A BRIEF OVERVIEW OF THE ARIES MODELLING PLATFORM

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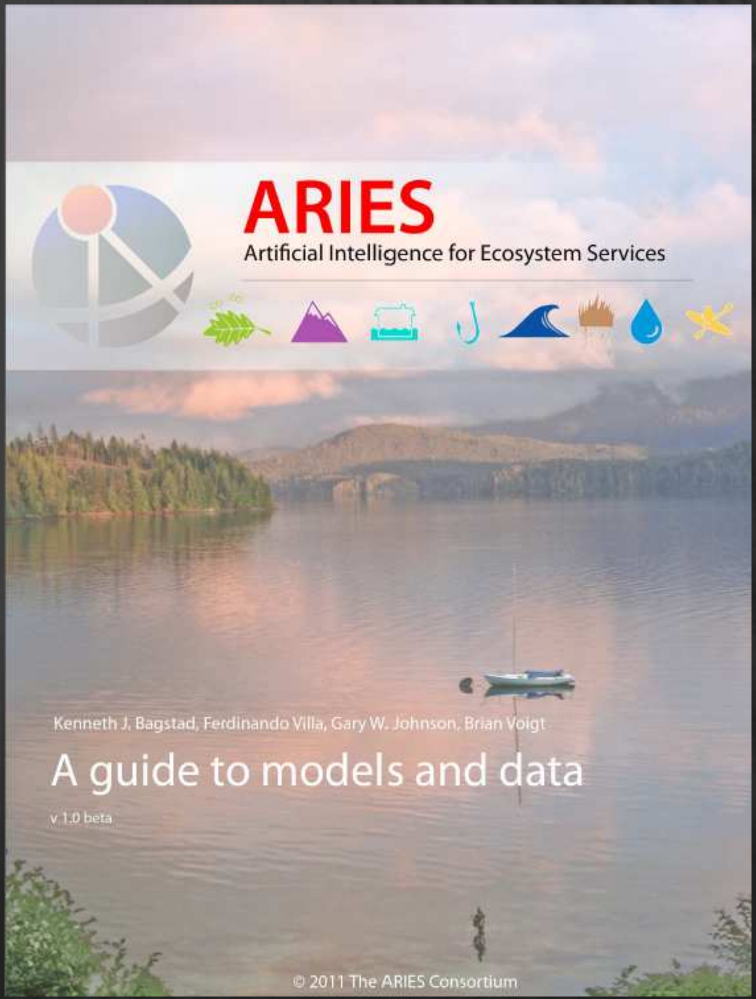
ARIES: A BRIEF OVERVIEW

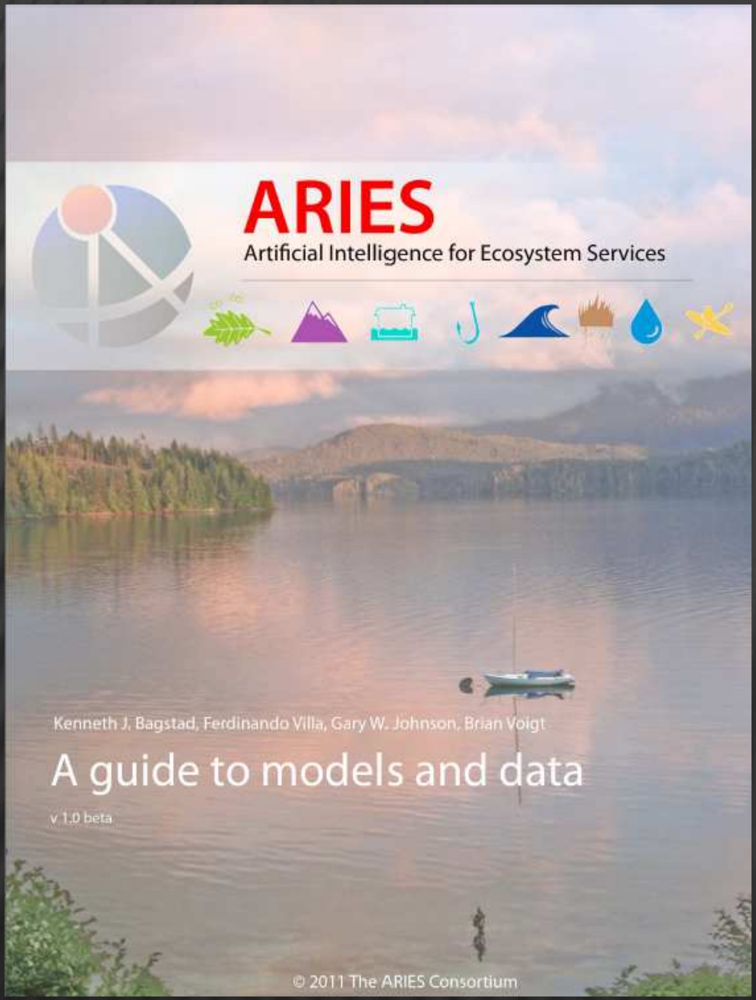
- *AR*tificial *I*ntelligence for *E*cosystem *S*ervices
- A modelling platform, not a model
- An assessment toolkit for quantifying ecosystem services and their values
- An intelligent system that customizes models to user goals.
- Demonstrate a mapping process for ecosystem service provision, use, and flow.
- “Honest” probabilistic models inform decision-makers of likelihood of all possible outcomes; users can explore effects of policy changes and external events.
- Open-source software

ARIES DOCUMENTATION: 1

- Documentation for existing models
  - Water supply: mm^3/yr
  - Subsistence fisheries: kg fish
  - Carbon sequestration: Tonnes C / ha / year
  - Flood regulation, Sediment regulation
  - Aesthetic viewsheds: abstract units (1 – 100)
  - Recreation: abstract units (1 – 100)

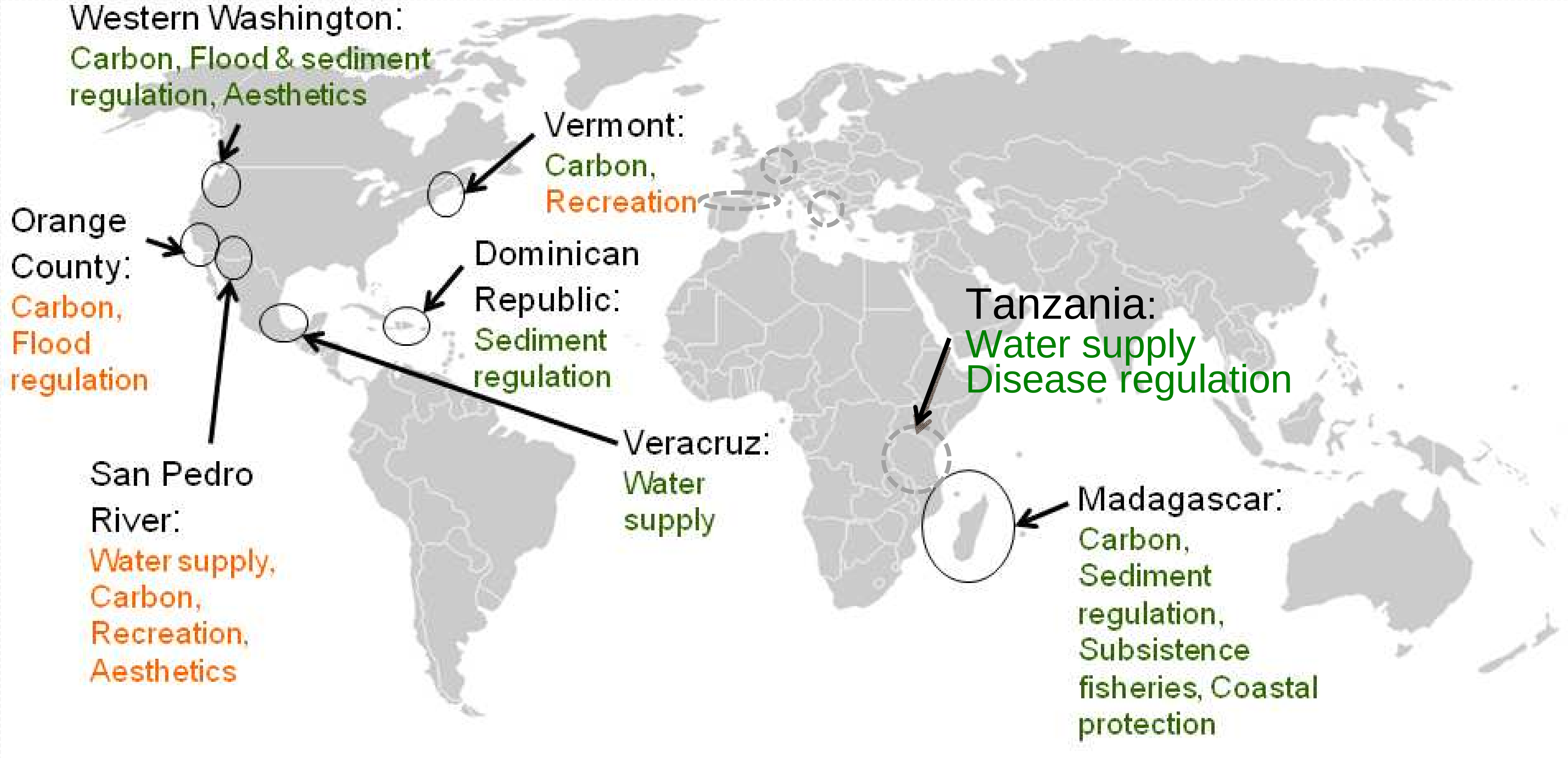


ARIES DOCUMENTATION: 2



- Data inputs
- Beneficiaries considered
- Bayesian networks developed
  - Justification / literature resources
- Forthcoming PLOS One paper:
  - Villa, F. et al: A methodology for adaptable and robust ecosystem services assessment

