

# INTEGRATING GIS-BASED REGIONALIZATION INTO LCA CALCULATIONS: THE EXAMPLE OF WATER

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# INTEGRATING GIS-BASED REGIONALIZATION INTO LCA

CALCULATIONS: ~~THE EXAMPLE OF WATER~~

*The status quo*

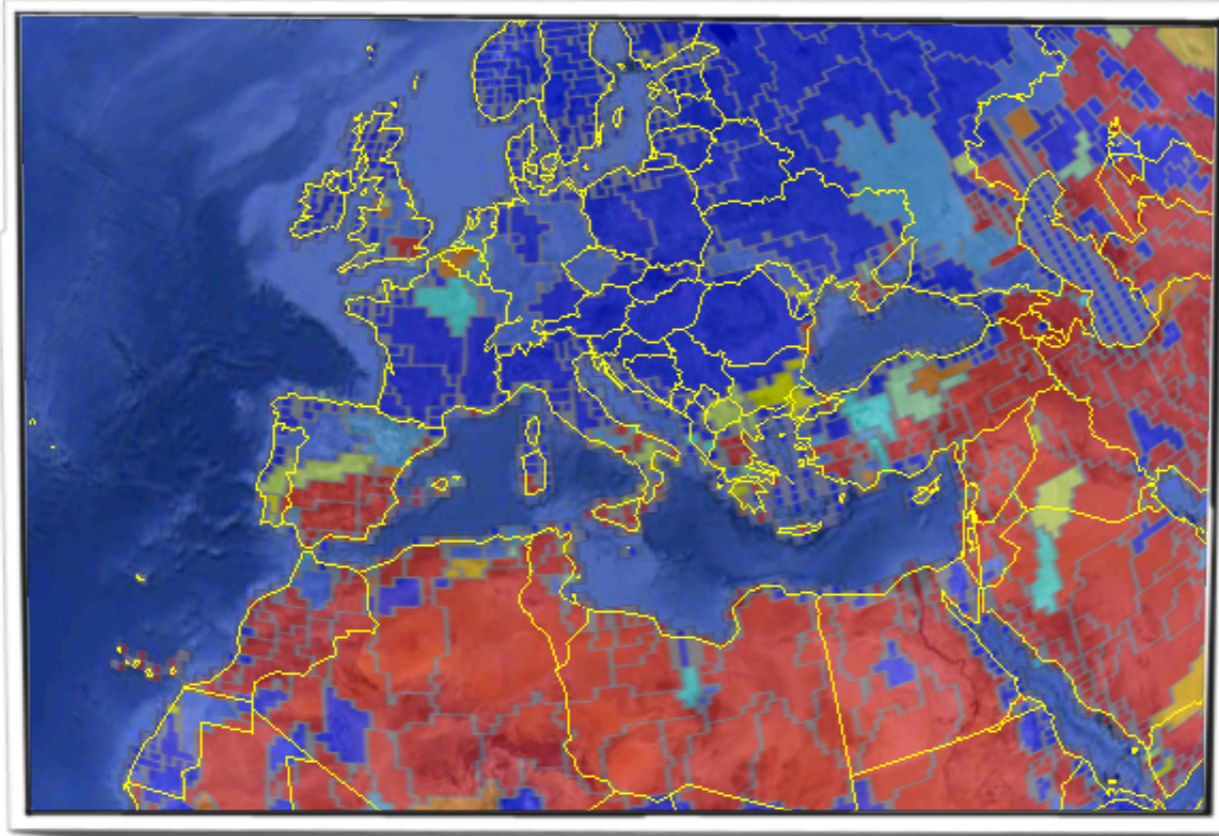
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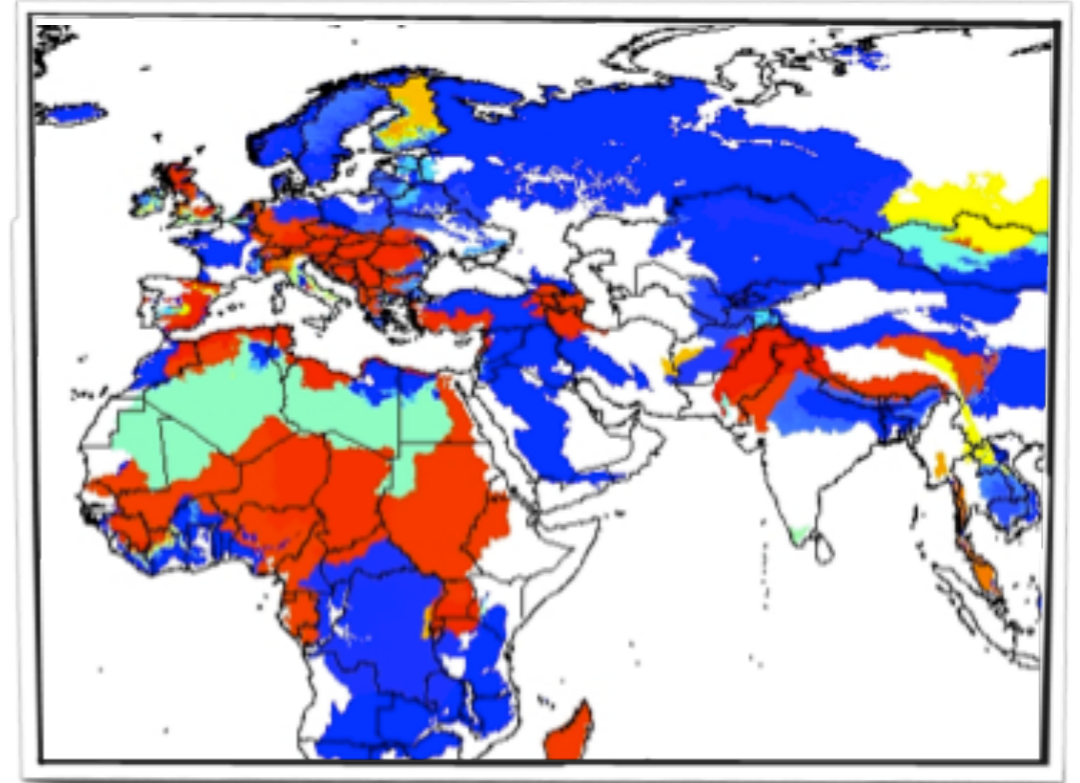
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# Problem



Freshwater use



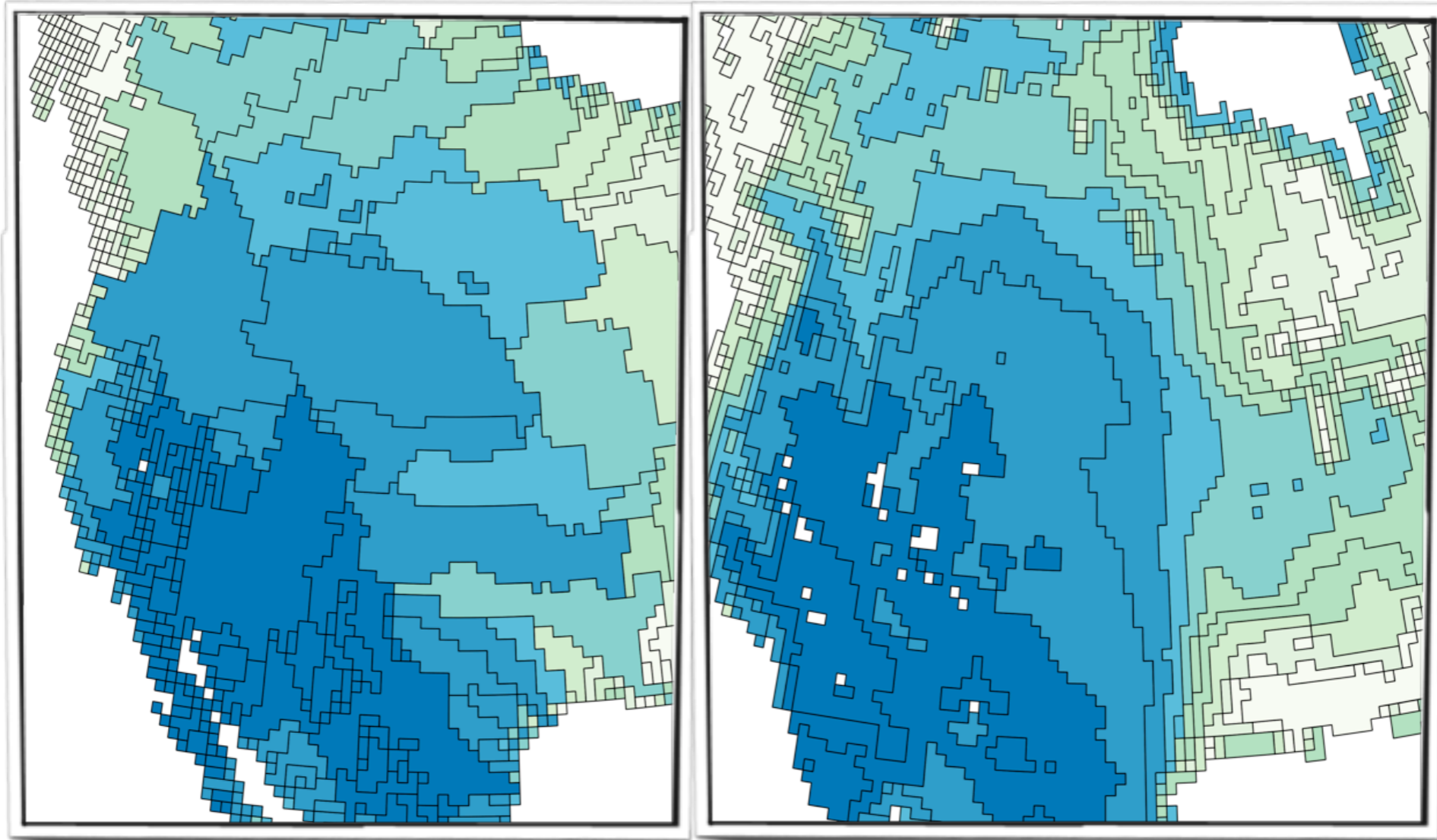
Wetlands

# Spatial scale of water use

Watersheds?

