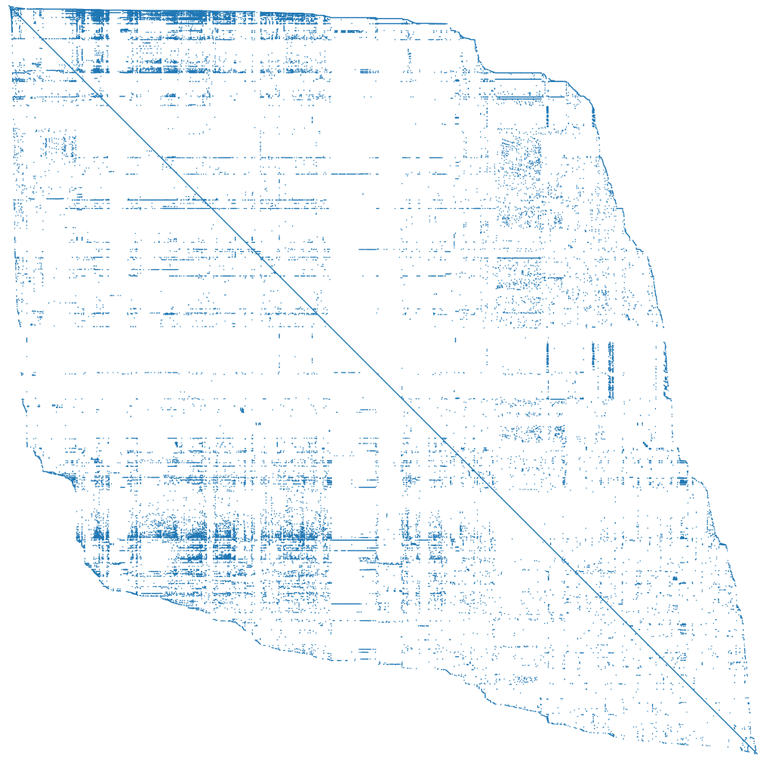
Computational structure of LCA: $h = CBA^{-1}f$

Processes
(>16k)

Products
(> 16k)



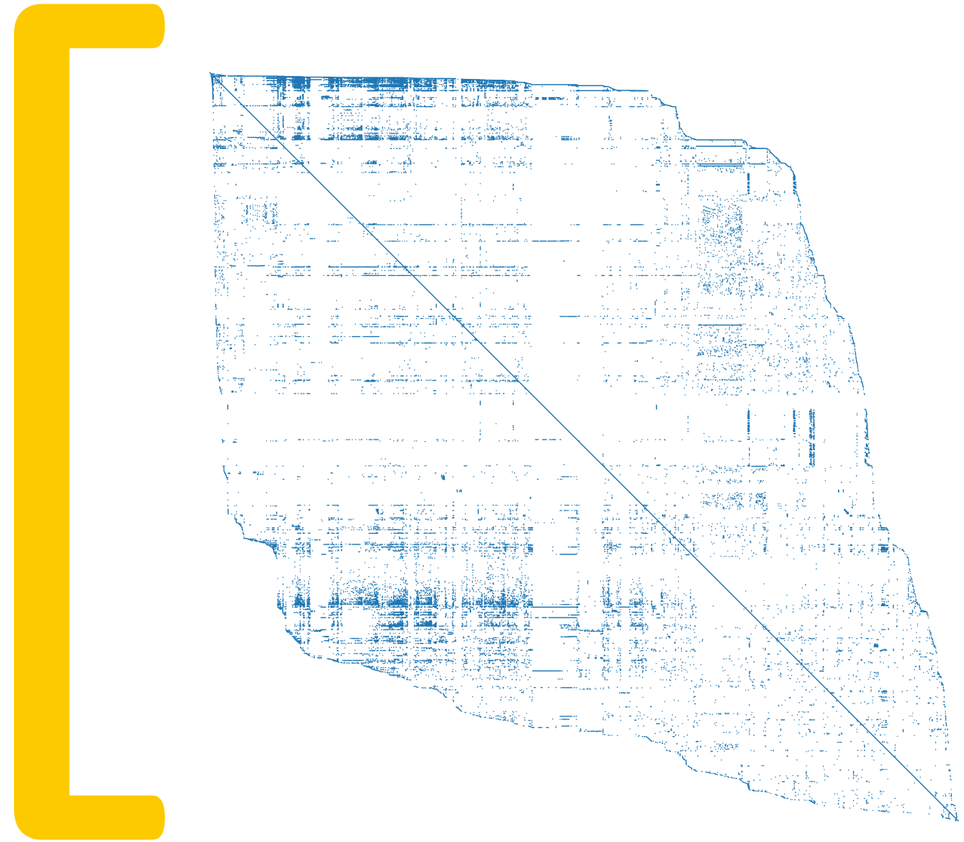
Technosphere matrix:
Model of industrial world
Sparse matrix (< 0.1% fill rate)

Computational structure of LCA: $h = CBA^{-1}f$

Run steel foundry

Processes (>16k)

Run CHP plant



Products (> 16k)

Technosphere matrix:

Model of industrial world

Sparse matrix (< 0.1% fill rate)

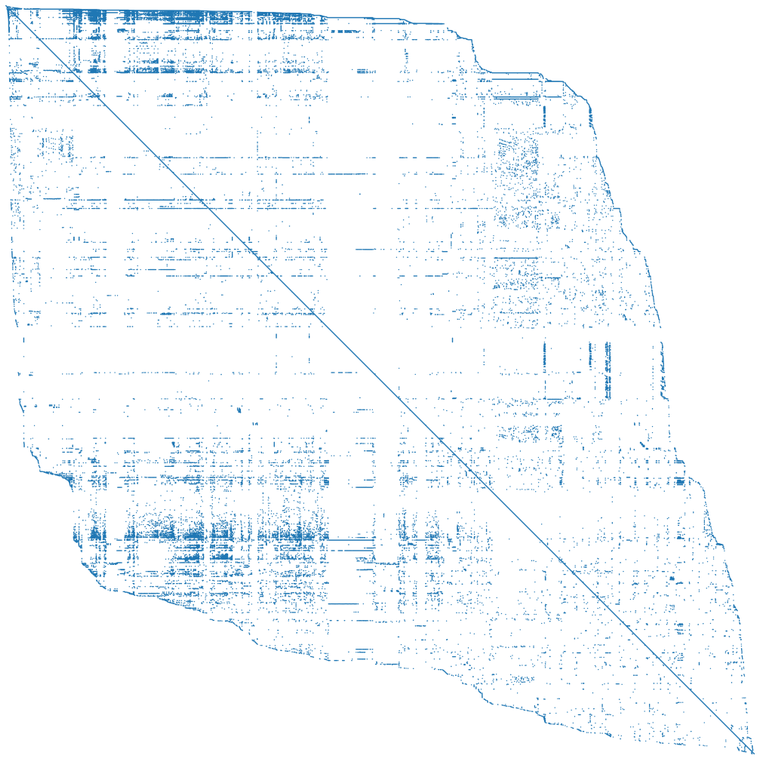
Computational structure of LCA: $h = CBA^{-1}f$

Run steel foundry

Processes (>16k)

Run CHP plant

1 kg steel



Products (> 16k)

1 km by bicycle

Technosphere matrix:

Model of industrial world

Sparse matrix (< 0.1% fill rate)

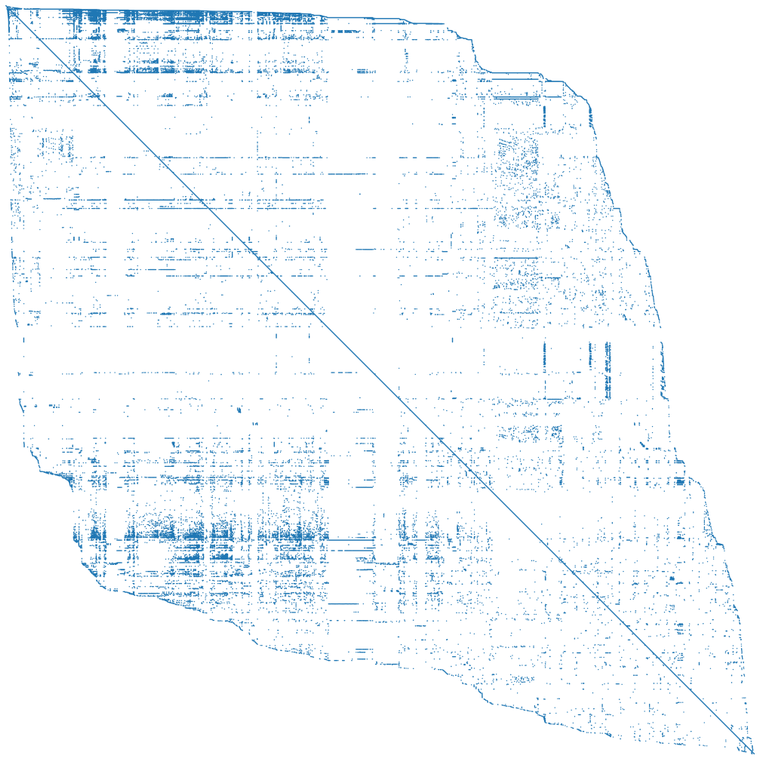
Computational structure of LCA: $h = CBA^{-1}f$

Run steel foundry

Processes (>16k)

Run CHP plant

1 kg steel



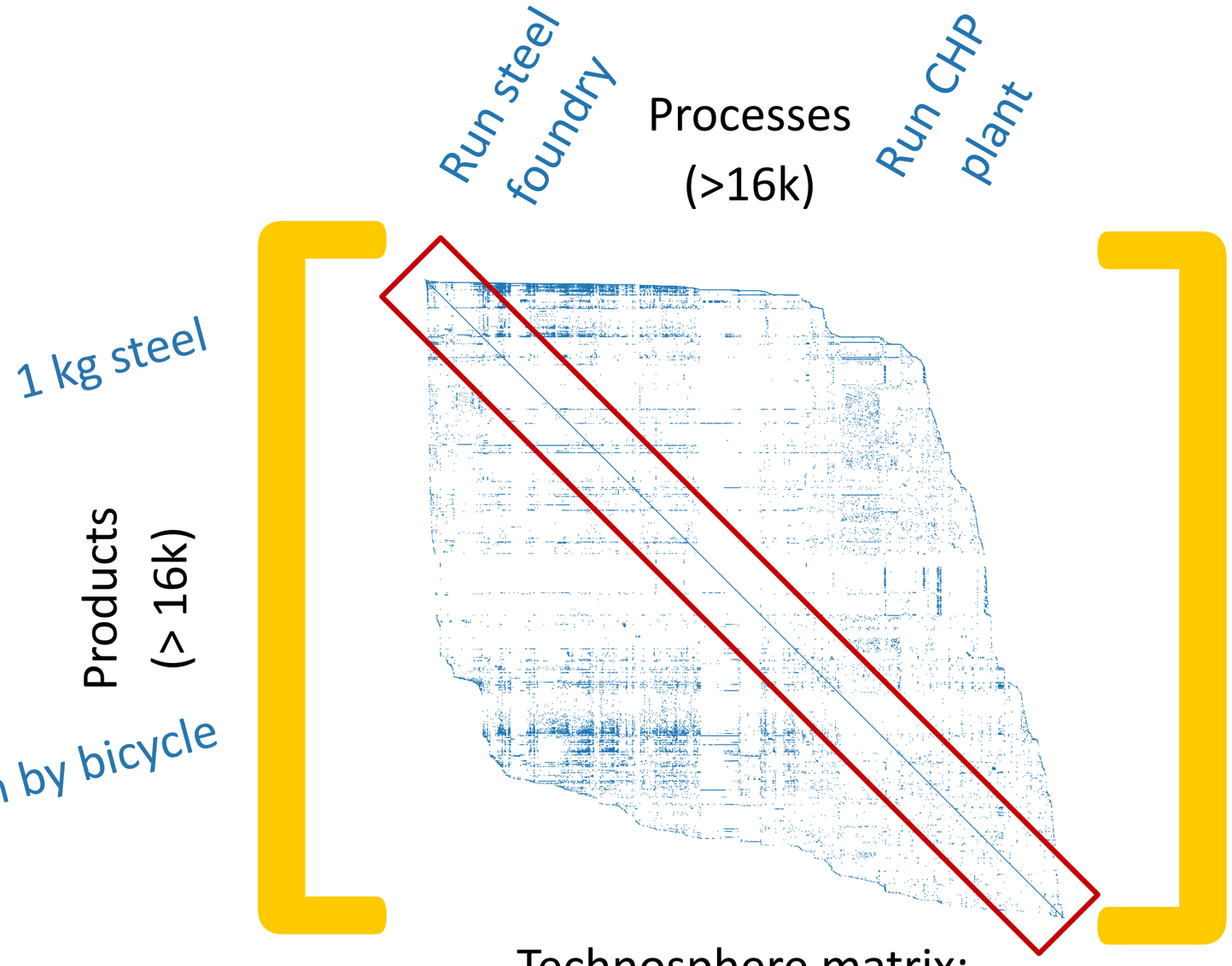
Products (> 16k)

