheds

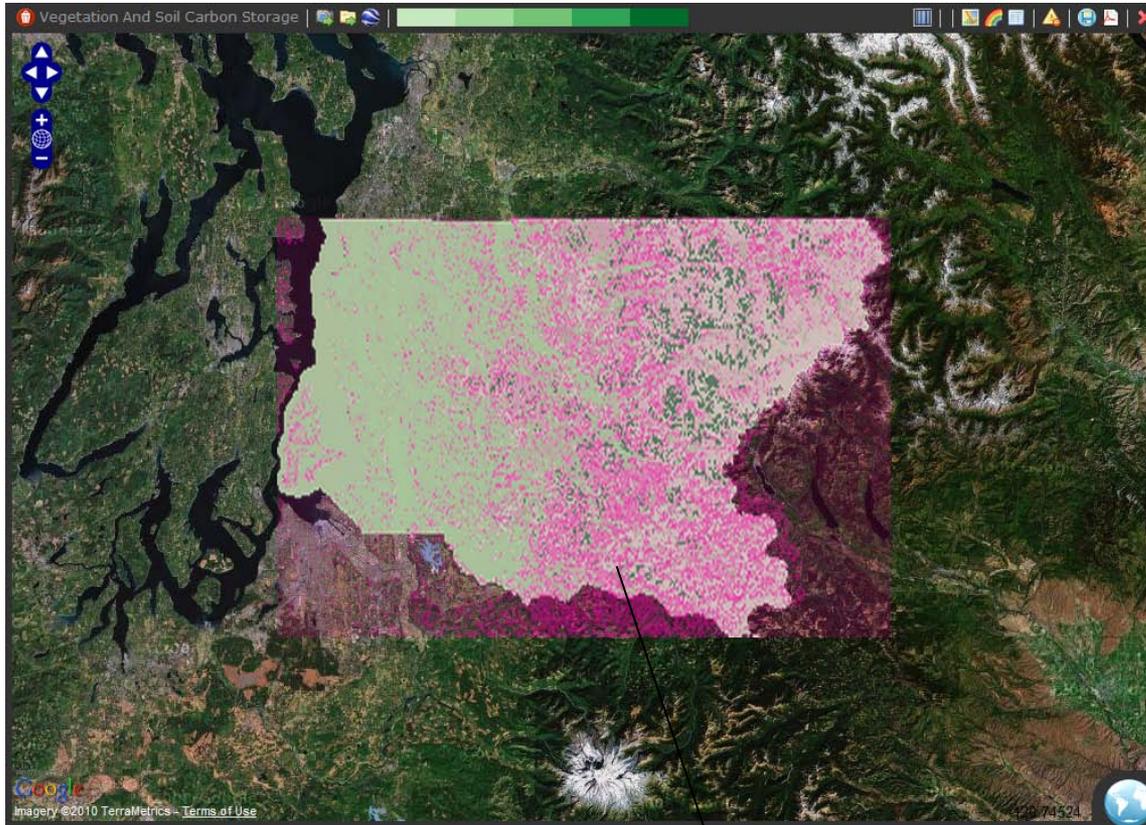


1. Areas of provision of ES and biodiversity

3. Flow paths between areas of provision and areas of use

2. Areas of use of ES and biodiversity where beneficiaries are located

“Conventional” ES source mapping



Pink overlay is a visual cue to uncertainty

Source mapping estimates the potential value provided by each ES (tonnes of sequestered C in this image)

ARIES builds the source models according to the geological, ecological and climate variables describing the areas.

ARIES is the only approach that also estimates in conditions of data scarcity.

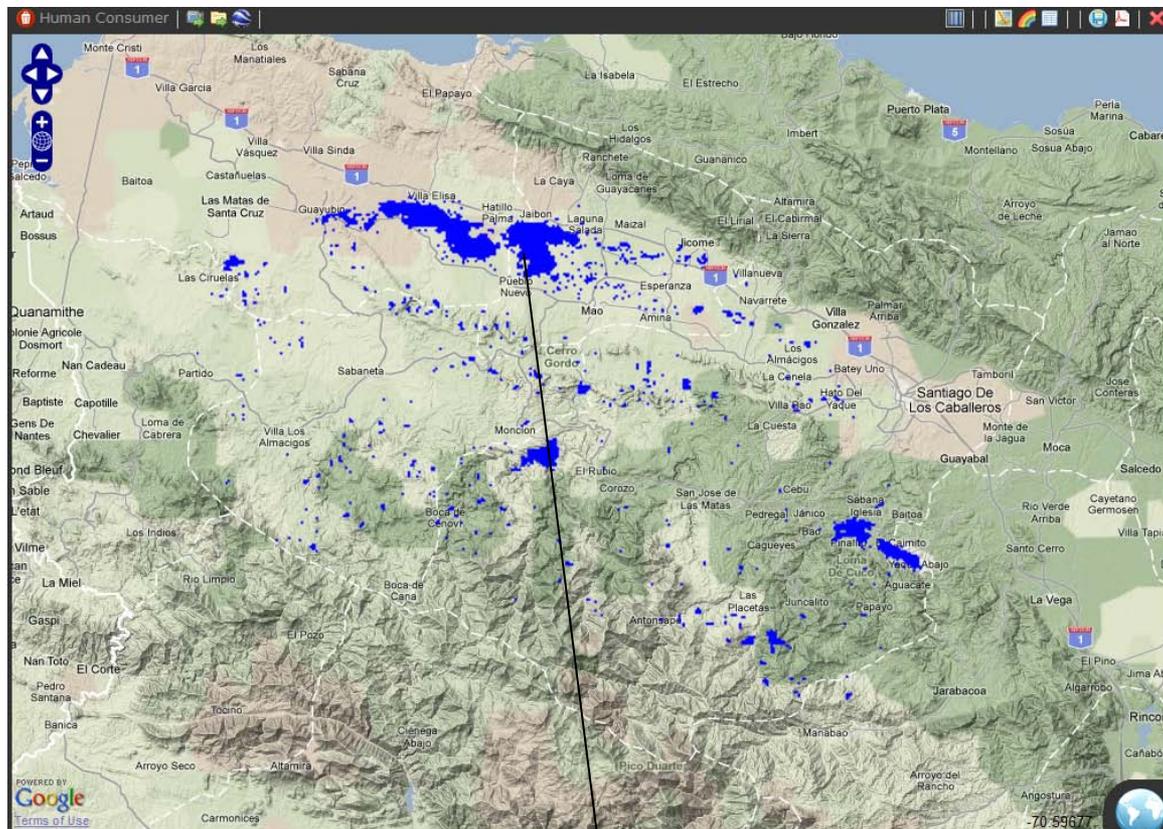
STAKEHOLDER MAPPING

Analysis can be performed for all relevant beneficiary groups

Maps the location and level of need of the potential beneficiaries of each service.

Beneficiary maps can be also made for actual and potential beneficiaries through flow analysis.

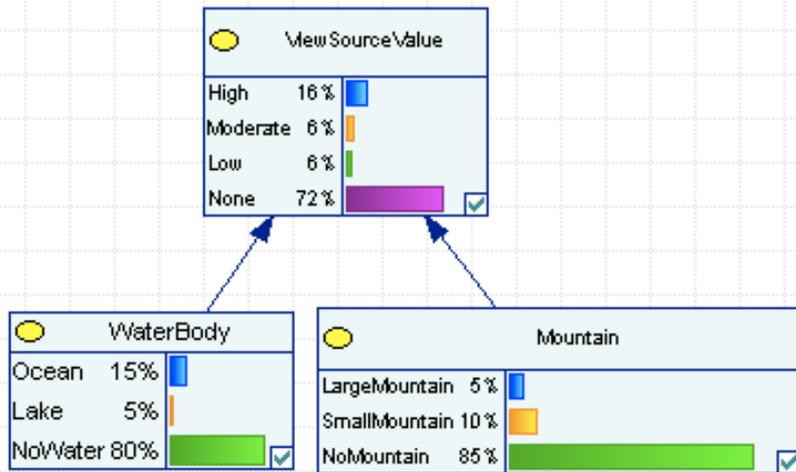
Potential beneficiaries can be the object of planning enhanced flows for positive impact assessment.



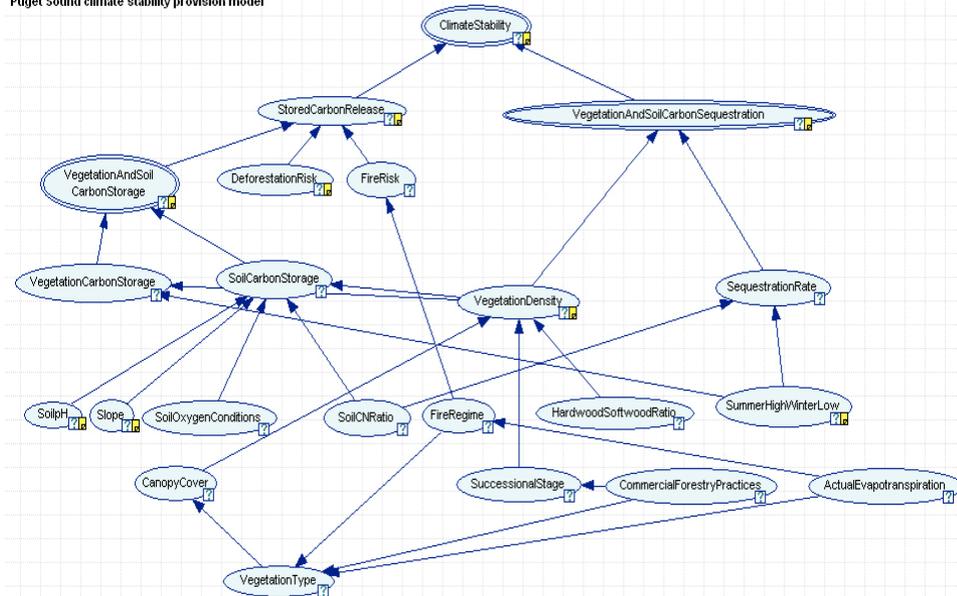
Blue overlay represents local farming communities and their dependence on soil deposition/erosion

Modeling ES provision

- For entire model or model inputs:
 - Use existing ecological models & their outputs if they exist
 - If no good models exist, build ad hoc models based on expert ecological knowledge
- How much of a given benefit is produced for each landscape district?