# Spatial scale of water use

Watersheds?

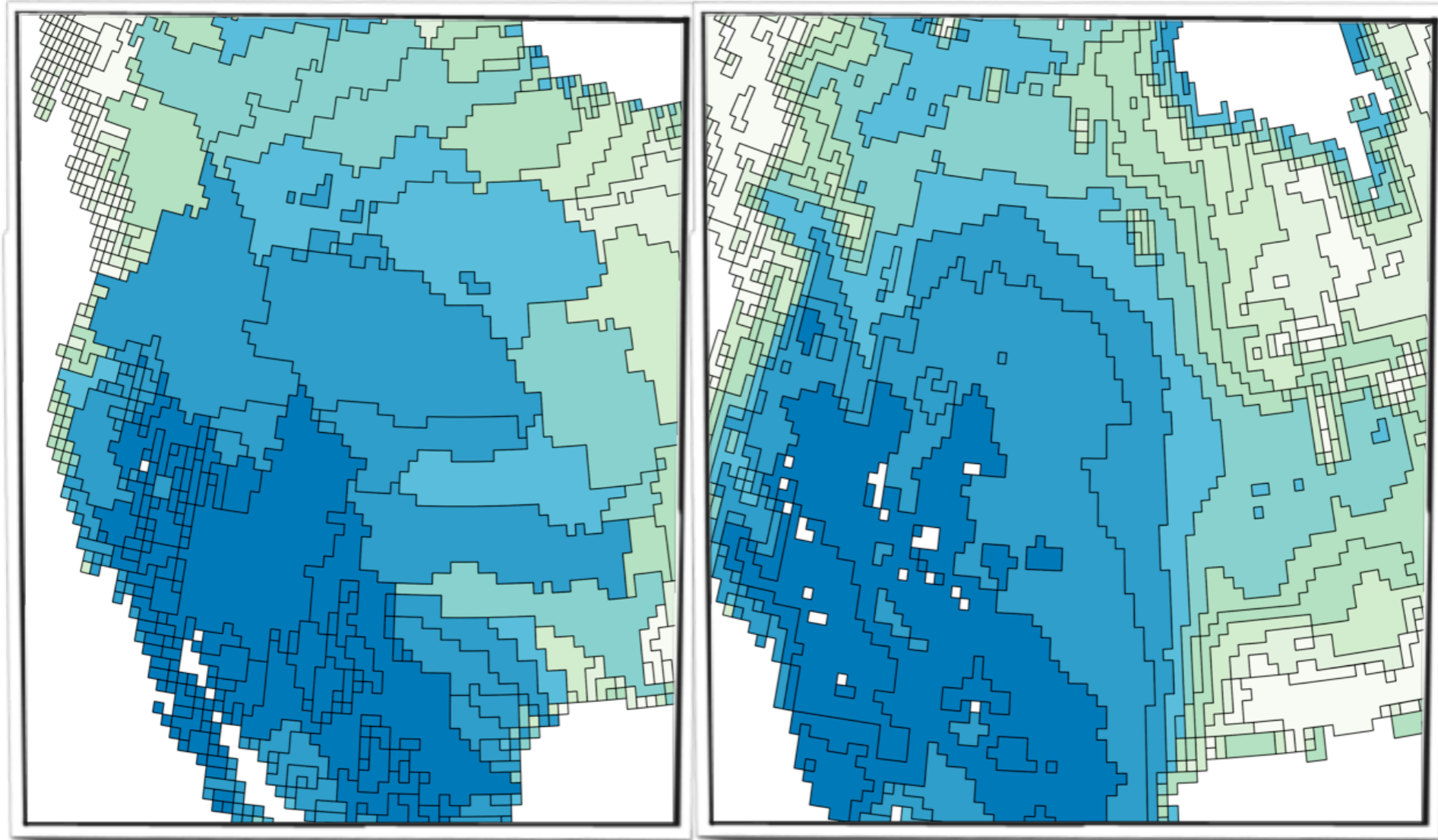


Watersheds

Autocorrelation-  
optimized

# Spatial scale of water use

Watersheds?

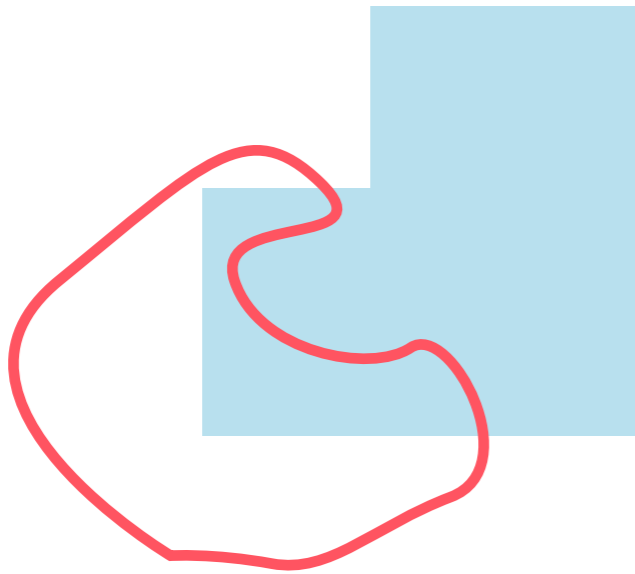


Watersheds

Autocorrelation-  
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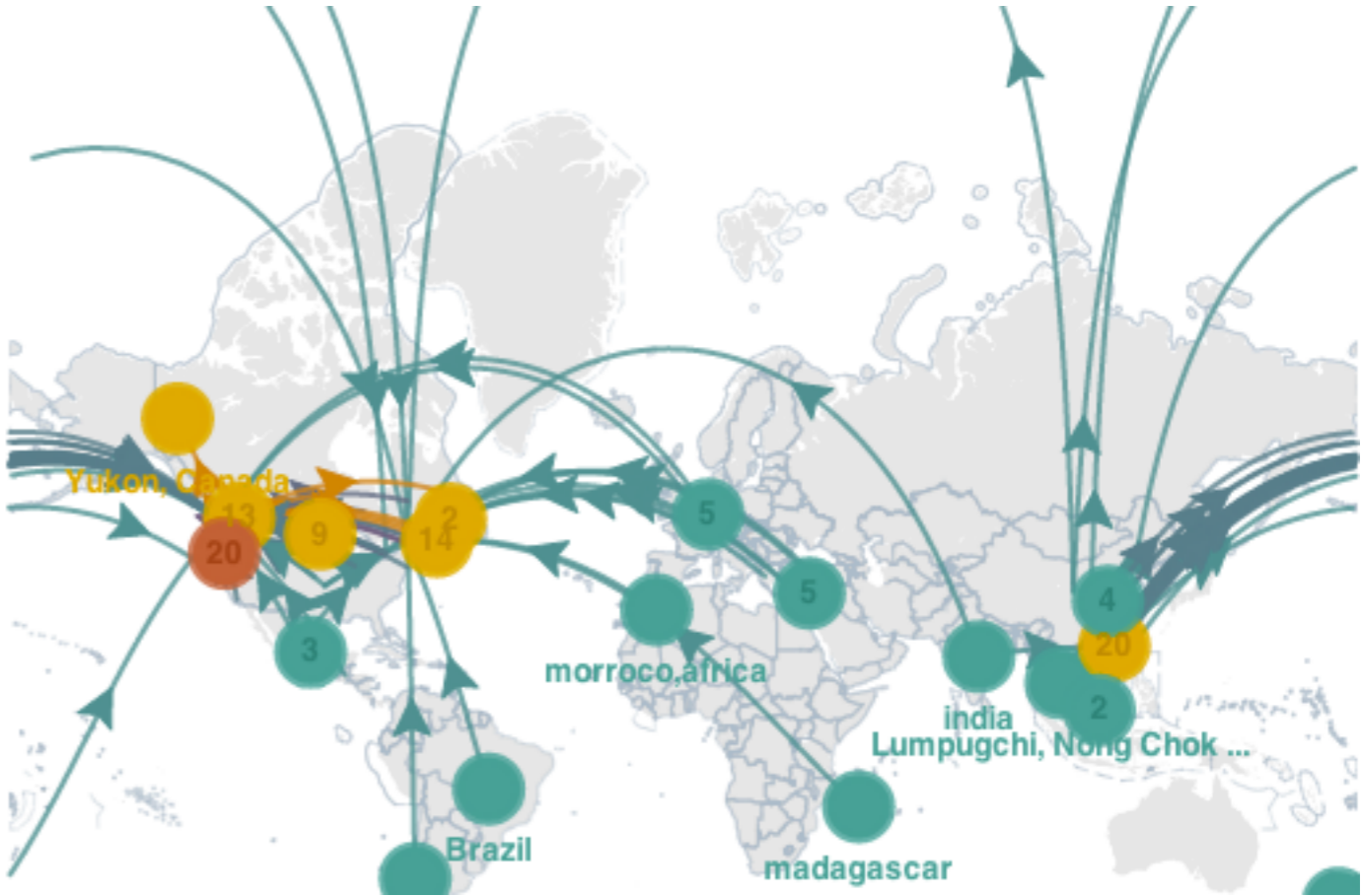
-> Need GIS to work with water CFs