1 km by bicycle

Technosphere matrix:
Model of industrial world
Sparse matrix (< 0.1% fill rate)

Positive values:
Production of products
Negative values:
Consumption of products

Computational structure of LCA: $h = CBA^{-1}f$



Technosphere matrix:
Model of industrial world
Sparse matrix (< 0.1% fill rate)

Positive values:
Production of products
Negative values:
Consumption of products

Each process has a reference product

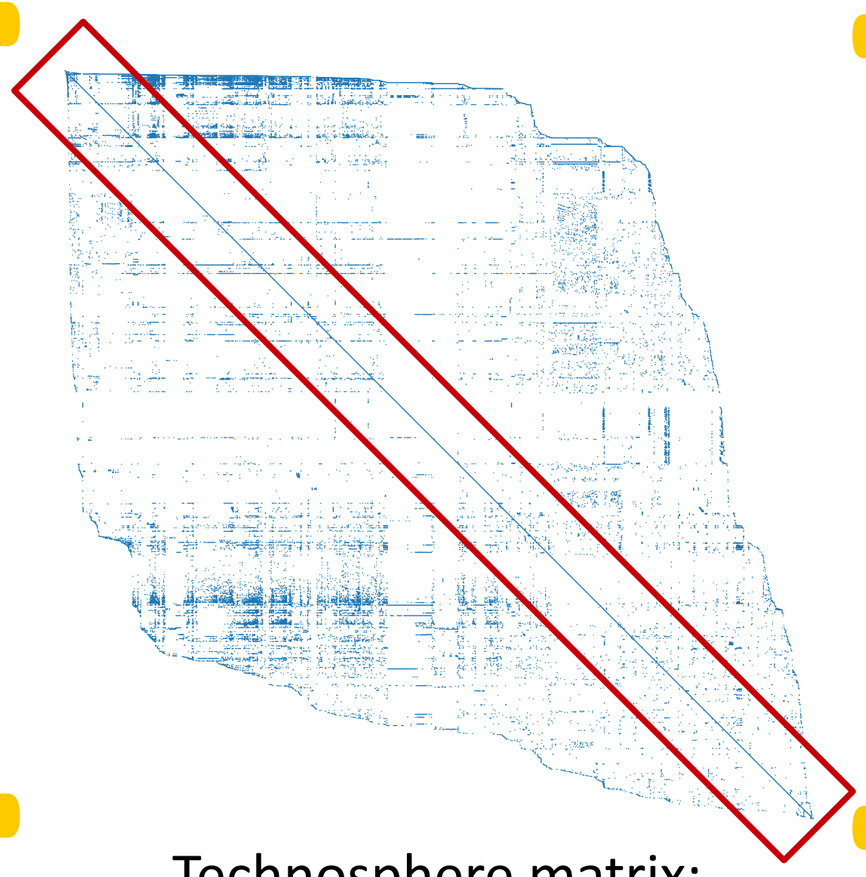
Computational structure of LCA: $h = CBA^{-1}f$

Run steel foundry

Processes (>16k)

Run CHP plant

1 kg steel



Products (> 16k)

1 km by bicycle

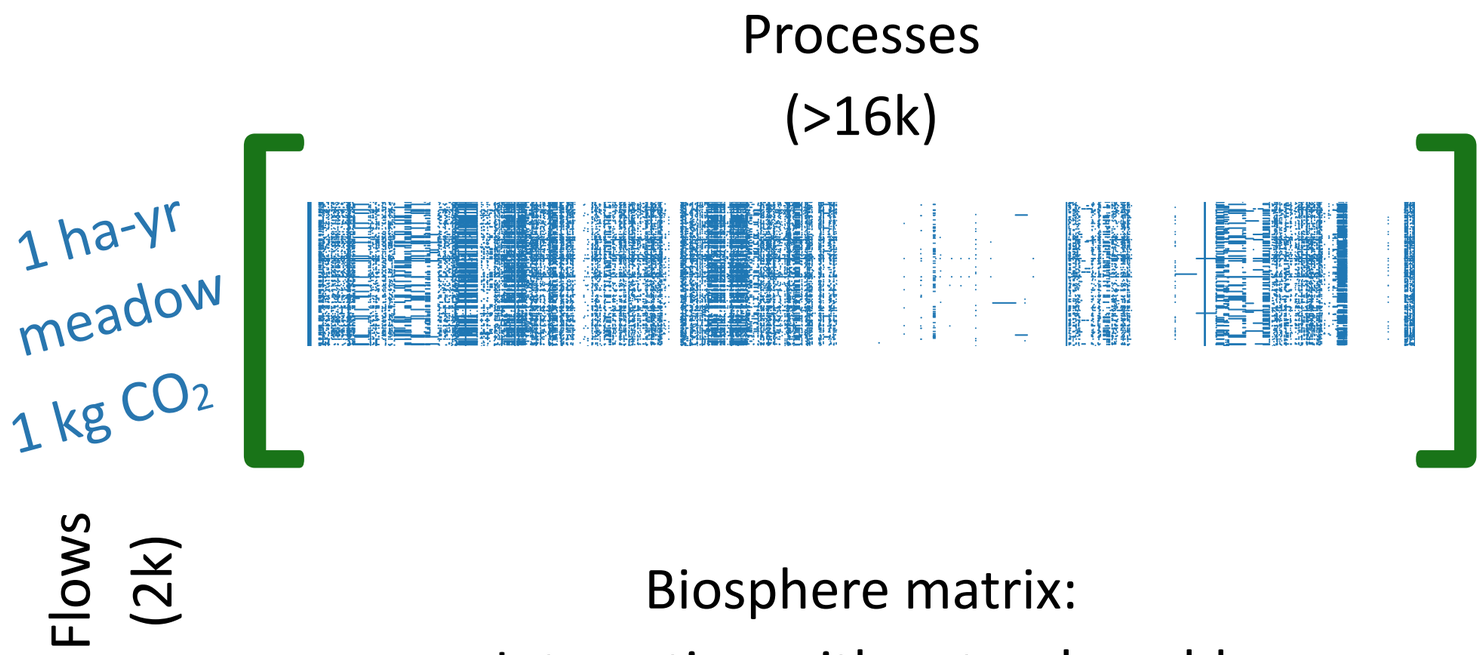
Technosphere matrix:
Model of industrial world
Sparse matrix (< 0.1% fill rate)

Valid for one reference year
e.g. 2016

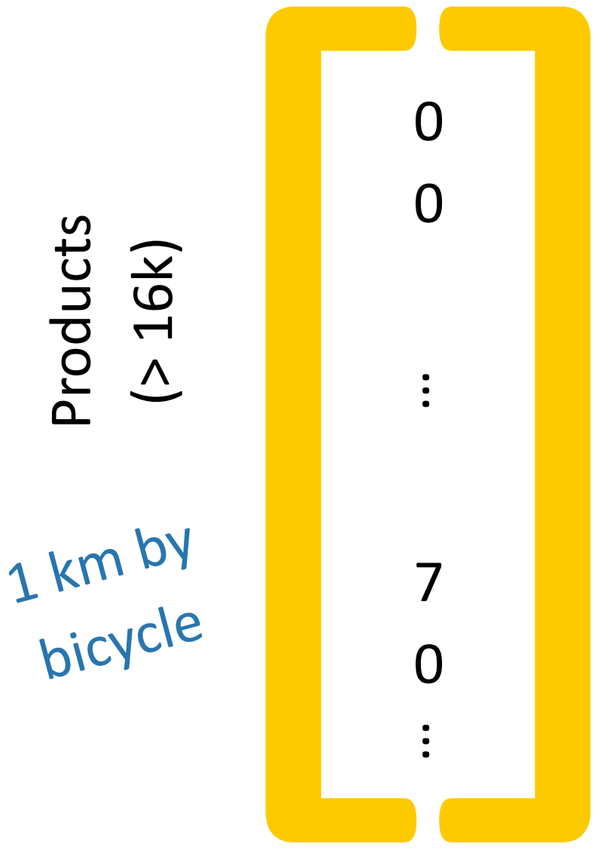
Positive values:
Production of products
Negative values:
Consumption of products

Each process has a reference product

Computational structure of LCA: $h = CBA^{-1}f$

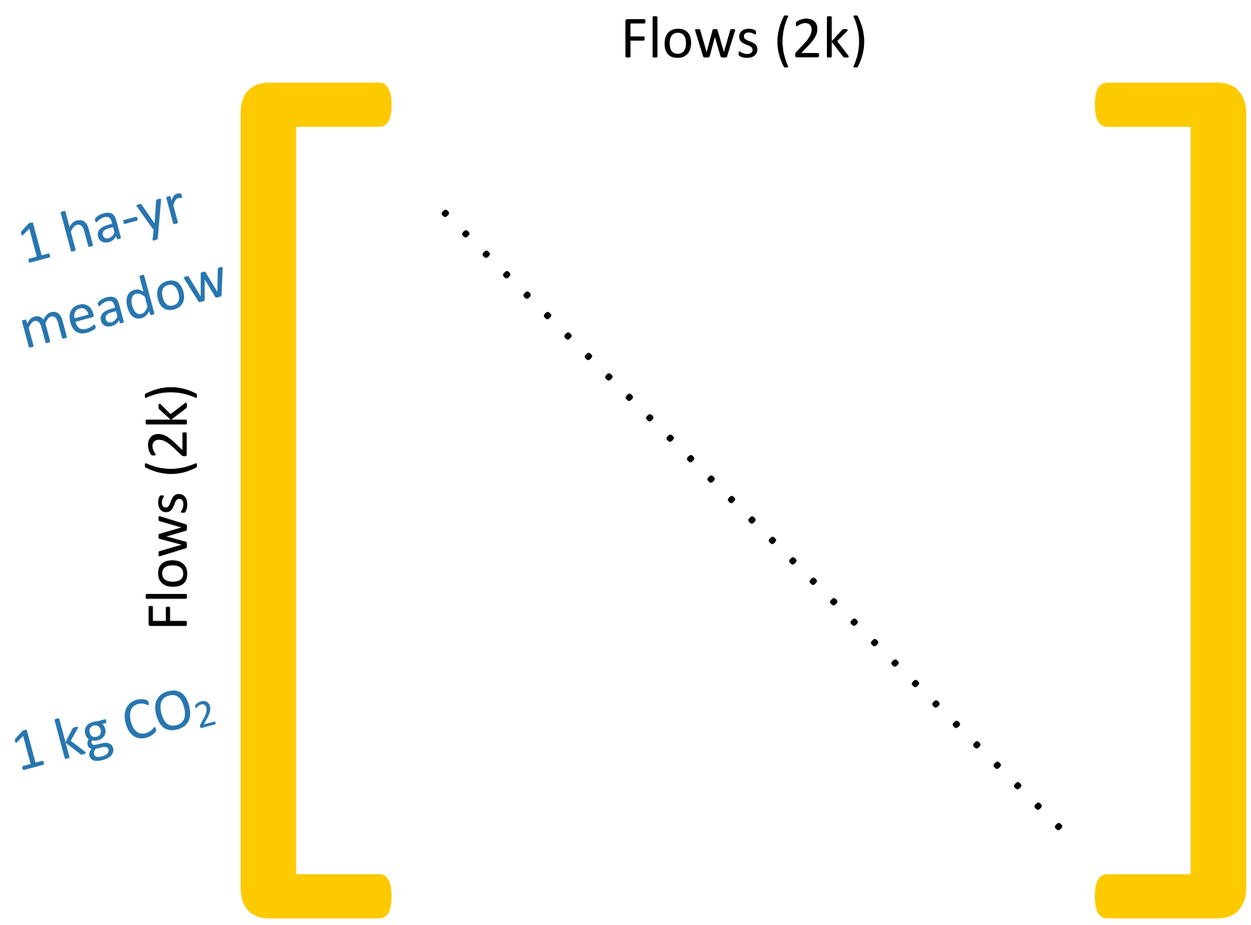


Biosphere matrix:
Interaction with natural world
Sparse matrix (0.1% fill rate)