CASE STUDY SITES

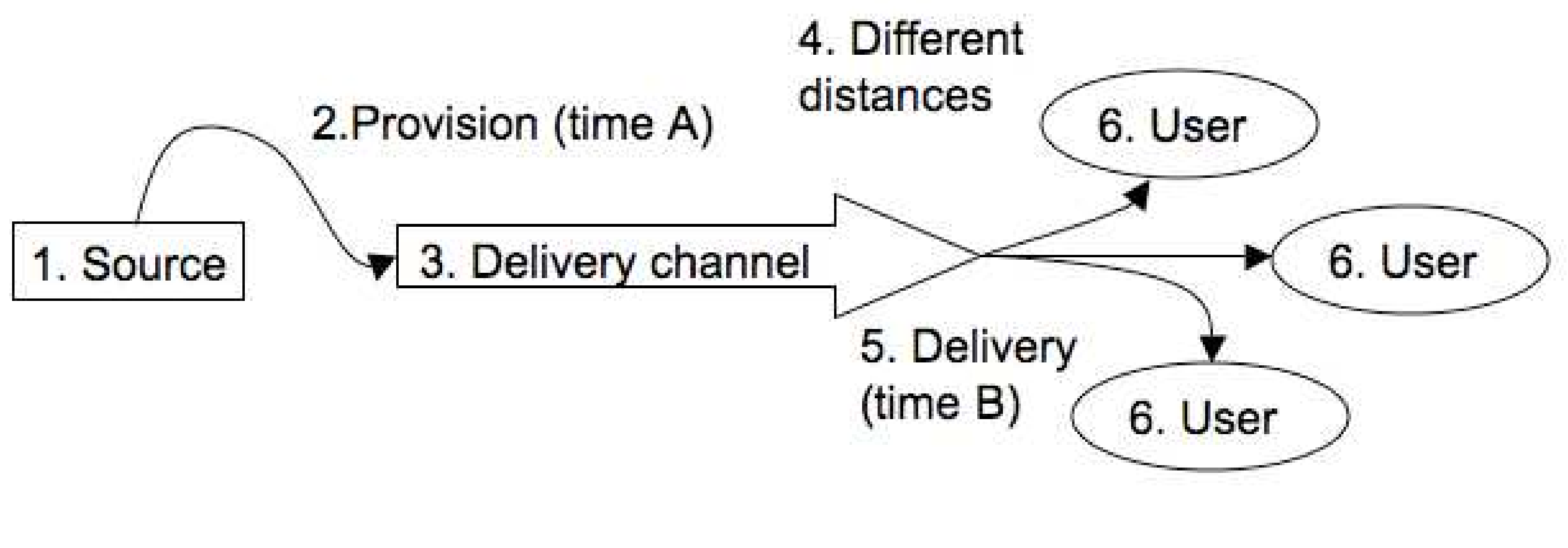


ARIES AND ECONOMIC VALUATION

- ARIES is agnostic about valuation and tries to counteract inaccuracies by incorporating:
  - explicit uncertainty
  - flexible definition of value
  - flexibility and innovation in methods
- VALUE can be based on ACTUAL or POTENTIAL physical flows or source values
- Economic valuation
  - Bayesian and Econometric modeling can be easily integrated
  - Intelligent benefit transfer methods are in development

FUNDAMENTAL QUESTIONS

- Where are the ecosystems providing benefits?
- Where are the service users?
- How do benefits move from ecosystems to users?
- What is the quantity and value of the realized services?