# Challenges

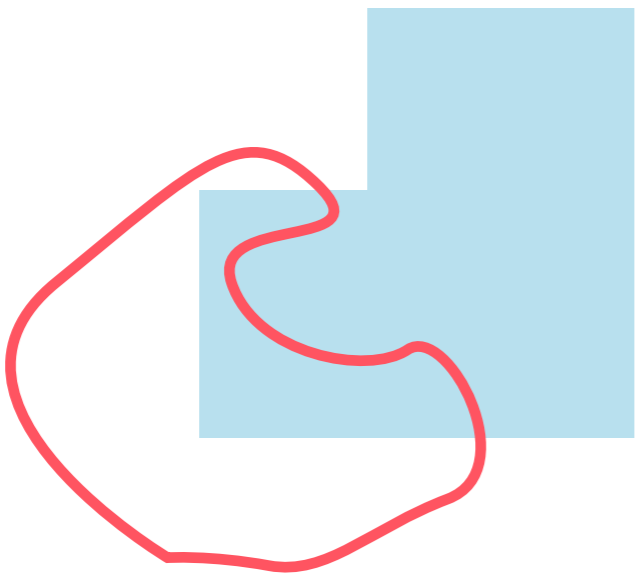


Matching spatial scales

# Challenges



Spatial supply chain data



Matching spatial scales





Two complete models

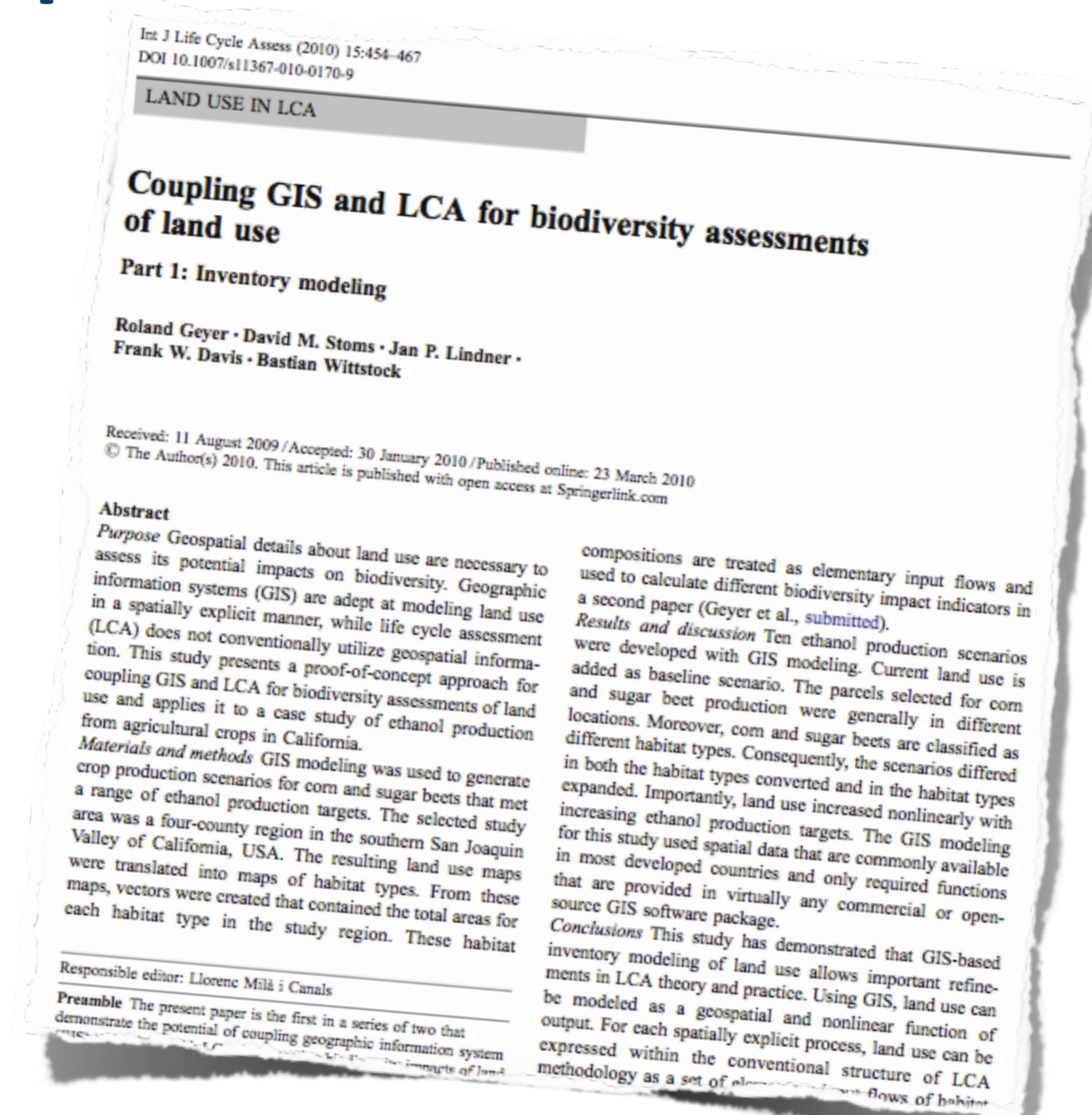
Resources



Computer training



# Two complete models

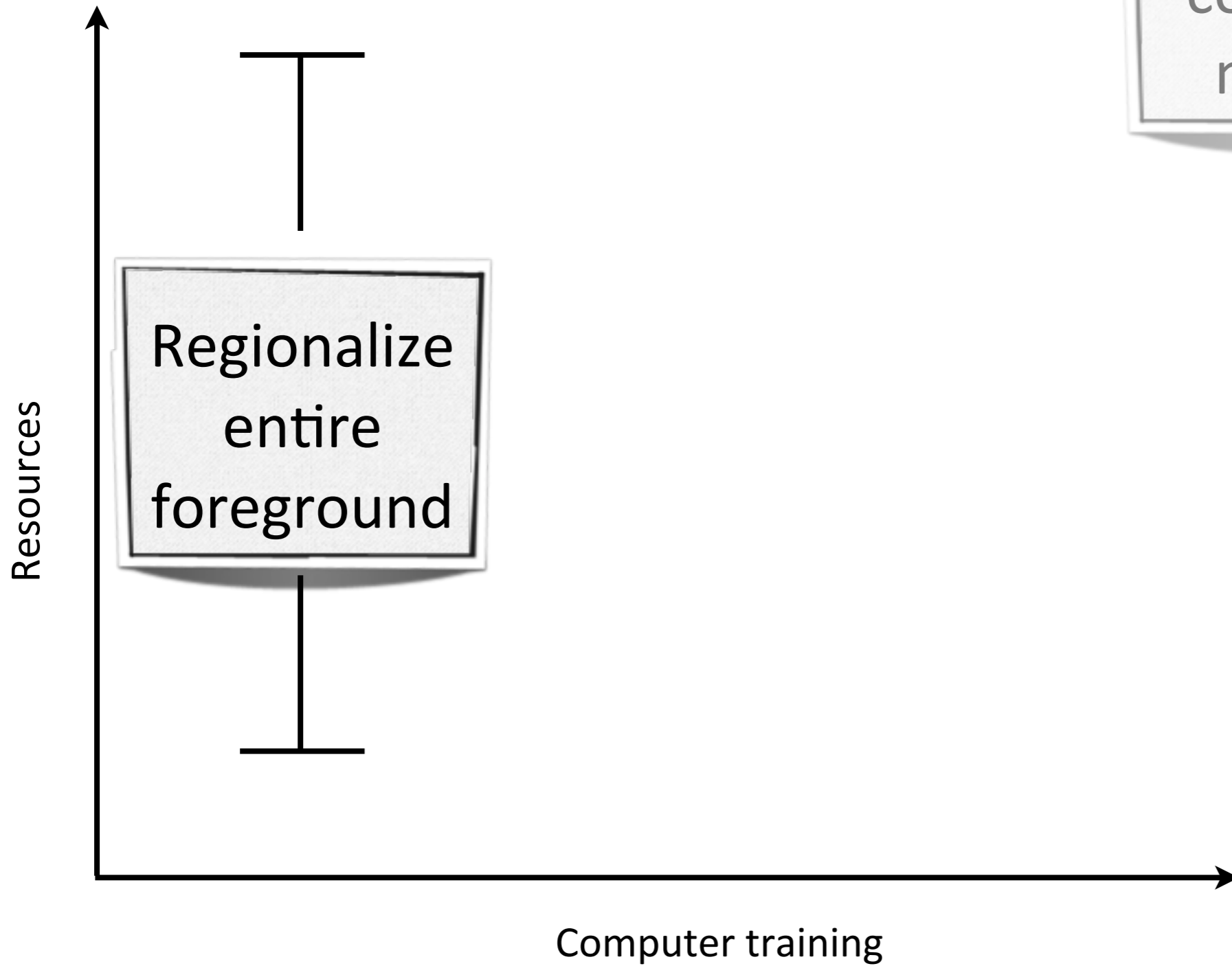


Geyer, R., Stoms, D., Lindner, J., Davis, F., & Wittstock, B. (2010-06-01). Coupling GIS and LCA for biodiversity assessments of land use. *The International Journal of Life Cycle Assessment*, 15(5), 454--467.

# Two complete models

- Very powerful
- Not really LCA
- Very resource intensive

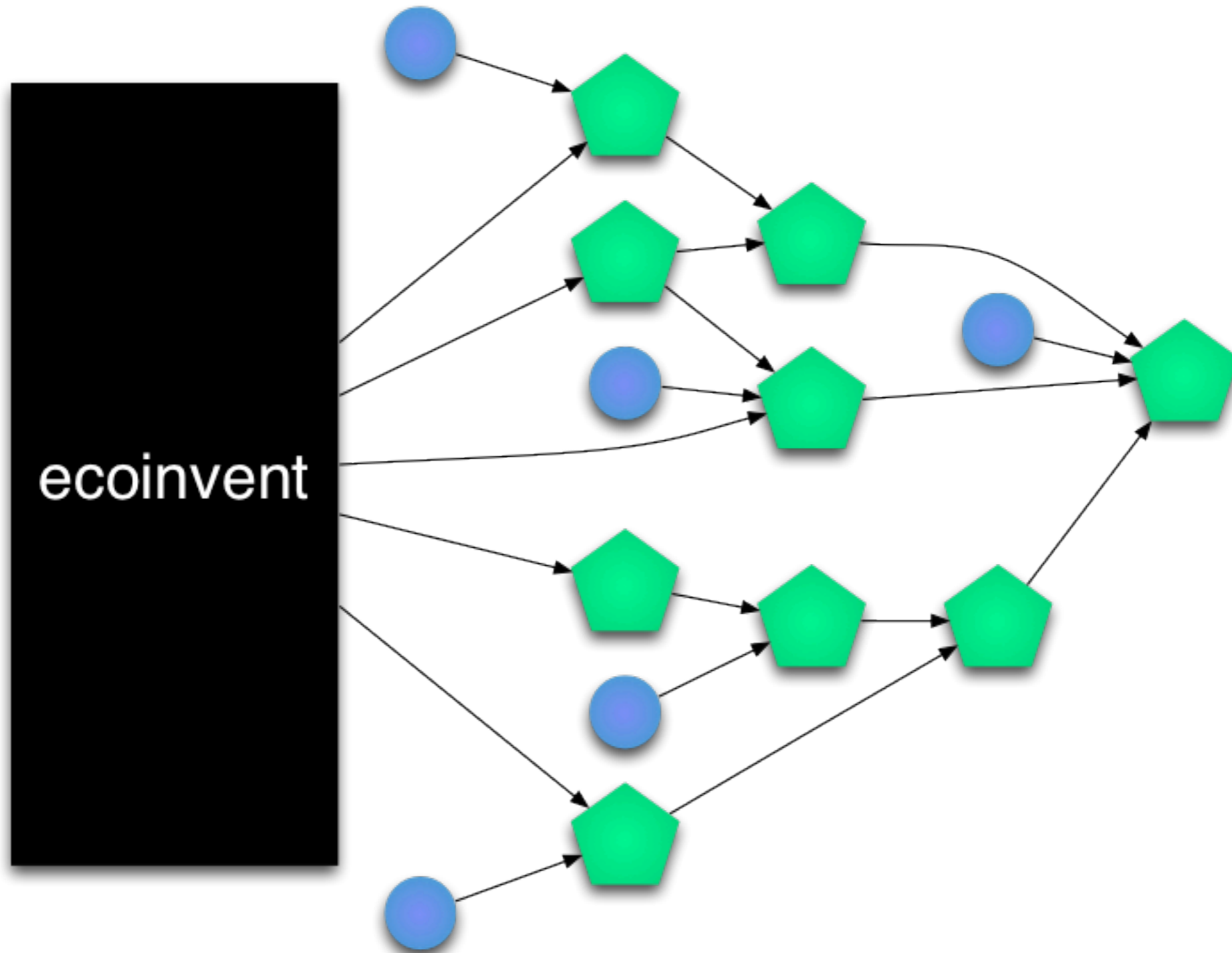