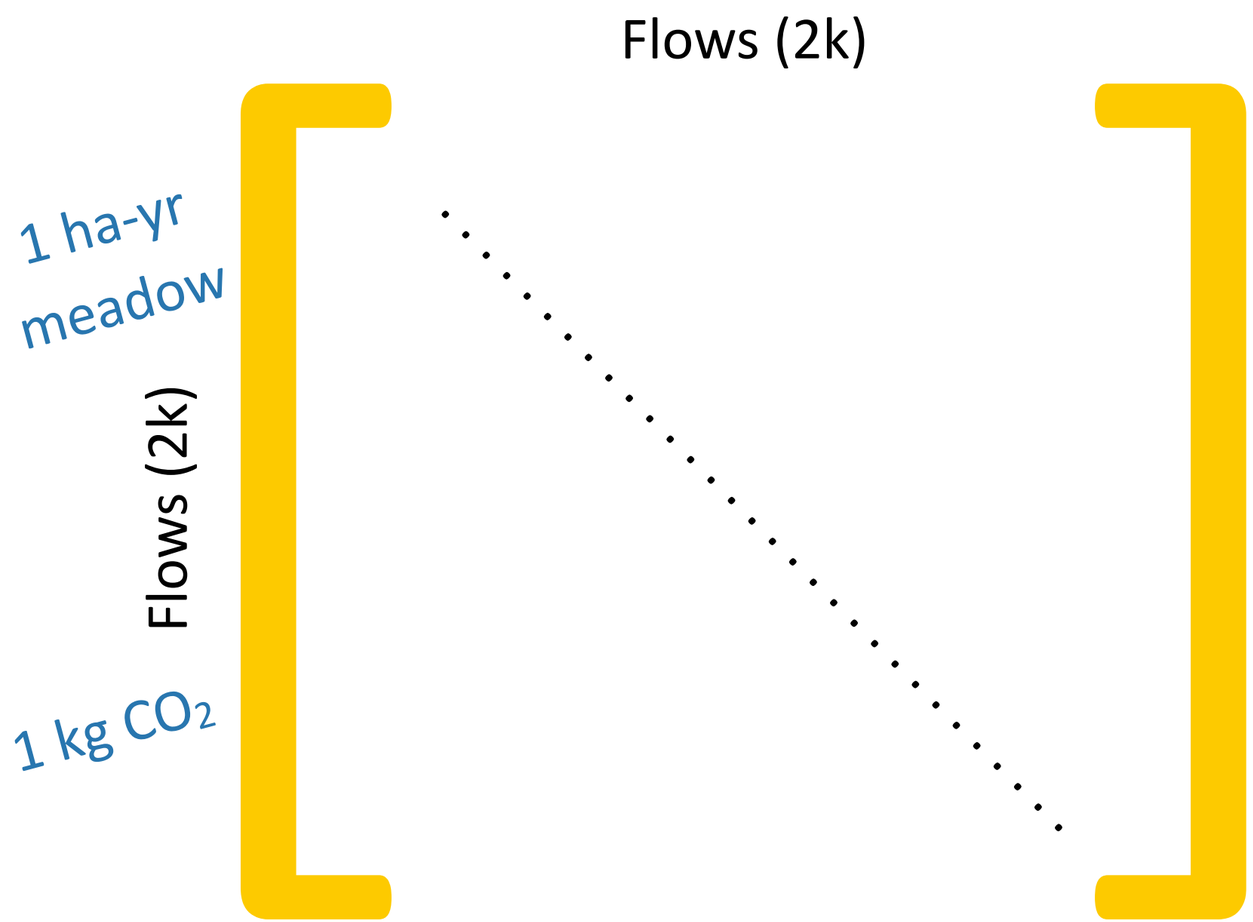
Functional unit:
Object of calculation

Computational structure of LCA: $h = CBA^{-1}f$



Damage characterization:
Impact per flow unit
(e.g. CHF/kg CO_2)

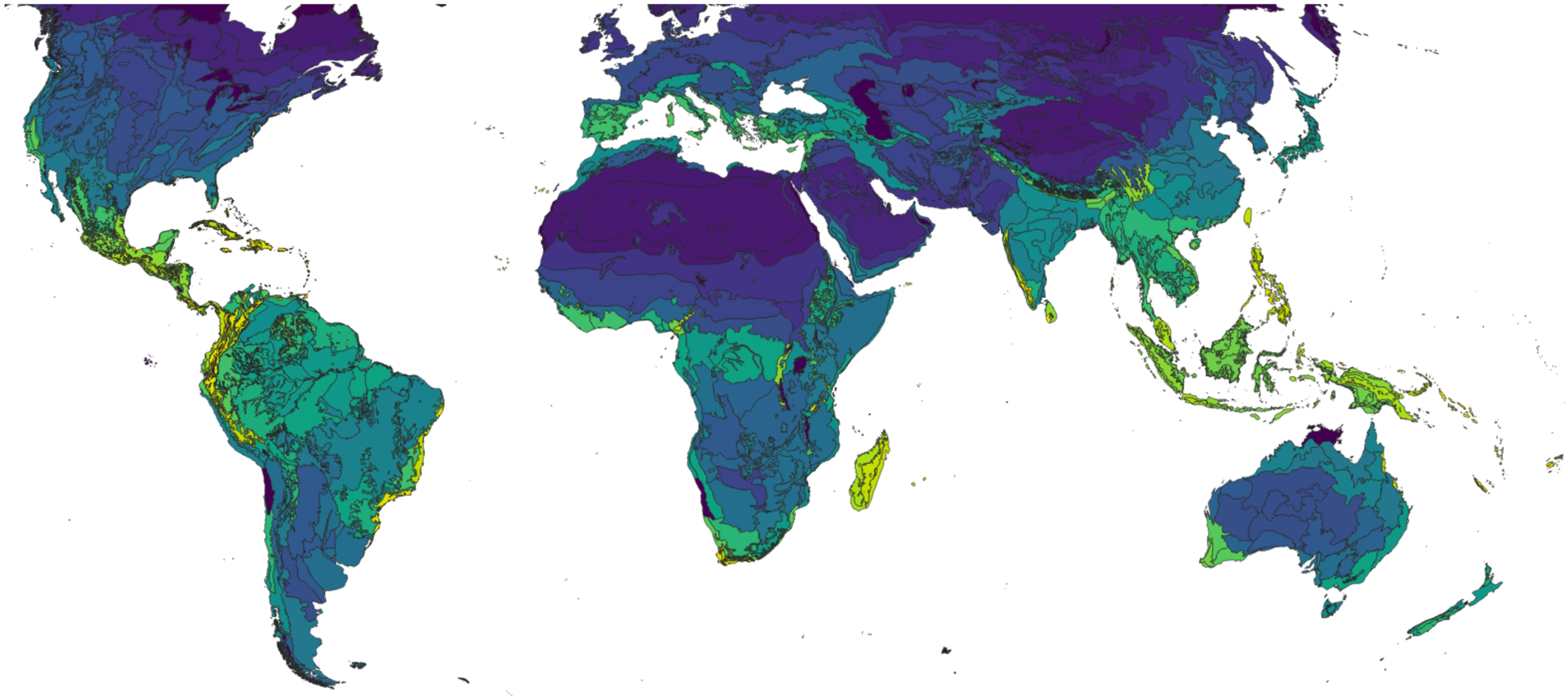
Computational structure of LCA: $h = \underline{CB}A^{-1}f$



Damage characterization:
Impact per flow unit
(e.g. CHF/kg CO_2)

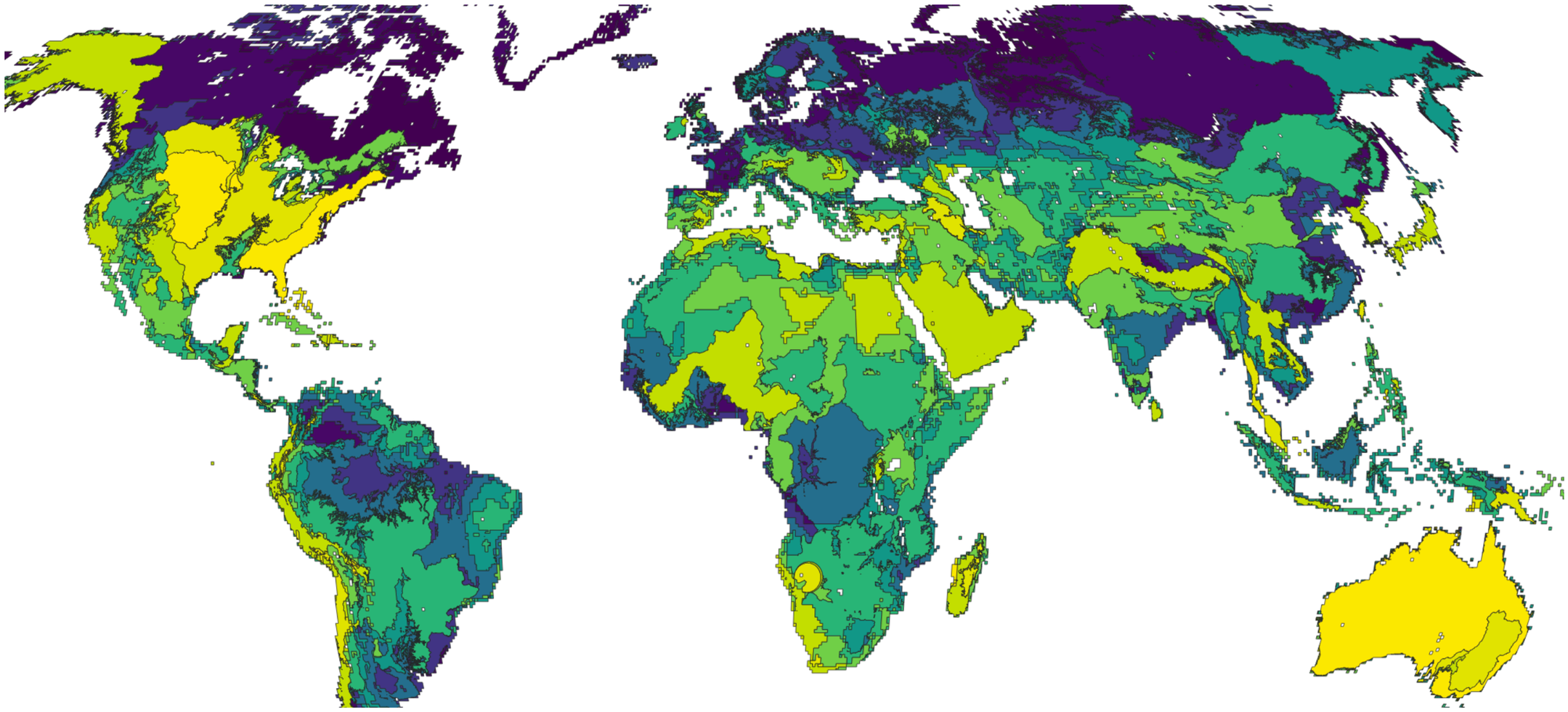
One value per flow
- Regardless of location
- Regardless of when emitted

LC-IMPACT IA maps



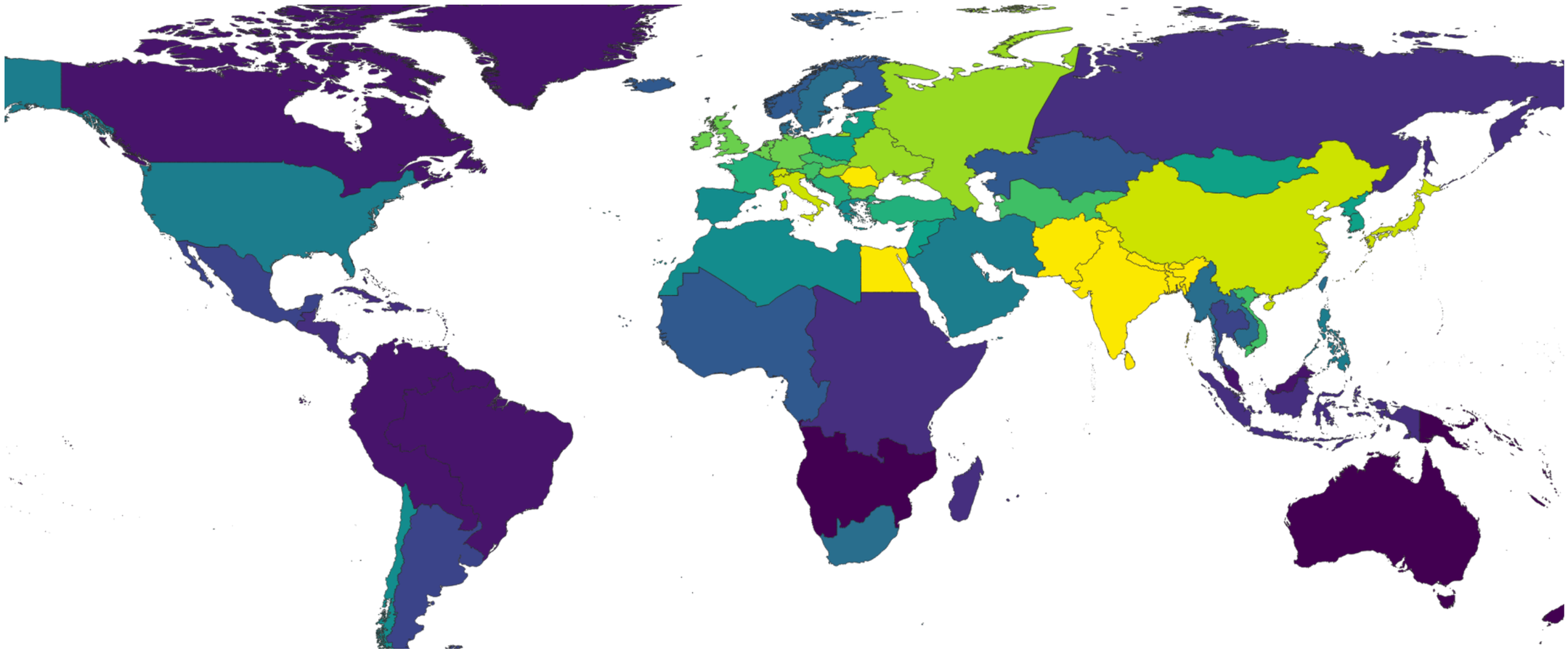
Land use - occupation - permanent crops ( )

