GreenDelta
sustainability consulting + software

Linking regionalized LCIA methods and LCA databases: concept and practical demonstration of implementation in LCA software

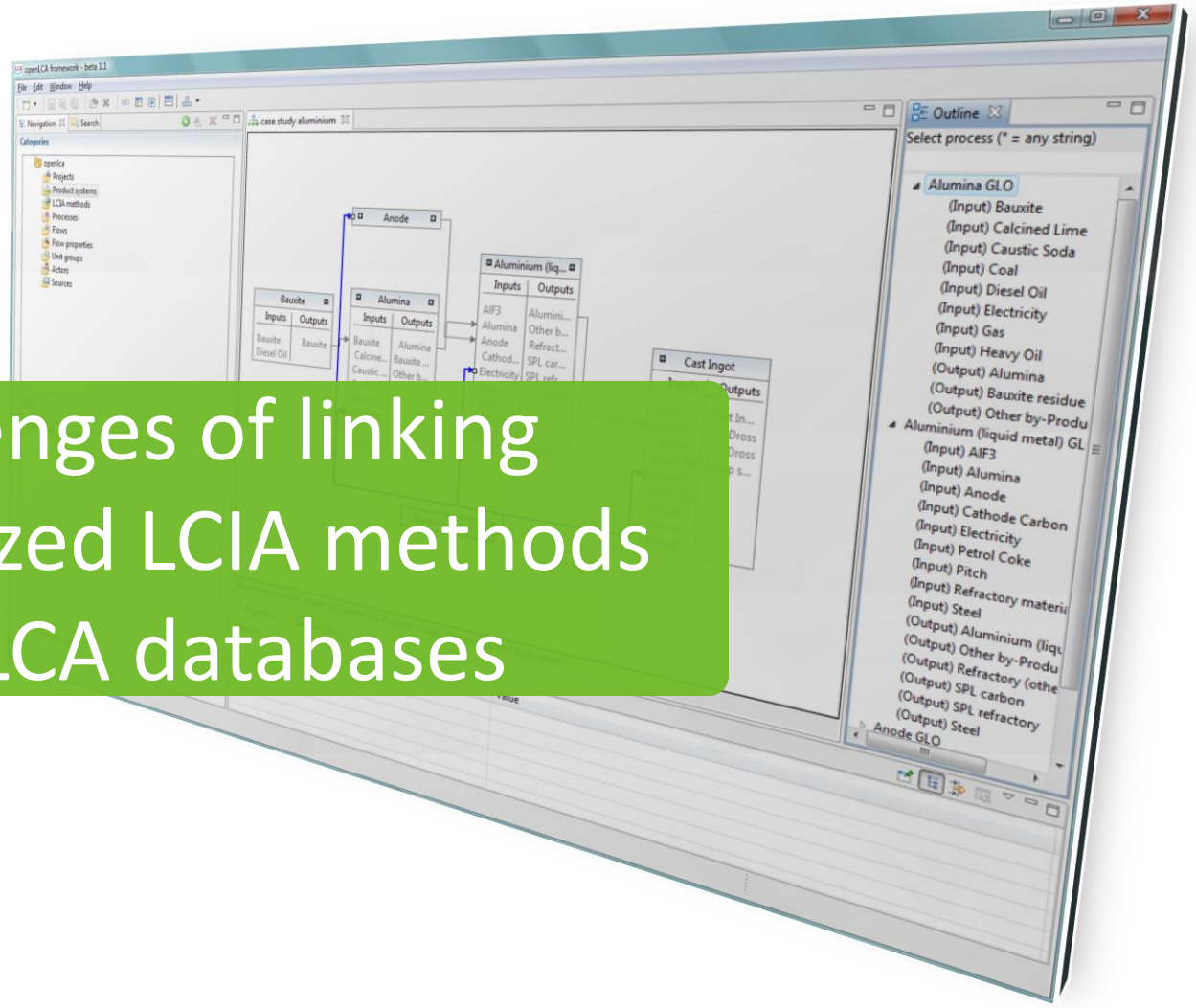
Cristina Rodríguez, Michael Srocka
GreenDelta GmbH

October 9, 2014
San Francisco, USA

Content

- Challenges of linking regionalized LCIA methods and LCA databases
- New concept for regionalized LCIA implementation in openLCA
- New concept implementations:
  - Parameterization of LCIA methods
  - Process locations extension
  - Calculation framework
- Application example
- Conclusions
- Outlook

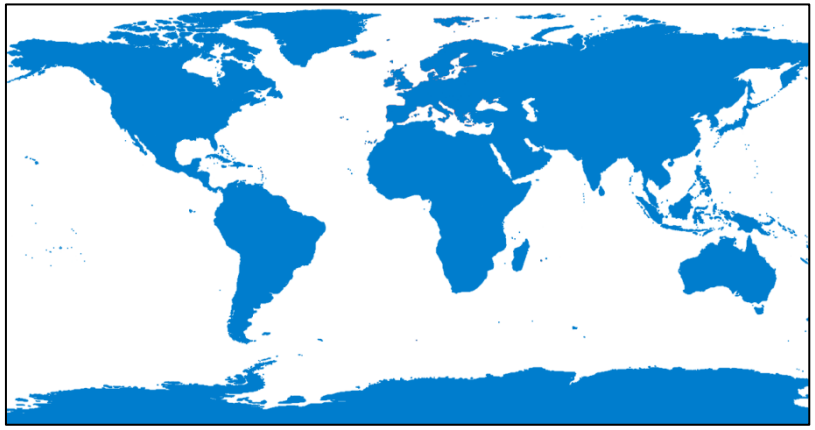
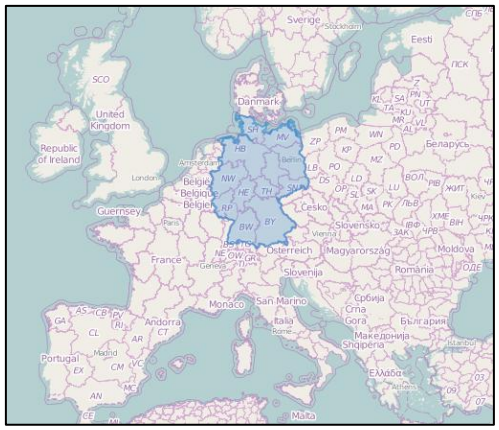
Challenges of linking regionalized LCIA methods and LCA databases