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Two complete models



# Regionalize entire foreground



# Looking up lots of data

- Create foreground as set of separate data
  - Geocode and match in an easy GIS
  - Quantum GIS is open source, free, and easy
  - Also consider Google Fusion Tables

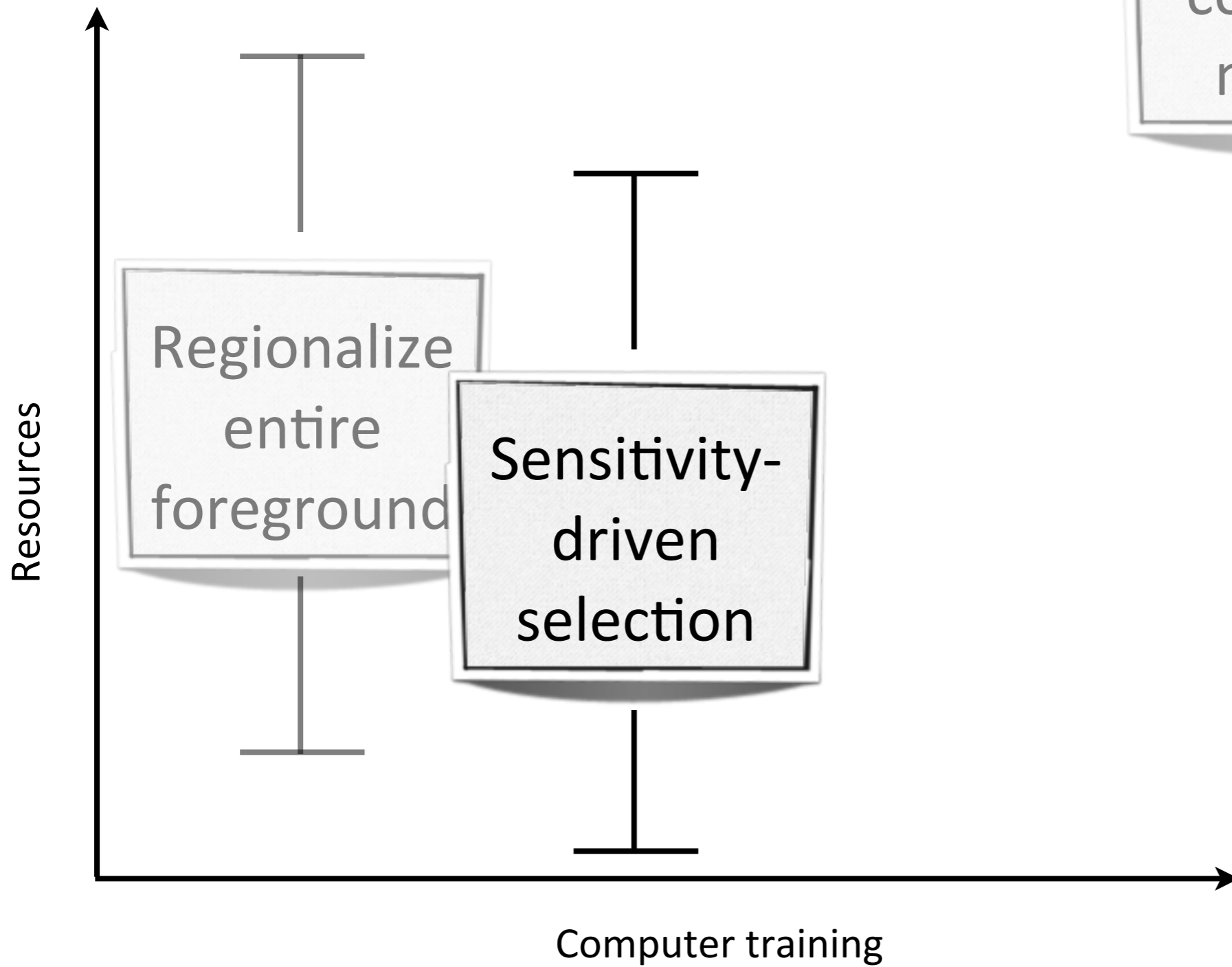
# Looking up lots of data

- Create foreground as set of separate data
  - Geocode and match in an easy GIS
  - Quantum GIS is open source, free, and easy
  - Also consider Google Fusion Tables
- Consider doing LCIA calculations in separate data
  - Import directly as EcoIndicator points
  - Easier than creating region-specific CFs in e.g. SimaPro

