Characterizing beneficiaries in integrated ES assessments

An artificial intelligence approach with ARIES

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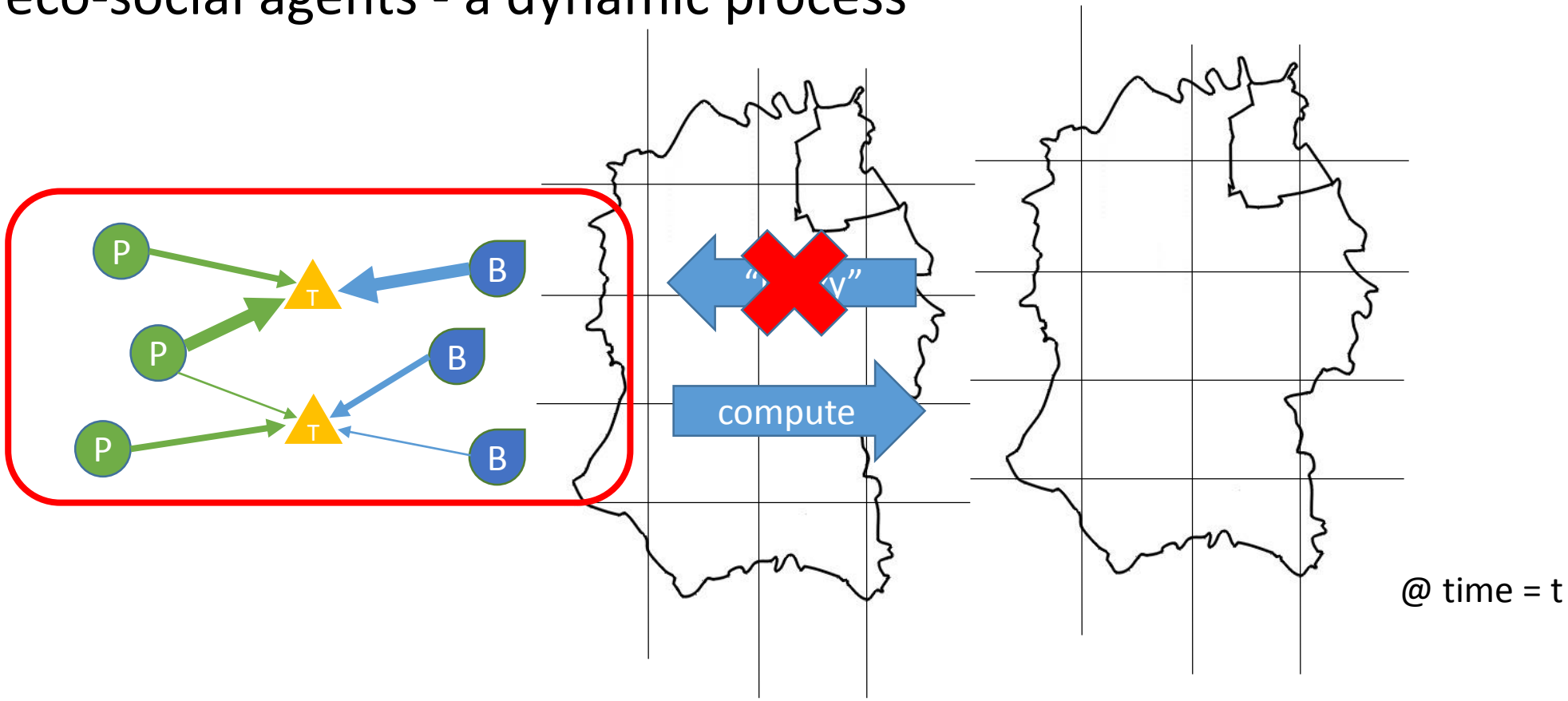
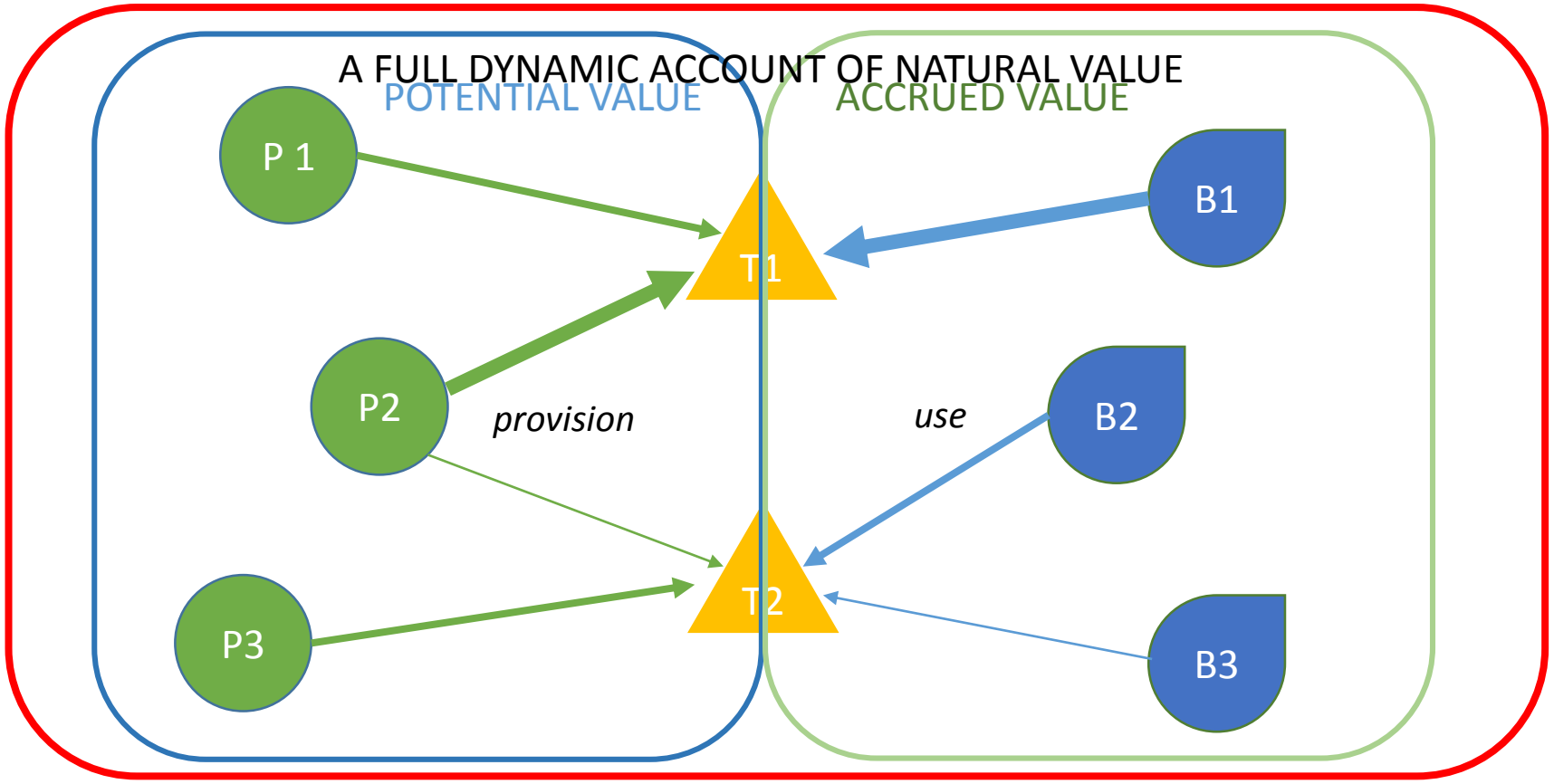
Accounting for human-natural interactions