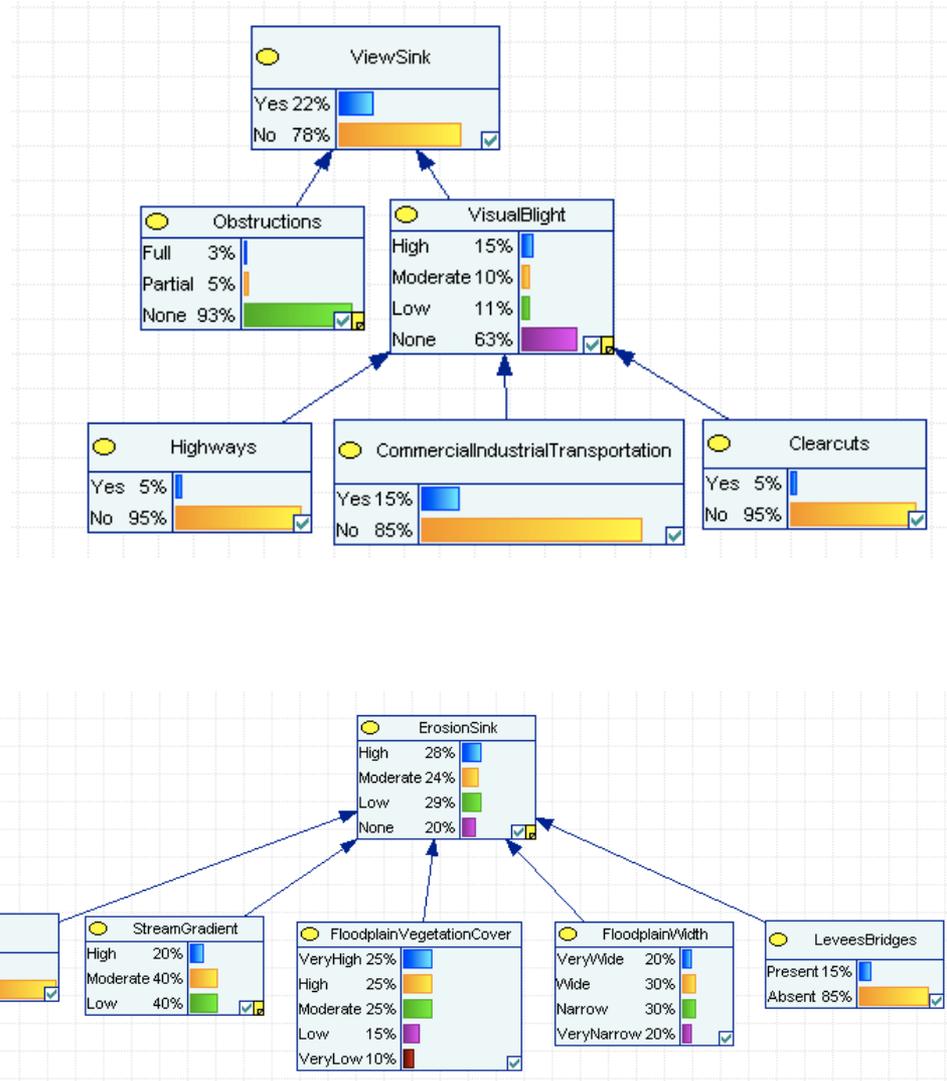


Puget Sound climate stability provision model



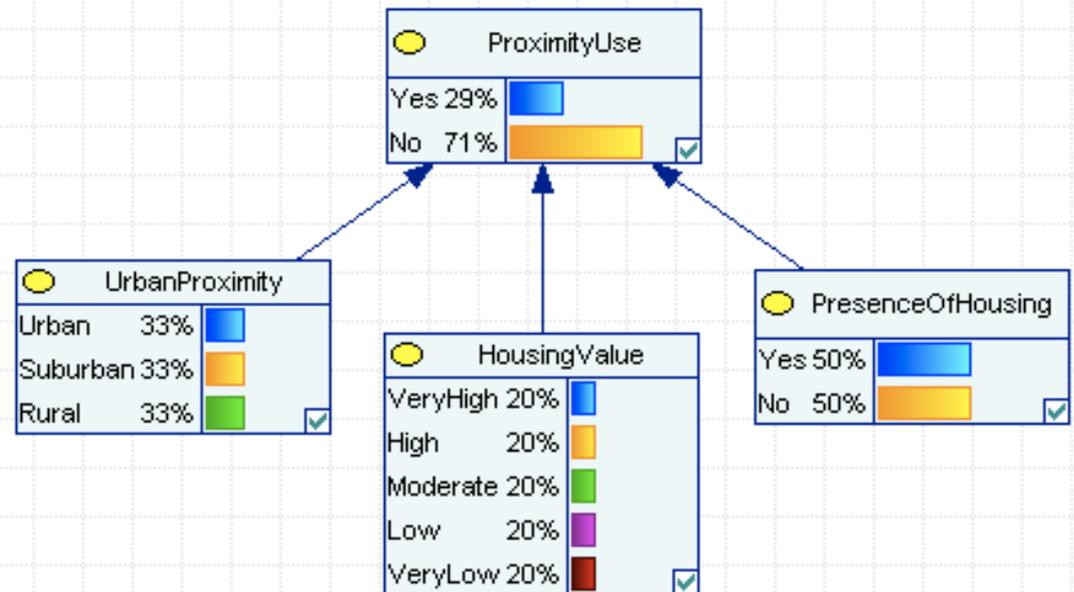
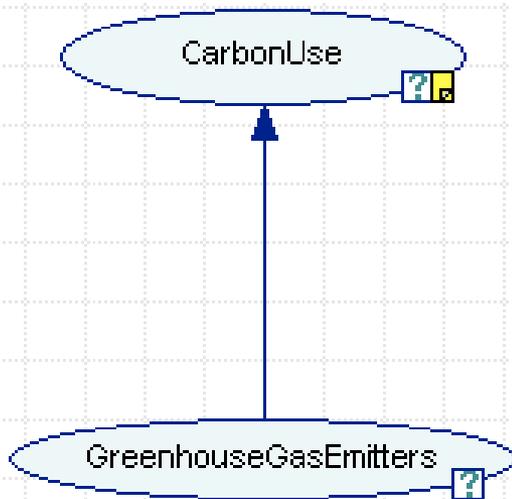
Modeling ES sinks

- Depending on the service, sinks could provide a benefit:
 - Absorption of flood water, nutrients
- Or a be a detriment:
 - Visual blight reducing the quality of views
 - Dampening out of values over distance

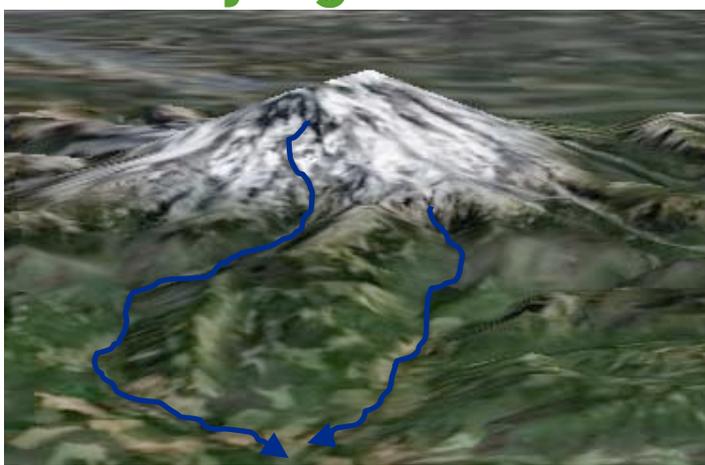


Modeling ES use

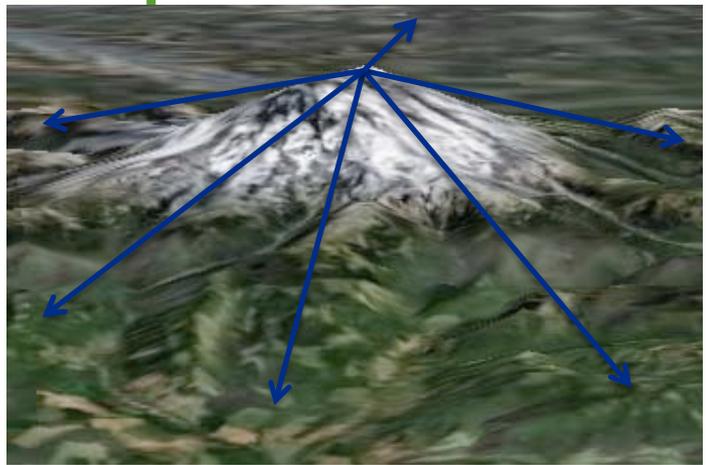
- Similar process to modeling ES provision
 - How do we locate (potential) users of ES on the landscape and quantify their need?



Identifying carriers & flow paths

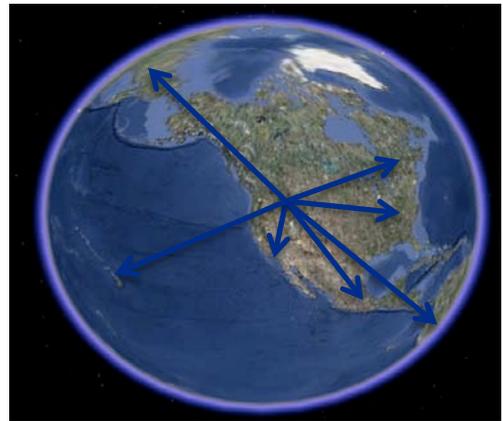


Hydrologic services



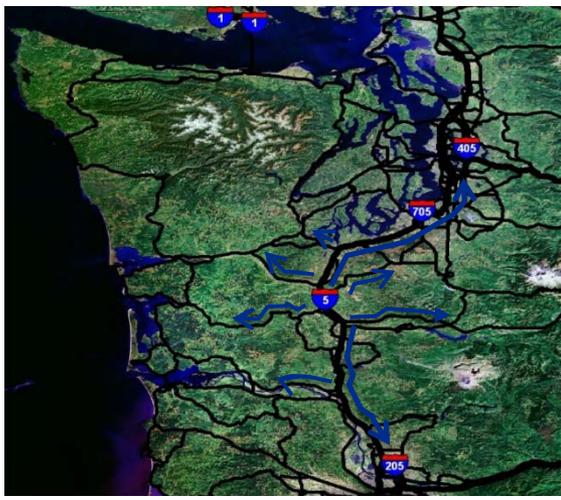
Aesthetic viewsheds

Recreation, flood regulation, many ecosystem goods



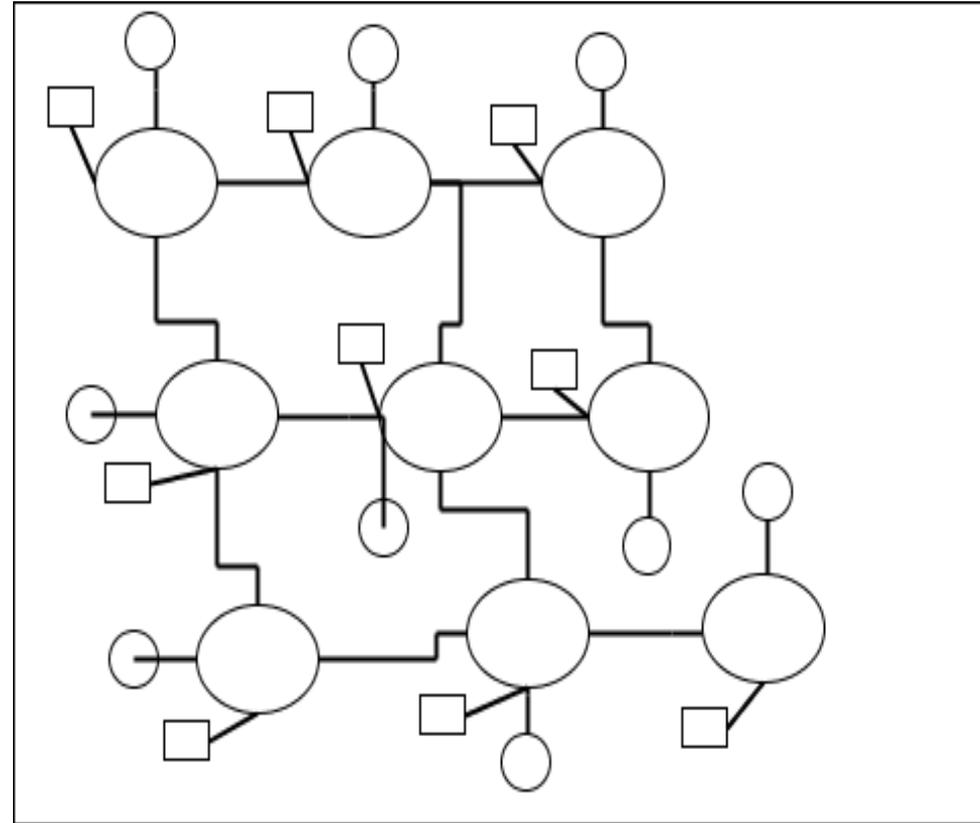
Carbon sequestration, some cultural values