# Regionalize entire foreground

- Can use existing workflows and LCA software
- Don't have to include water in LCA inventories
- Resource use depends on breadth of foreground
- Difficult to iterate or include variations
- Can miss significant impacts



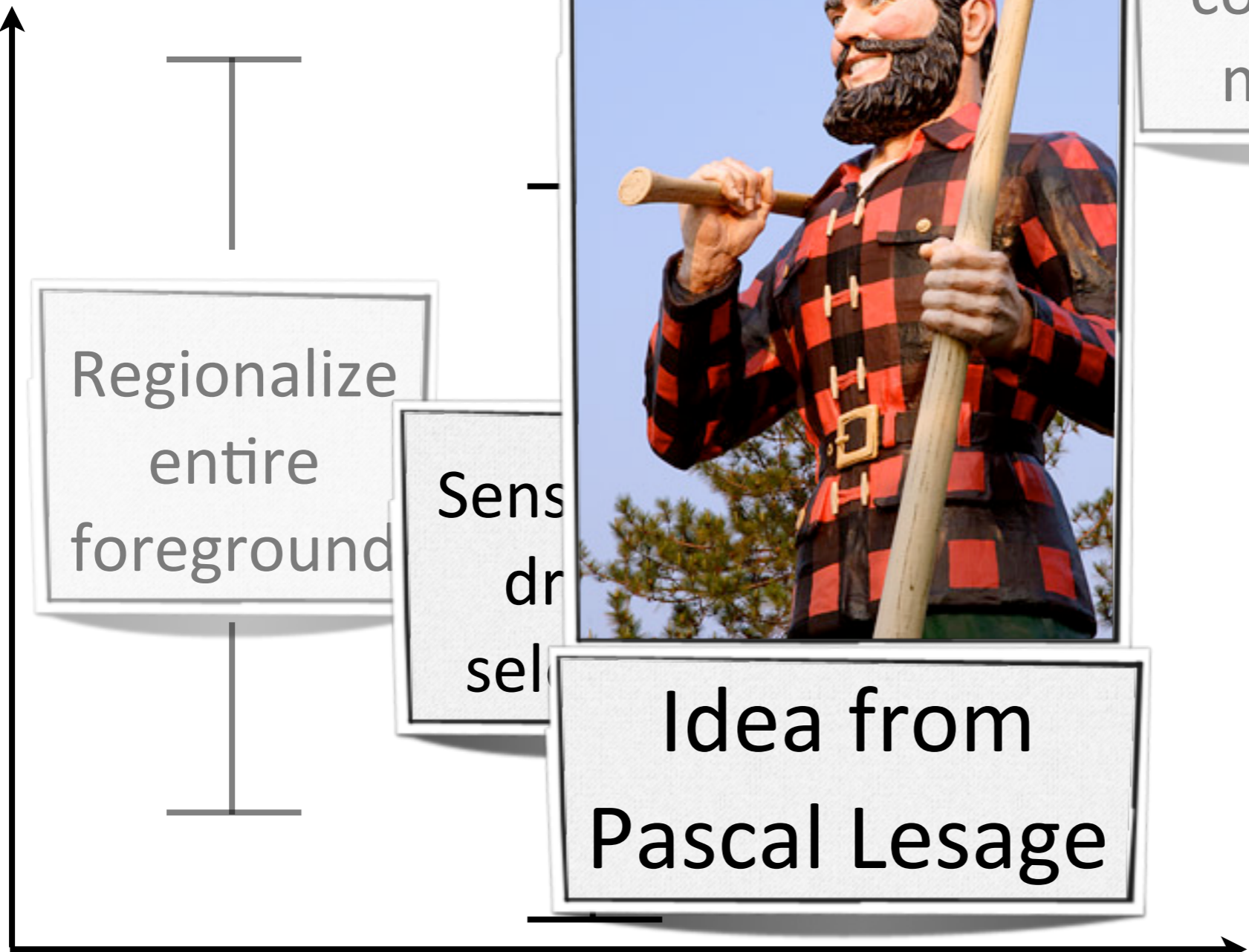


Two complete models





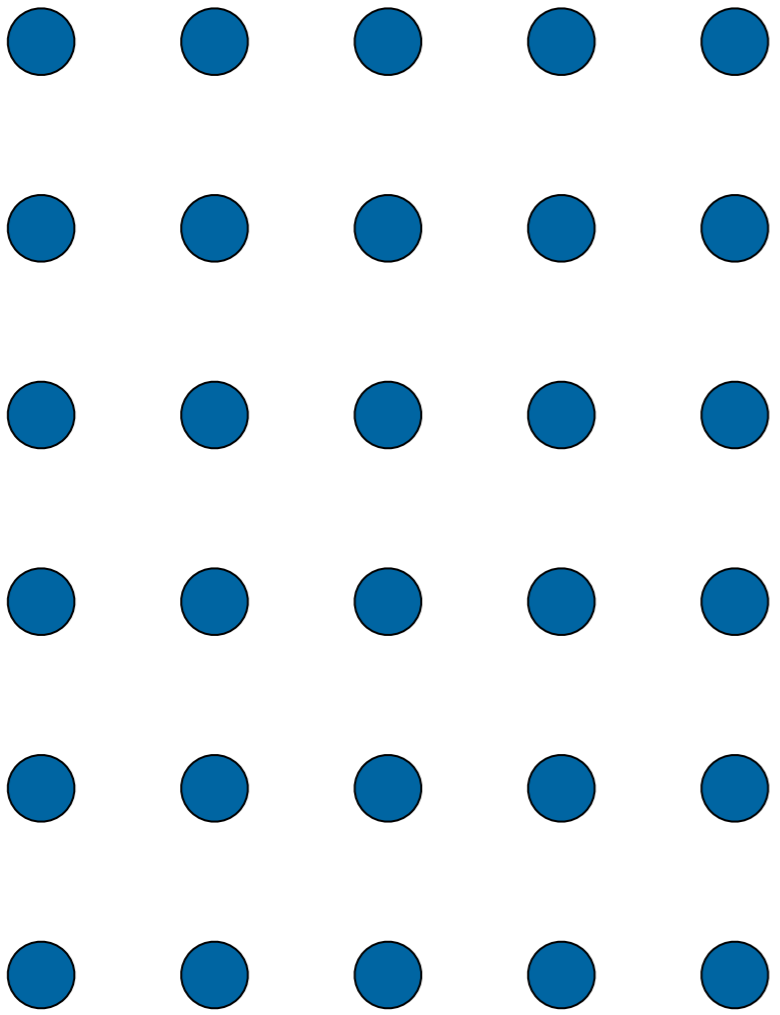
Resources



Computer training



# Sensitivity-driven selection

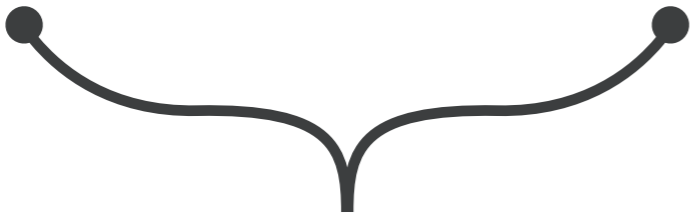
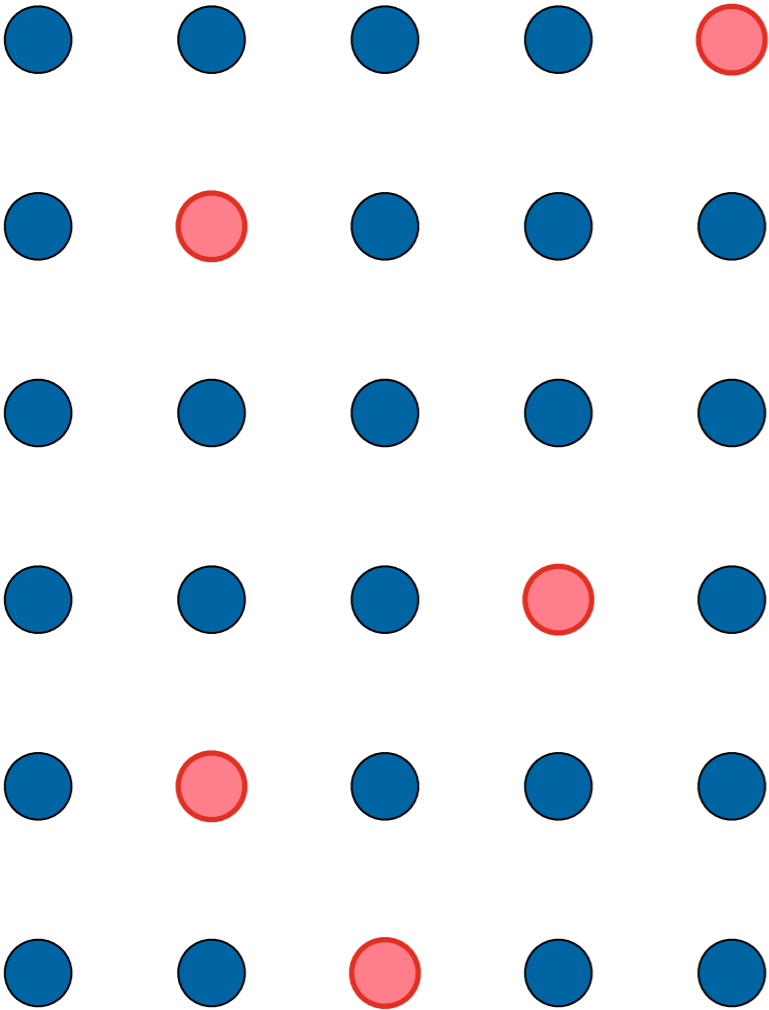