- Extend “the ES as a mapped stock” paradigm: we are better than that
- ES are the throughput of the values exchanged within a network of eco-social agents - a dynamic process



Characterizing the system adaptively

Agent network defines both structure and function. **Ecosystem service-shed** example:



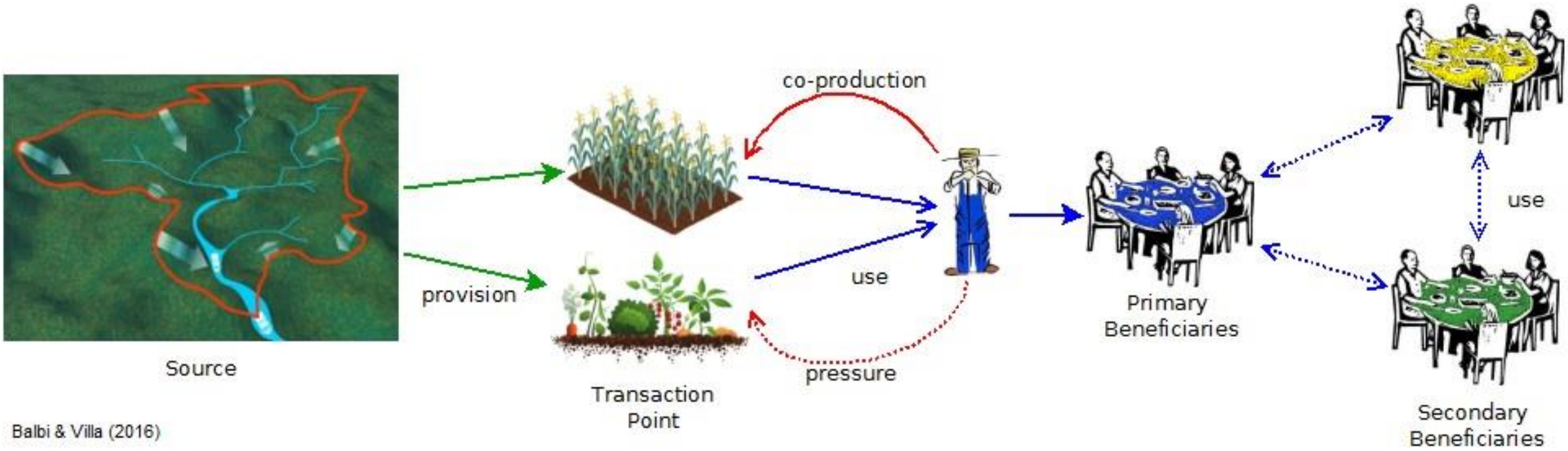
Providers (e.g. forests, watersheds): where valuable ecosystem function happens