Recreation, aesthetic proximity, some cultural services

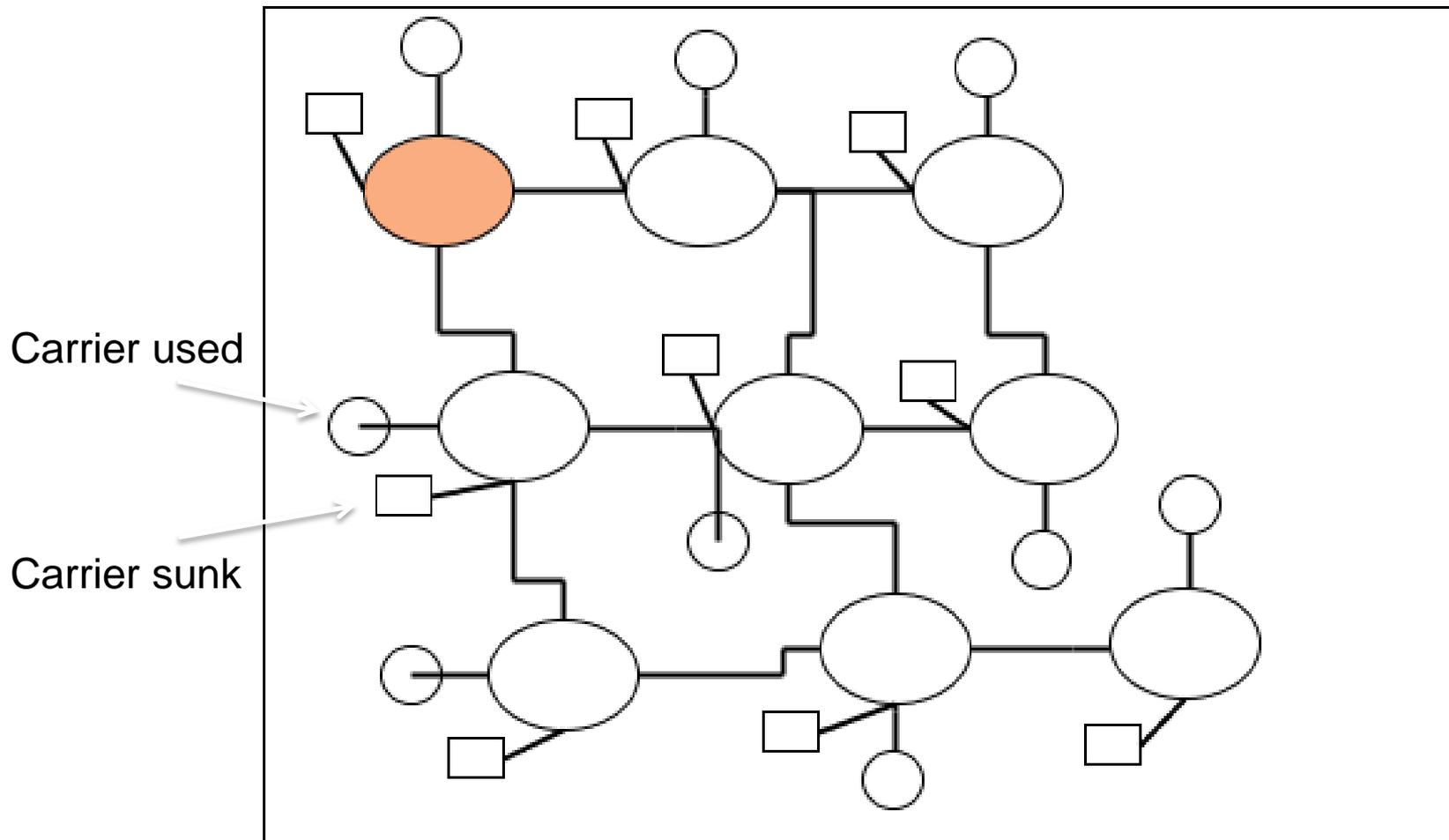


ES Flow mapping

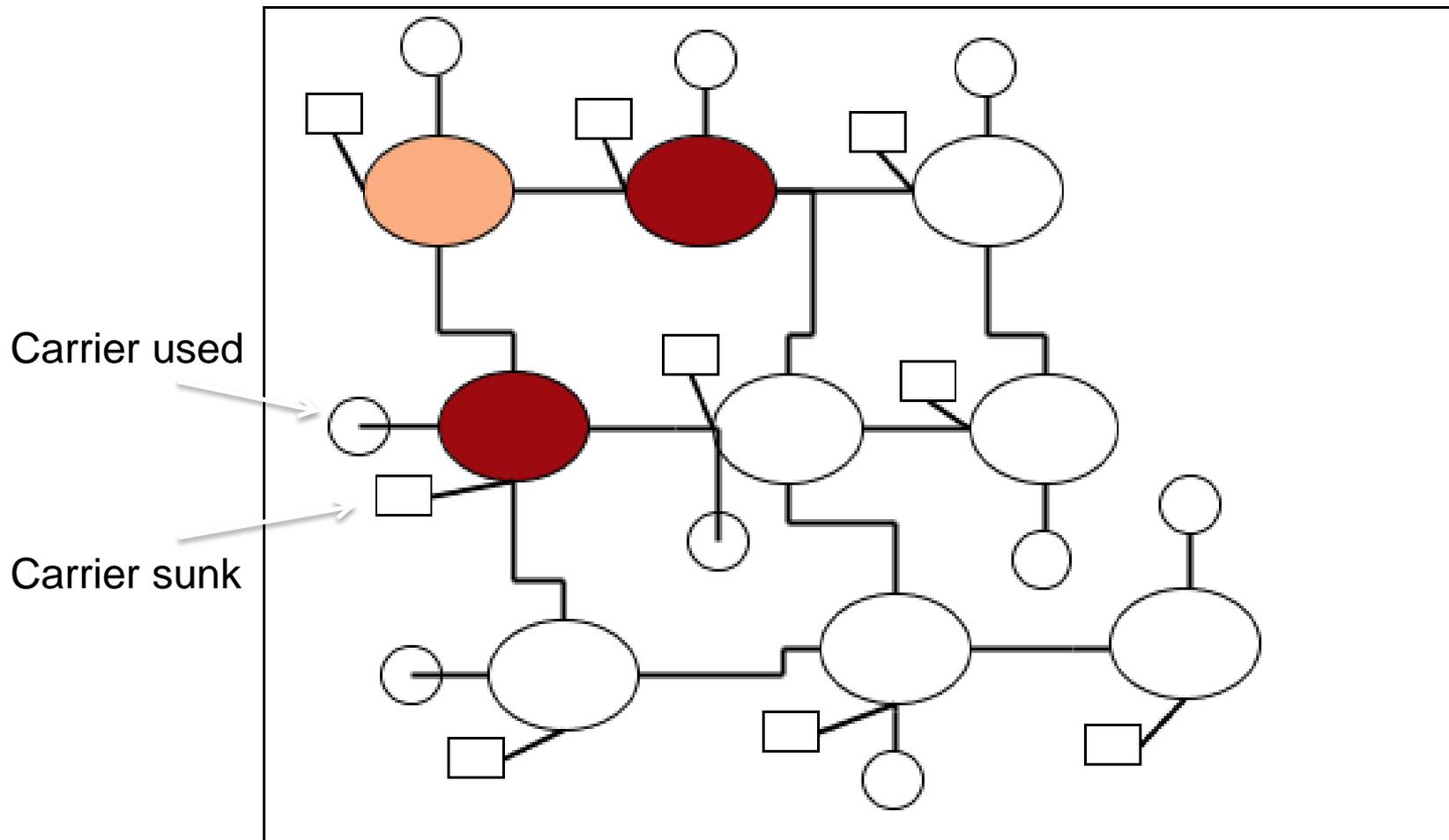
- All flow districts start in an empty state
- Edges represent transition probabilities
- Each location contains:
 - Source value
 - Sink and use rates & capacities
 - Sink cache
 - Use cache
 - Carrier cache