Highest sensitivity

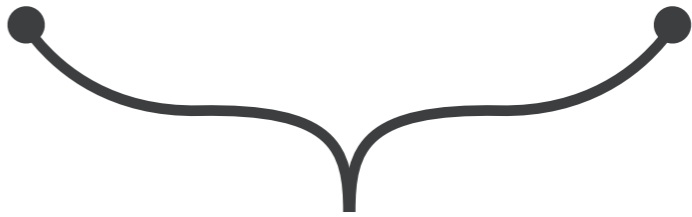


Regionalize selected

# Sensitivity-driven selection

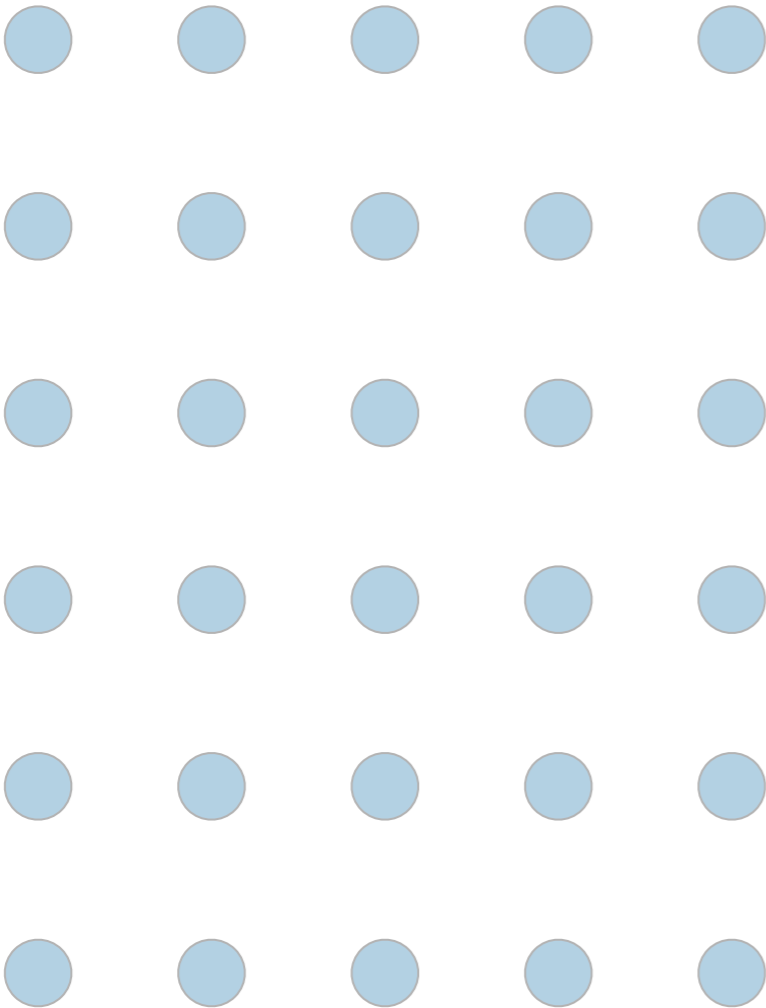


Highest sensitivity



Regionalize selected

# Sensitivity-driven selection

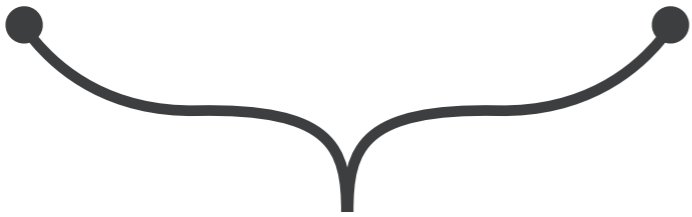
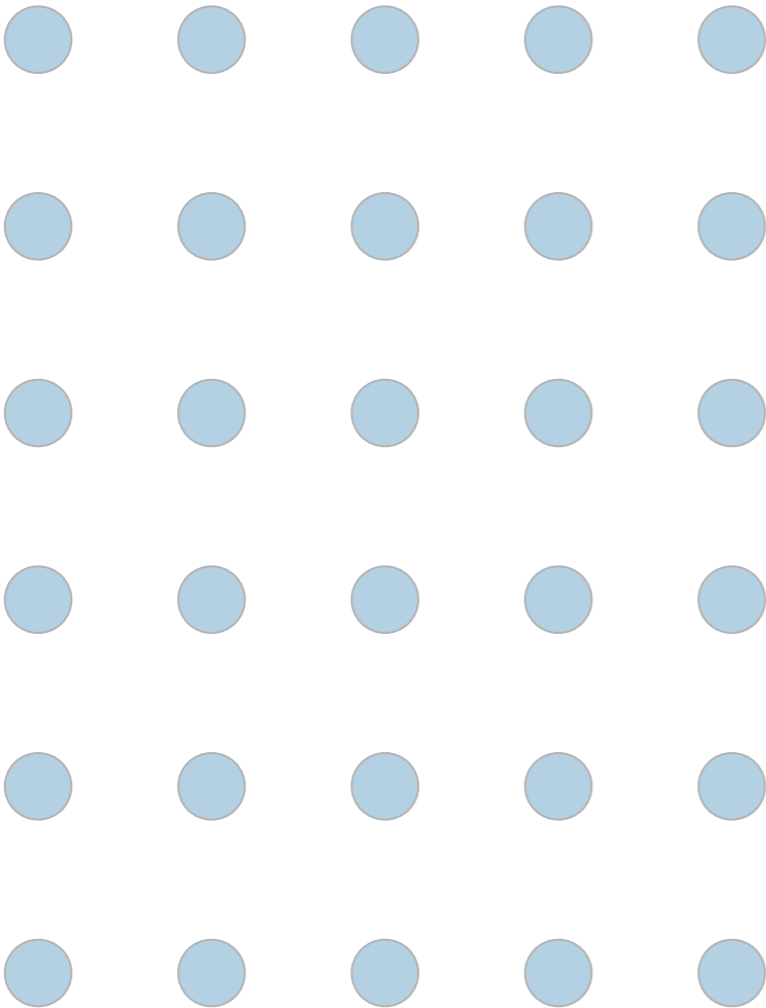