Ruhl et al. 2007

ARIES MODELING ELEMENTS

1. Provision-shed

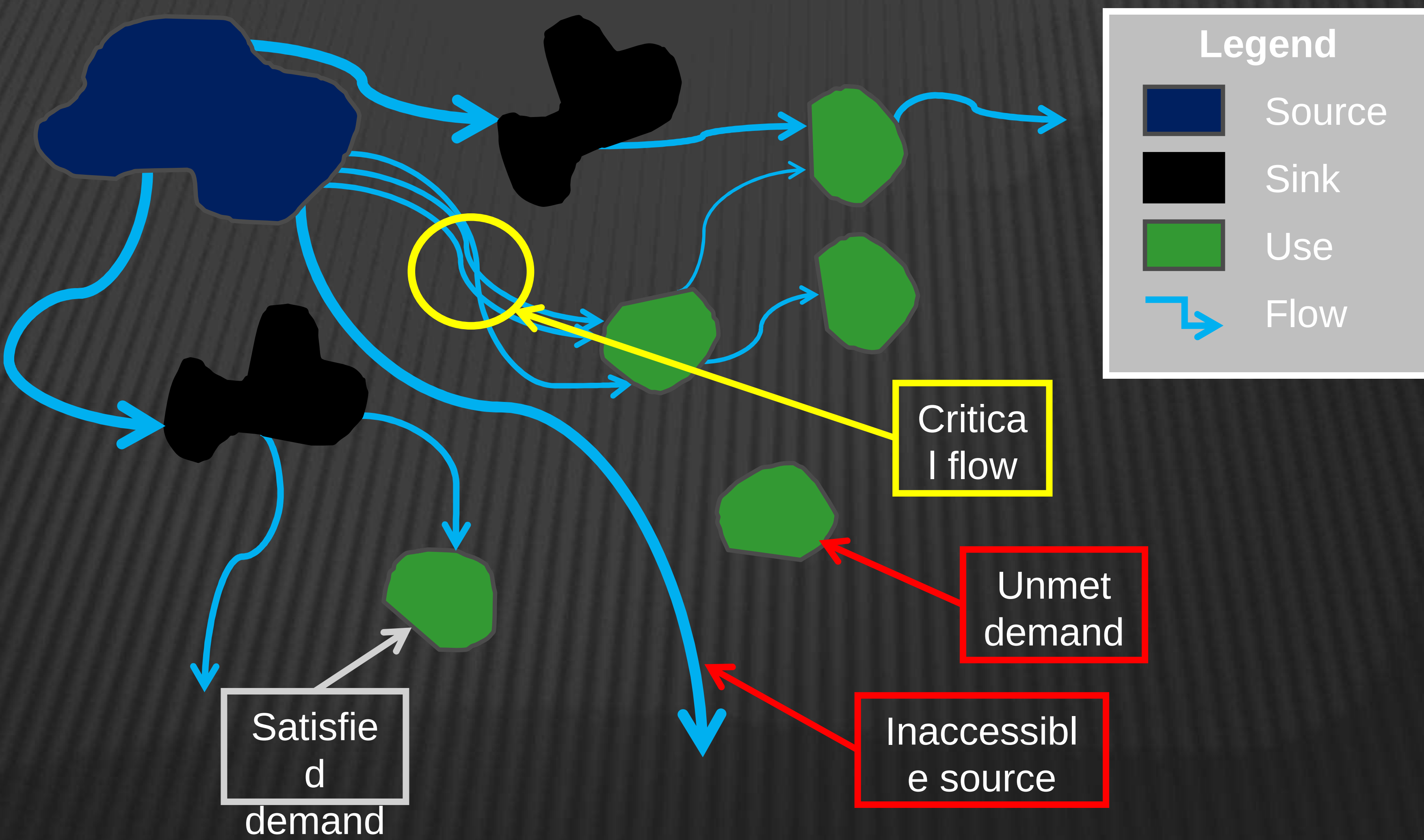
1. Areas of ES provision

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

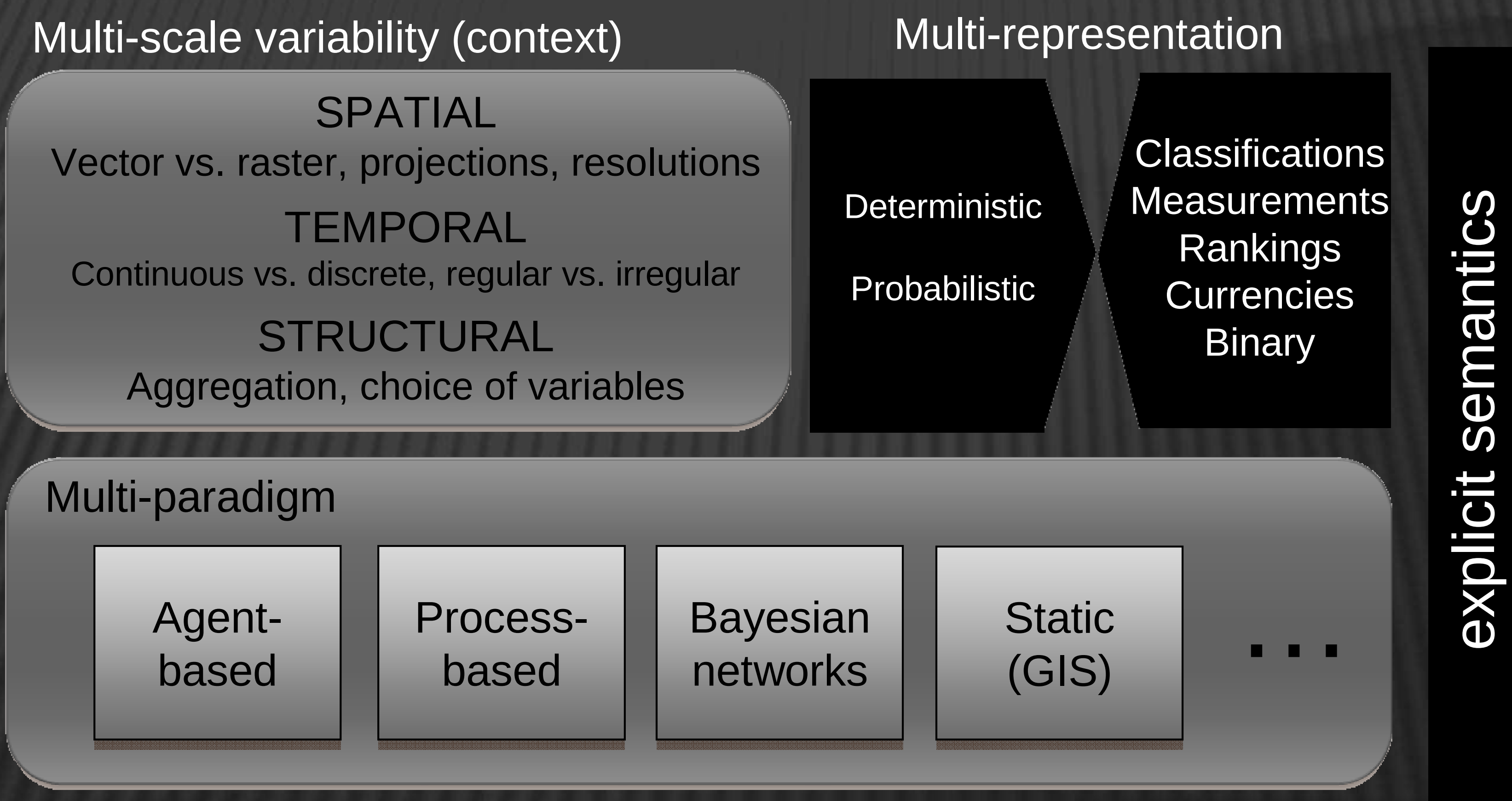
2. Areas of ES use

2. Benefit-shed

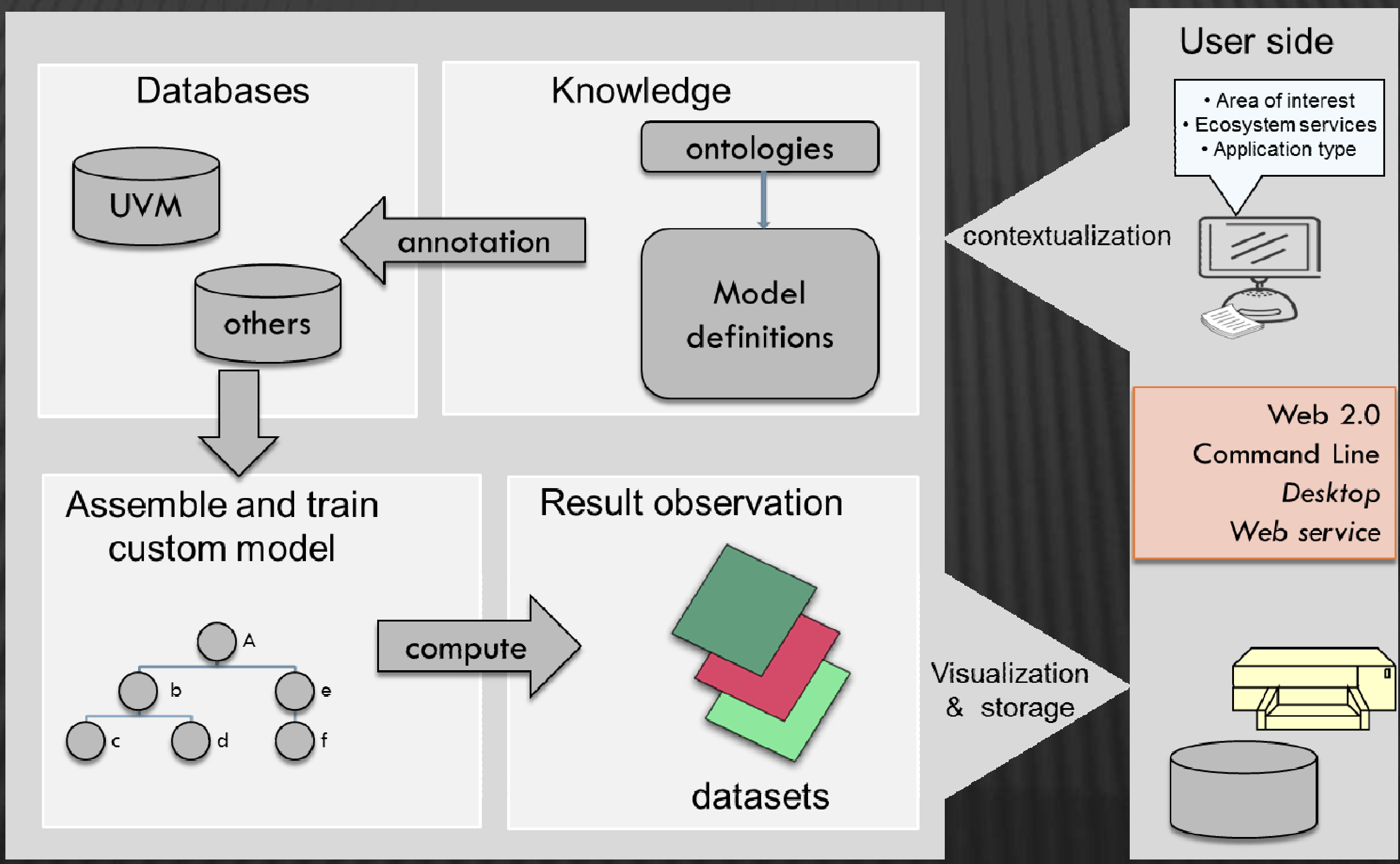
ECOSYSTEM SERVICE FLOWS



THE INTEGRATED MODELING PLATFORM



ARIES SESSION WORKFLOW: 1



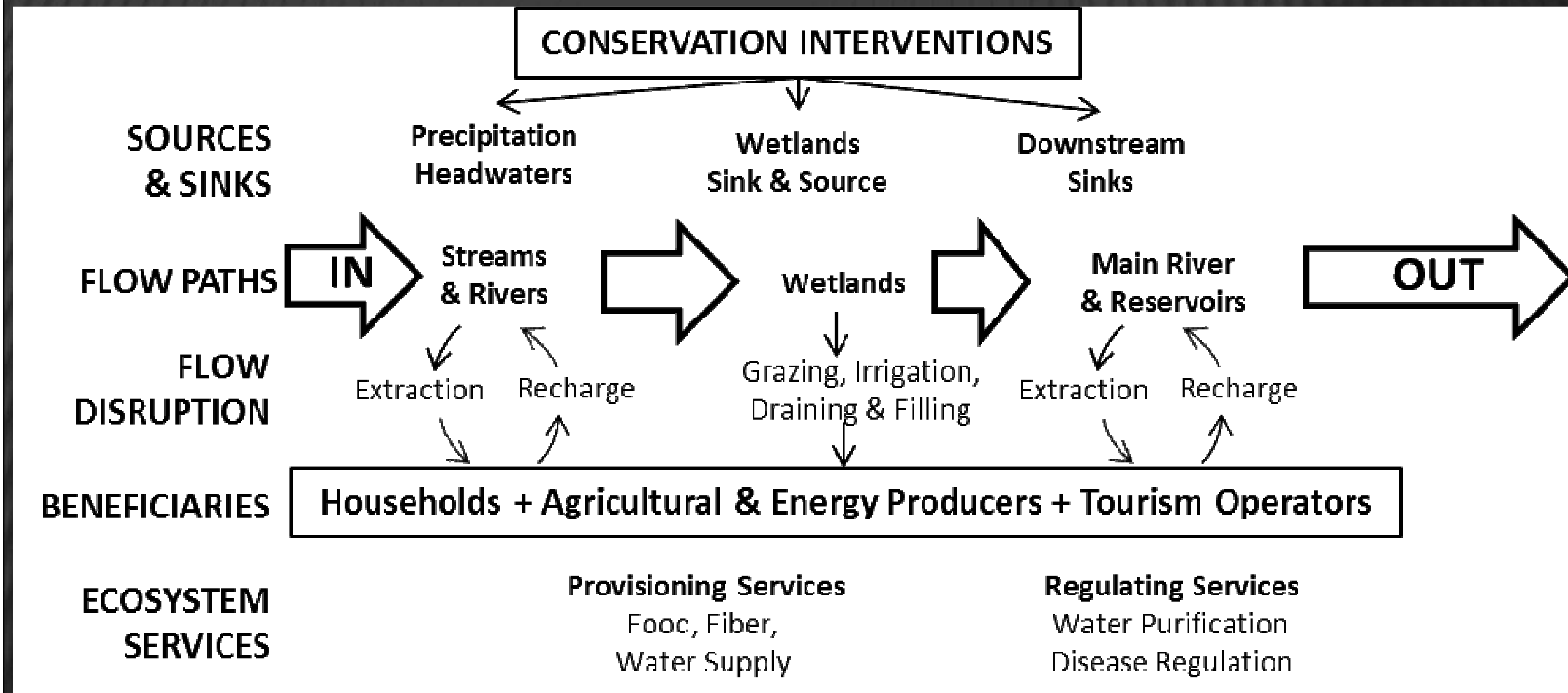
ARIES SESSION WORKFLOW: 2

1. Collect spatial data
2. Identify beneficiaries
3. Develop models for source, sink, and use
4. Develop / apply model to “flow” services between ecosystems and people