LC-IMPACT IA maps



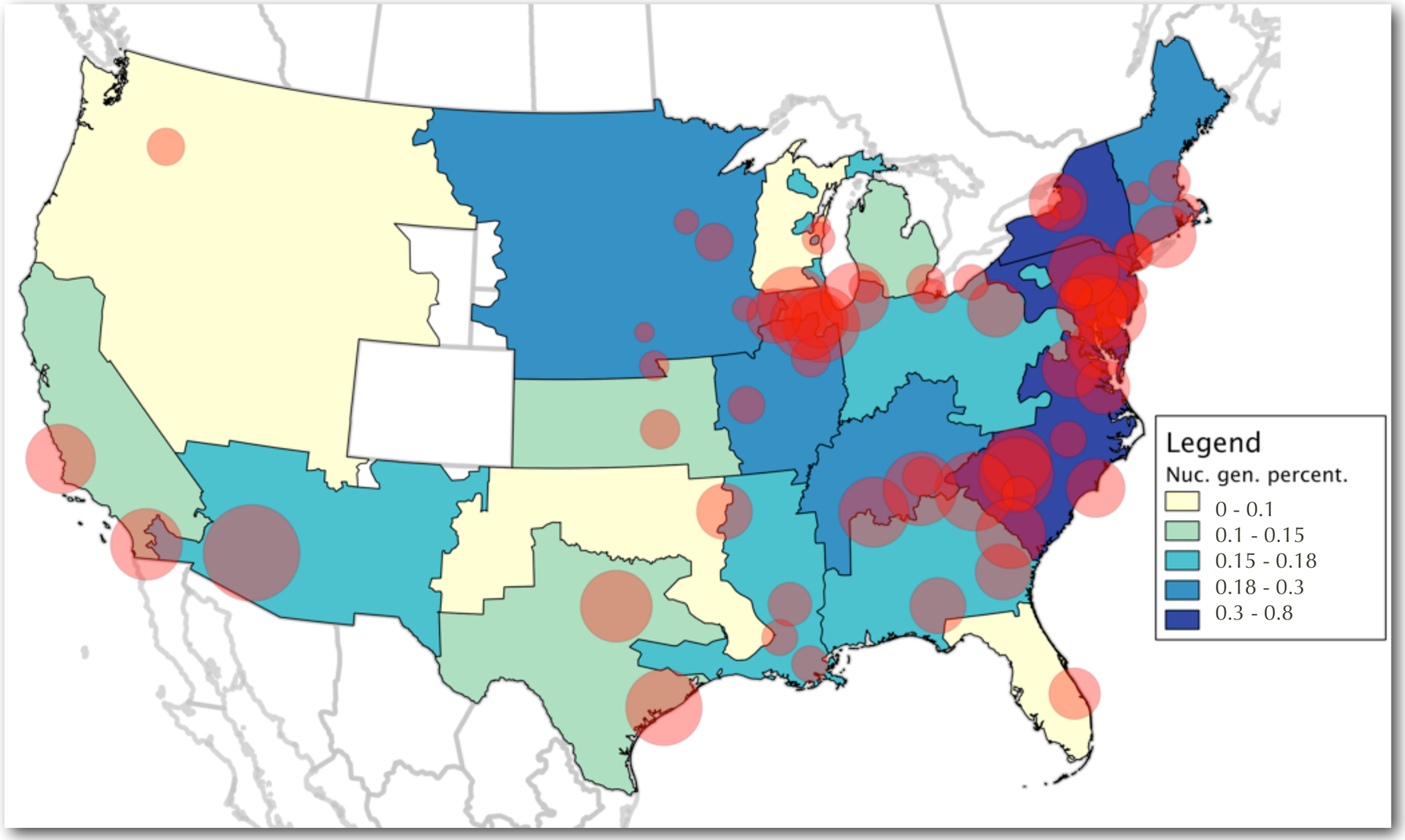
Water use - surface water - ecosystems ( )

LC-IMPACT IA maps

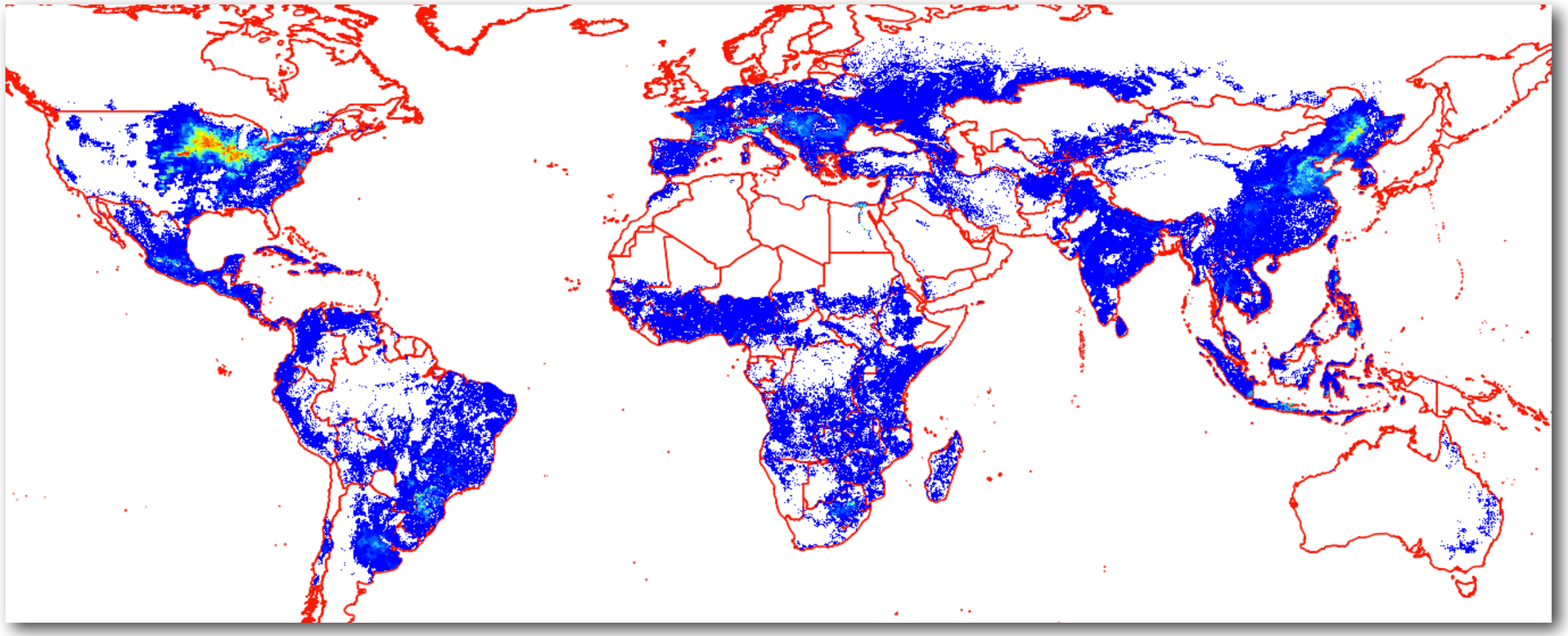


Particulate matter - human health ( )

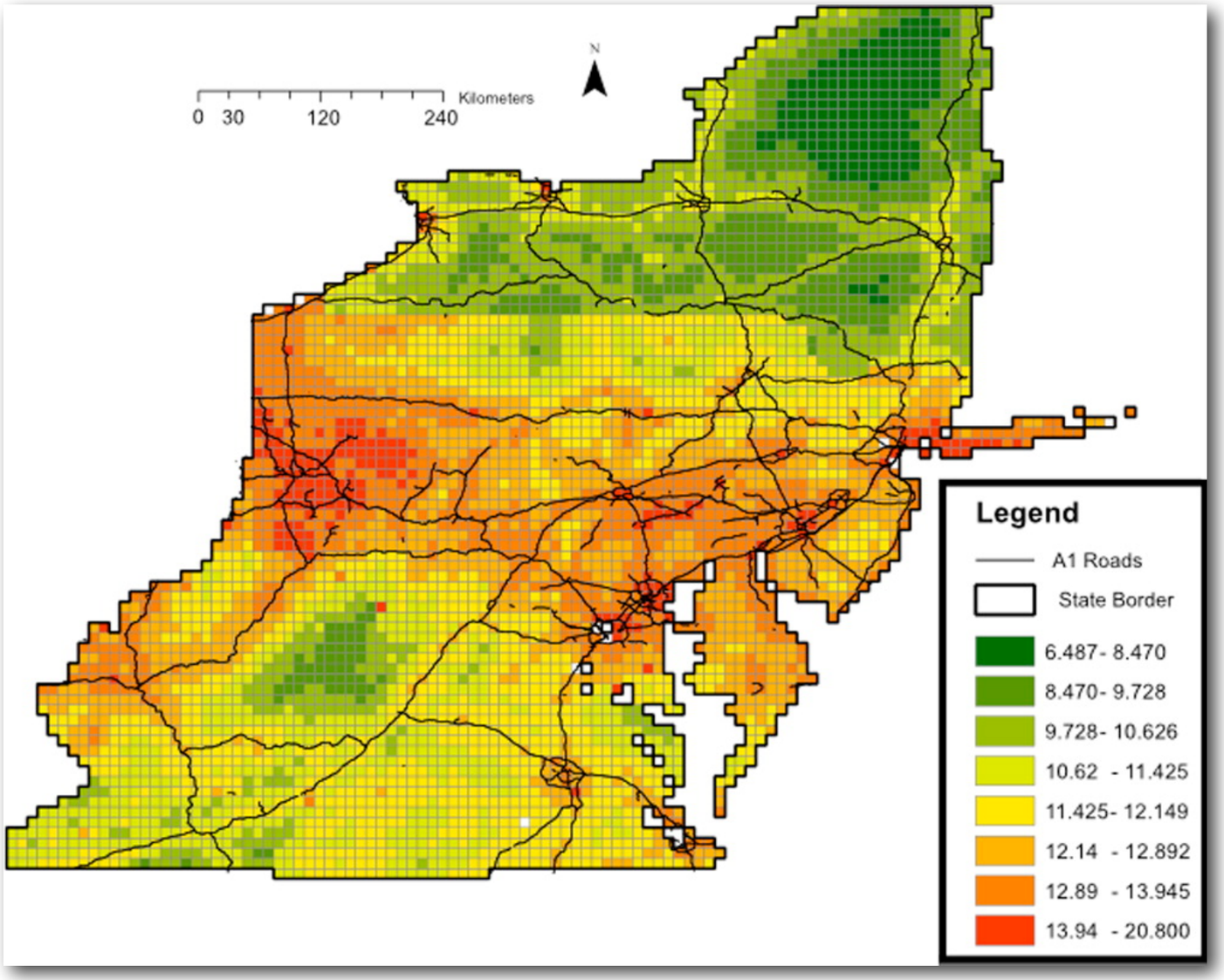
Spatial inventories



Global scale?

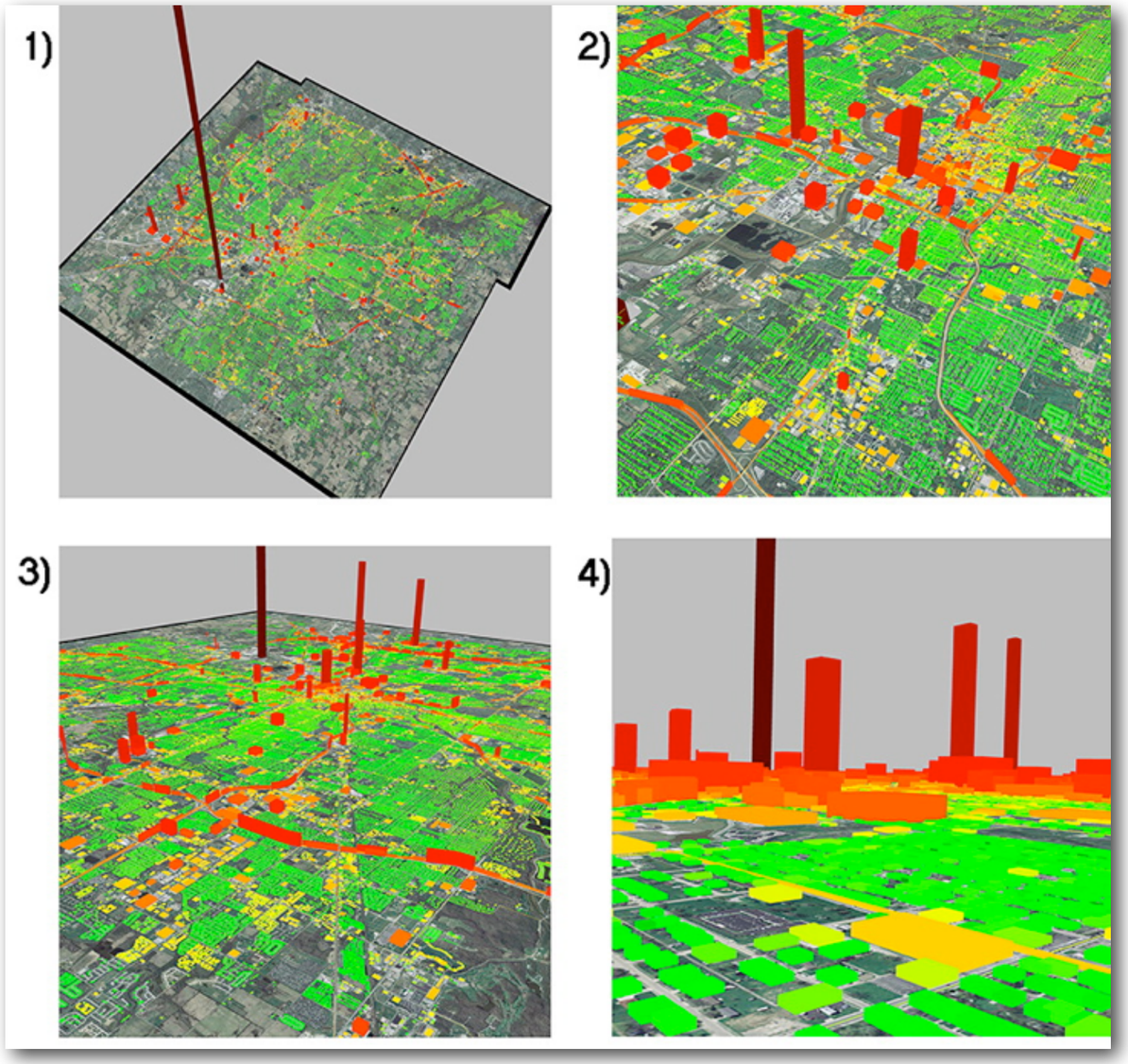


Regional scale?