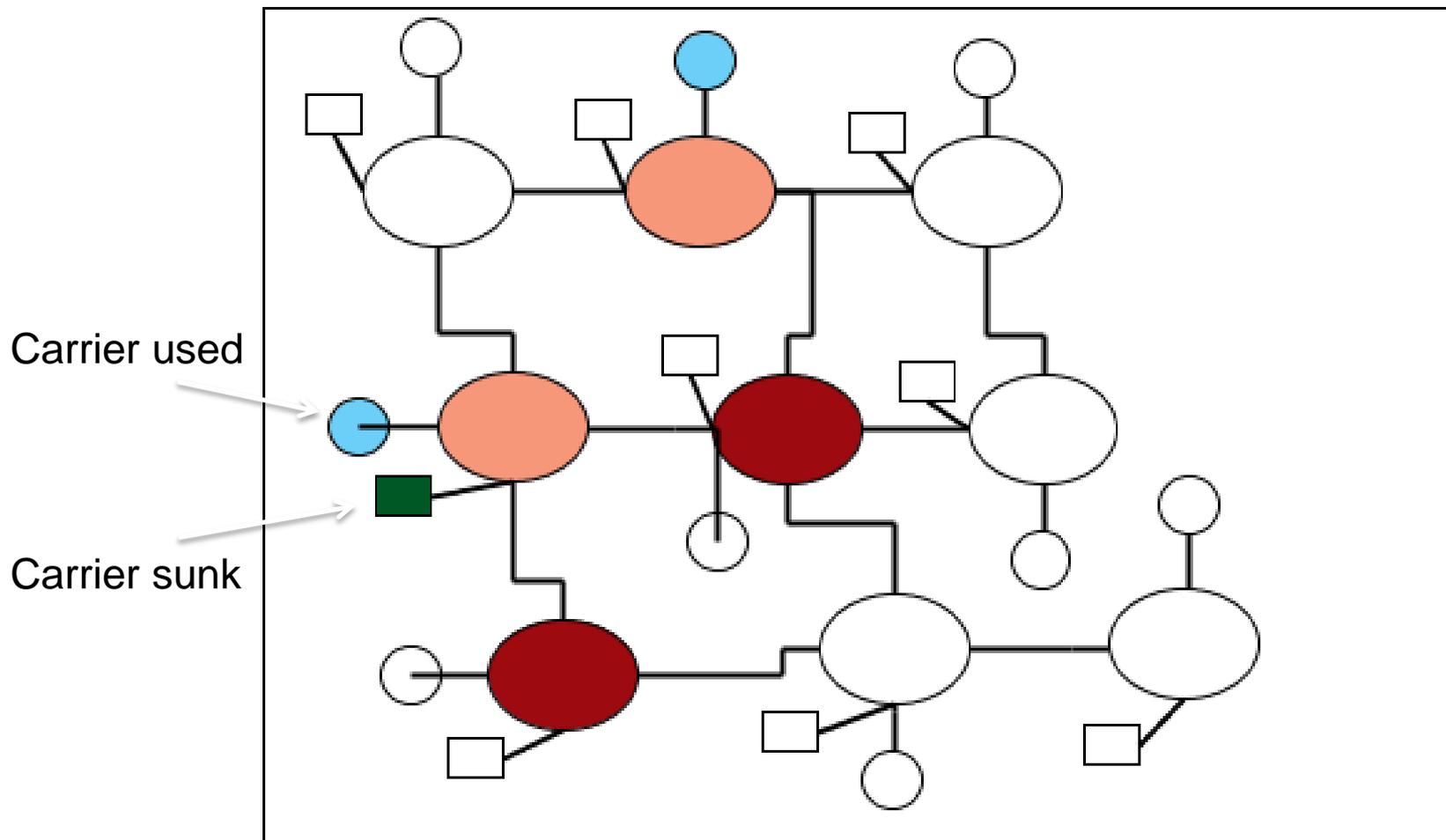
4. ES flow propagation



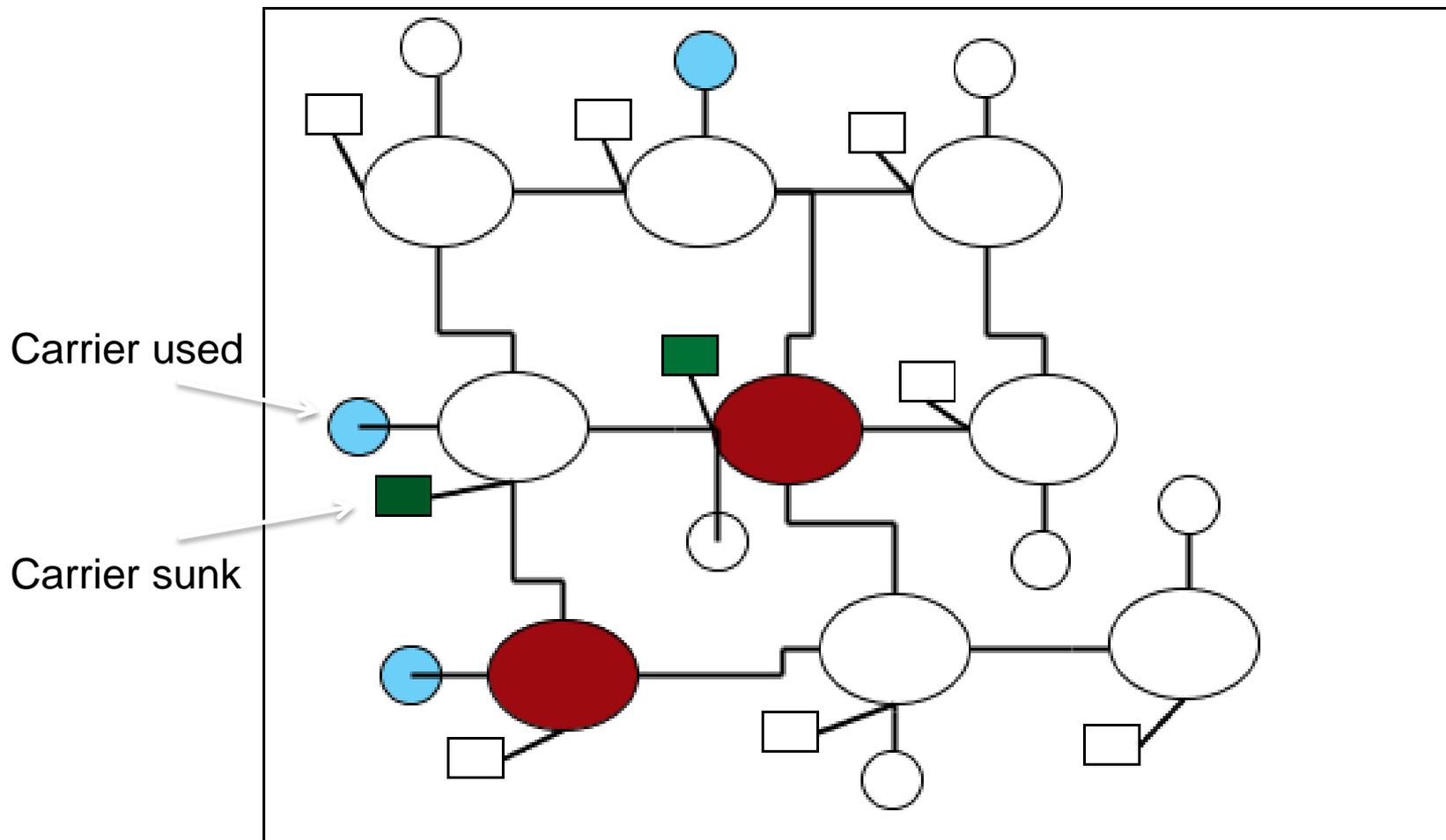
4. ES flow propagation



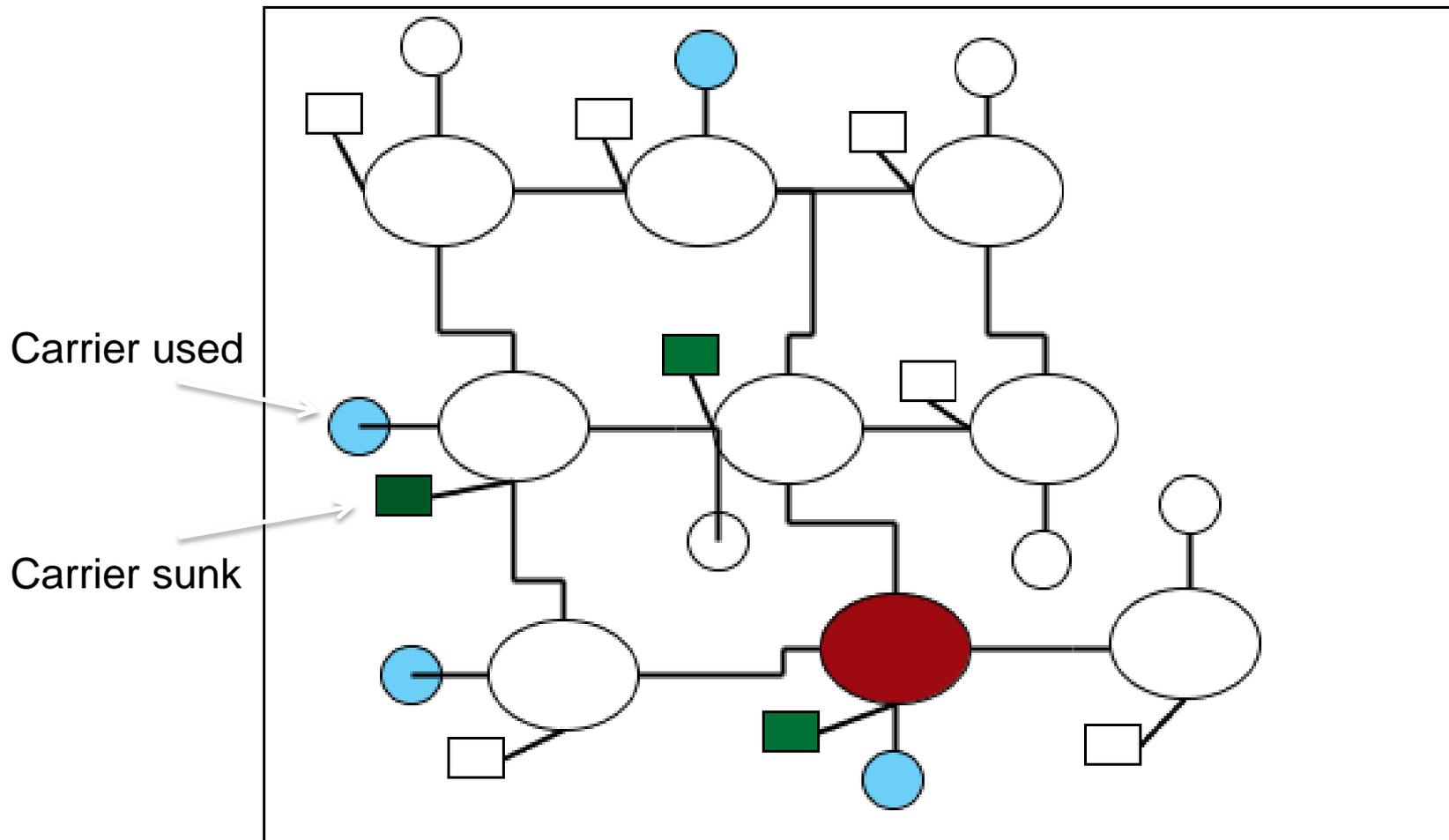
4. ES flow propagation



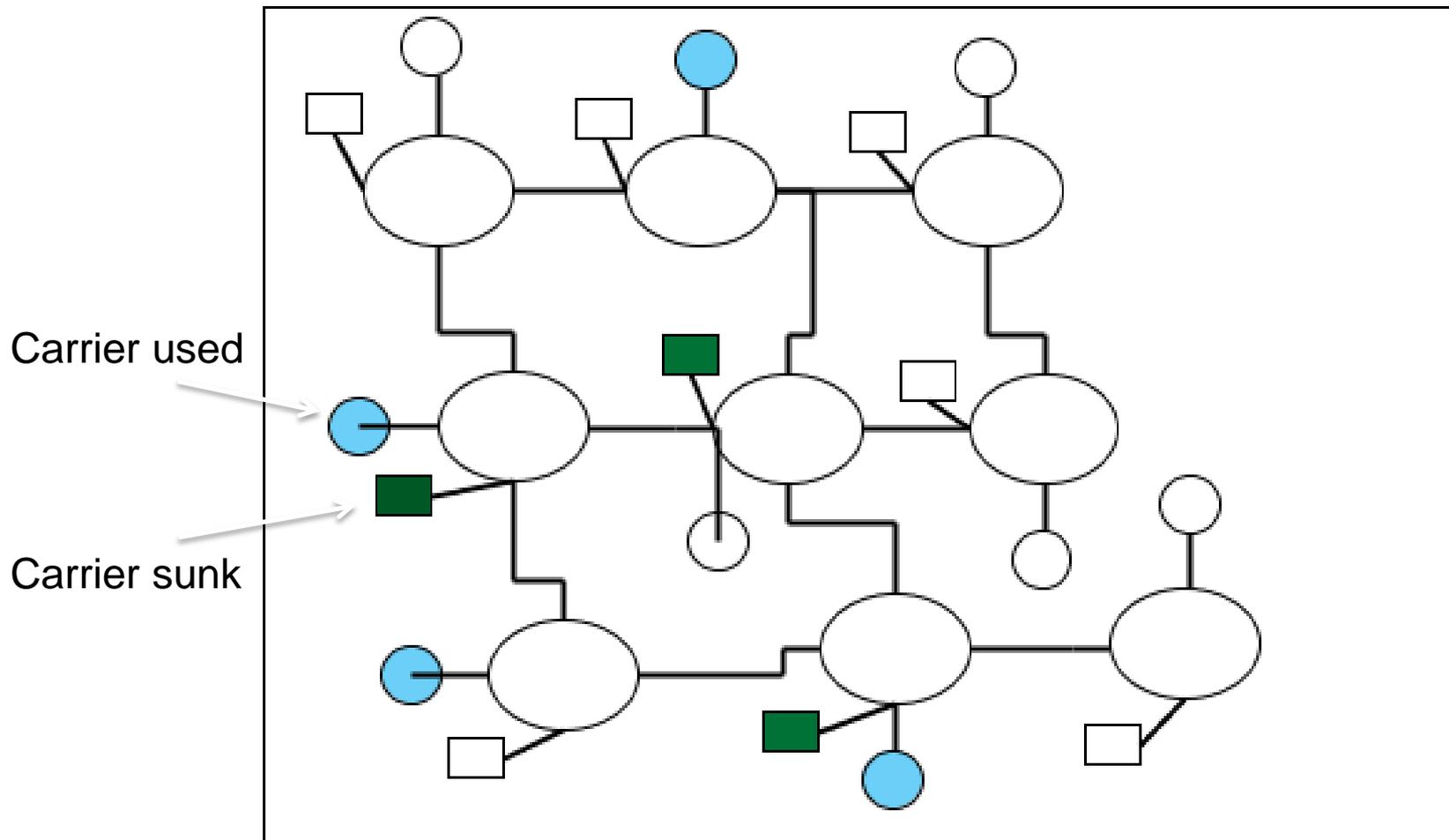
4. ES flow propagation



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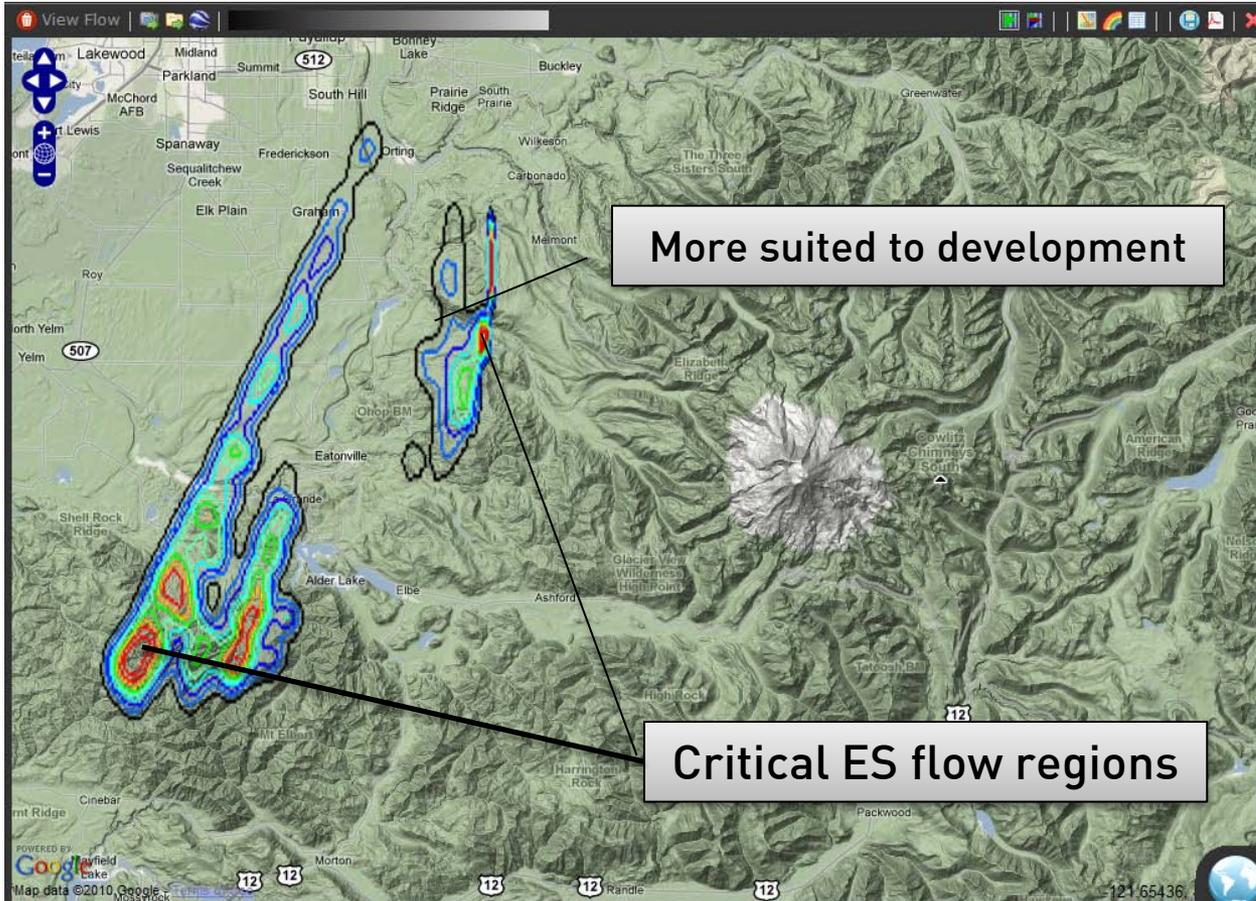


4. ES flow propagation



ES FLOW MAPPING

Flows connect sources and beneficiaries



Critical flow paths show areas most critical to ensure ES flow to the intended beneficiaries.

Regions of high flow density should be protected or enhanced for positive impact

Regions of lower flow density can be developed without impacting ES provision.