RUAHA RIVER WATERSHED, TANZANIA

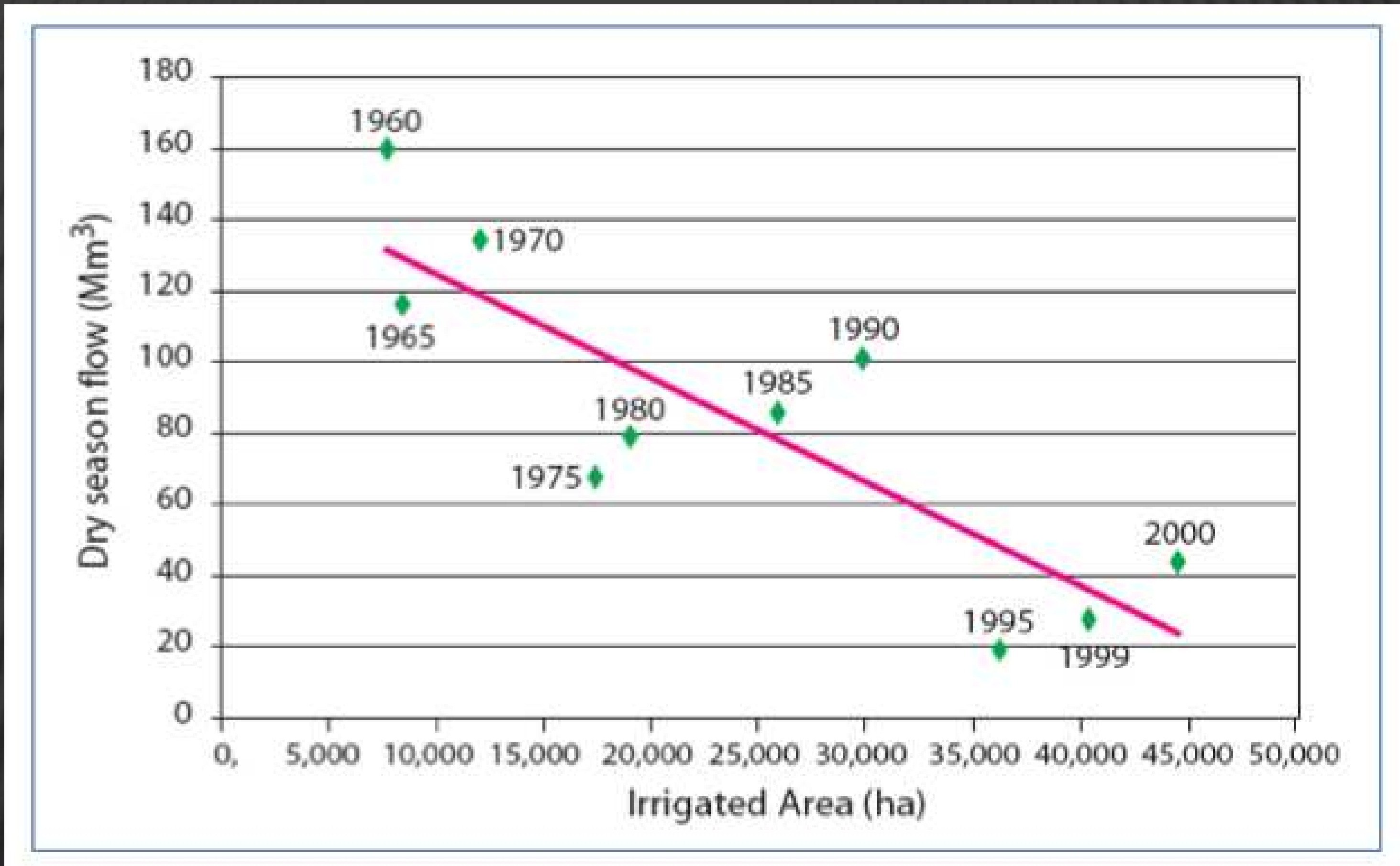
- Modeling freshwater provision + economic livelihood + spread of infectious disease
- Collaborators: Sokoine University of Agriculture, Iringa Water District, Friends of Ruaha Society
- Mediated modeling workshop (April 2013)
  - Data development & sharing
- Refining the model & communicating results (January 2014)

RUAHA CONCEPTUAL FRAMEWORK



IRRIGATION PRESSURES

Source: WWF, 2010 [IWMI Research Report]



Dry Season Flow at Msembe stream gauge plotted against ha of irrigated area in the Usangu Plains

1. COLLECTING SPATIAL DATA

- GIS data for as many components as possible
  - Map provision (source), sink, and use
- Local data where possible for case studies, otherwise use global data
- Where no data exists / data quality is poor, use Bayesian belief networks
  - Prior probabilities determined in consultation with local experts
  - Benefit from similar contextual settings where complete data exists

2. IDENTIFYING BENEFICIARIES

Beneficiary	Water Demand
Agricultural producers: Slopes, rangeland & rain-fed maize	Transpiration for vegetative growth
Domestic users in villages	In-stream needs for cooking, drinking, etc.
Agricultural producers: Irrigated agriculture, rice	Transpiration, seepage for vegetative growth and open water evaporation
Livestock producers: Permanent & seasonal wetland	Evapotranspiration & in-stream consumption (for livestock, fisheries, wildlife, wetland ecology; domestic needs for inhabitants)
Tourism: Ruaha National Park	In-stream needs for wildlife and drinking needs
Power producers: Mtera/Kidatu HEP Stations	Release for hydro-electricity power
Urban power users	Light, power, heating, cooling

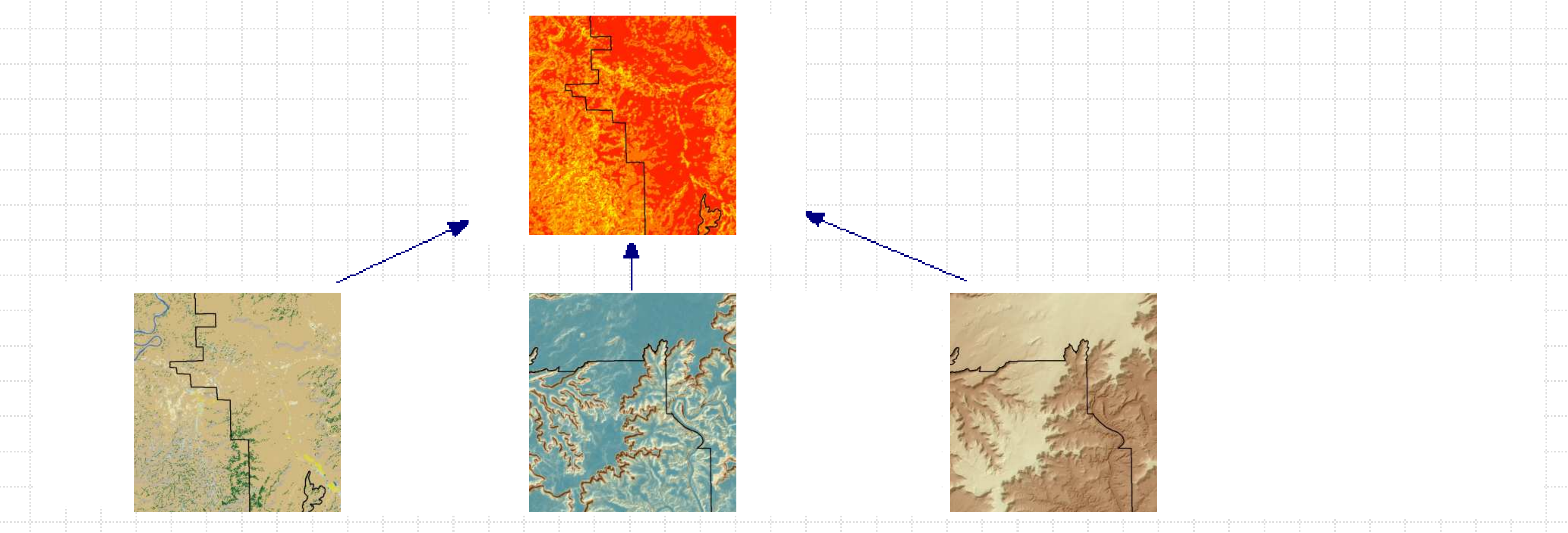
Modified from Lankford et al 2004

3. SURFACE WATER SOURCE MODEL

- Annual Precipitation
  - Global: WorldClim
  - Local: ?
- Springs: ?