Transactors (e.g. wells, crops, atmosphere): where natural value is generated

Beneficiaries (e.g. farmers, coastal dwellers): demand agents for natural value

An extended, agent-based ES framework

generalizes the SSE concept and is optimized for semantic web computation



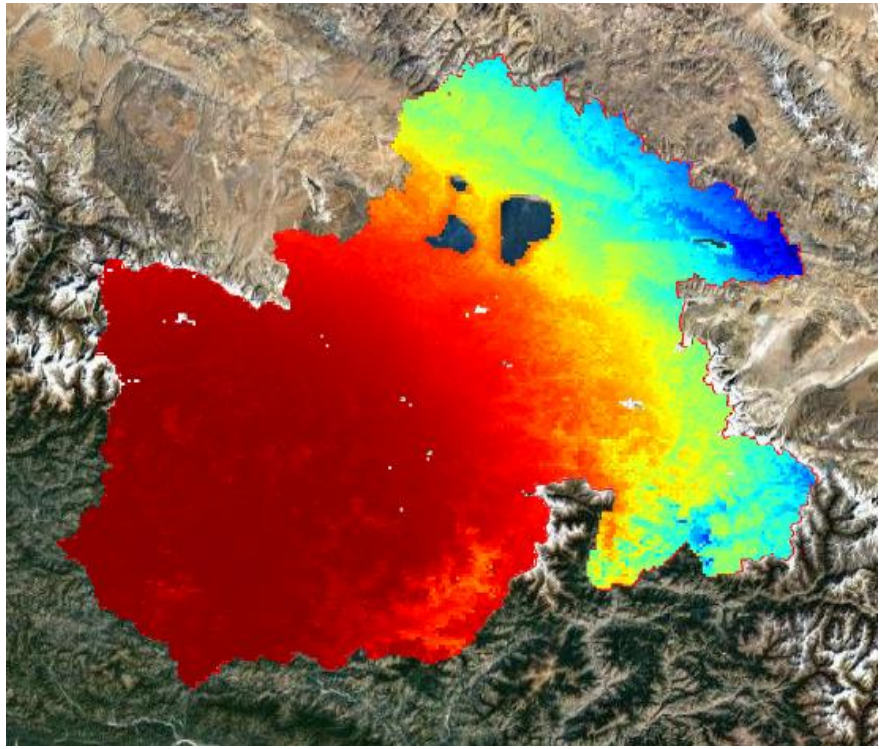
Building social agents 1

Start with maps, but don't stop there

Level of dependency on ES

Blue: net exporters

Red: net importers



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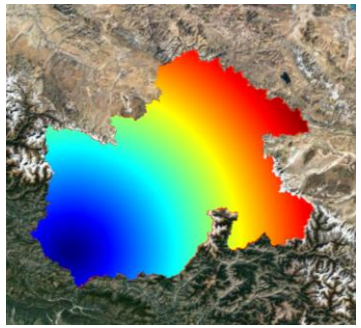
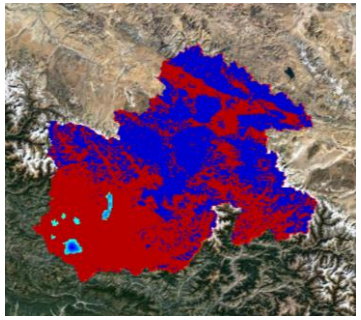
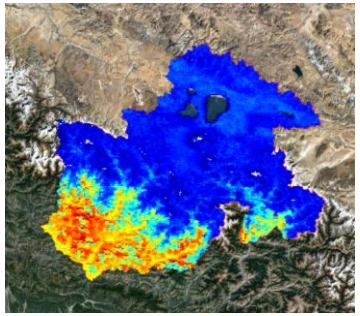
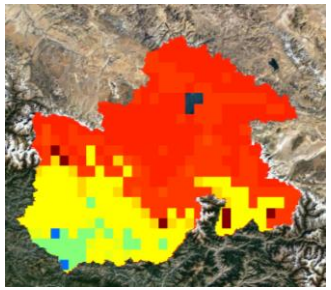






- Learns **net importers** (deep red) based on Anthromes

  11 & 12
- (Urban +
- Dense settlements)



- REF: Ellis, E. C. and N. Ramankutty. 2008. Putting people in the map: Anthropogenic biomes of the world. Frontiers in Ecology and the Environment 6(8):439-447.

- Builds **similarity map** using the ENFA algorithm with predictors:

1. Distance to Human presence (Nightlights: GRUMP)
2. Poverty data
3. Minimum NDVI

Improved learning algorithm can use crowdsourced features (OSM)