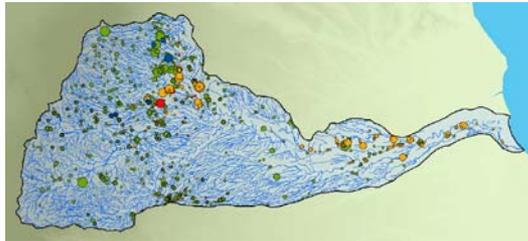
EXAMPLES: Subsistence fisheries for coastal communities, Madagascar



1. total demand for subsistence fisheries
2. met demand fraction (from flow analysis)
3. unmet demand fraction.

The model uses poverty, population density, pollution, habitat suitability and harvest data. Problem areas are immediately visible.

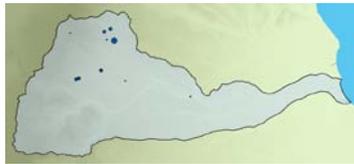
EXAMPLES: Veracruz, Mexico: water services



total demand from:



Agriculture



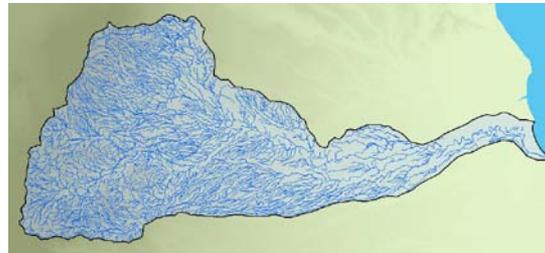
Aquaculture



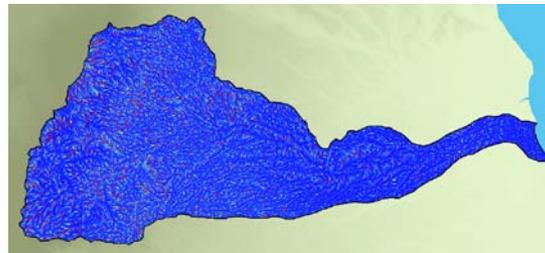
Industrial



Residential



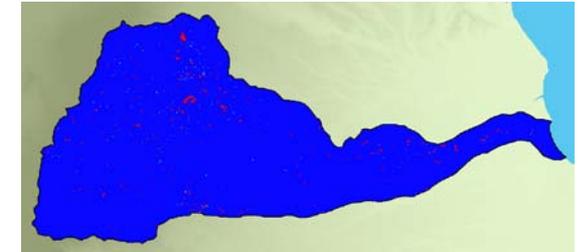
Stream network, elevation, porosity...