GreenDeLTa

Several levels of regionalization in a life cycle

Foreground processes

Site-generic	Site-dependent	Site-specific
		

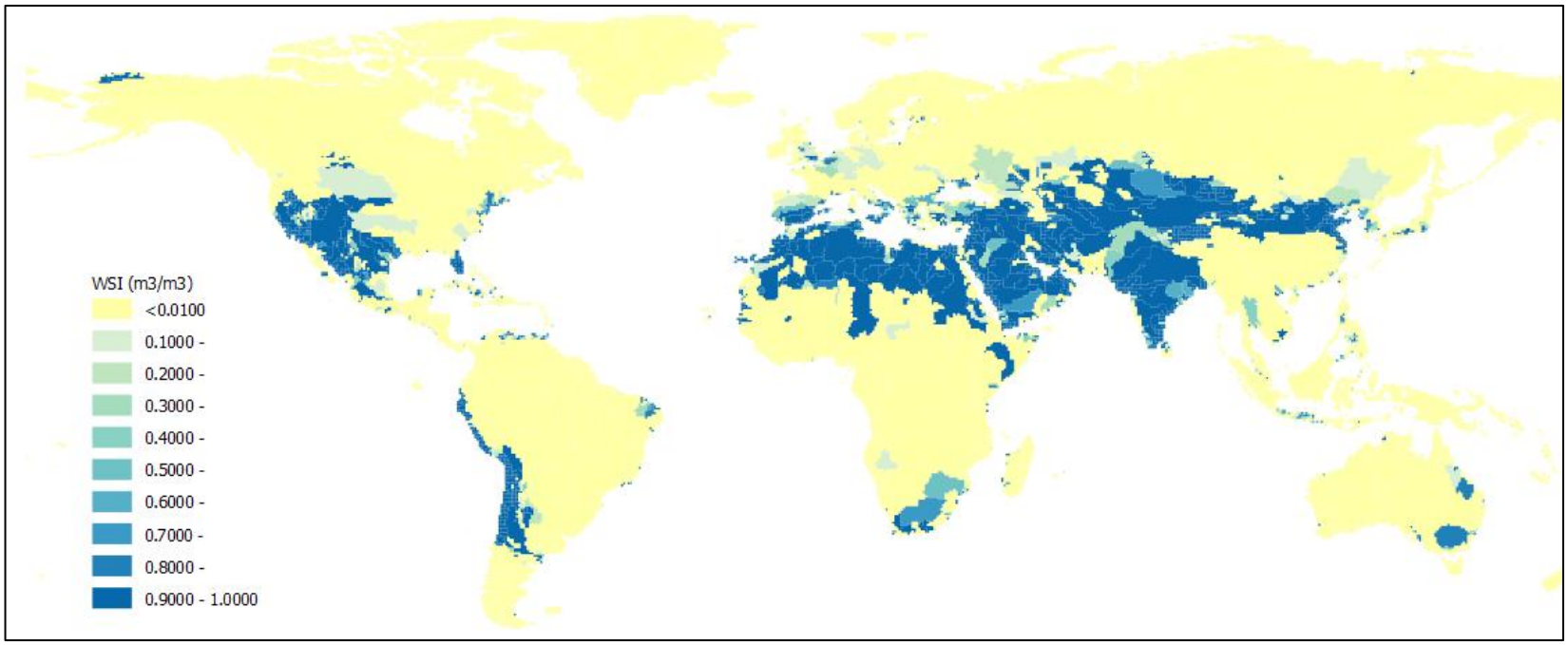
Most common in LCA databases

Background processes

GreenDelta

Different spatial units per impact category

- e.g. biomes, watersheds, etc.



WSI per m3 water consumed (Source: EI99+)

Spatial uncertainty

- High spatial resolution might add precision to results but decrease relative accuracy
- Spatial uncertainty of inventory and CFs should be considered
  - What is the likelihood of an activity occurring in a specific location?
  - What is the real area of impact of an emission?

Amount of data

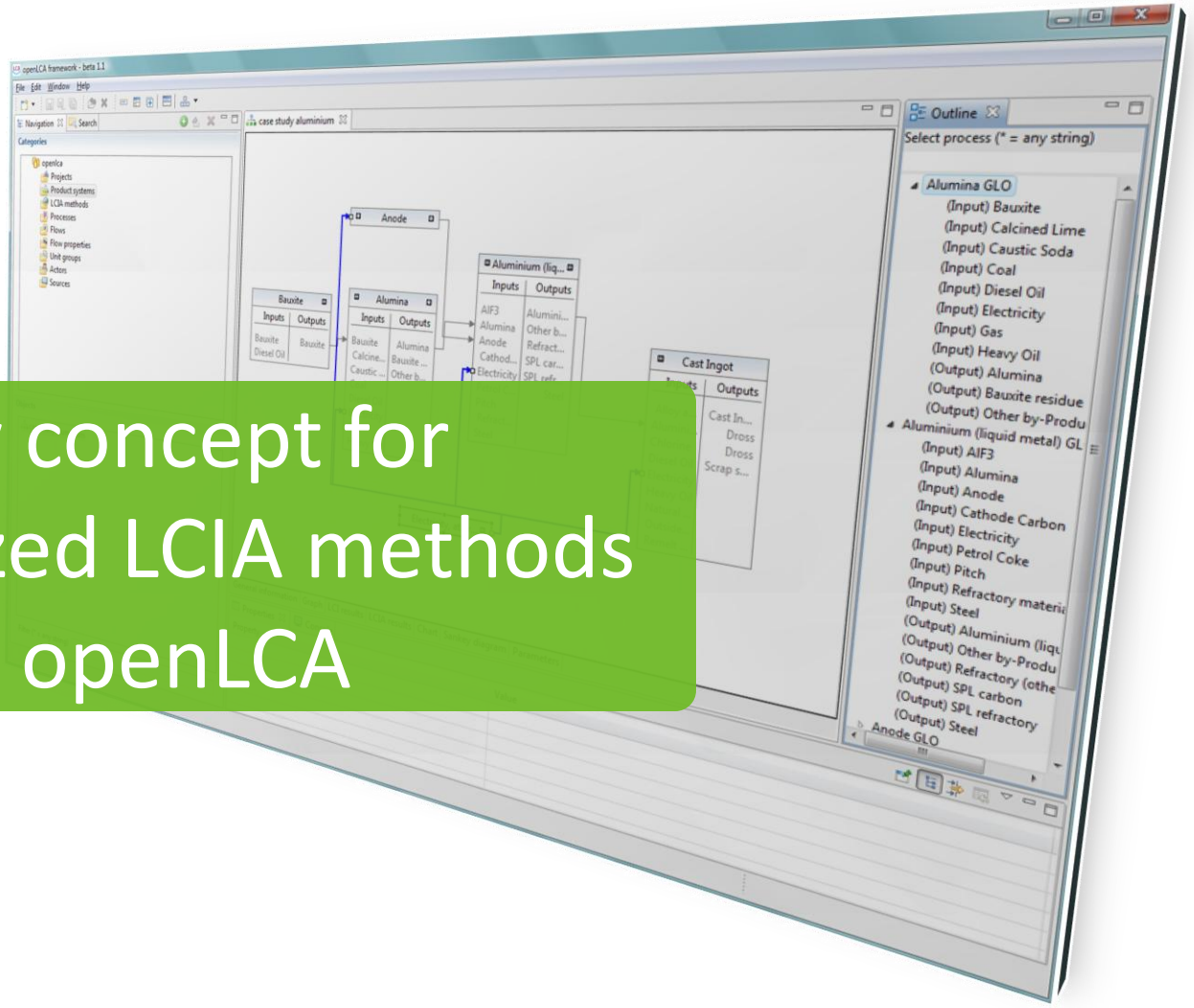
- High amount of data:

  fhprocesses*elementary exchanges*locations

  - Data storage capacity
  - Computing power
  - Interpretation of results by non-expert users

→GIS (Geographic Information Systems)