Building social agents 2: issues and methods

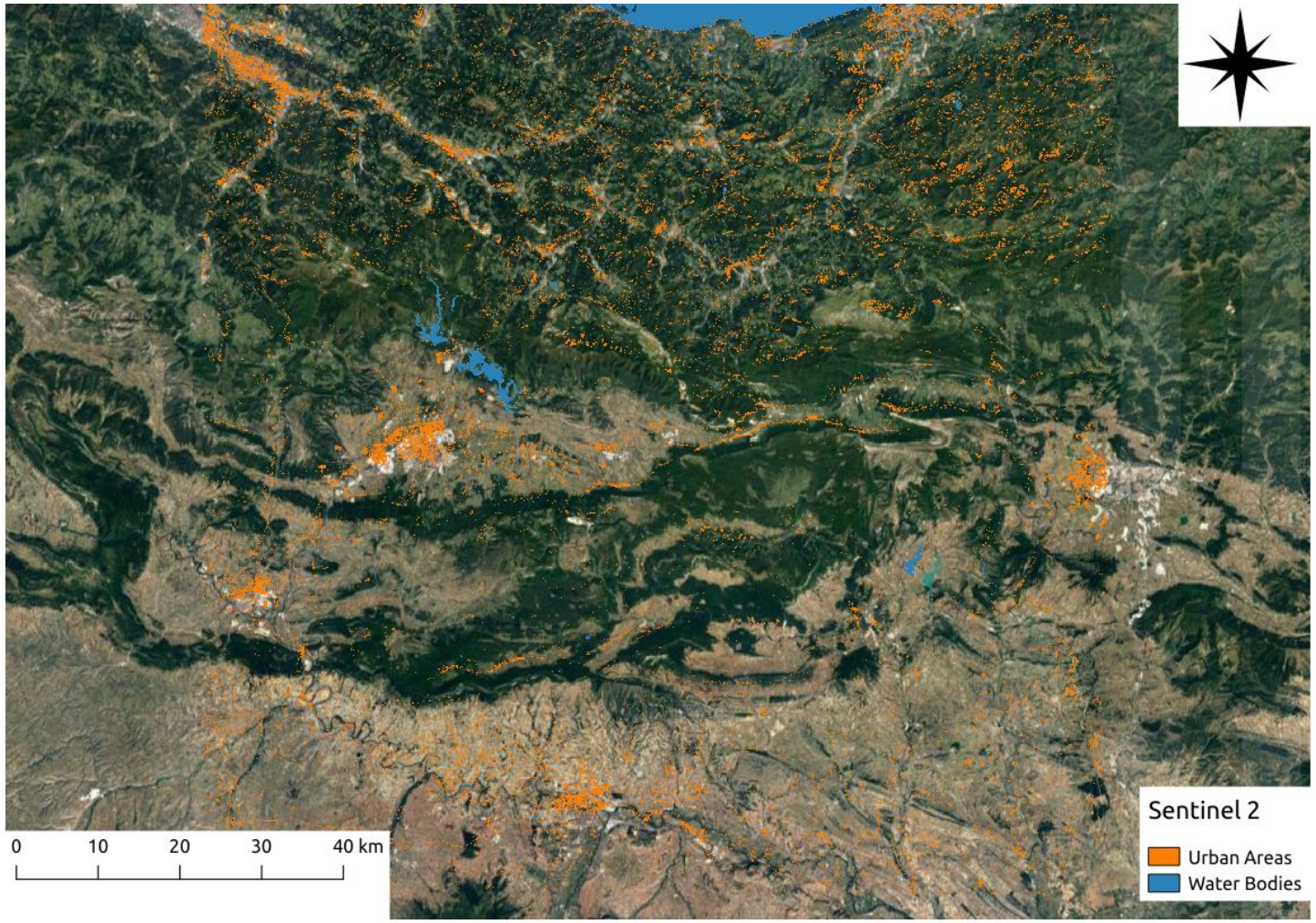
Build agents, not maps

- **Scaling**: agents depend on scale. E.g., at the national scale models may focus on cities; at the regional scale models may need to see households.
  - Within an agent paradigm, this choice can be automated
- **Identity**: given natural features (i.e. ecosystem extent and condition), establish the likely ES demand and supply, i.e. which ecological and social agents types are involved
- With these issues addressed, social agents can be characterized by either
  - Feature extraction from dependency or probability maps
  - Classification of demand for previously mapped agents