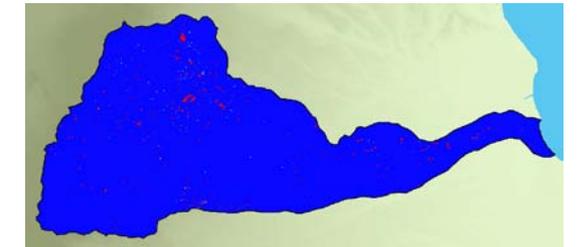
Actual flow to beneficiaries

→ used to compute.... →

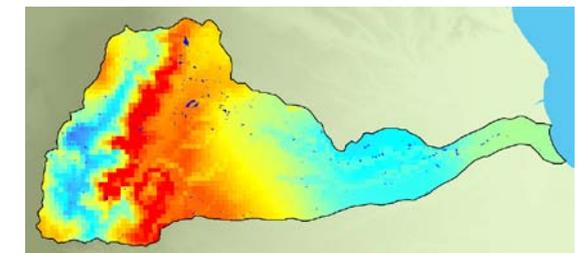
Selected results of flow modeling



Possible (usable) source



Actual surface water use



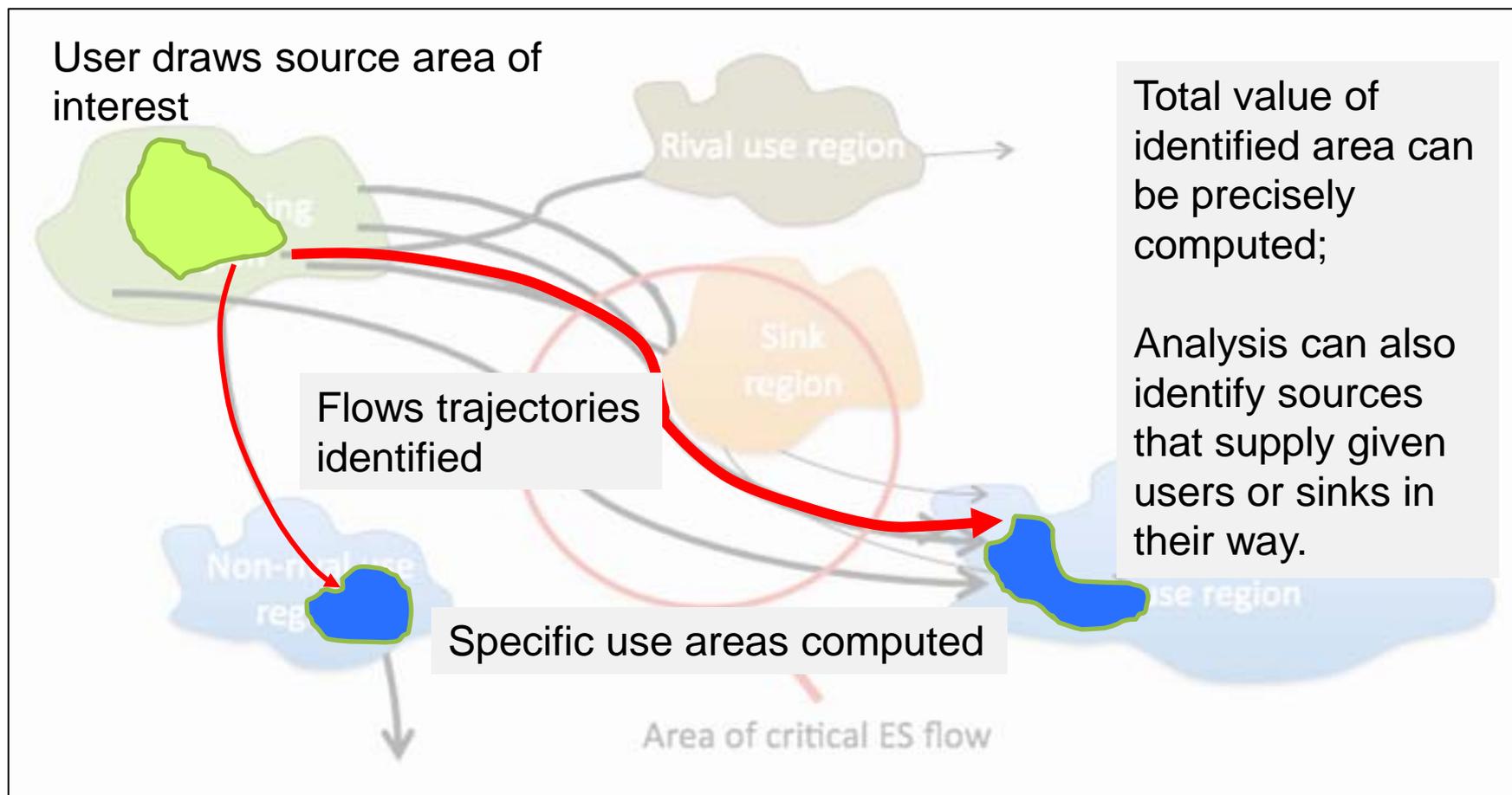
Inaccessible water source

Novel results from flow analysis

- Analysis of flows wasn't available before and computes source, sink, use and flow profiles.
- Flow analysis yields crucial maps to assist decision, such as critical flow contours, **unmet service demand** or **unused service production**.
- **Quantification** is based on *flow strength, actual use and provision*. **Policy scenarios** can be analyzed by comparing such contextual information, resulting in more accurate, beneficiary-dependent, science-based estimates of values. **Uncertainty** is preserved in flow computation and can be visualized.

TARGETING PRECISE AREAS THROUGH FLOW ANALYSIS

applicable to source, use and sink



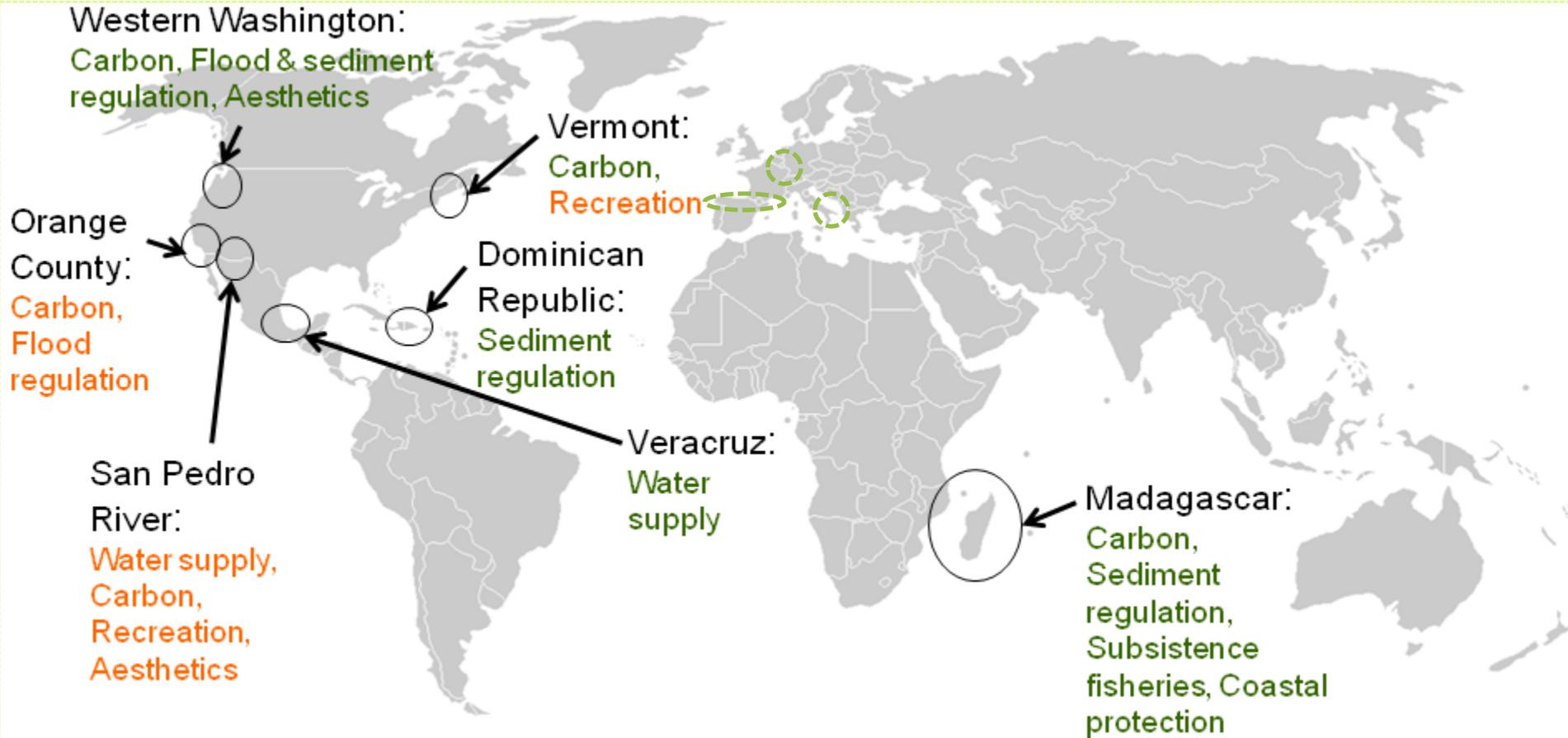
The “magic number”: new indicators

Using information about actual flows, new overall indicators can be computed (with associated uncertainties) for:

- EFFICIENCY of provision (actual vs. potential) 0 -1
- EFFICIENCY of use (need met or unmet vs. total) 0 -1
- EQUITY of distribution (winners and losers) 0 -1
- TOTAL: actual use, actual production, unused potential, unmet need

Such indicators can be used as good objective functions in scenario analysis.

AREAS of APPLICATION (changing rapidly)



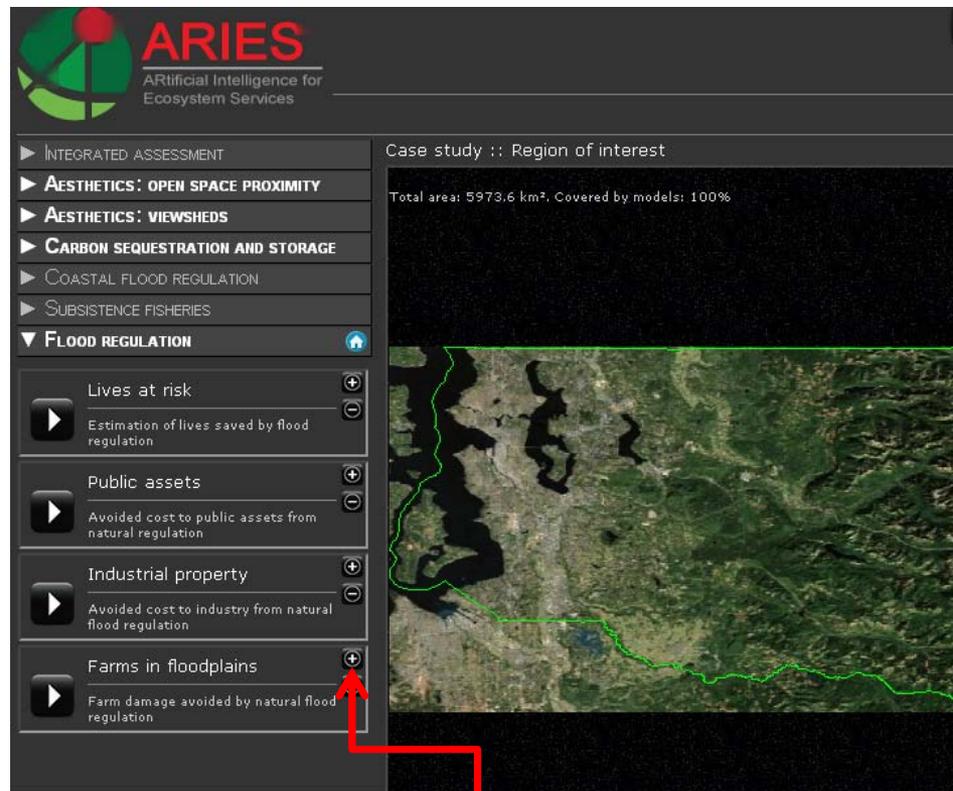
STORYLINES are suggested by ARIES and created by users to address each benefit deriving from ES

Services are broken down into storylines that address specific benefits for specific users.

Computed storylines look like presentations, with explanatory text and sequence, and can be exported to PDF and web pages.

The ARIES knowledge base looks at the data to suggest storylines that match the geographical and policy context.

ARIES case studies develop new storylines that augment the knowledge base in more areas.



A scenario is a user-defined storyline based on an existing one.

Ex-ante scenario definition

Global change scenarios can be merged with local land use changes

Pre-defined GLOBAL SCENARIOS
e.g. IPCC climate change

Scenario editor

Global scenarios

IPCC HADLEY B1

This scenario represents the effects of the Hadley B1 IPCC climate scenario. The B1 world is a convergent world with the same global population as in the A1 storyline but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.