New concept for regionalized LCIA methods in openLCA

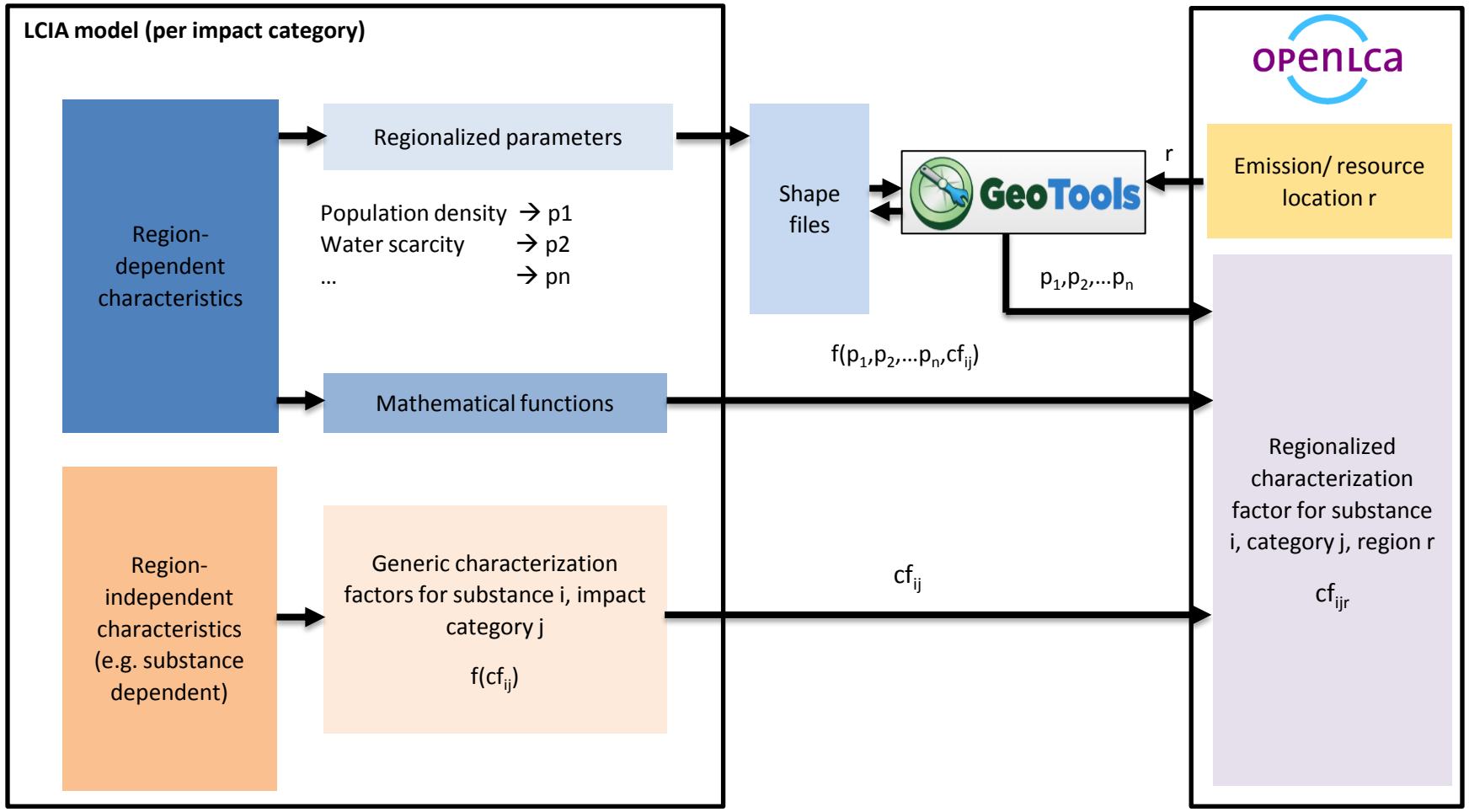


GreenDelta

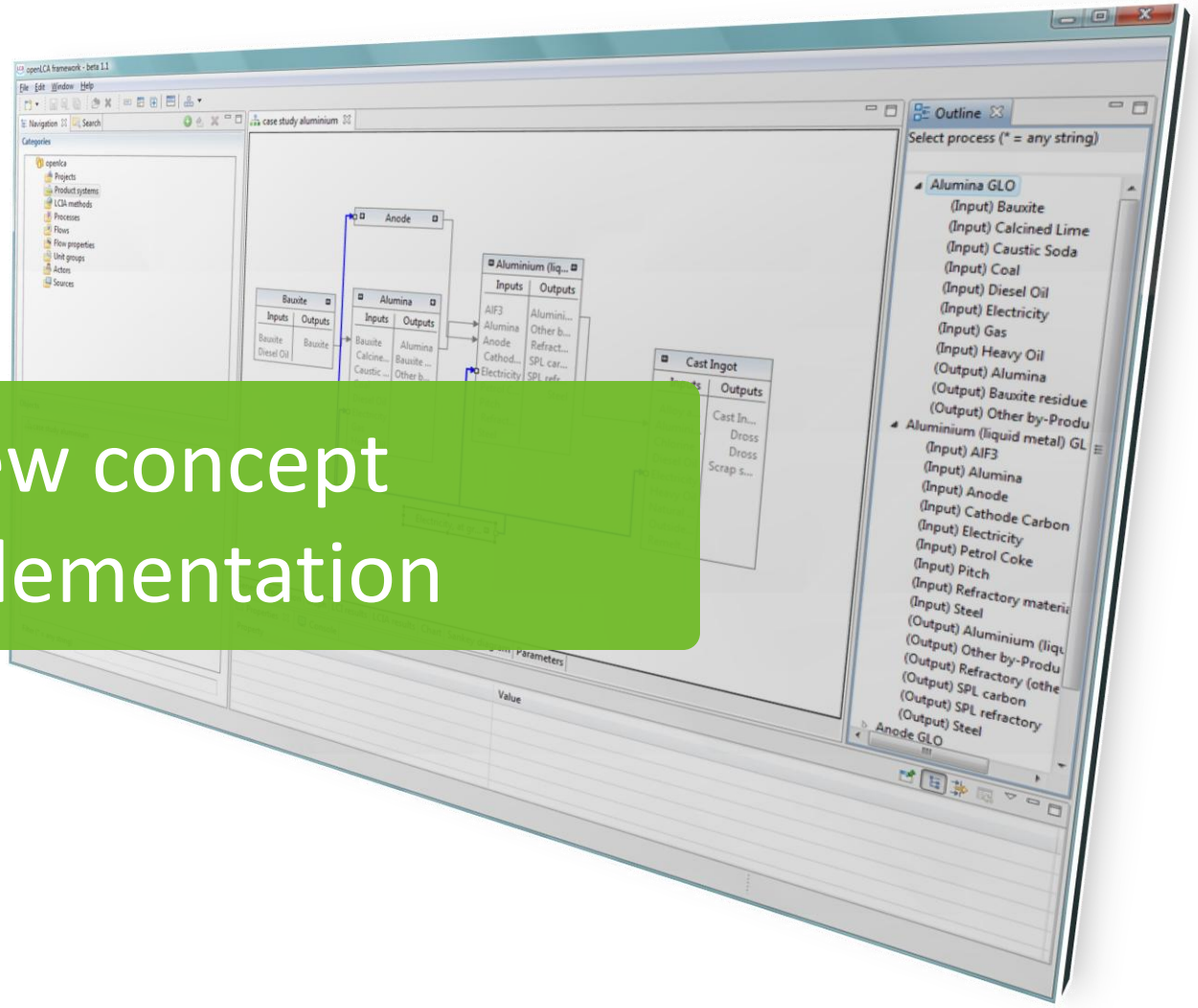
Software: openLCA

- Free, open source LCA software developed by GreenDelta since 2006
- Written in Java
- Regionalized LCIA implemented in a project supported by the US Department of Agriculture (USDA), National Agricultural Library
- www.openlca.org

Parameterization of LCIA methods



New concept implementation



GreenDelta

Parameterization of LCIA methods

- Formulas for calculating the characterisation factors (CFs) can be defined
  - Input and dependent parameters can be used as in

Impact factors

Impact category: Land use

Flow	Category	Flow property	Unit	Factor	Uncertainty
Occupation, arable	resource/land	Area*time	m2*a	(0.60*ratio_biom)/SA_CF	lognormal: gmean=1.36 g...
Occupation, construction site	resource/land	Area*time	m2*a	(0.44*ratio_biom)/SA_CF	lognormal: gmean=1.00 g...
Occupation, forest, intensive	resource/land	Area*time	m2*a	(0.04*ratio_biom)/SA_CF	lognormal: gmean=9.09E-...
Occupation, forest, intensive, clear-c...	resource/land	Area*time	m2*a	(0.18*ratio_biom)/SA_CF	lognormal: gmean=0.41 g...

Parameters

Global parameters

Input parameters

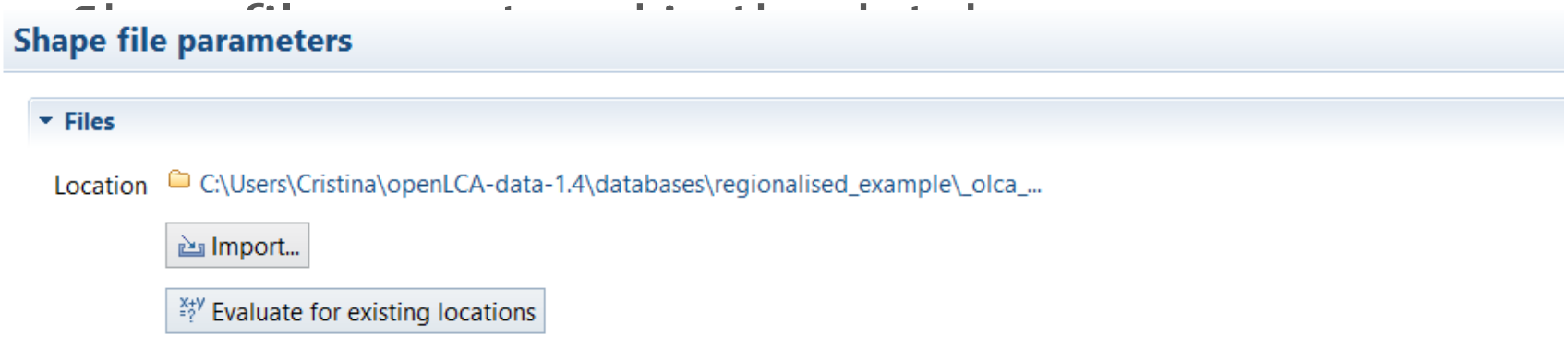
Name	Value	Uncertainty	Description
ratio_biom	1.0	uniform: min=0.21 max=1.97	from shapefile: ecoregions_with_biome_ratio
SA_CF	0.44	none	Settlement Area Characterization Factor
SA_EF	300.0	none	Settlement Area Ecofactor

Shapefiles containing regional characteristics

- Regional characteristics affecting the CFs can be defined with parameters:

  e.g. population density, precipitation variability,etc.