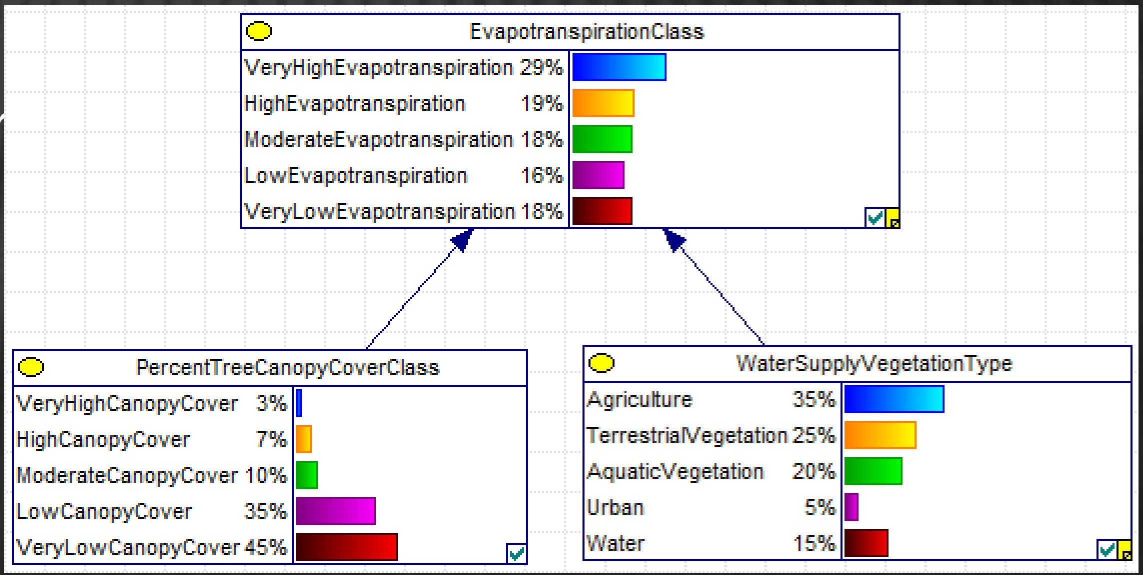
3. SURFACE WATER SINK MODEL

- Soil Infiltration
  - Hydrologic Soils Group: ORNL
  - Slope: Derived from SRTM (90-m)
  - % Impervious:
    - NOAA-NGDC: Global Land Cover
    - FAO: Africover



3. SURFACE WATER SINK MODEL

- Evapotranspiration
  - Percent Canopy Cover & Vegetation Type
    - NOAA-NGDC: Global Land Cover
    - Food and Agriculture Organization Africover
    - European Space Agency GlobCover
  - Land Cover
    - FAO: Africover

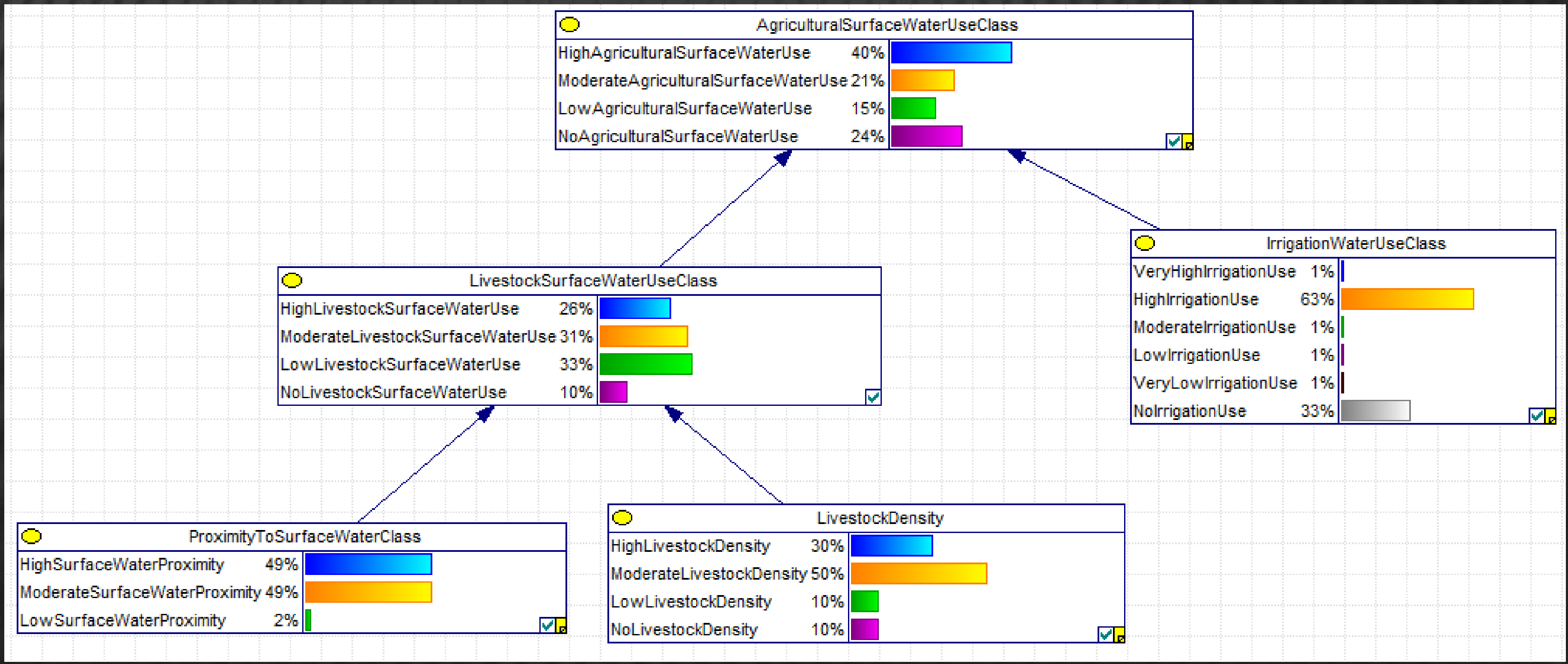


3. SURFACE WATER USE MODEL: 1

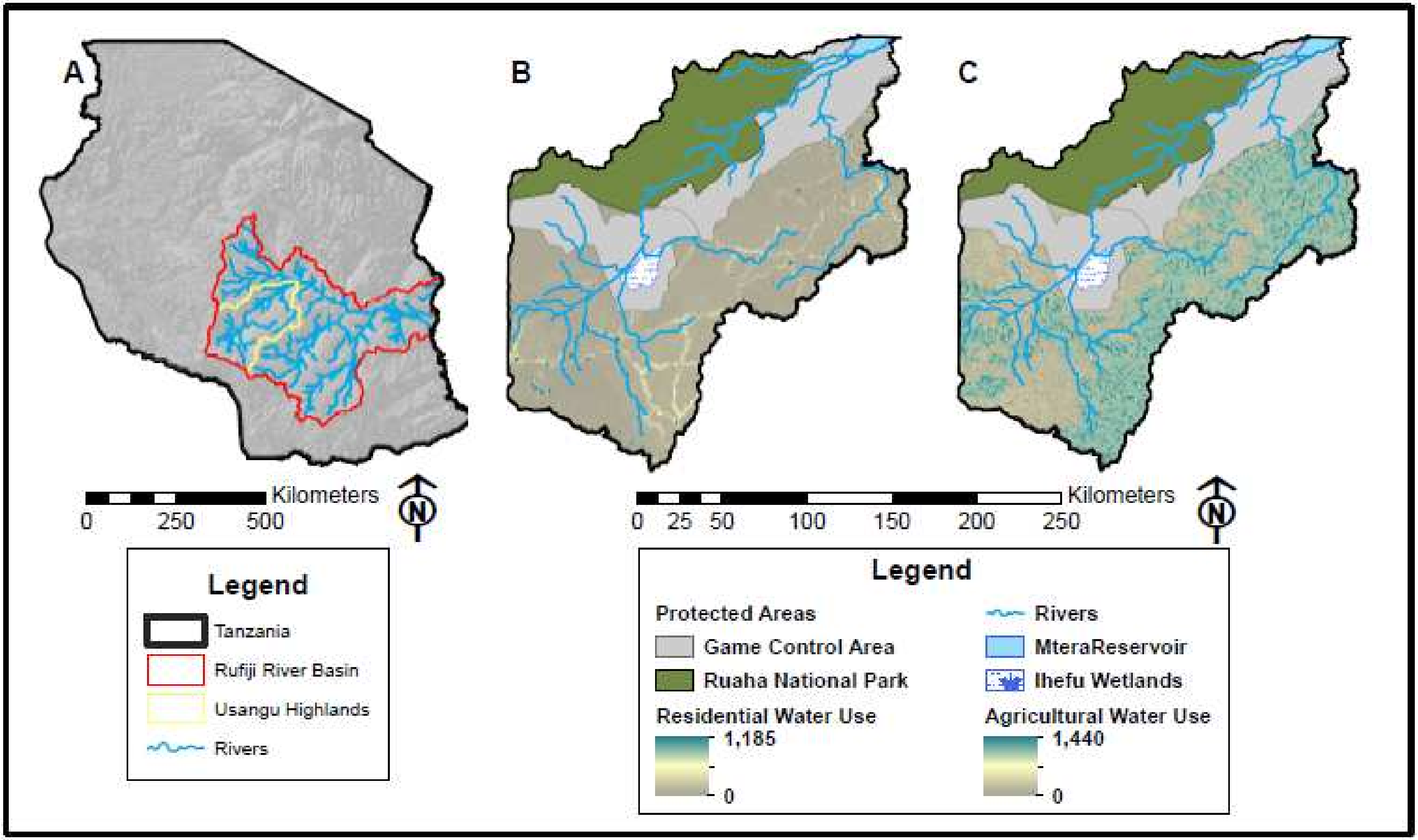
- Residential Use
  - Based on population counts
    - Data disaggregation leads to erroneous assumptions about residential locations
    - Currently developing water demand profile for residential users based on location, access to piped water, proximity to other water sources
  - Open questions
    - Water rights: Converting paper files to digital format for inclusion in the modelling framework
    - Water supply wells: Survey of village water resources
    - Surface diversions: Mapping land cover change