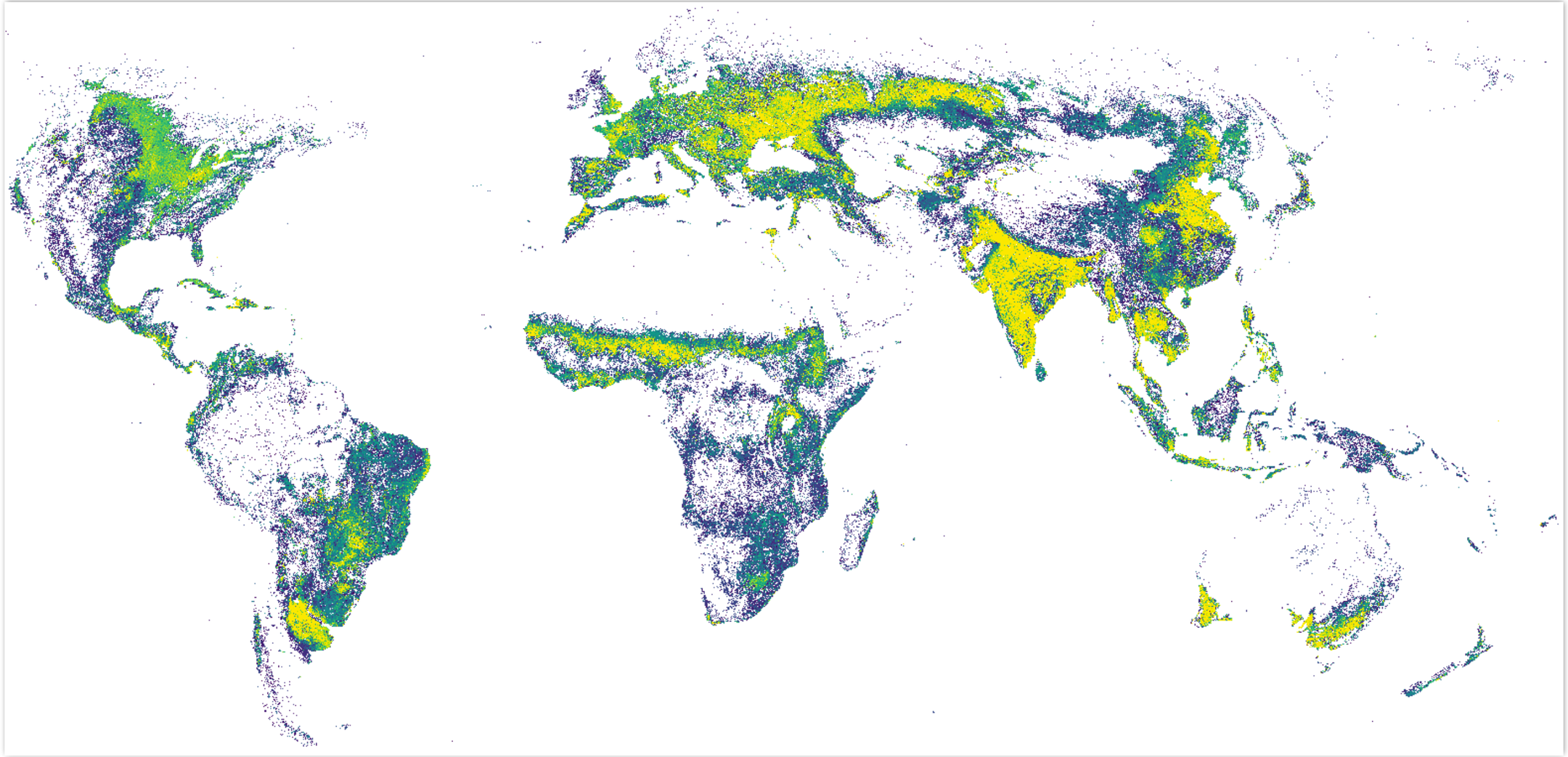


http://pubs.acs.org/doi/full/10.1021/es302673e

Building scale?

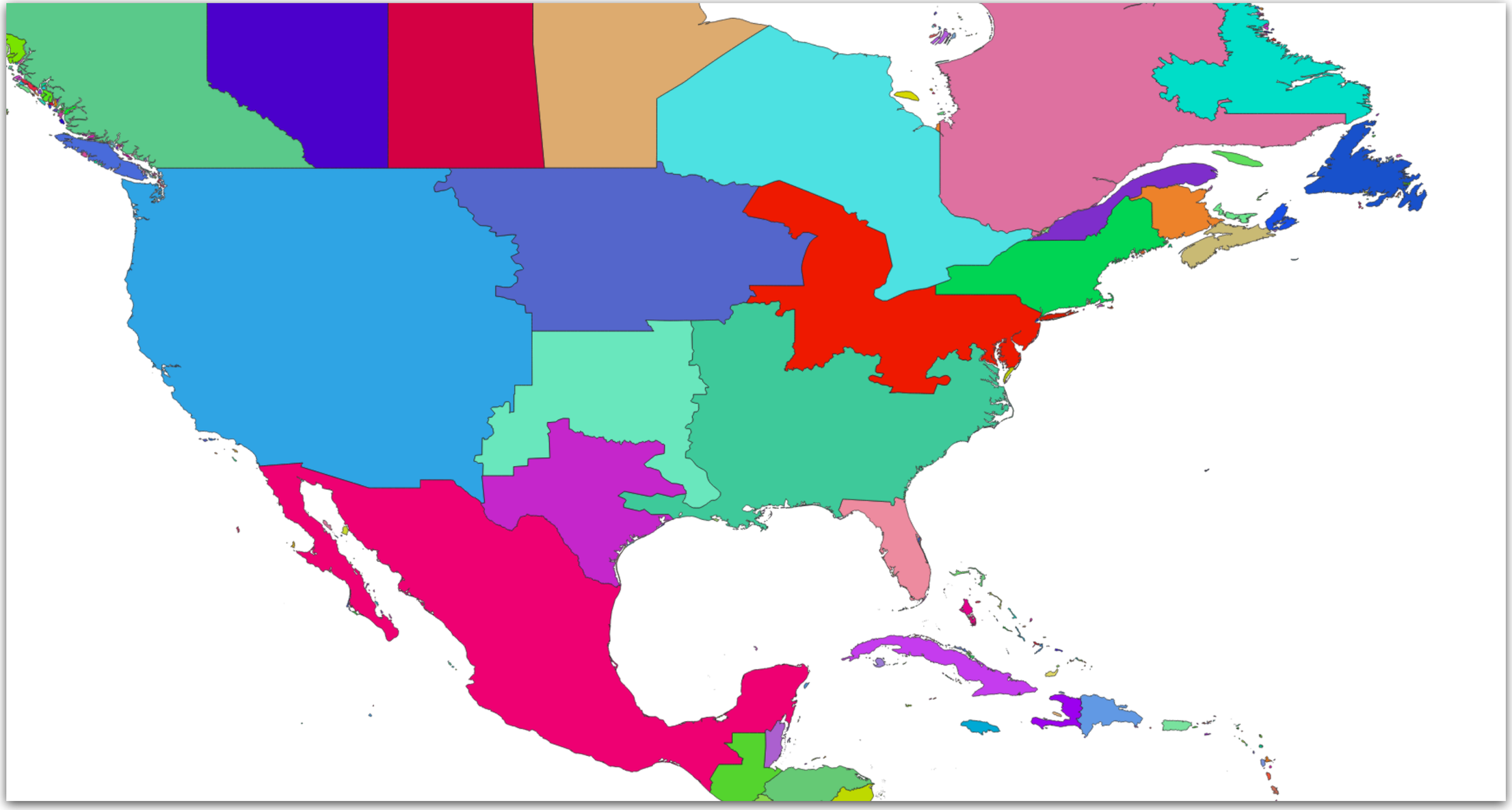


http://pubs.acs.org/doi/full/10.1021/es302673e

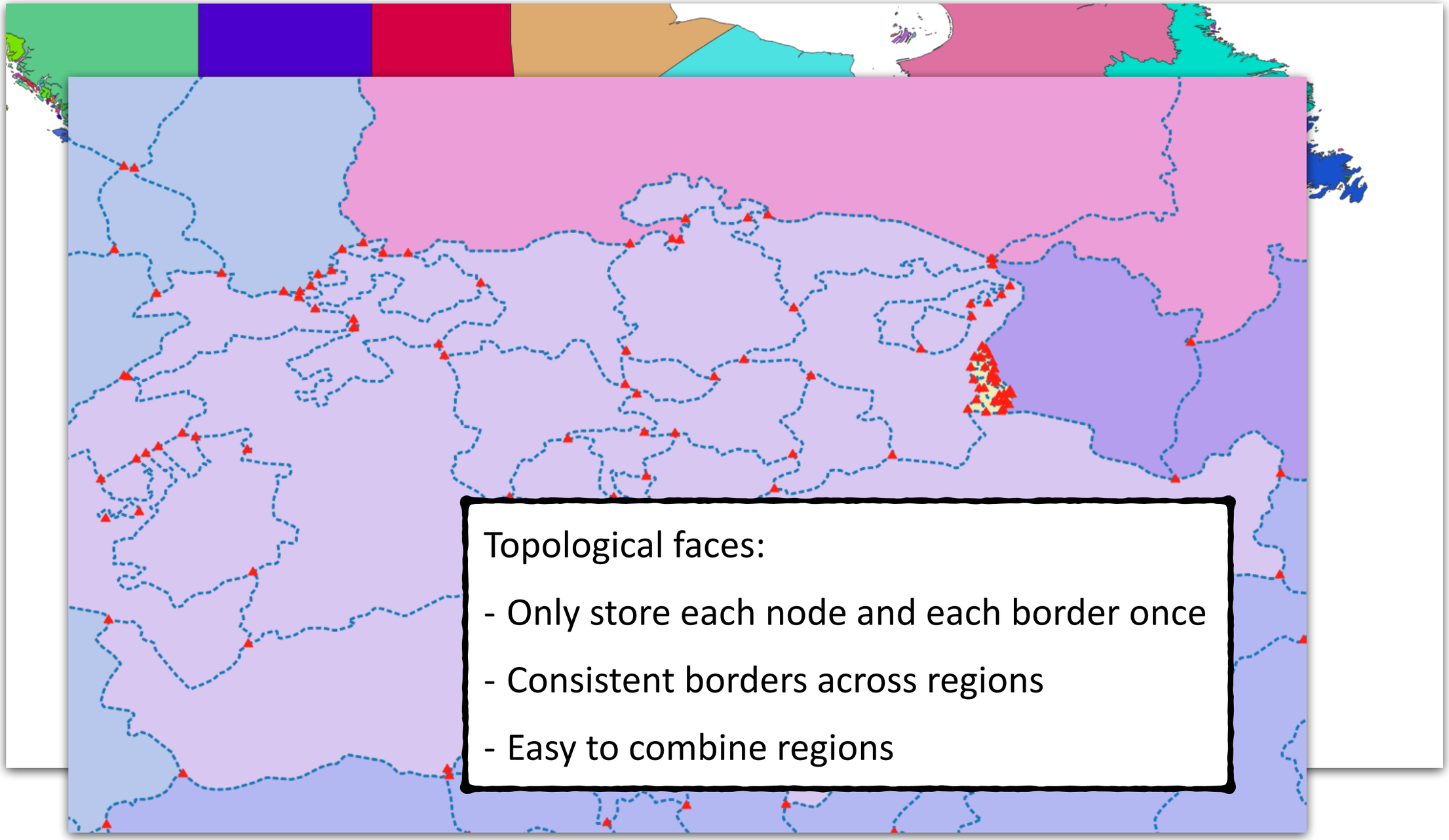


Cultivated and Managed Vegetation

Base data: Consistent world map



Base data: Consistent world map



Topological faces:

- Only store each node and each border once
- Consistent borders across regions
- Easy to combine regions

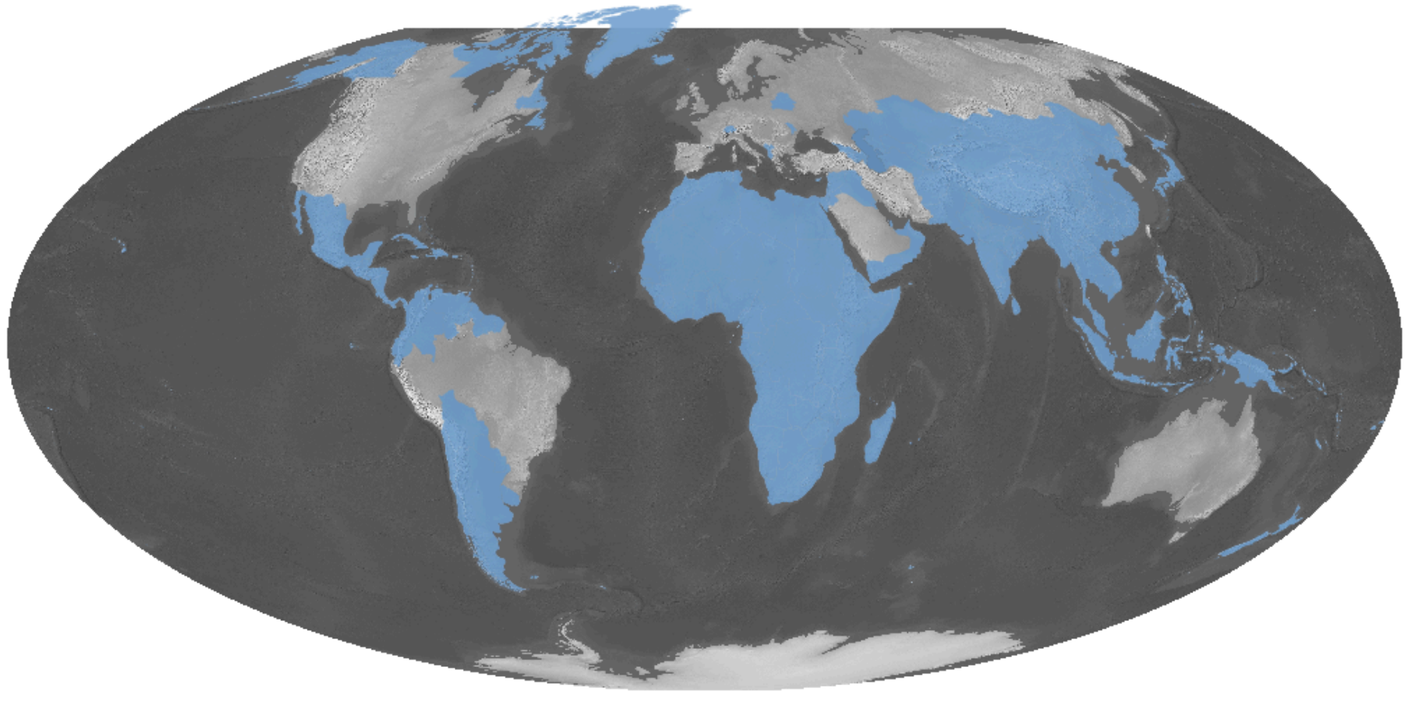
Label “Rest-of-Worlds”

Rest-of-World location: RoW_15 | RoWs report

Rower version: (0, 2)

constructive_geometries version: (0, 6, 4)

Excluded from this "Rest-of-World": AQ, AT, AU, AUS-AC, BA, BE, BG, BR, Bajo Nuevo, CA-AB, CA-BC, CA-MB, CA-NB, CA-NS, CA-NT, CA-ON, CA-PE, CA-QC, CA-SK, CZ, Clipperton Island, Coral Sea Islands, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IR, IT, KR, LT, LU, LV, MK, NL, NO, PE, PL, PT, RO, RS, RU, SA, SE, SI, SK, TR, TW, UA, US-ASCC, US-FRCC, US-MRO, US-NPCC, US-RFC, US-SERC, US-SPP, US-TRE, US-WECC



ecoinvent 3.4 APOS

Activity Name	Reference Product	Unit
heat and power co-generation, natural gas, conventional power plant, 100MW electrical	heat, district or industrial, natural gas	megajoule
heat and power co-generation, natural gas, conventional power plant, 100MW electrical	electricity, high voltage	kilowatt hour

Regionalized calculations

$$h_r = \left[\mathrm{MN}_{dx}\mathrm{DXN}_{g}\mathrm{GR}\right]^{T} \circ \left[\mathrm{B} \cdot (\mathrm{A}^{-1} f)\right]$$

Inventory

Normalization

Normalization

Mapping

Inventory Processes to

Inv. Spatial Units

(1 or 0)

Extension Table

Extension tables values

Regionalized LCIA

Regionalized CFs

Distribution

Inv. Spatial Units to

Extension Spatial Unit

(area)

Geographic Transform

Extension Spatial Unit to

LCIA Spatial Units

(area)

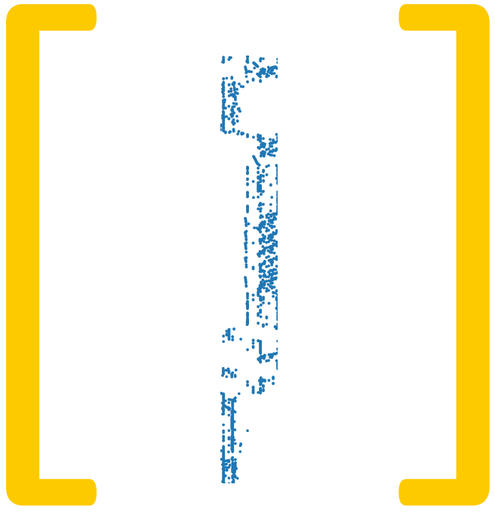
Calculation methodology

$$h = CBA^{-1}f \Rightarrow h_r = \left[\mathrm{MN}_{dx}\mathrm{DXN}_{g}\mathrm{GR}\right]^{T} \circ [\mathrm{BA}^{-1}f]$$

Flows (2k)

Inventory locations (500)

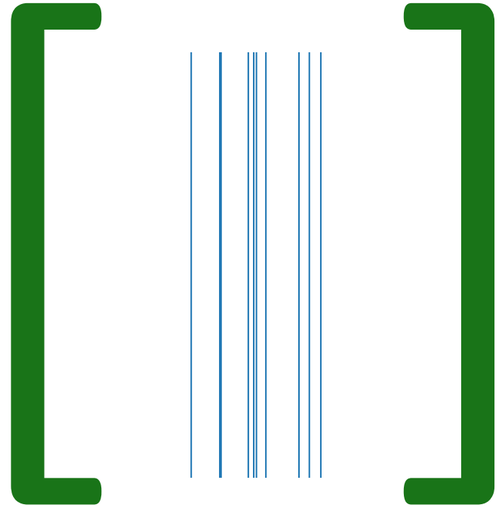
Processes (16k)



?

Flows (2k)

IA locations e.g. Watersheds (32k)



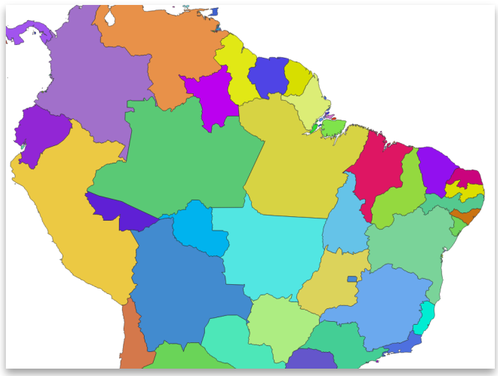
1 or 0

Damage characterization: Impact per flow unit (e.g. CHF/kg CO_2)

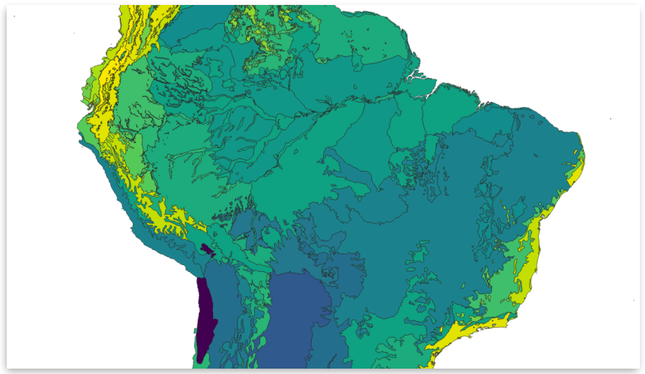
Mutel, C, Hellweg, S. 2018. *Matrix-based Methods for Regionalized Life Cycle Assessment*. Environmental Science & Technology, submitted.

Calculation methodology

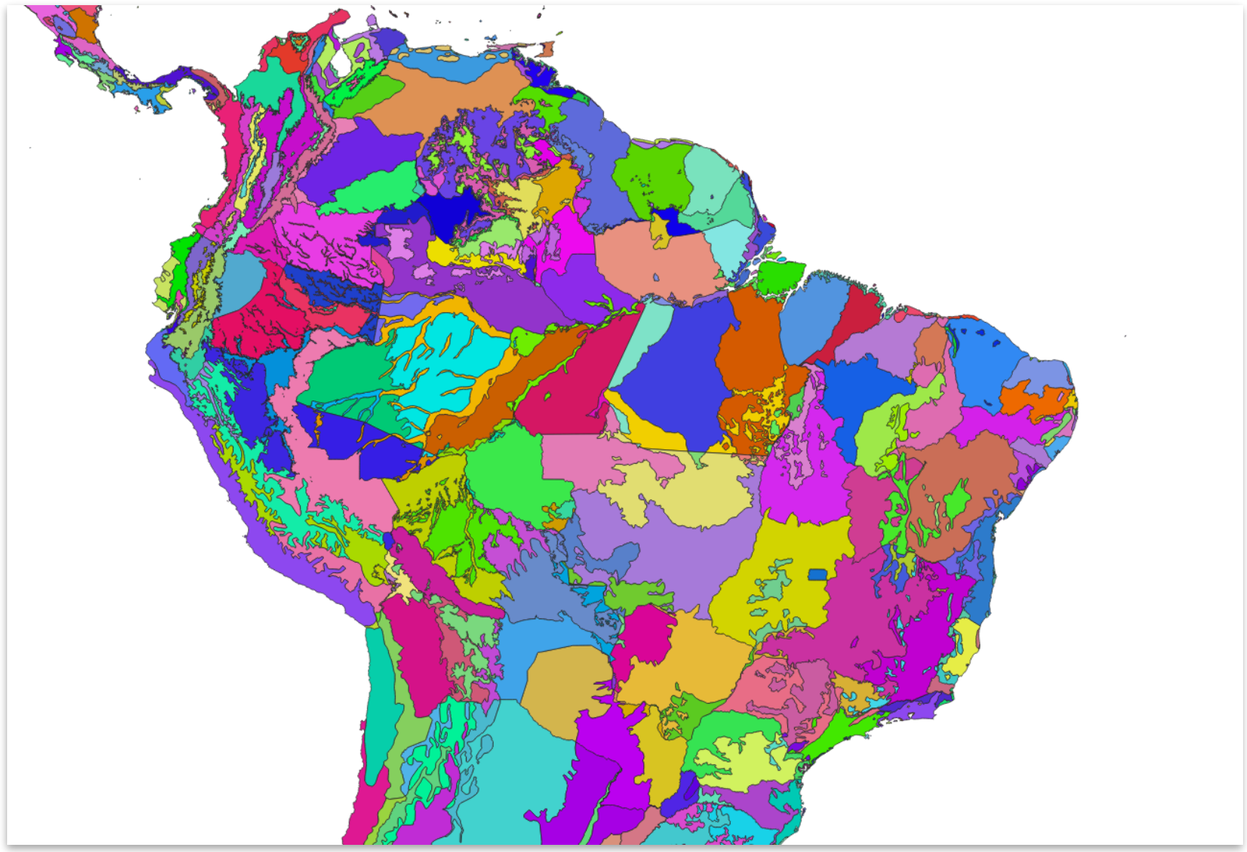
$$h = CBA^{-1}f \Rightarrow h_r = \left[\mathrm{MN}_{dx}\mathrm{DXN}_{g}\mathrm{GR}\right]^{T} \circ [\mathrm{BA}^{-1}f]$$