- Data for those characteristics is contained in shapefiles, which can be imported to openLCA
- Parameters are extracted during the shapefile import

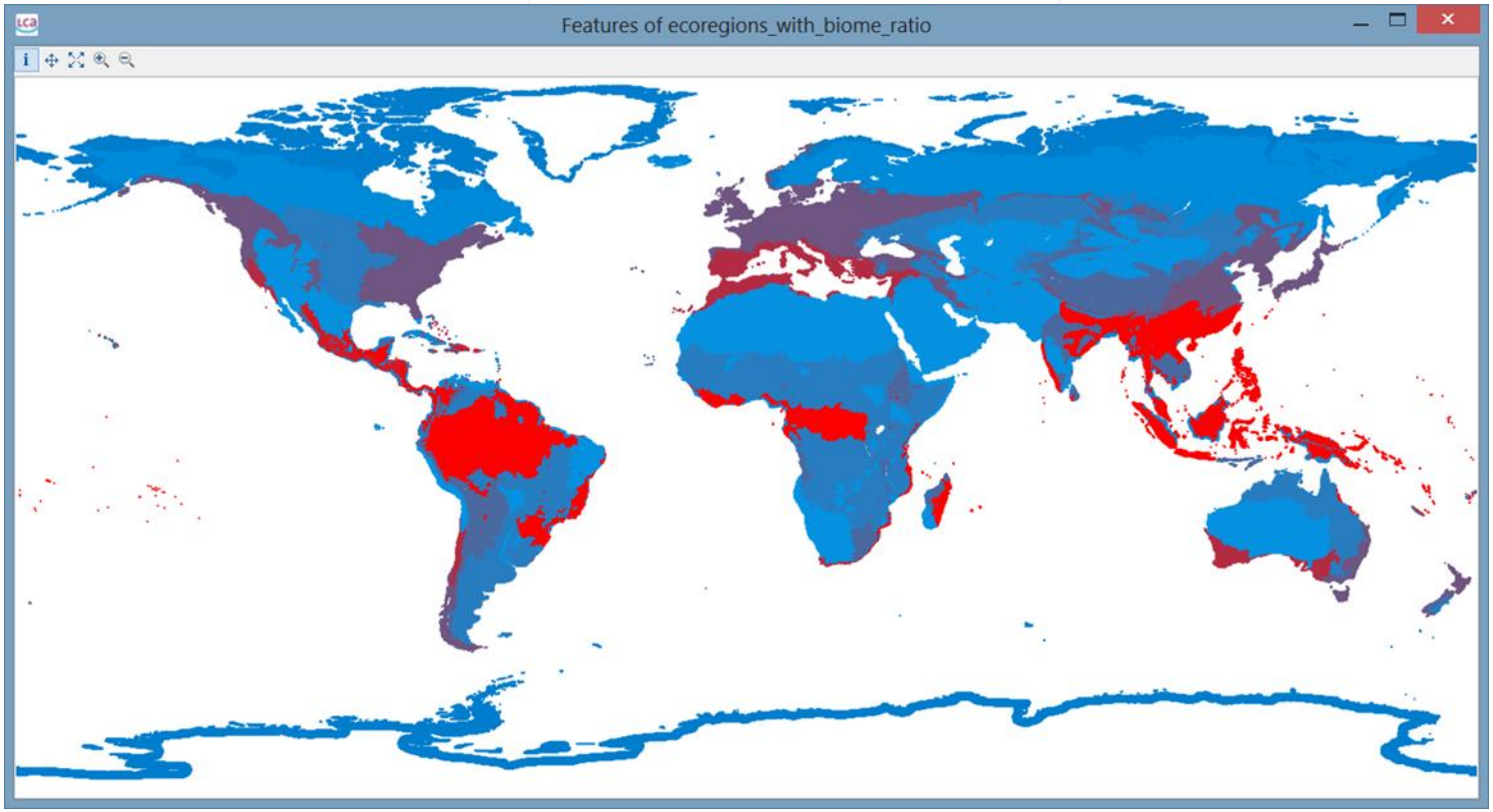


GreenDelta

Shapefiles containing regional characteristics

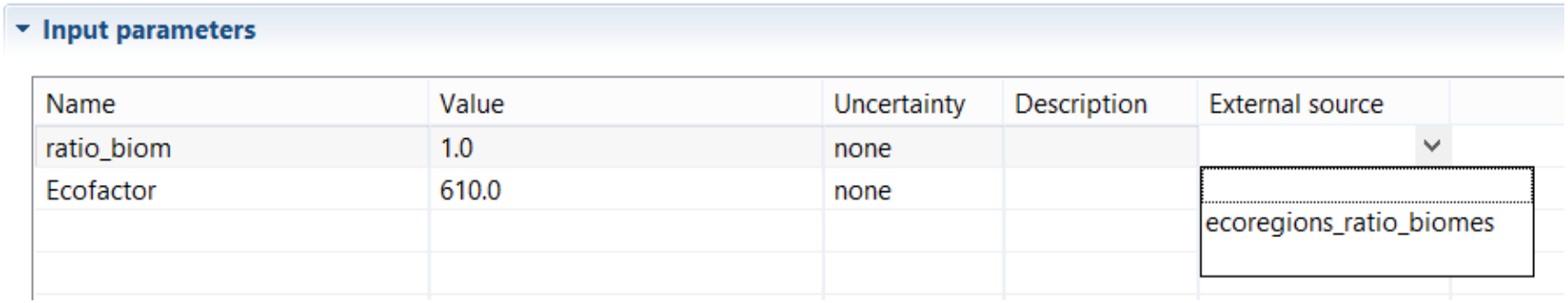
Parameters of ecoregions_with_biome_ratio

Name	Minimum	Maximum
f_x CLS_CODE	0.0	1144.0
f_x ECO_ID_U	10000.0	17109.0
f_x ECO_NUM	1.0	99.0
f_x ratio_biom	0.20929077	1.96750671



Binding shapefiles and LCIA method parameters

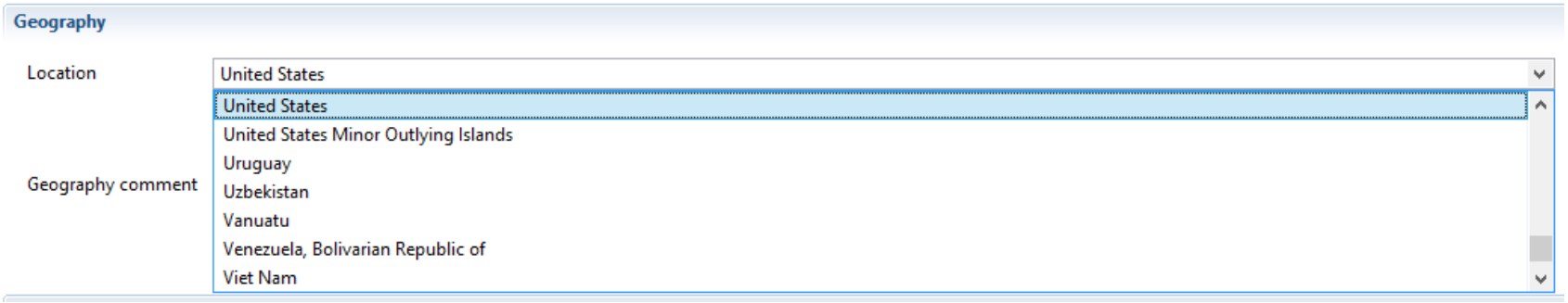
- Parameters of shapefiles can be bound to input parameters
- Default value of parameters is used for normal calculations and formula evaluation
- In regionalized assessment the parameter value derived from the shapefile is used for the formula