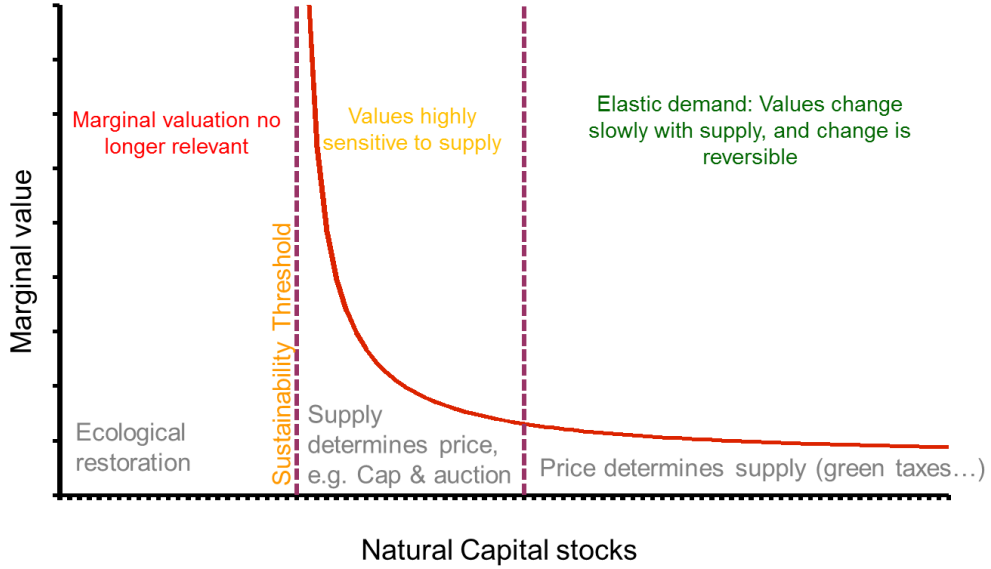
Socializing the pixels

An automated, AI-driven process

- Automatic segmentation algorithm builds and updates assessments continuously
- Context-dependent strategy, built by AI according to availability of data and models in each segment
- RS data are coupled with other info to build maps from which to classify or extract agents
- Information available: RS for spectral info, local data + OSM and others for feature info. Data are accessible from distributed databases. As models are refined, assessments improve
- Example data: Sentinel 2 (March 10th 2017, Bizkaia, Spain)
  - Combination of Green and Near Infrared bands
  - Water bodies
  - Built-up areas
  - 20 meters spatial resolution
  - OSM used to find clusters of agents; pixels help characterize them.