Merge IPCC HADLEY B1

Editable parameters

Sequestration relevance threshold
0 100 tons C/ha/yr

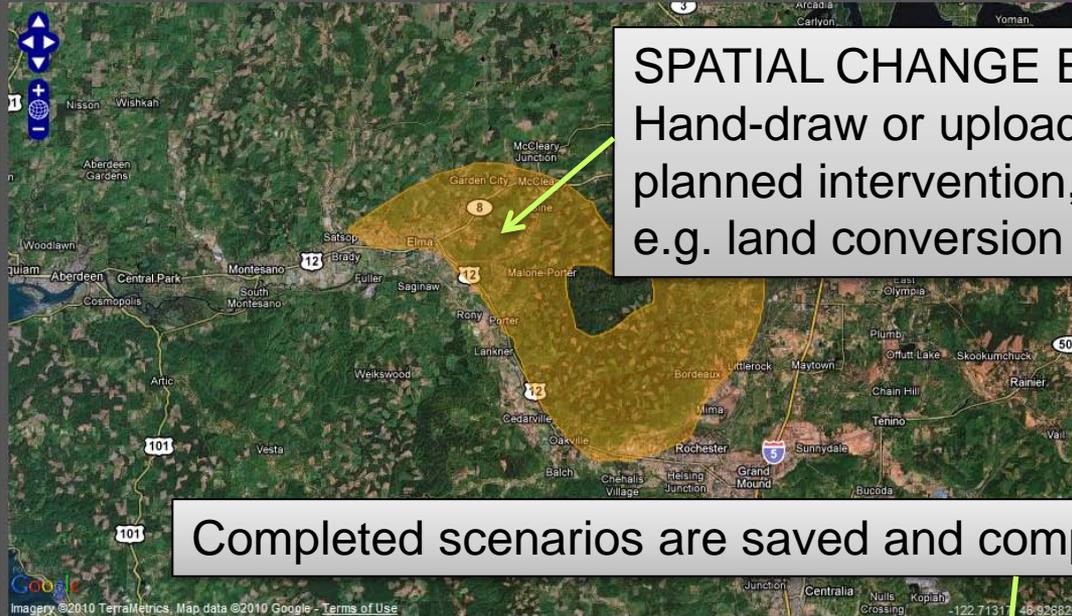
Use relevance threshold
0 100 tons C/ha/yr

Sink relevance threshold
0 100 tons C/ha/yr

MODEL PARAMETERS
and THRESHOLDS of
RELEVANCE (options,
law or governance
indications)

Apply to all modules Scenario name: B1 w/ reforestation

Policy options editor



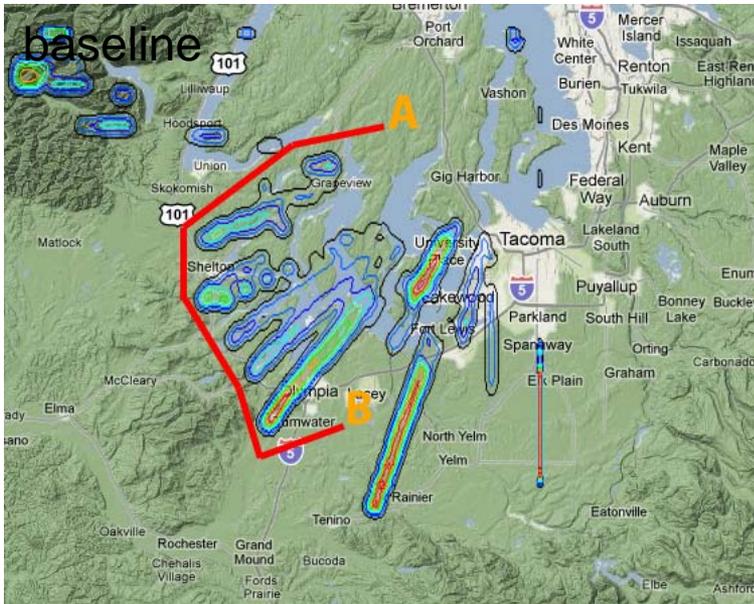
SPATIAL CHANGE EDITOR
Hand-draw or upload
planned intervention,
e.g. land conversion forest

Completed scenarios are saved and compared

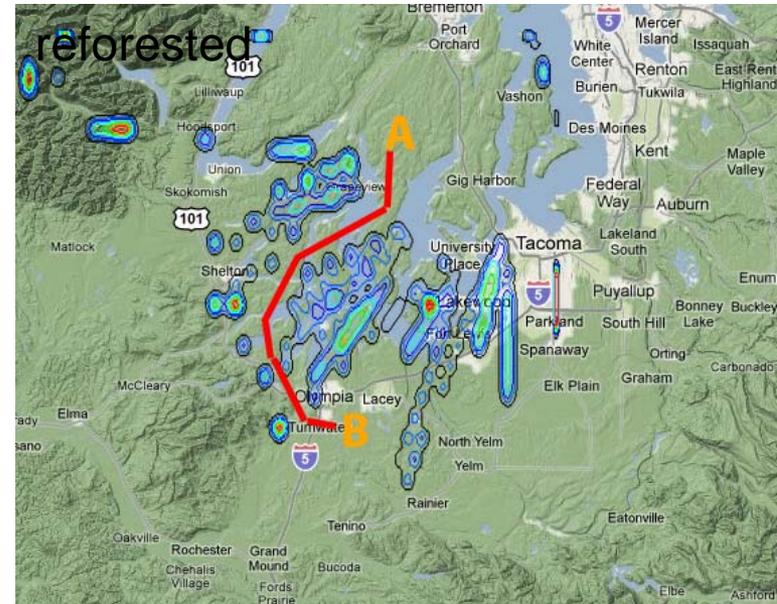
Save Cancel

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Routing linear features (roads, pipelines)

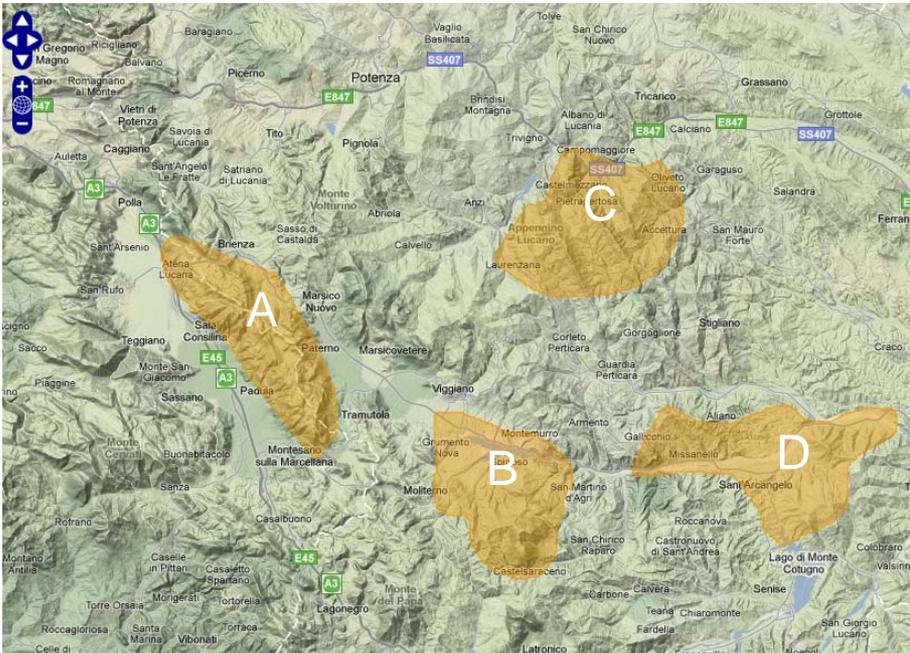


Scenario 1: routing that minimizes impact to flows of ES under *business as usual* scenario. A long feature is required to avoid impacting water provision.



Scenario 2: routing that minimizes impact on flows of ES with reforested corridors. Shorter feature offsets reforestation costs.

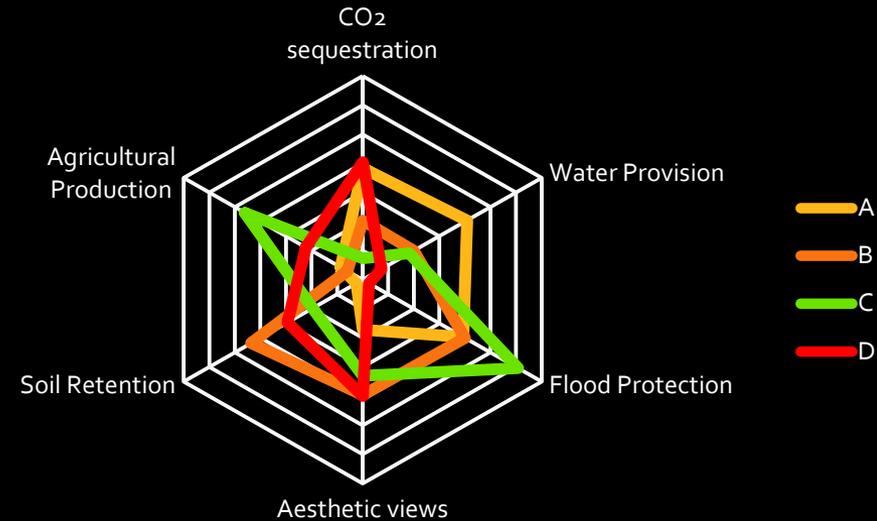
Identification and ranking of areas for offsetting



ARIES can produce a full ES profile for a set of areas under consideration for offsetting, under baseline or ex-ante intervention scenarios.

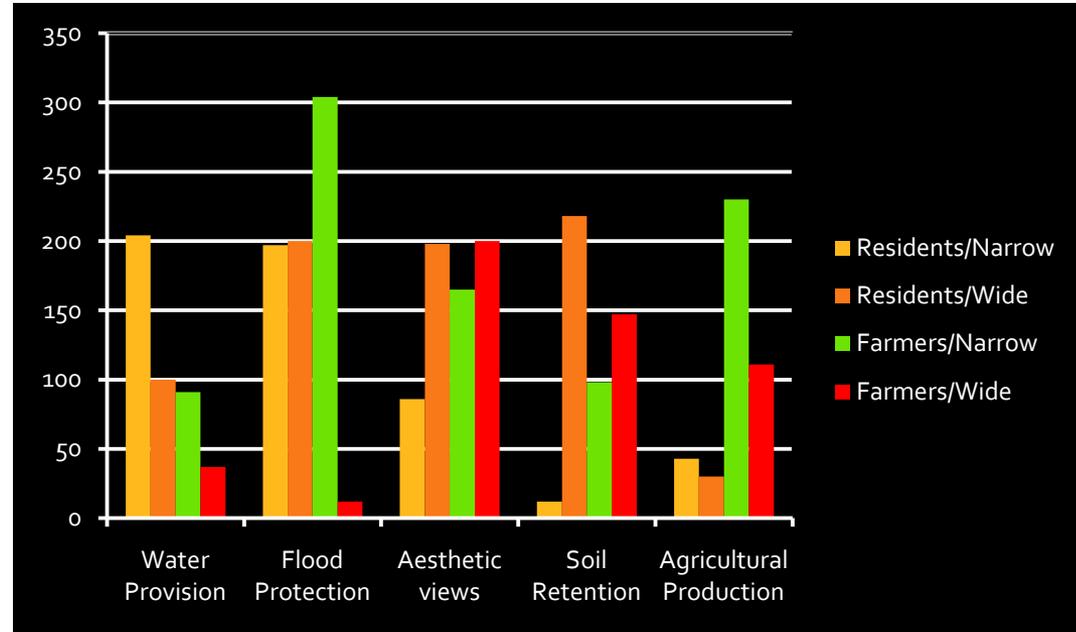
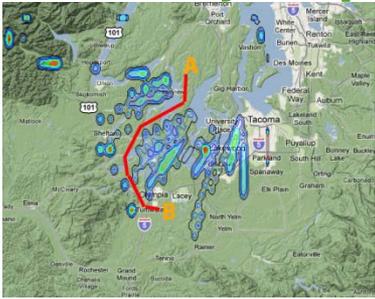
Such profiles help selection of areas and documentation of ES offsets.