Extension of locations in openLCA (I)

Traditional approach:

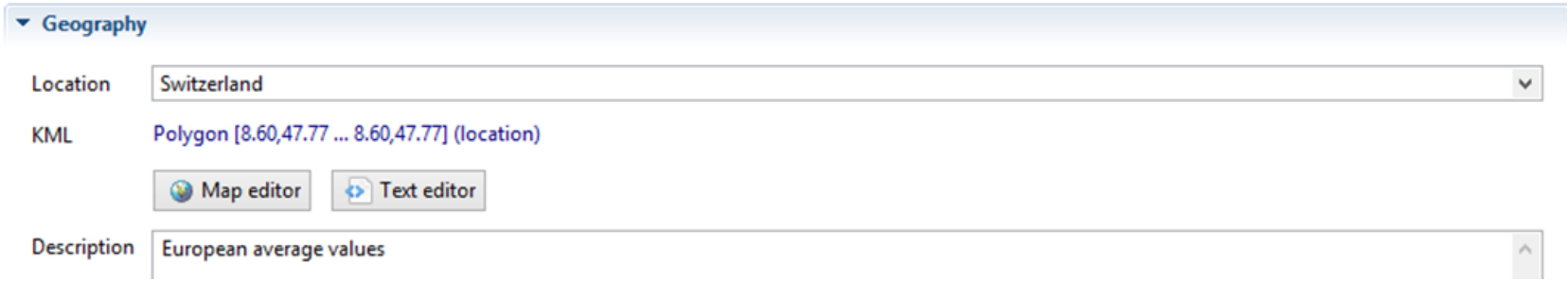
- A list of locations available in the database level.
- The geographic information of the locations was limited to a pair of latitude, longitude data.
- The processes could only used locations from the pre-defined list.
  - Usually, only countries, global or group of



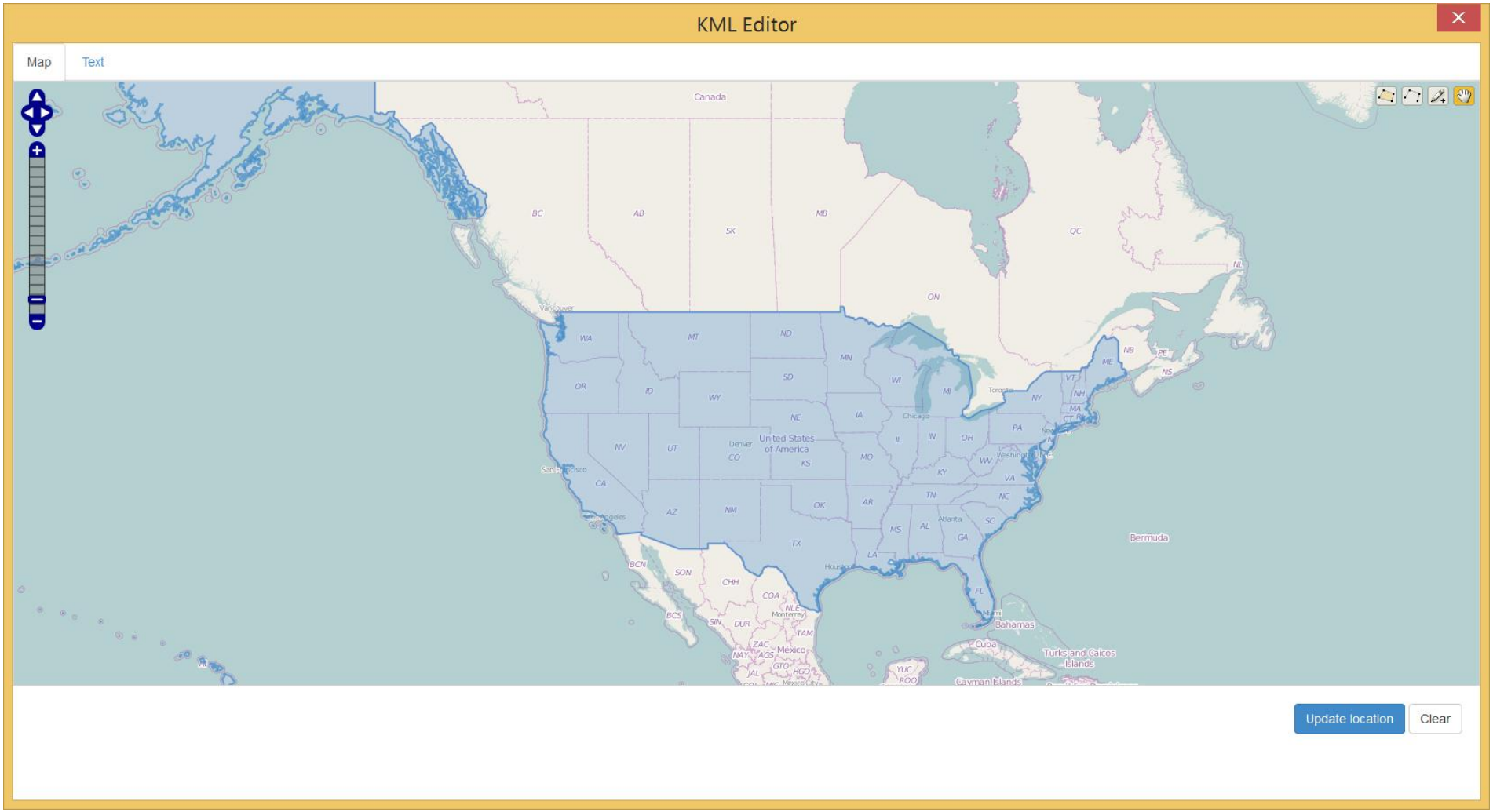
Extension of locations in openLCA (II)

New approach:

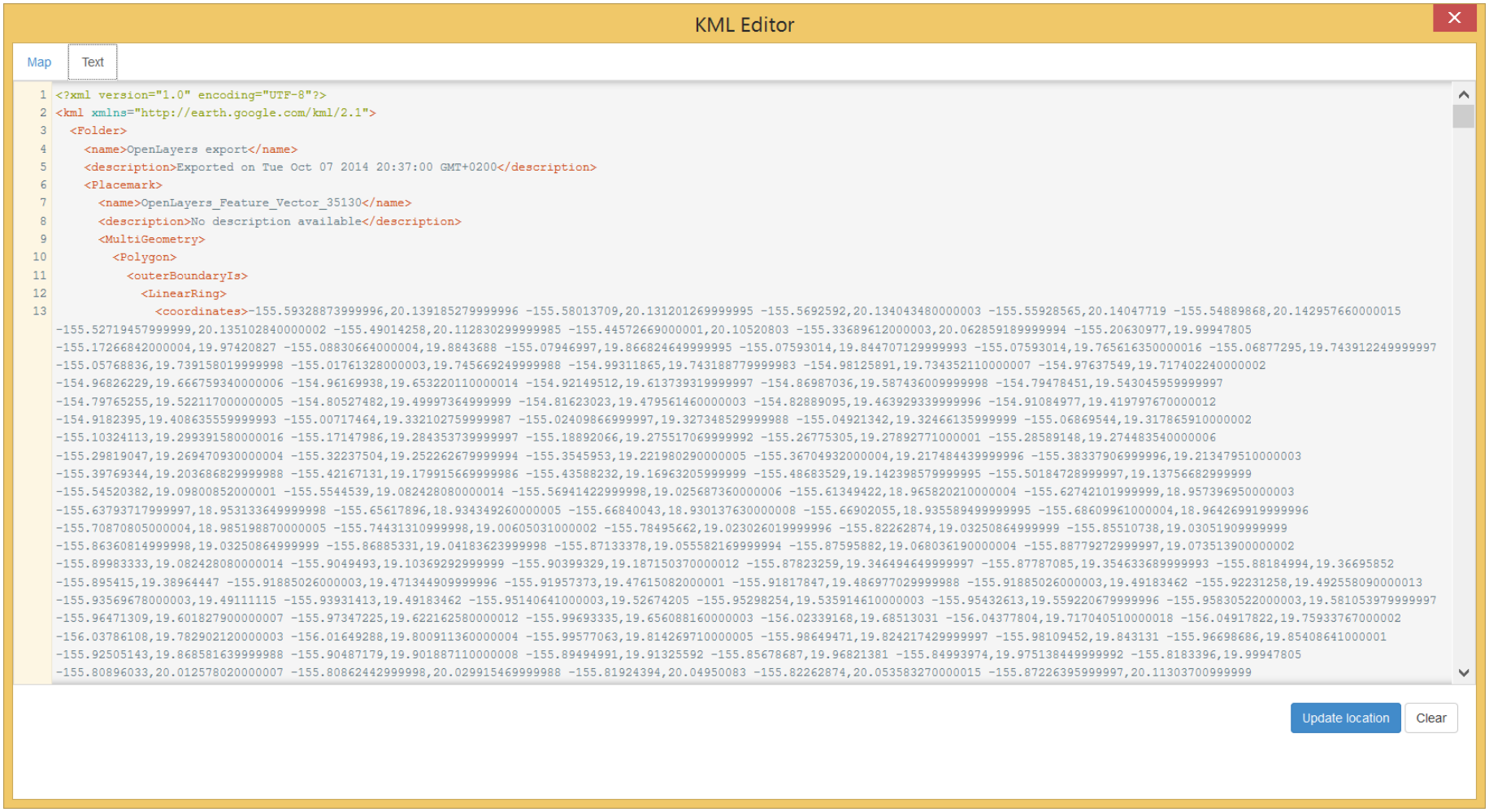
- KML data can be added to each location (polygons, lines, points):
  - Import of kmz/xml files with geographic data.
  - Write coordinates in the “Text editor”.
  - Draw the polygons, lines or points in the KML editor.