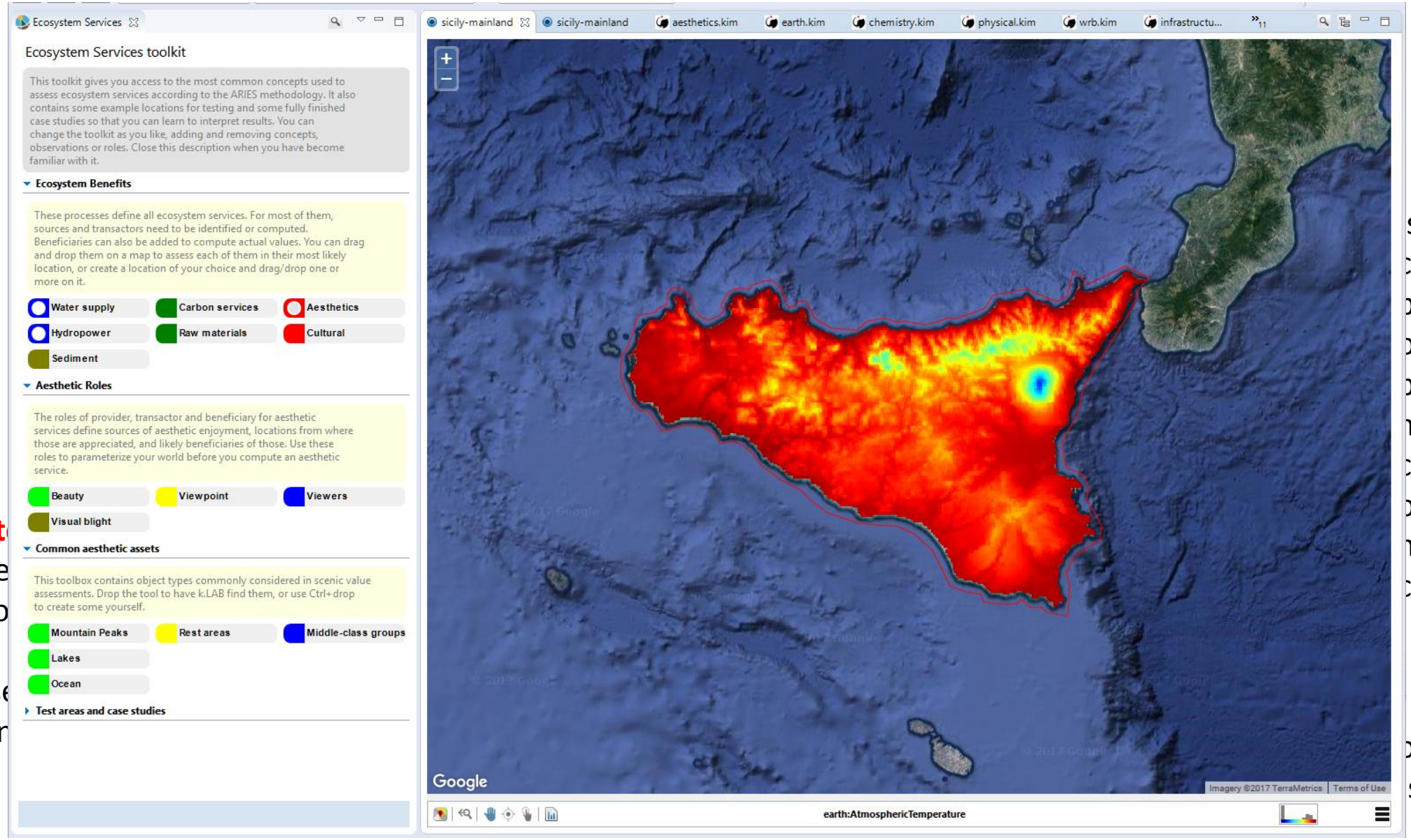
Characterizing social agents



- Demand or need?
  - Supply vs. Demand analysis
  - Substitutability vs. Value
- Characterization
  - Basic needs (→ focus on water/food/energy) vs. non-essential (e.g. recreation)
  - Net producers or importers of ES (red/green loops)
    - Key point: analyzing access to institutions (market vs subsistence)
- Methods
  - Semantics first!
  - Machine learning + remote sensing; use ALL data (including crowdsourced information) at their appropriate scales

The user side: a two-step assessment

Client software (desktop & soon web-based) allow modeling with minimal configuration and training. Provenance info is compiled into user documentation for each result set.



Drag-and-drop paradigm for end users

“Palette” of ES tools can store finished studies and scenario results

Models are built and computed when user drops the concept

Full reports are built to document the computation

The underlying vision: shared, distributed, collaborative models

SEMANTICS for data and models

- Core concepts: **subjects**, qualities, processes, events, relationships…
- Domain ontologies for socio-environmental systems, land cover; integration with vocabularies

APPLICATIONS

- Ecosystem services assessment (ARIES)
- Food and other environmental securities (ASSETS)
- Integrating hydrology, primary production, nutrients with agent models to best represent SSE.