Highest sensitivity



Regionalize selected

# Sensitivity-driven selection



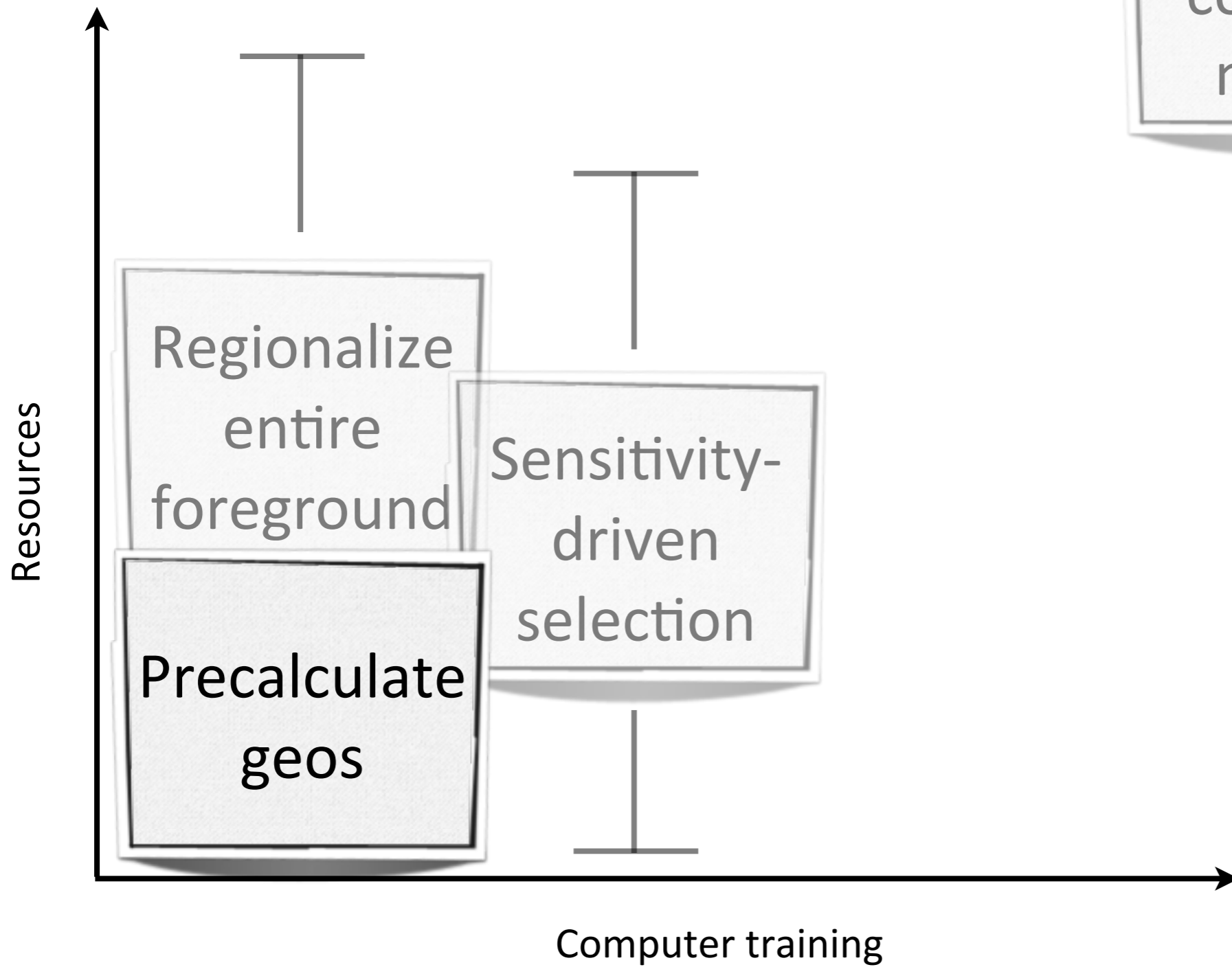
Highest sensitivity



Regionalize selected

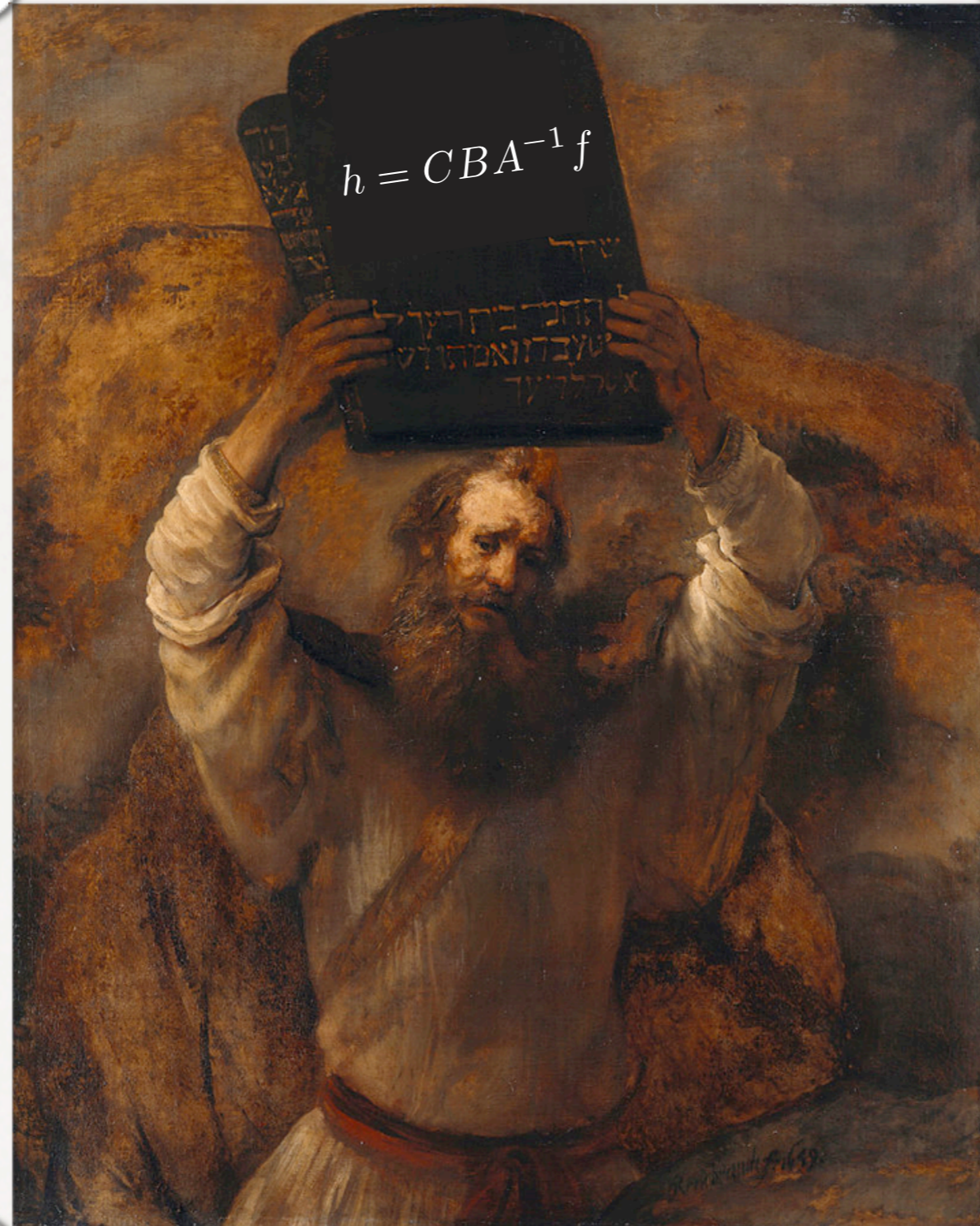
# Sensitivity-driven selection

- Sensitivity-testing not built into most LCA software
- IA uncertainty not built into most LCA software
- Foreground and background
- Small regionalized data-entry
  - (assumes uncertain, aggregated CFs available)





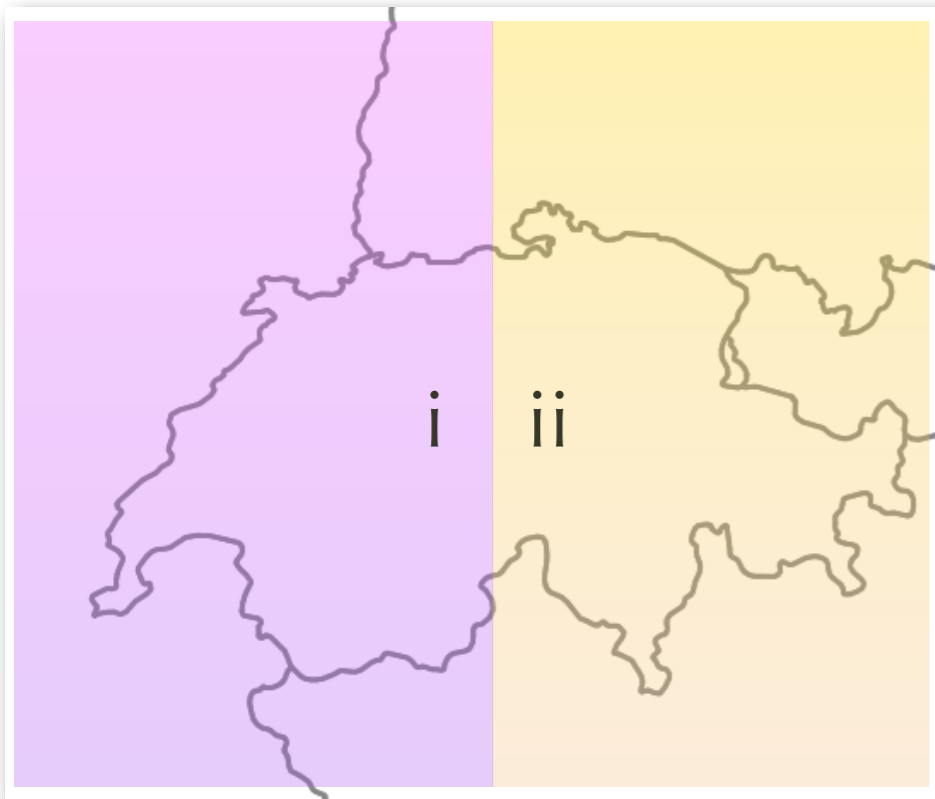
# Precalculatate geometry intersections



# Precalculate geometry intersections

$$h_r = [\mathbf{MGR}]^T \circ [\mathbf{BA}^{-1} \text{diag}(f)]$$

$G$  is the geographic transform matrix, from inventory spatial support to impact assessment spatial support



$$\begin{array}{c} \text{CH} \\ \text{FR} \end{array} \begin{array}{cc} \text{i} & \text{ii} \\ \left[ \begin{array}{cc} 0.5 & 0.5 \\ 1 & 0 \end{array} \right] \end{array}$$