3. SURFACE WATER USE MODEL: 2

- Agriculture
  - Open questions: Surface diversions, Water supply wells, Water rights



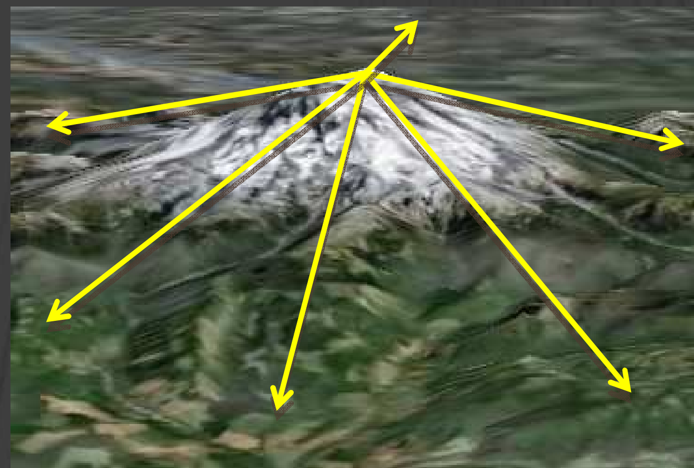
MODEL OUTPUTS: WATER DEMAND



Villa, Voigt & Erickson, forthcoming

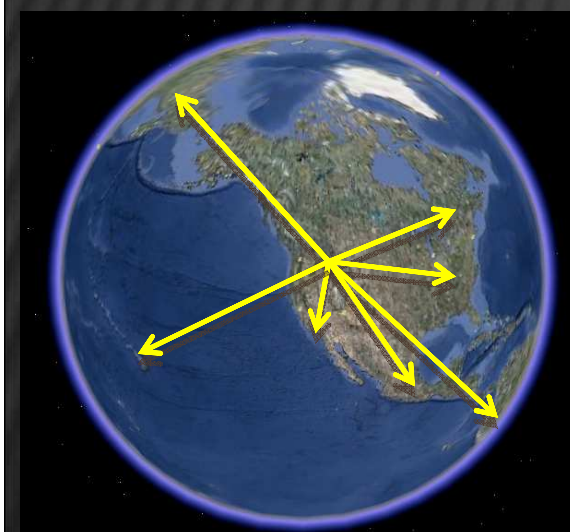
4. FLOW MODELS

Hydrologic services



Aesthetic viewsheds

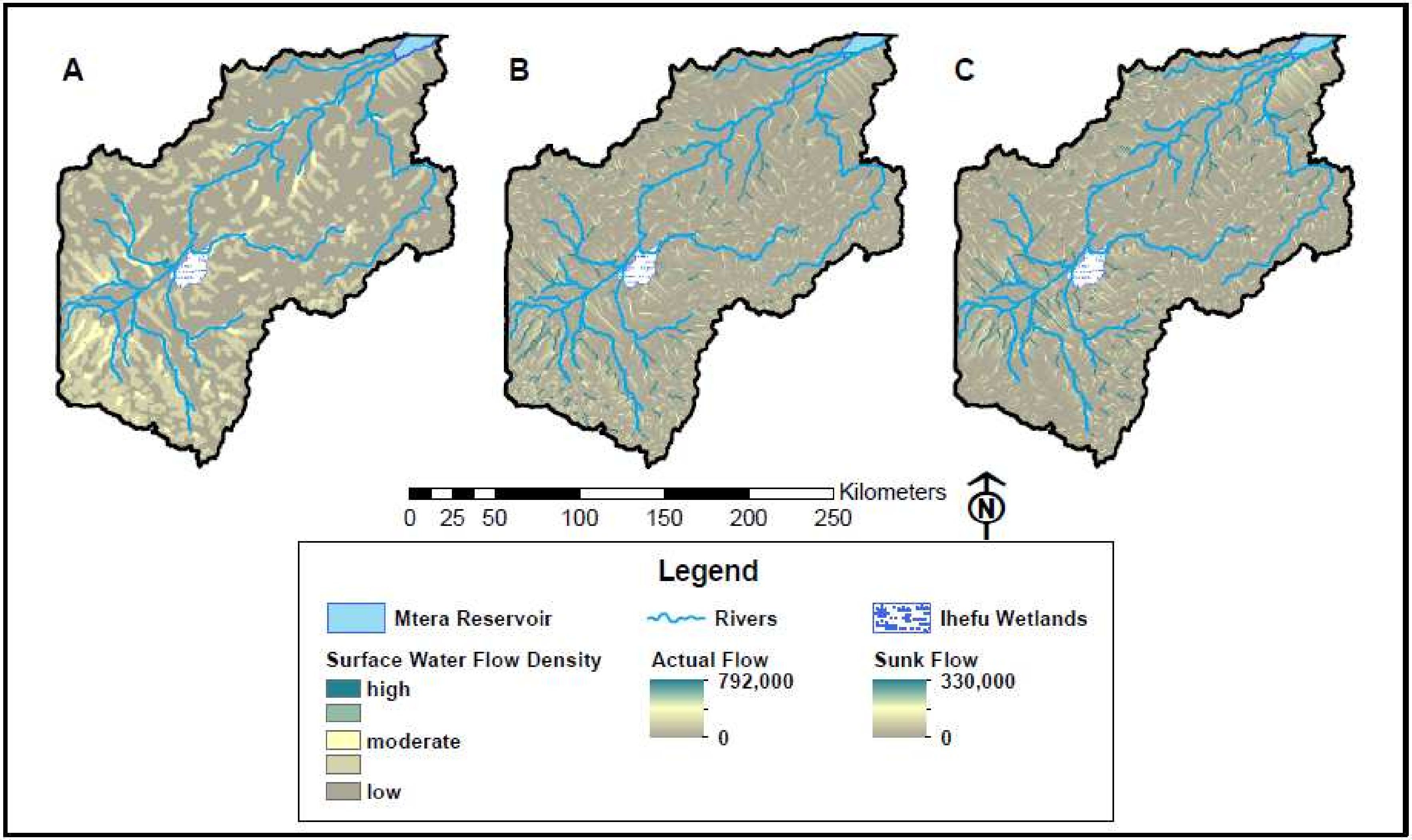
Recreation, flood regulation, many ecosystem goods