Extension of locations: KML editor (map)



Extension of locations: KML editor (text)



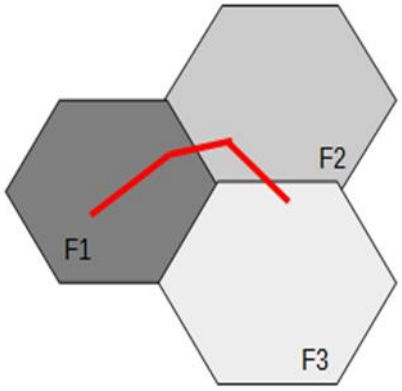
GreenDelta

Calculation framework

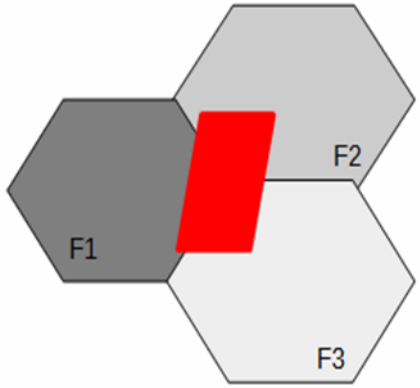
Linking of process locations and LCIA methods spatial units

- GeoTools libraries integrated in openLCA
  - The intersection between shapefiles features and process geometries is calculated.

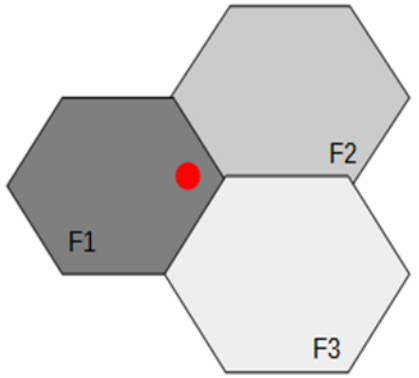
ed me or ea



$$\frac{\sum_{i=1}^{n}(p_{Fi} L_{Fi})}{\sum_{i=1}^{n} L_{Fi}} = p$$



$$\frac{\sum_{i=1}^{n}(p_{Fi} A_{Fi})}{\sum_{i=1}^{n} A_{Fi}} = p$$



$$p_{Fi} = p$$

GreenDelta

Calculation framework

Regionalised LCIA calculation

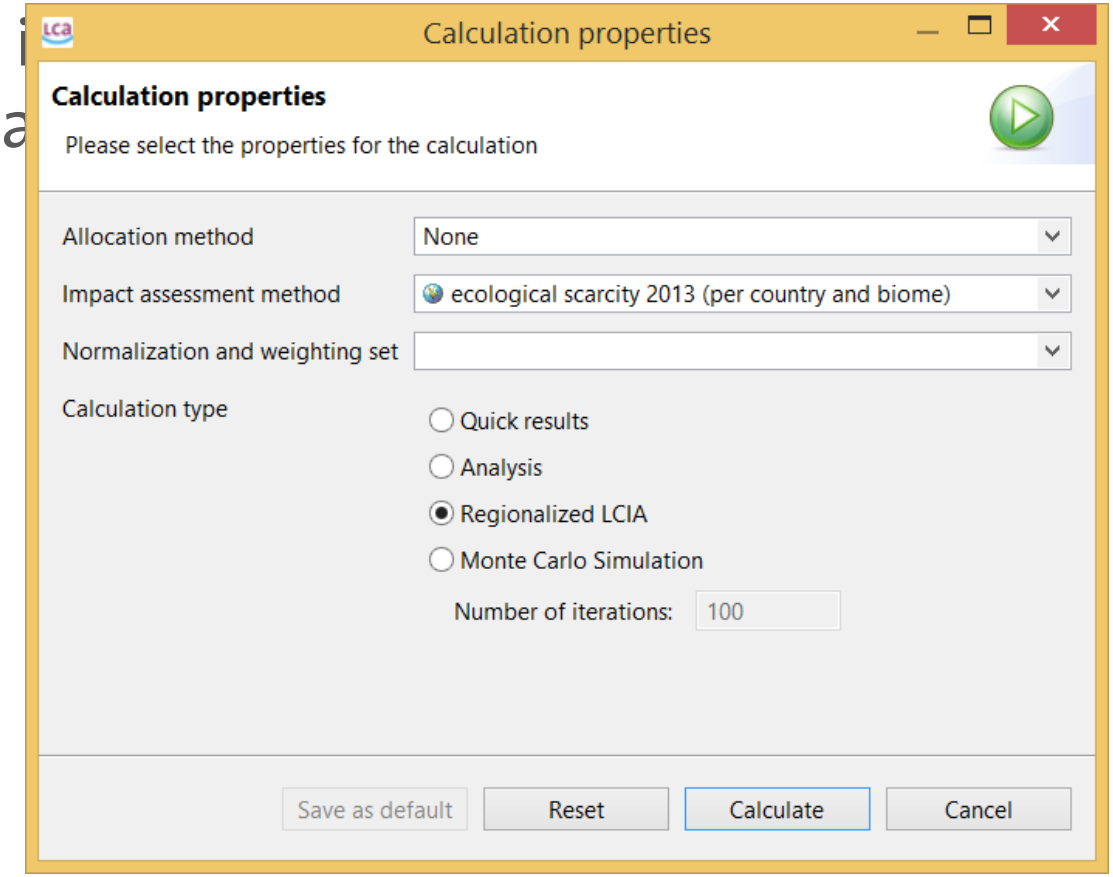
- Creation of a regionalised result matrix for the inventory (GR)
- Creation of a regionalised LCIA matrix (CR)
- Creation of the regionalised LCIA result (RR)

$$RR = CR * GR$$

Regionalised LCIA: Calculation procedure

- Select the “Regionalized LCIA” option in the calculation properties window:

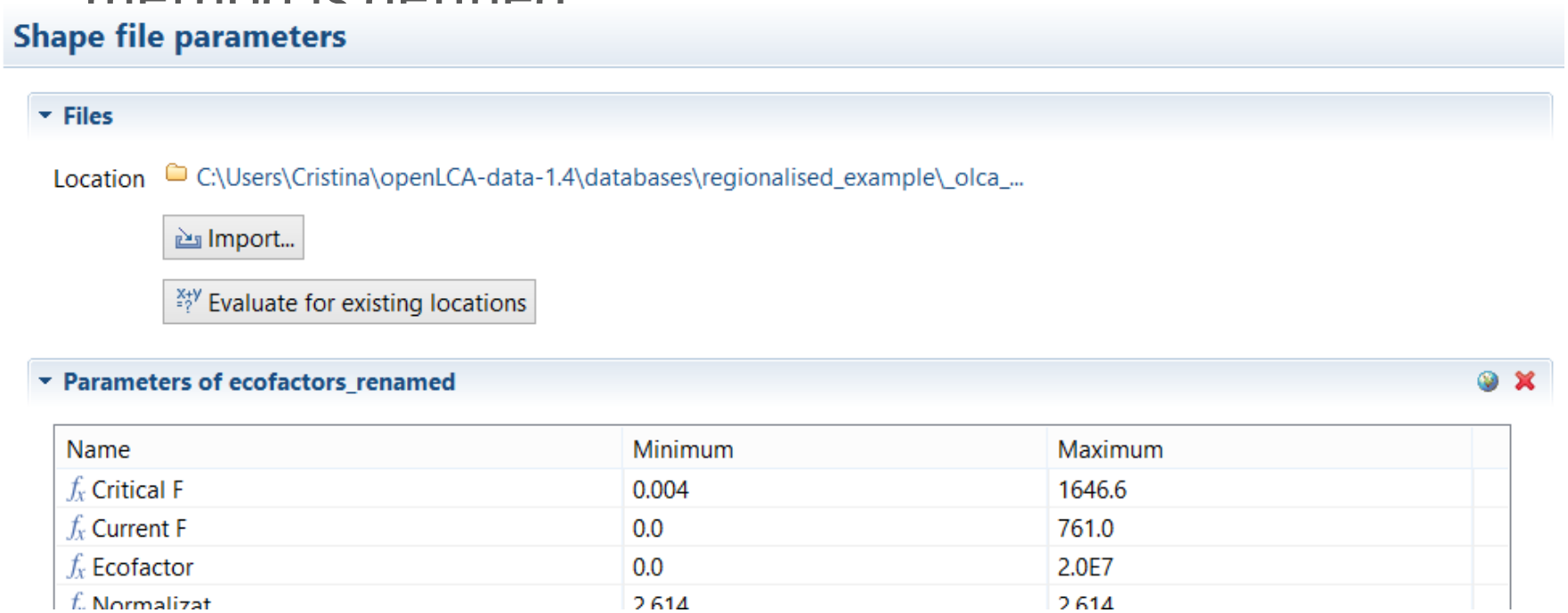
→ The i
regiona



GreenDelta

Regionalised LCIA: Calculation procedure

- To reduce the calculation time for complex systems, it is recommended to evaluate the intersections with the existing database locations when the impact method is defined.