Inventory
e.g. Countries



Impact Assessment (IA)
e.g. Watersheds



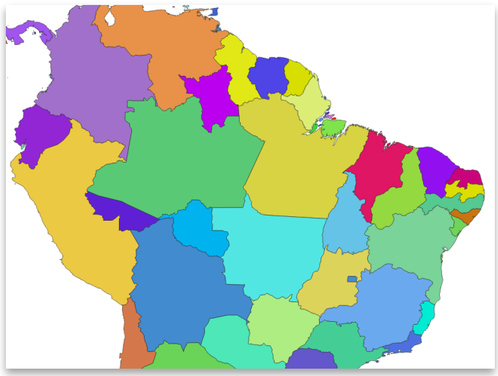
Inventory ∩ IA scale =

Mutel, C, Hellweg, S. 2018. *Matrix-based Methods for Regionalized Life Cycle Assessment*. Environmental Science & Technology, submitted.
Mutel, C. 2017. *Pandarus: GIS toolkit for regionalized life cycle assessment*. Journal of Open Source Software, 2 (13)

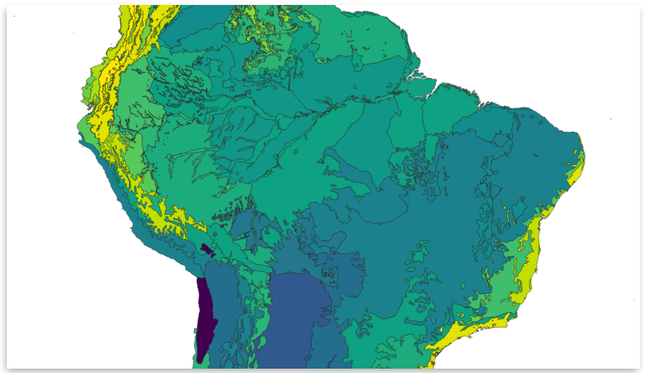
Calculation methodology

$$h = CBA^{-1}f \Rightarrow h_r = \left[\mathrm{MN}_{dx}\mathrm{DXN}_{g}\mathrm{GR}\right]^{T} \circ \left[\mathrm{BA}^{-1}f\right]$$

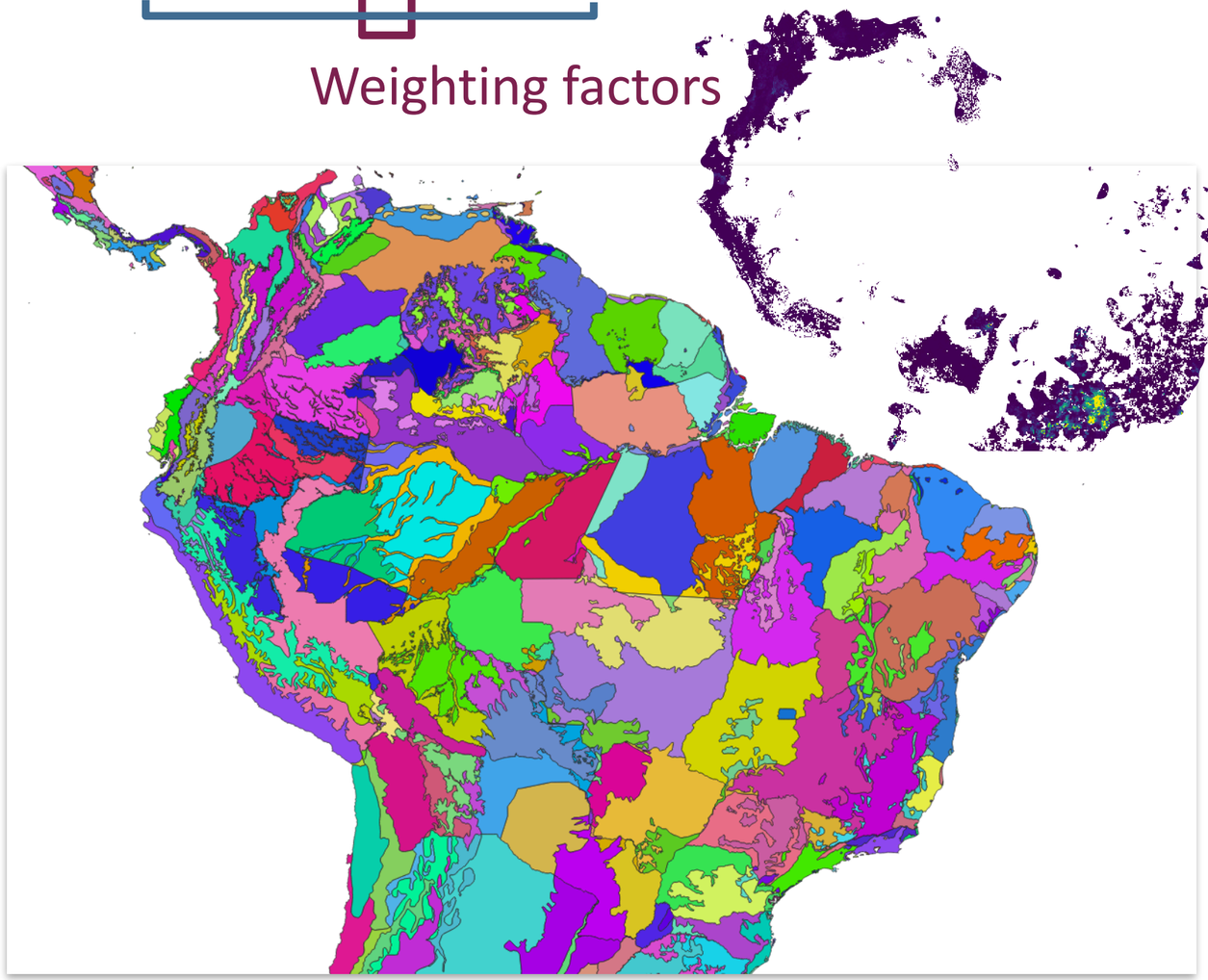
Weighting factors



Inventory
e.g. Countries



Impact Assessment (IA)
e.g. Watersheds

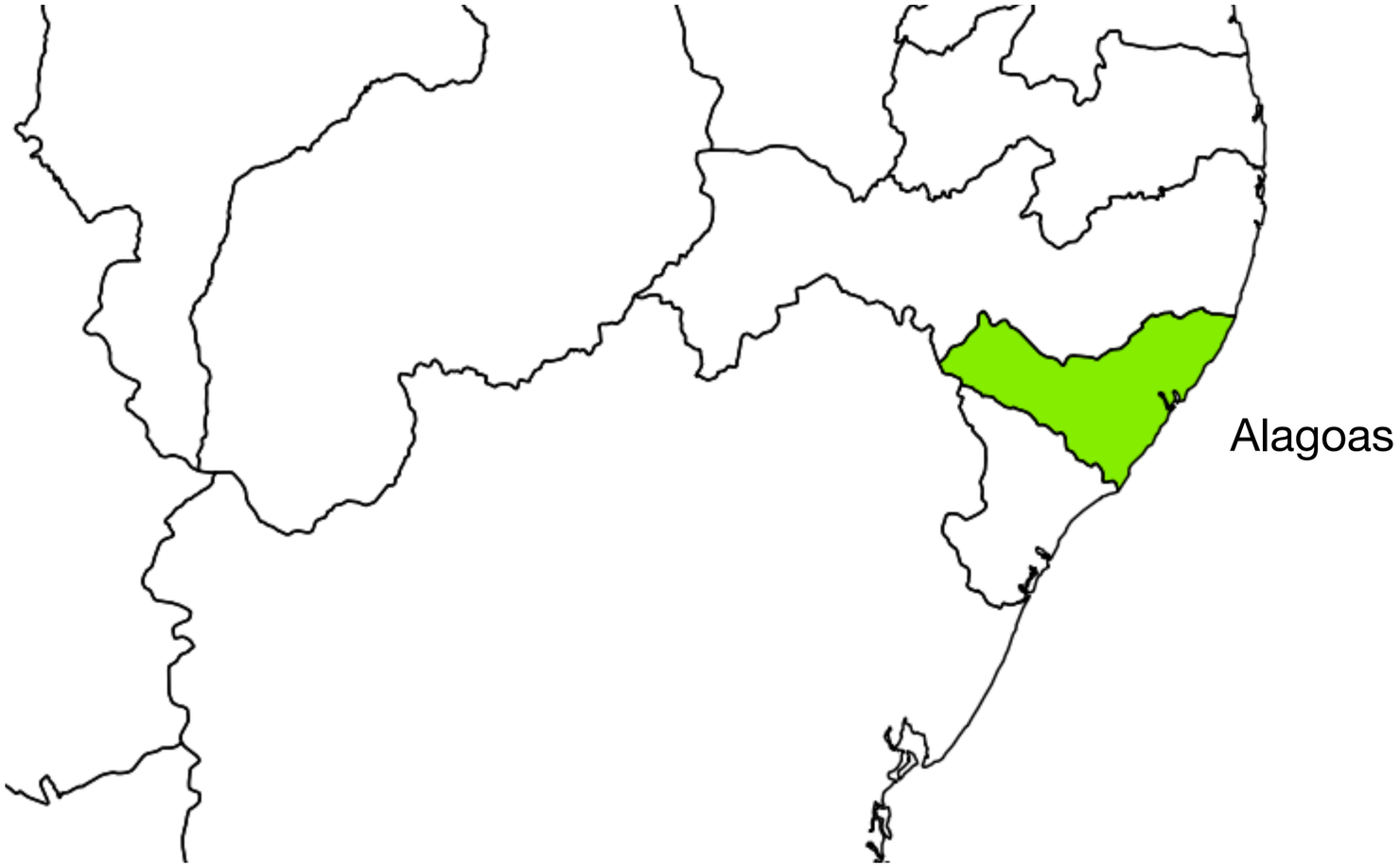


Inventory ∩ IA scale =

Mutel, C, Hellweg, S. 2018. *Matrix-based Methods for Regionalized Life Cycle Assessment*. Environmental Science & Technology, submitted.
Mutel, C. 2017. *Pandarus: GIS toolkit for regionalized life cycle assessment*. Journal of Open Source Software, 2 (13)

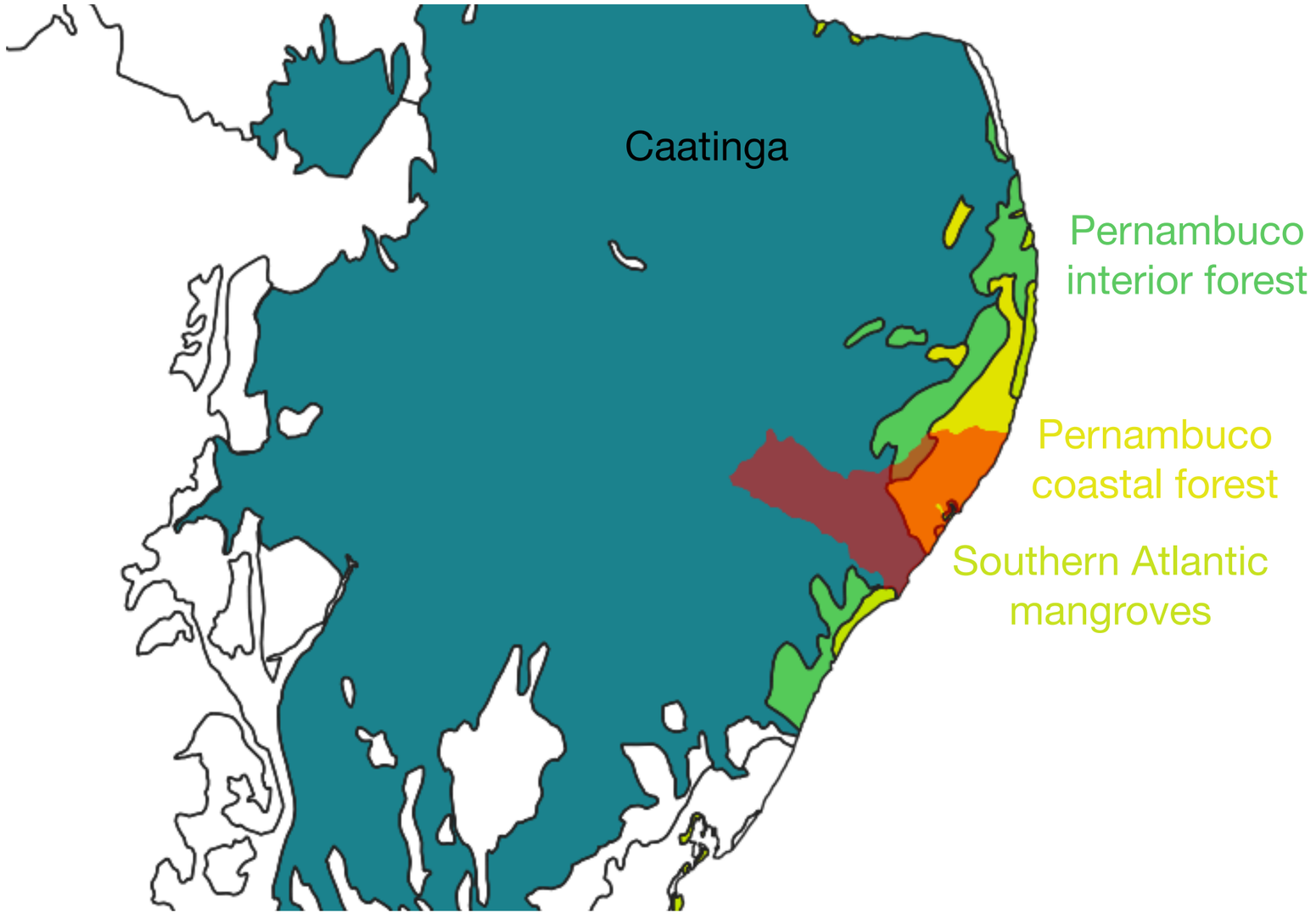
Vector calculations

$$h = CBA^{-1}f \Rightarrow h_r = \left[\mathsf{MN}_{dx}\mathsf{DXN}_{g}\mathsf{GR}\right]^{T} \circ [\mathsf{BA}^{-1}f]$$