Carbon sequestration, some cultural values

Recreation, aesthetic proximity, some cultural services

MODEL OUTPUTS: FLOW MODEL



Villa, Voigt & Erickson, forthcoming

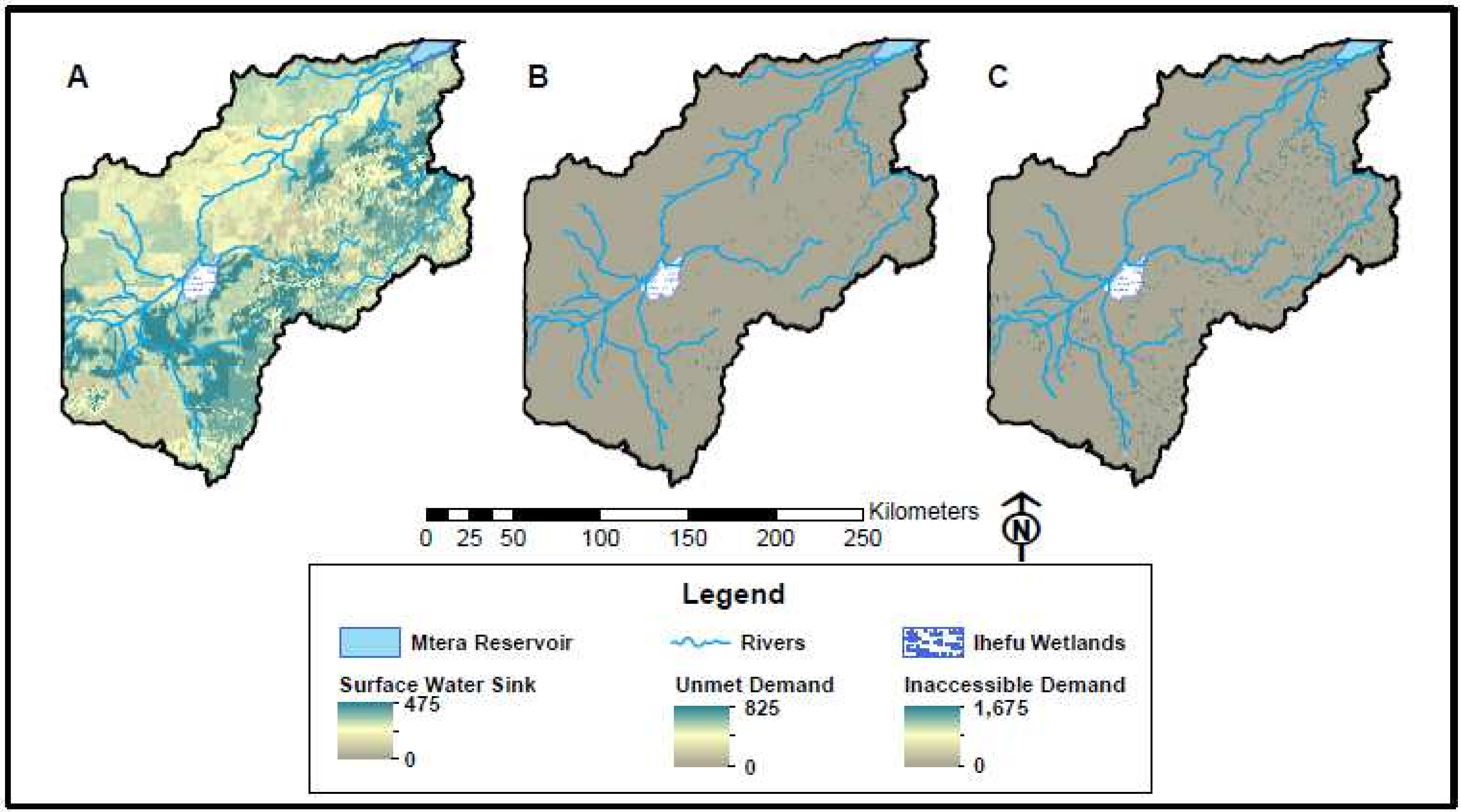
INDICATORS

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

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

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

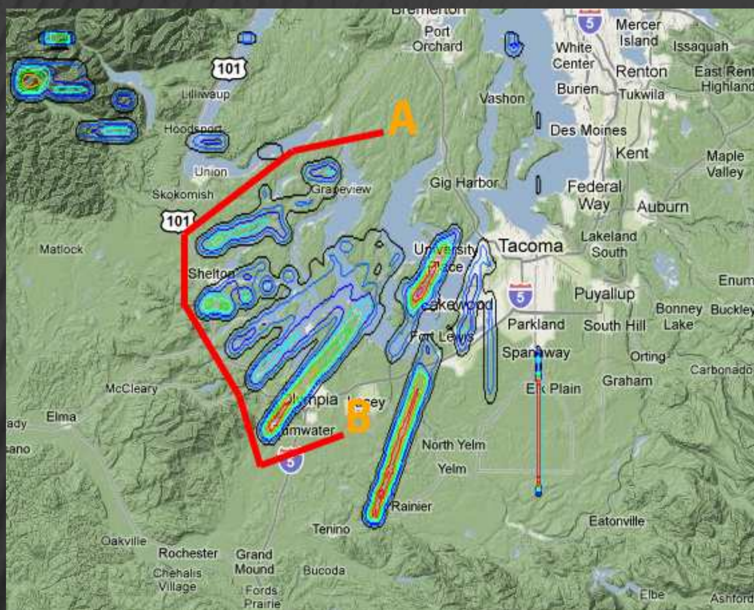
WATER SUPPLY SINK & DEMAND PROFILES



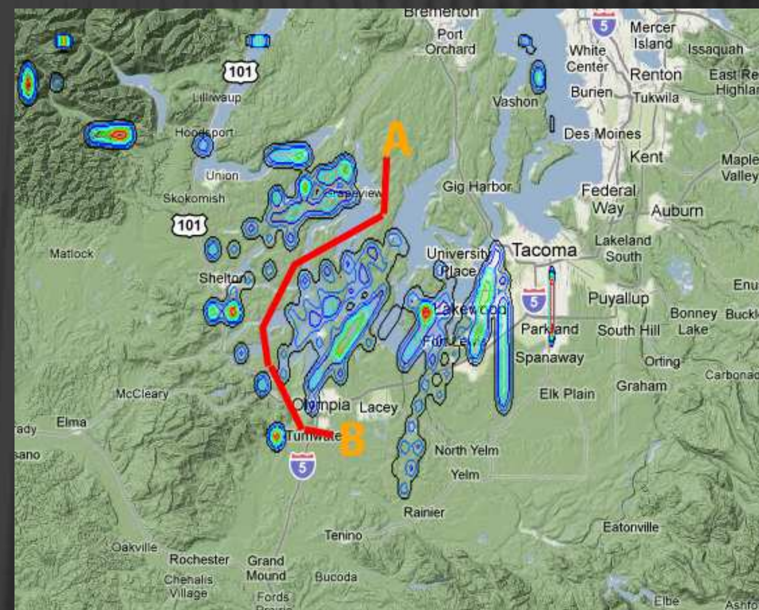
Villa, Voigt & Erickson, forthcoming

SCENARIO ANALYSIS: INFRASTRUCTURE

Scenario 1: Baseline



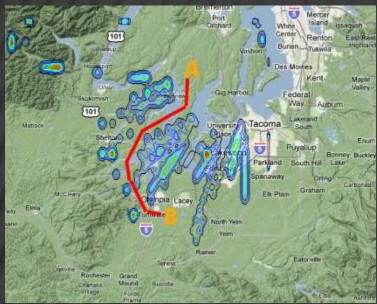
Scenario 2: Reforestation

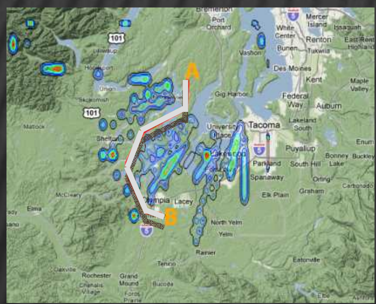


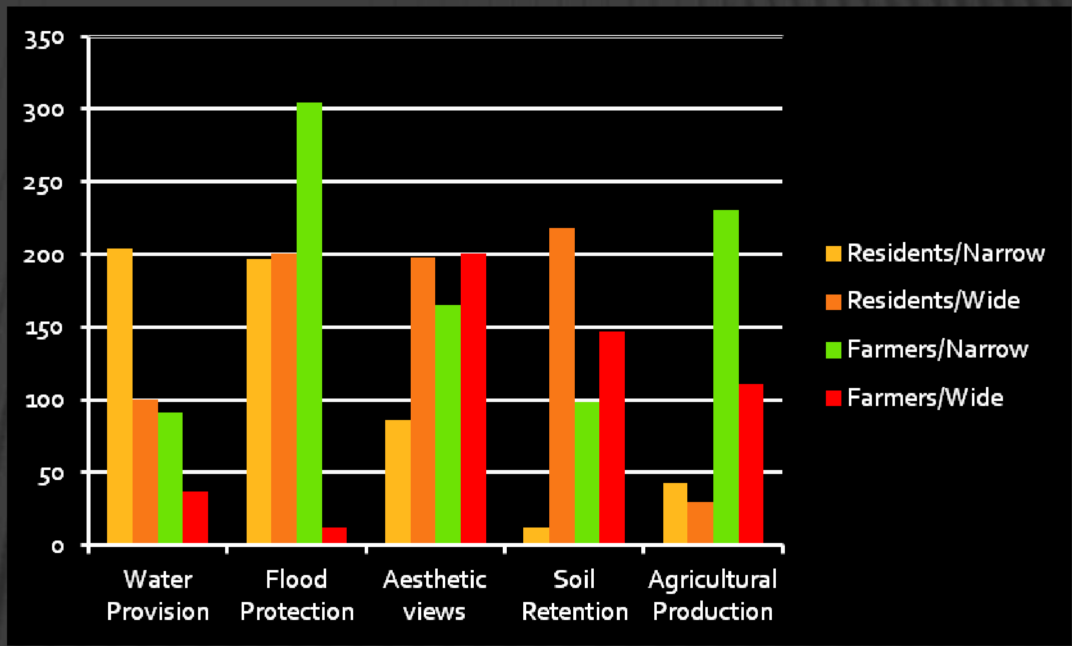
Routing that minimizes impact ES flows in *business as usual* scenario. Long feature required to avoid impacting water provision.