OPEN SOURCE SOFTWARE

- User-end (modelers and end users)
- Cloud technology (institutions)

COLLABORATIVE MODELING

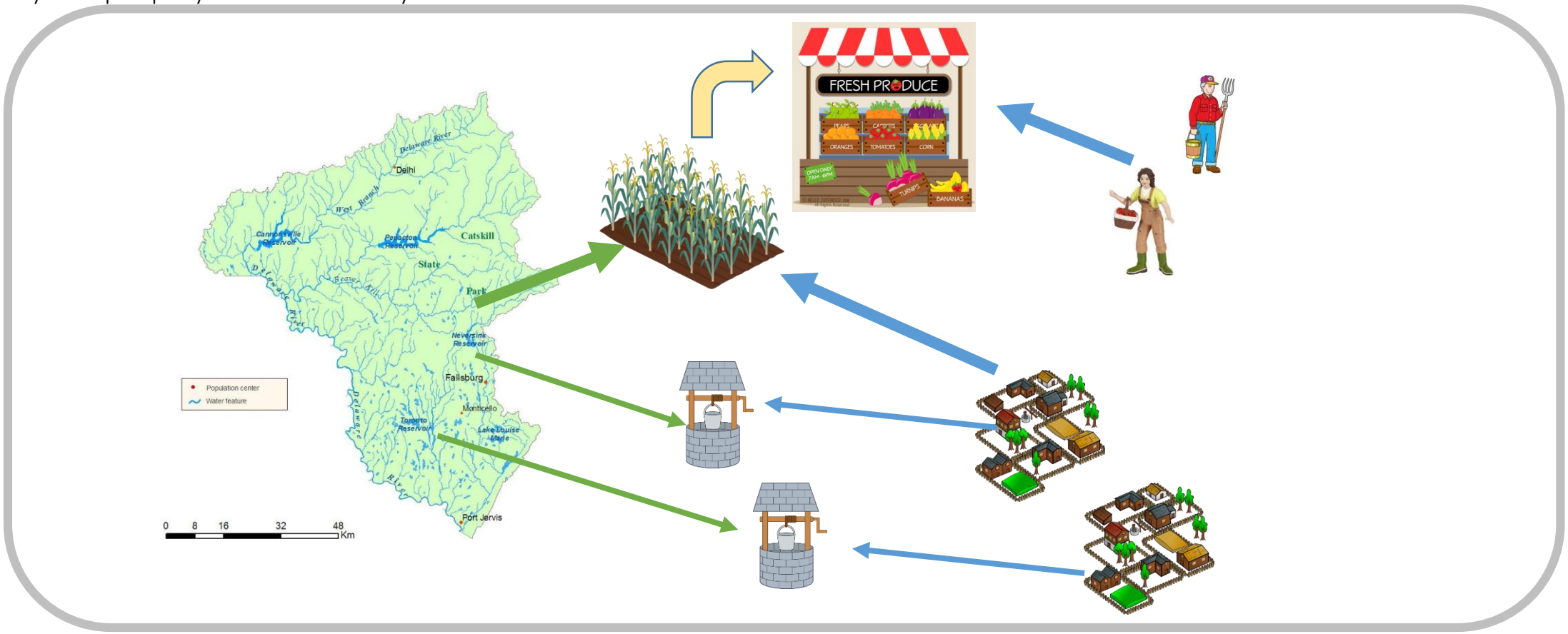
- Interoperable data and models
- Independent development of coordinating components
- International Spring University since 2013

INTEGRATED MODELING INFRASTRUCTURE

- Assembly of models from networked data and model components
- Accurate coupled human-natural system representations

Example: building an eco-social flow network

Triggered by a simple query: “observe social dynamics of water in watershed X”



Providers (e.g. forests, watersheds) are first identified and built.

The knowledge base identifies Transactors (e.g. wells, crops, atmosphere) and queries them.

Beneficiaries (e.g. farmers, coastal dwellers) are identified and queried next.