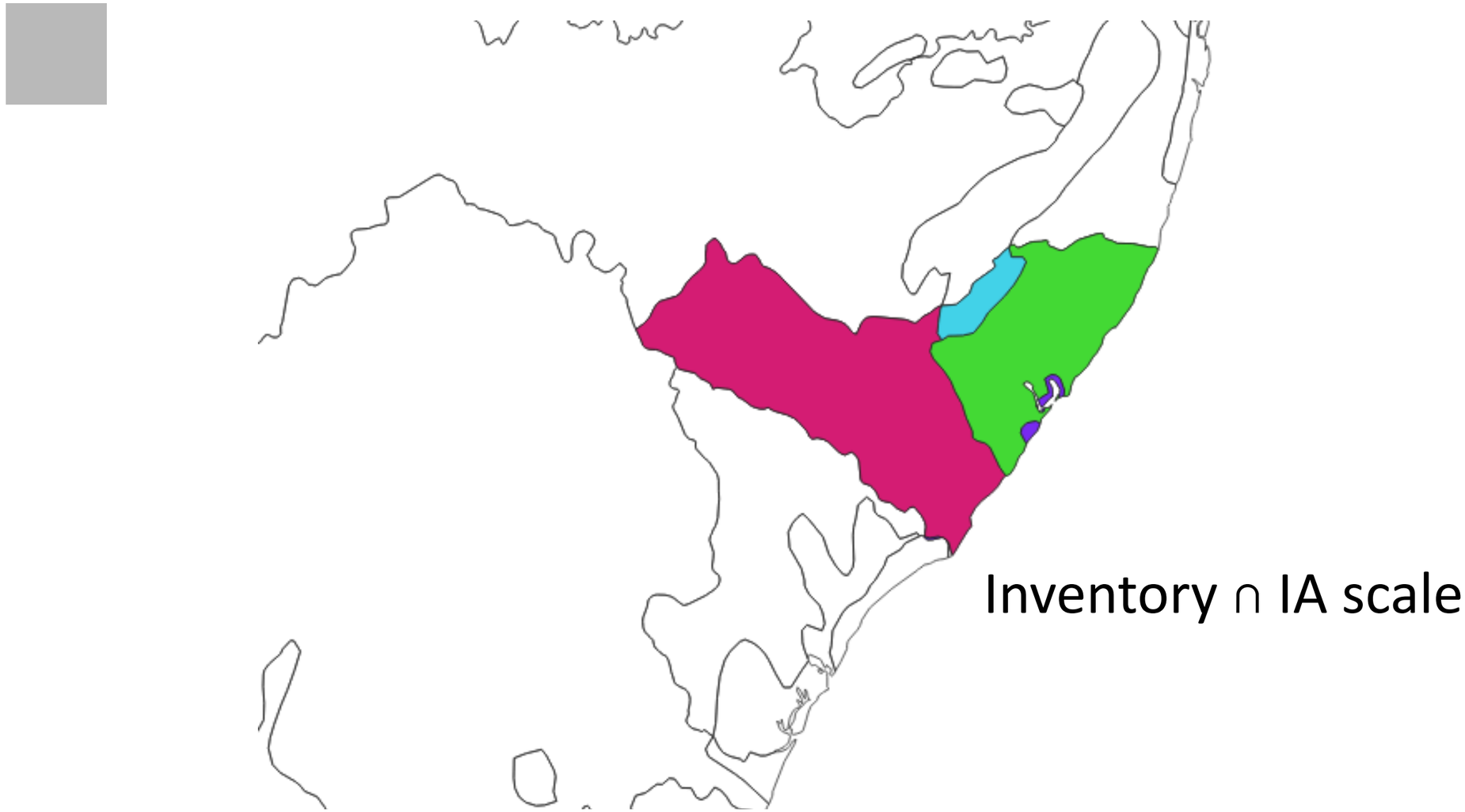
Vector calculations

$$h = CBA^{-1}f \Rightarrow h_r = \left[\mathrm{MN}_{dx}\mathrm{DXN}_{g}\mathrm{GR}\right]^{T} \circ \left[\mathrm{BA}^{-1}f\right]$$



Vector calculations

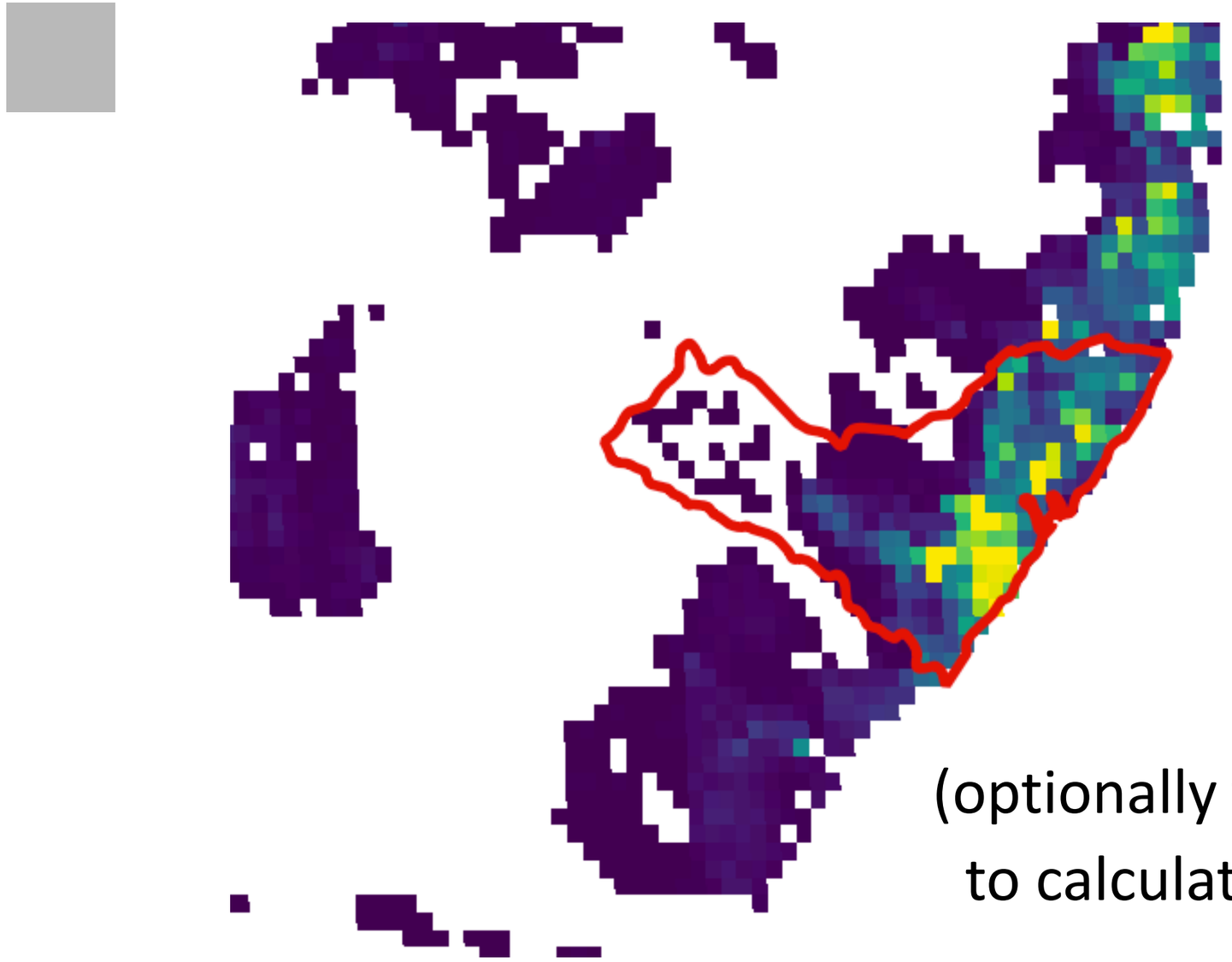
$$h = CBA^{-1}f \Rightarrow h_r = \left[\mathrm{MN}_{dx}\mathrm{DXN}_{g}\mathrm{GR}\right]^{T} \circ \left[\mathrm{BA}^{-1}f\right]$$



Inventory ∩ IA scale

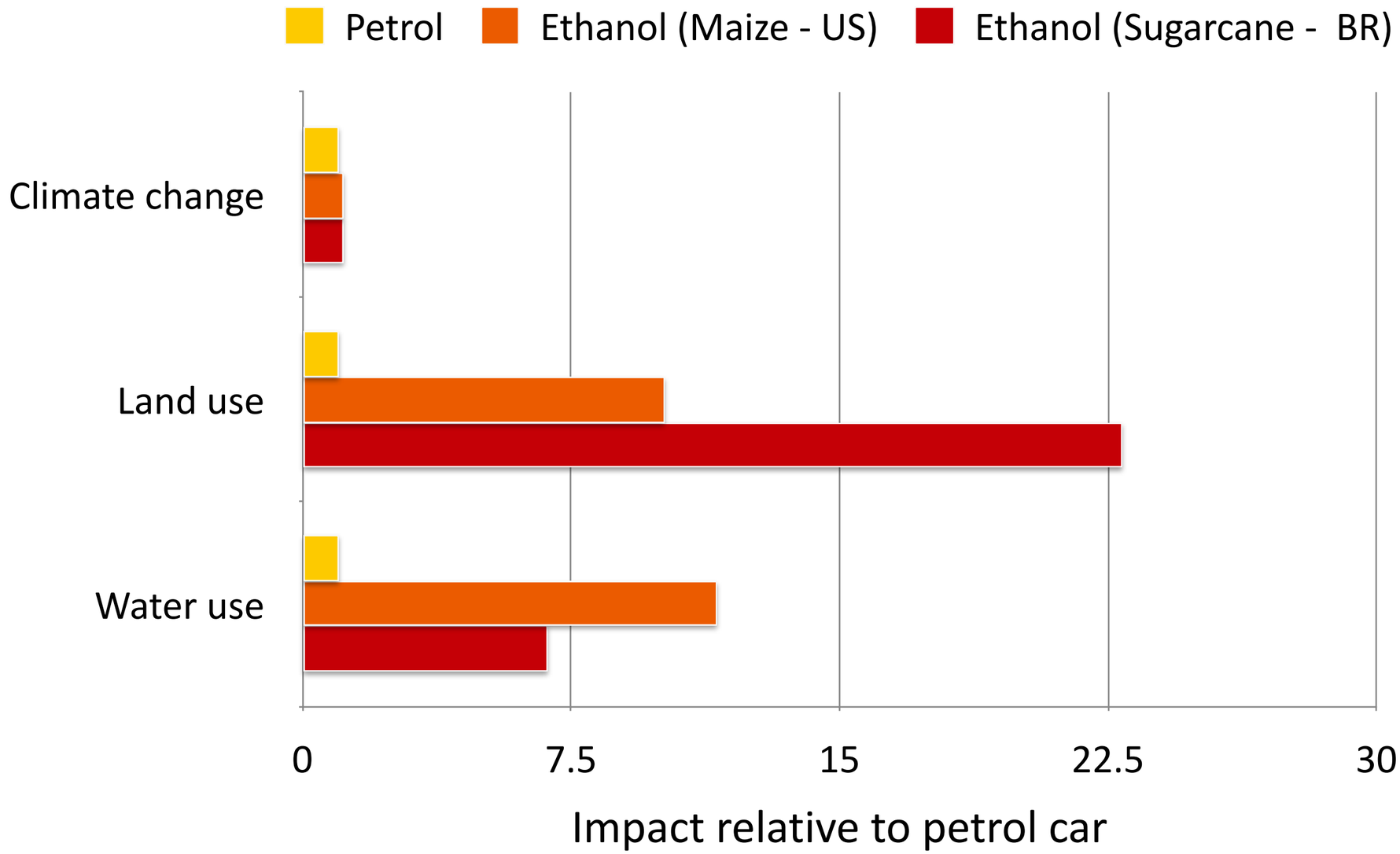
Vector calculations

$$h = CBA^{-1}f \Rightarrow h_r = \left[\mathrm{MN}_{dx}\mathrm{DXN}_{g}\mathrm{GR}\right]^{T} \circ \left[\mathrm{BA}^{-1}f\right]$$



Use detailed data
(optionally from another scale)
to calculate weighted average

Case study: 1 km combustion car driving in Europe



Verones, Mutel, *et al*. *Overview of LC-IMPACT Impact Assessment Method*. In preparation.