Routing that minimizes impact on flows of ES with reforested corridors. Shorter feature offsets reforestation costs.

SCENARIO ANALYSIS: STAKEHOLDER IMPACTS



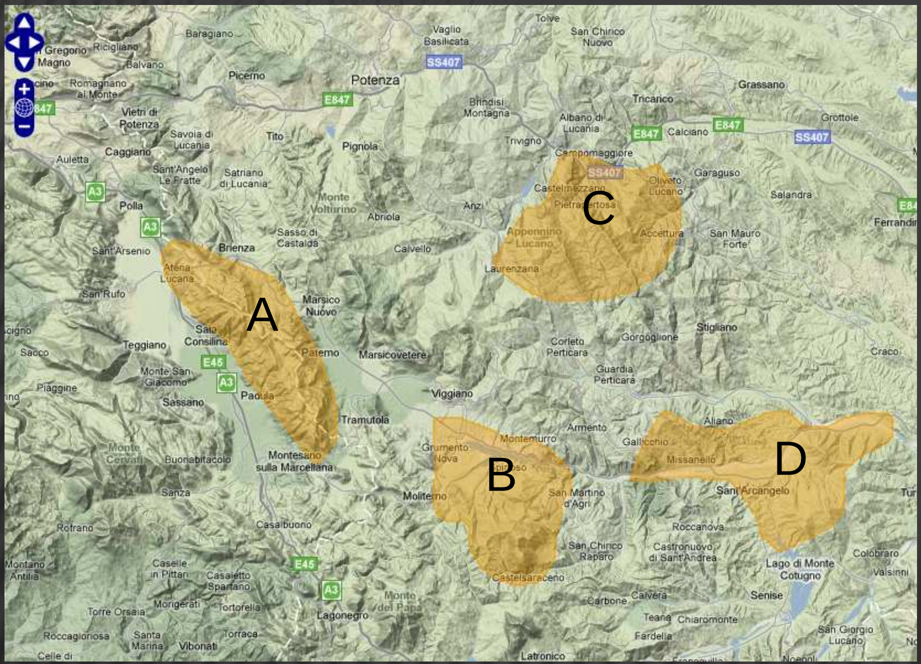




Alternative options (different buffer zones) evaluated for ecosystem service impact(s) …

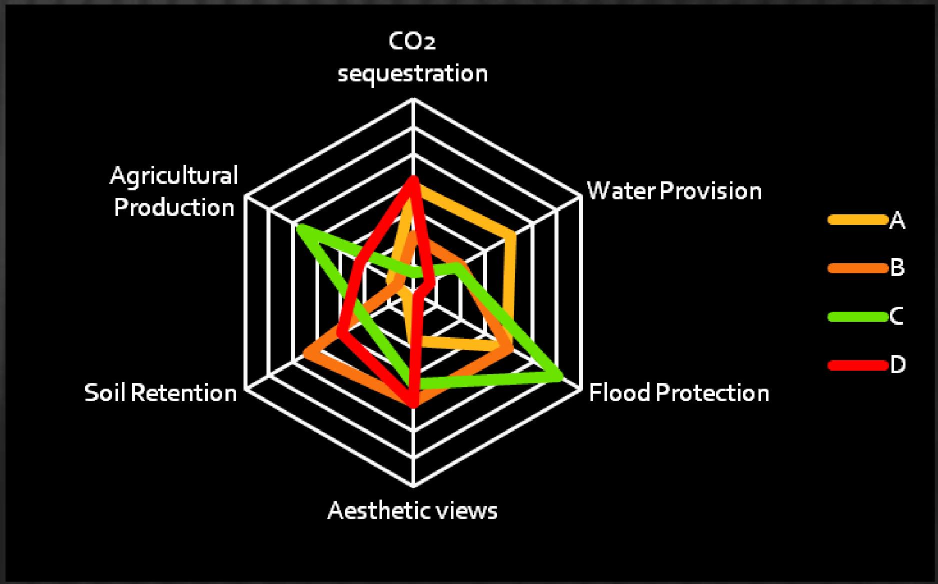
…against the needs of different stakeholder groups.

SCENARIO ANALYSIS: TRADEOFFS



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.



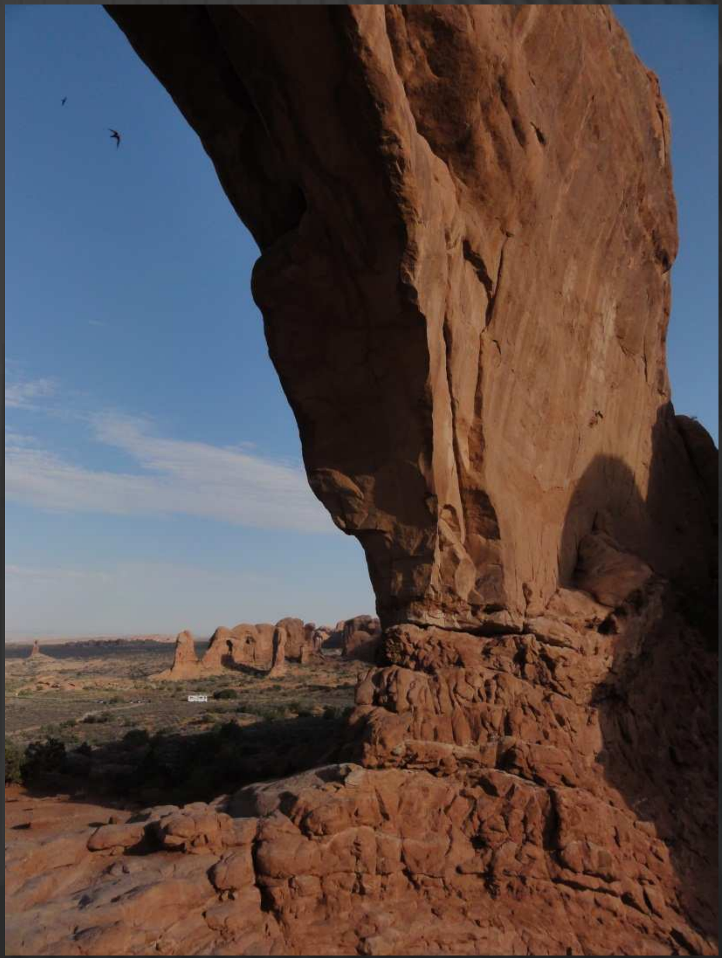
Multiple Criteria analysis allows customizing the ES profiles to pre-existing priorities or legal constraints.

ALGONQUIN PROVINCIAL PARK: ONTARIO, CA

- Modeling Carbon sequestration and recreation
- Project collaborator: Ontario Ministry of Natural Resources
- Beneficiaries: recreational users – camping, hiking, canoeing
- Management considerations: Forest thinning, timber extraction, trail development, park leases
- Economic valuation
  - Carbon: based on social cost of Carbon (Tol, 2008)

RECREATIONAL SERVICES: MOAB, UT

- Modeling the effects of minerals development on recreation and ground water resources
- Project collaborators: BLM, USGS, UVM & NPS
- 950,000 acres in east-central Utah
- Expressions of interest
  - Oil & gas: 120,000 acres of new development
  - Potash: 350,000 acres of new development



RESOURCE MANAGEMENT ISSUES

- BLM has identified lands with outstanding visual resources, high value recreation and wilderness areas, & high quality air resources.
- Addendum to the existing Resource Management Plan (MLP)
- Analysis of alternatives
  - Beneficiary groups: hiking, mountain biking, jeep safari, rafting
  - Support designation of Areas of Critical Environmental Concern
  - Identify potential conflict areas due to mineral development

ADDITIONAL ONGOING PROJECT WORK

- ESPA: Agricultural production
  - Columbia, Peru & Malawi
- Vermont, USA: Flood and nutrient regulation, aesthetic views, recreation
- Molise, IT: Sediment regulation, agricultural tourism

MODEL CRITERIA & QUESTIONS: 1

- Quantitative output
  - Output units depend on service(s) being analyzed (tonnes/ha/year, mm^3/year, etc.)
- Model rigor
  - Existing biophysical models can be incorporated
  - Bayesian models developed with input from local experts and review of literature
- Adaptability
  - Flexibility of Bayesian model structure
  - User-designed models to capture local context / setting
- Scalability
  - Dependent on model resolution (including # of source, sink, use locations)

MODEL CRITERIA & QUESTIONS: 2

- Classification
  - Semantic modeling system allows for existing / customized LULC schemes
- Labor & Infrastructure
  - Steep learning curve requiring technical abilities (programming, spatial analysis)
  - 2-week training Spring 2014, Basque Centre for Climate Change
- Data requirements
  - Intentionally flexible, based on local context
  - Bayesian approach can accommodate / overcome data deficiencies

MODEL CRITERIA & QUESTIONS: 3

- Uncertainty
  - Standard with Bayesian models
- Scenarios & Policy Alignment
  - Alter inputs to evaluate trade-offs
- Economic Valuation
- Beneficiaries
  - Strong focus on connecting ecosystem service provision to beneficiaries
  - Distinguish beneficiary types and identify their location(s)