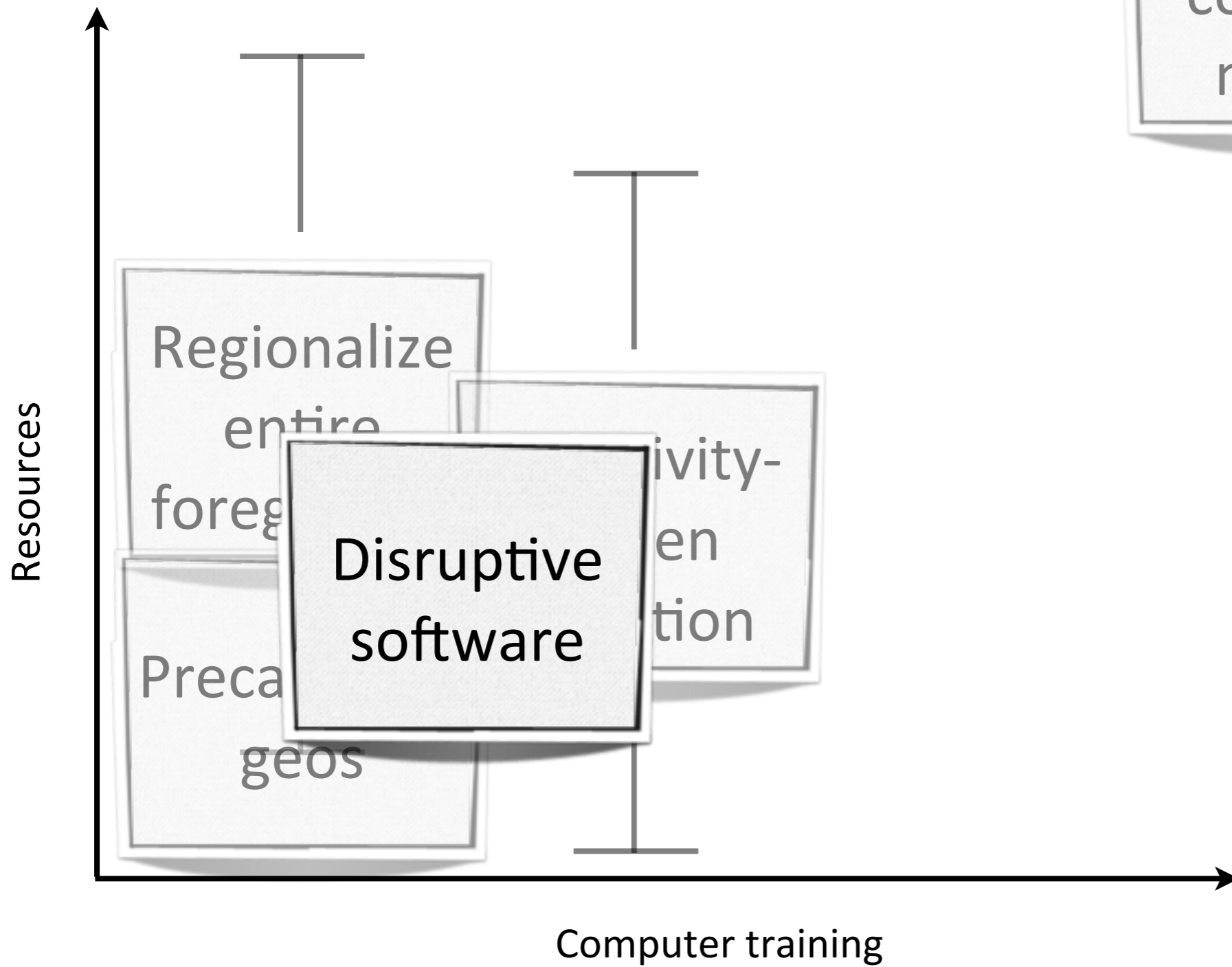
Mutel, C. L., Pfister, S., & Hellweg, S. (2011). GIS-Based Regionalized Life Cycle Assessment: How Big Is Small Enough? Methodology and Case Study of Electricity Generation. *Environmental Science & Technology*, 46(2), 1096--1103.

# Precalculate geometry intersections

- Little to no effort from practitioners
  - More effort from software developers
  - Precalculation by web service or method developers

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- Little to no effort from practitioners
  - More effort from software developers
  - Precalculation by web service or method developers
- Difficult to add new locations
  - Stuck with pre-defined locations



Two complete models



# Disruptive software

- Inclusion of GIS functionality directly in LCA
  - or other way around

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# Disruptive software

- Inclusion of GIS functionality directly in LCA
  - or other way around
- Brightway2 is one such attempt
  - But regionalization is not scheduled for 2-3 months
- Inclusion of GIS **increases** data requirements
  - Shouldn't just know countries



# Brightway2 web

## Functional unit:

- wheat grains conventional, Castilla-y-Leon, at farm: 1 kg

## Impact assessment method:

IPCC 2007: climate change: GWP 20a

## Total score:

**0.77** kg CO<sub>2</sub>-Eq

## Monte Carlo results

### Median

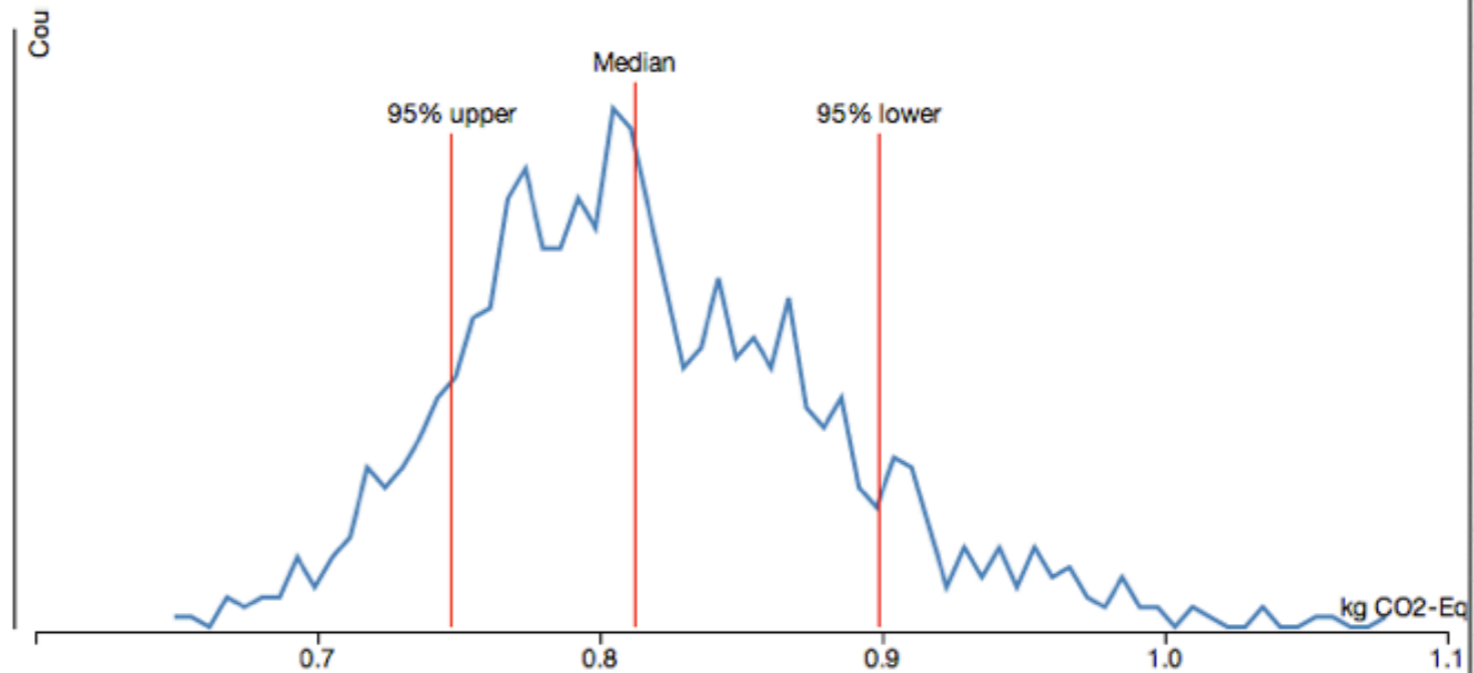
**0.81** kg CO<sub>2</sub>-Eq

### Average

**0.82** kg CO<sub>2</sub>-Eq

### 95% interval

**0.75 - 0.9** kg CO<sub>2</sub>-Eq



# Spatial supply chain data

- Water database in ecoinvent 3
- Global data on agriculture is available
- Country-level data on power production as well
- Eternal burden of LCA...

# Thank you for your attention.

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