Multiple Criteria analysis allows customizing the ES profiles to pre-existing priorities or legal constraints.

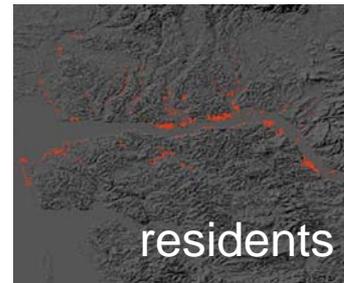
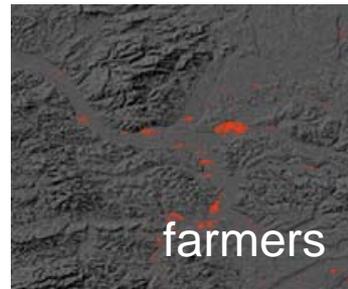


Scenario based quantitative valuation

Quantify impact of choices on specific stakeholder groups



Two alternative options (different buffer zone widths) evaluated for impact on ecosystem services...



...against the different needs of two different stakeholder groups.

What about ECONOMIC VALUATION?

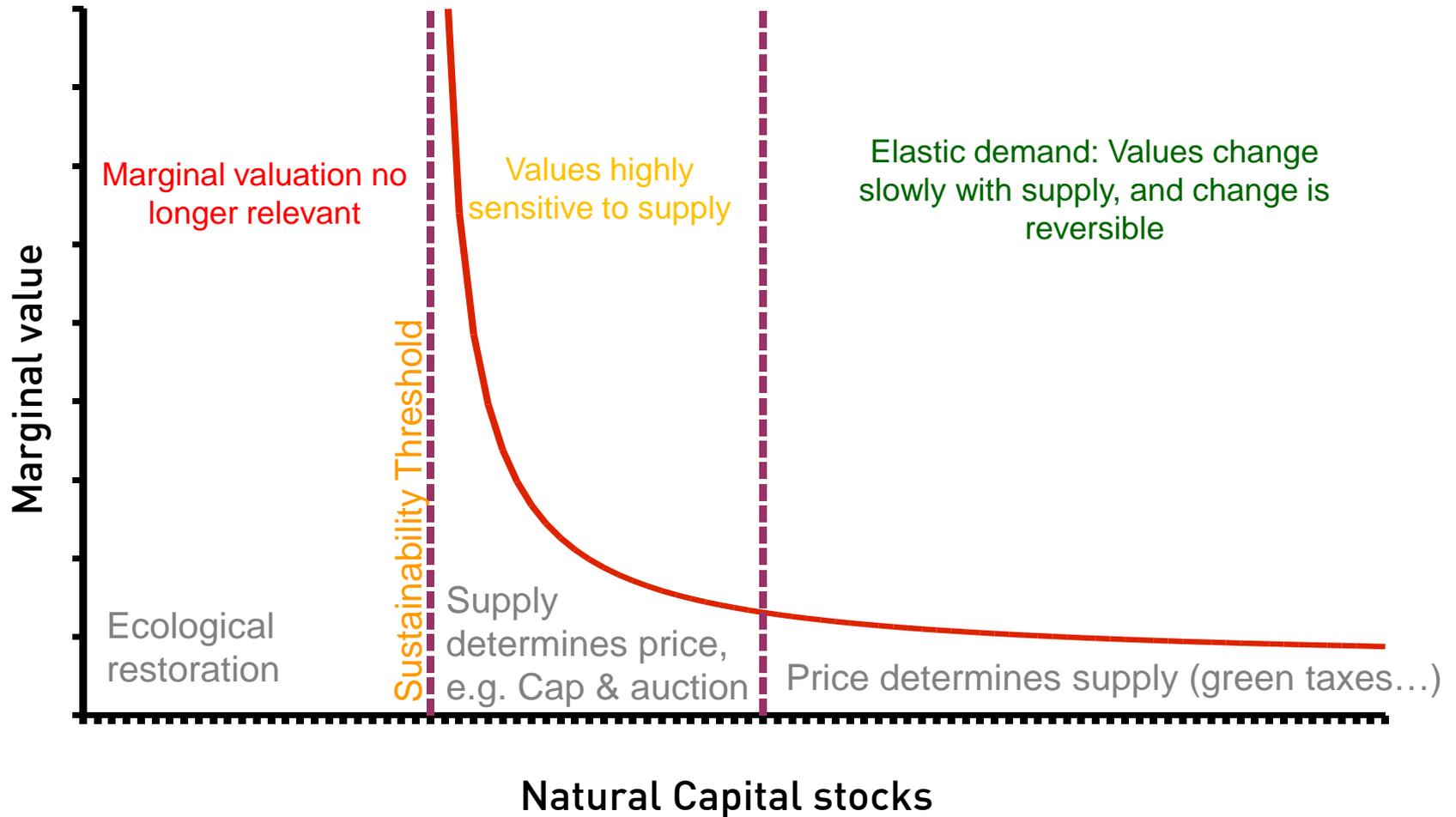
ARIES is agnostic about valuation and tries to counteract inaccuracy in the “state of the art” by incorporating:

- explicit uncertainty
- flexible definition of *value*
- flexibility and innovation in methods
- validation opportunities.

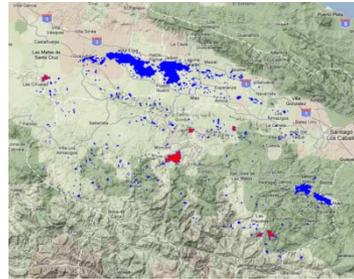
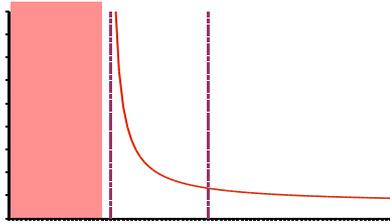
VALUE can be BASED ON:

- ACTUAL or POTENTIAL physical flows or source values
- Concordance value with stakeholder priorities
 - MCA (Electre3, Prometheus, Evamix)
 - AHP
- Economic valuation
 - Bayesian and Econometric modeling can be easily integrated
 - Intelligent benefit transfer methods are in development

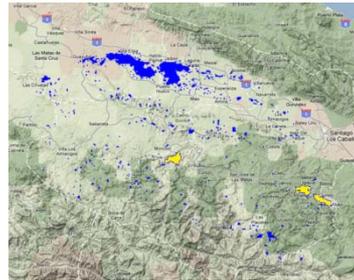
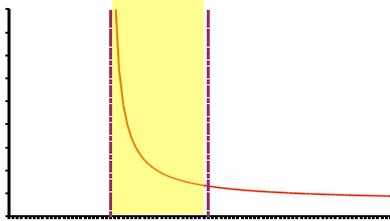
Criticality thresholds and valuation



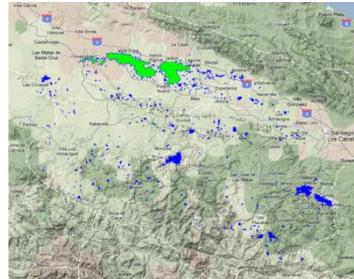
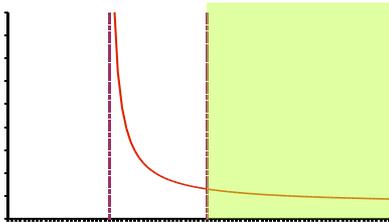
Valuation methods should be informed by **CRITICALITY**



Users can set thresholds based on scenarios



Beneficiaries are classified based on criticality of actual provision

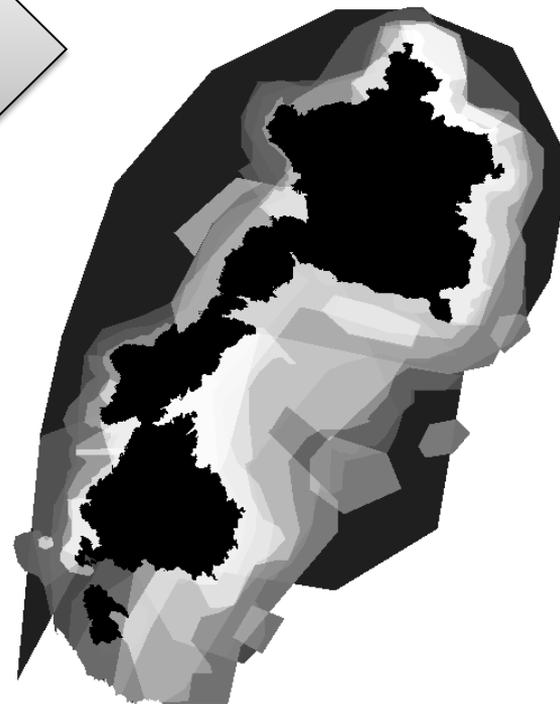


Provision areas contributing to different beneficiary classes can be computed and valued independently

CONCORDANCE VALUE vs. MONETARY

abstract valuation = concordance between benefit flows and stakeholder priorities

| | C | F | W | R | Value |
|---------|---|---|---|---|------------|
| Climate | 1 | 9 | 9 | 9 | 377 |
| Flood | | 1 | 9 | 3 | 455 |
| Water | | | 1 | 2 | 51 |
| Raw mat | | | | 1 | 51 |



Relative importance values for benefits are input by users

Overall value map is recalculated to reflect stated priorities in each scenario of management

Concordance values are the equivalent of value to stakeholders, and vary between 0 (no value) to 1 (complete concordance)

Economic valuation: a summary

- Primary valuation:
 - WTP surveys, hedonics, travel cost, consumer expenditures, avoided/replacement cost
- Secondary valuation:
 - *Value transfer*: apply primary values from a database to site of interest
 - Land use driven
 - Traditional multiple regression
 - Bayesian multiple regression
 - Artificial Intelligence mediated (choice of source studies and transfer function learning)
 - Flow-based
- Ecological-economic modeling
 - may become part of ARIES as new model content

THANK YOU
For more information:

www.ariesonline.org

info@ariesonline.org

The screenshot shows the ARIES website homepage. At the top, there is a navigation menu with links for 'About', 'Modules', 'Case studies', and 'Resources'. Below the menu is the ARIES logo, which consists of a stylized globe icon and the text 'ARIES Artificial Intelligence for Ecosystem Services'. The main content area features a 'Latest News' section with several articles, each with a date and a brief description. To the right of the news section, there is a large text block that reads: 'ARIES redefines ecosystem services assessment and valuation in decision-making. The ARIES approach to mapping benefits, beneficiaries, and service flows is a powerful new way to value and manage the ecosystems on which the human economy and well-being depend.' Below this text, there are three columns of content. The first column is titled '4. web-based technology' and features a map of a region with various colored areas. The second column is titled 'Focus on conservation' and features an image of a bird. The third column is titled 'Focus on business' and features an image of an industrial facility. At the bottom of the page, there is a 'Project sponsored by' section with logos for the United Nations (UN), UNEP WCMC, The University of Vermont, Conservation International, and Earth Economics.