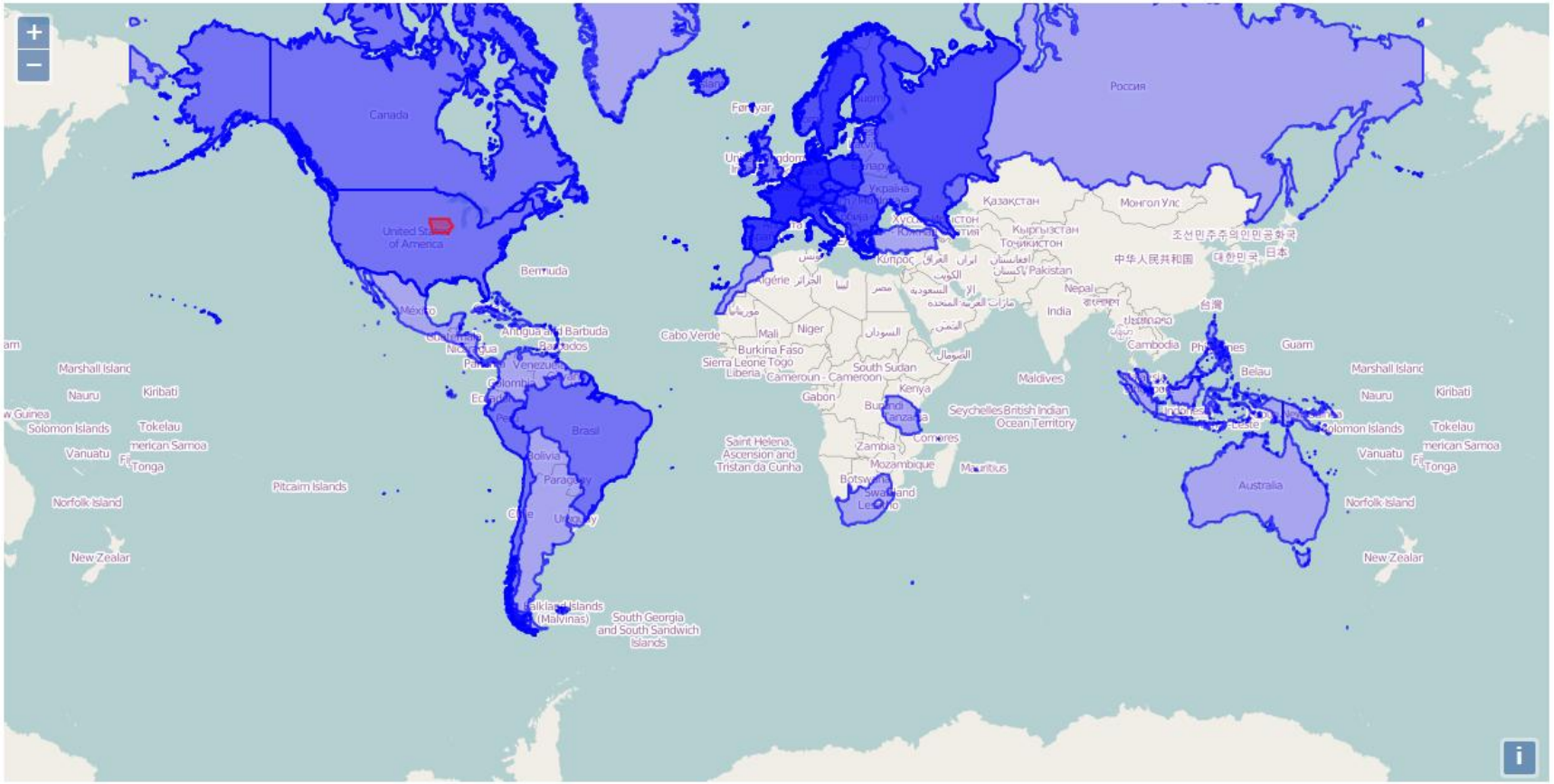


Regionalised LCIA: Results

Result map

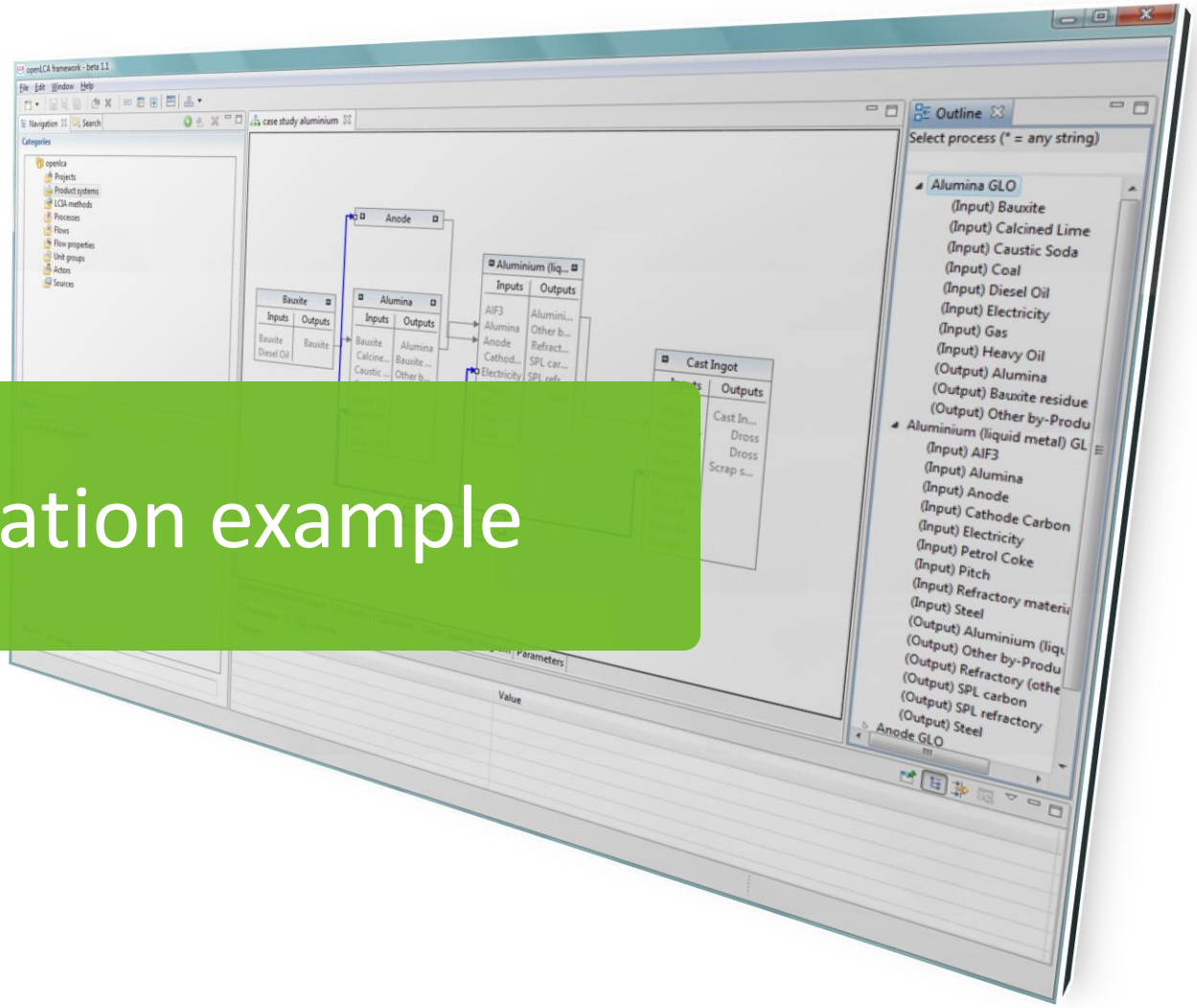
Flows — Hydrogen-3, Tritium - water/ocean

Impact categories — total - Land use



GreenDelta

Application example



GreenDelta

Case study

- Functional unit: Production of 1kg of corn grain, at harvest in 2005; at farm; 85%-91% moisture
- Production in 5 estates of US: Illinois, Iowa, Minnesota, Nebraska and North Dakota
- System boundaries: Cradle to farm-gate
- Foreground system:
  - USDA crop database
  - KML data: US Census Bureau
- Background system:
  - ecoinvent 2.2. unit processes, GaBi 2012 full US
  - KML data: ecoinvent 3 geographies

Regionalized impact category

- **Land use:**
  - de Baan et al. (2012), as implemented in Ecological Scarcity 2013:

$$Eco-factor^{\mathrm{Re}gion\_1} = K^{\mathrm{Re}gion\_1} \cdot \frac{1 \cdot UBP}{F_n^{CH}} \cdot \left(\frac{F}{F_k}\right)^2 \cdot c$$

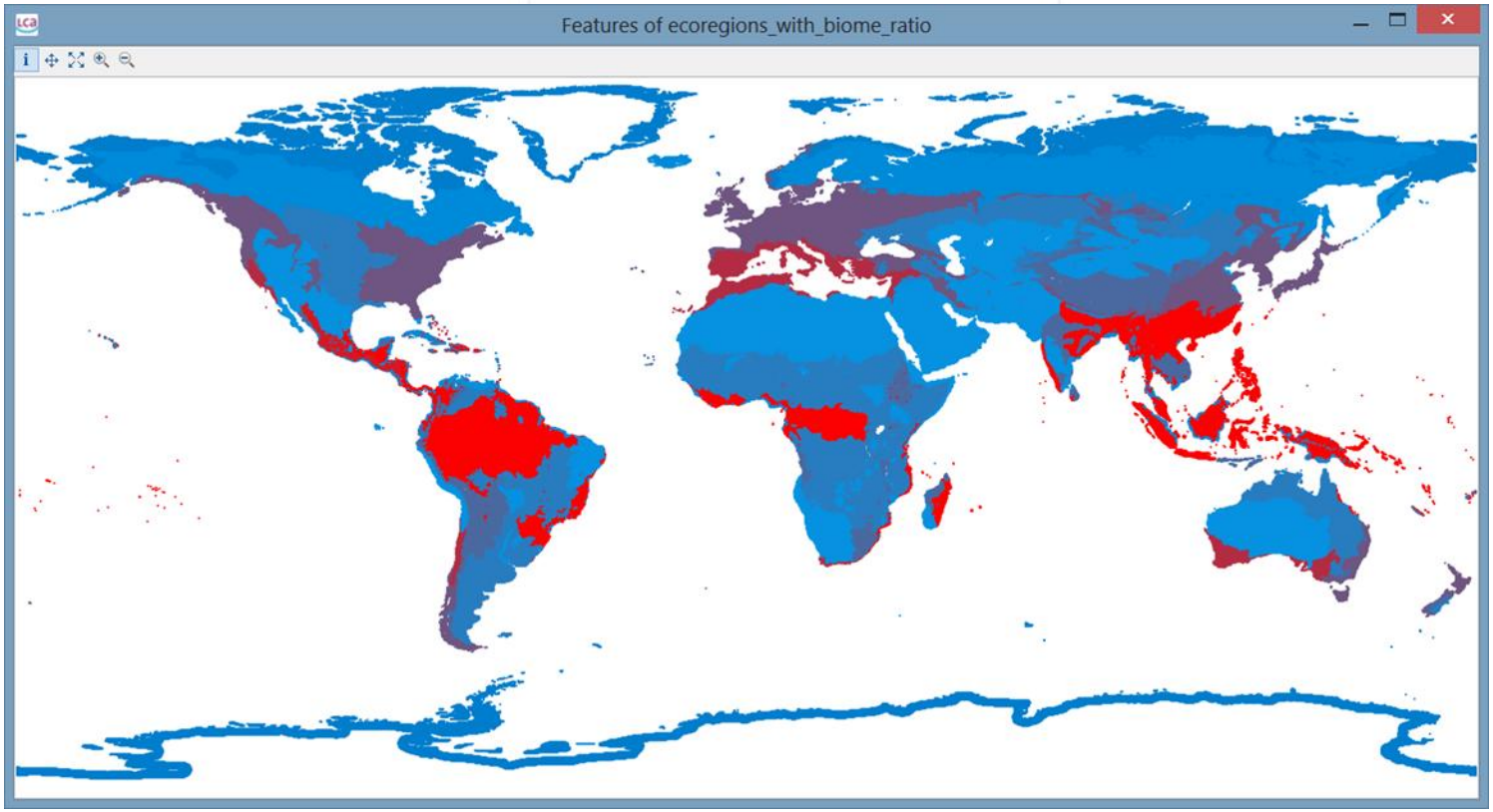
Regionalized parameter

$$K^{biome\_i} = \frac{BDP^{biome\_i}}{BDP\_settlement\_area\_biome5} = \frac{BDP^{biome5} \cdot ratio^{biome\_i}\_to\_biome5}{BDP\_settlement\_area\_biome5}$$

Land use regionalized parameter

Parameters of ecoregions_with_biome_ratio

Name	Minimum	Maximum
f_x CLS_CODE	0.0	1144.0
f_x ECO_ID_U	10000.0	17109.0
f_x ECO_NUM	1.0	99.0
f_x ratio_biom	0.20929077	1.96750671



Land use parameterized formulas

Impact factors

Impact category: Land use

Flow	Category	Flow property	Unit	Factor	Uncertainty
Occupation, arable	resource/land	Area*time	m2*a	(0.60*ratio_biom)/SA_CF	lognormal: gmean=1.36 g...
Occupation, construction site	resource/land	Area*time	m2*a	(0.44*ratio_biom)/SA_CF	lognormal: gmean=1.00 g...
Occupation, forest, intensive	resource/land	Area*time	m2*a	(0.04*ratio_biom)/SA_CF	lognormal: gmean=9.09E-...
Occupation, forest, intensive, clear-c...	resource/land	Area*time	m2*a	(0.18*ratio_biom)/SA_CF	lognormal: gmean=0.41 g...

Parameters

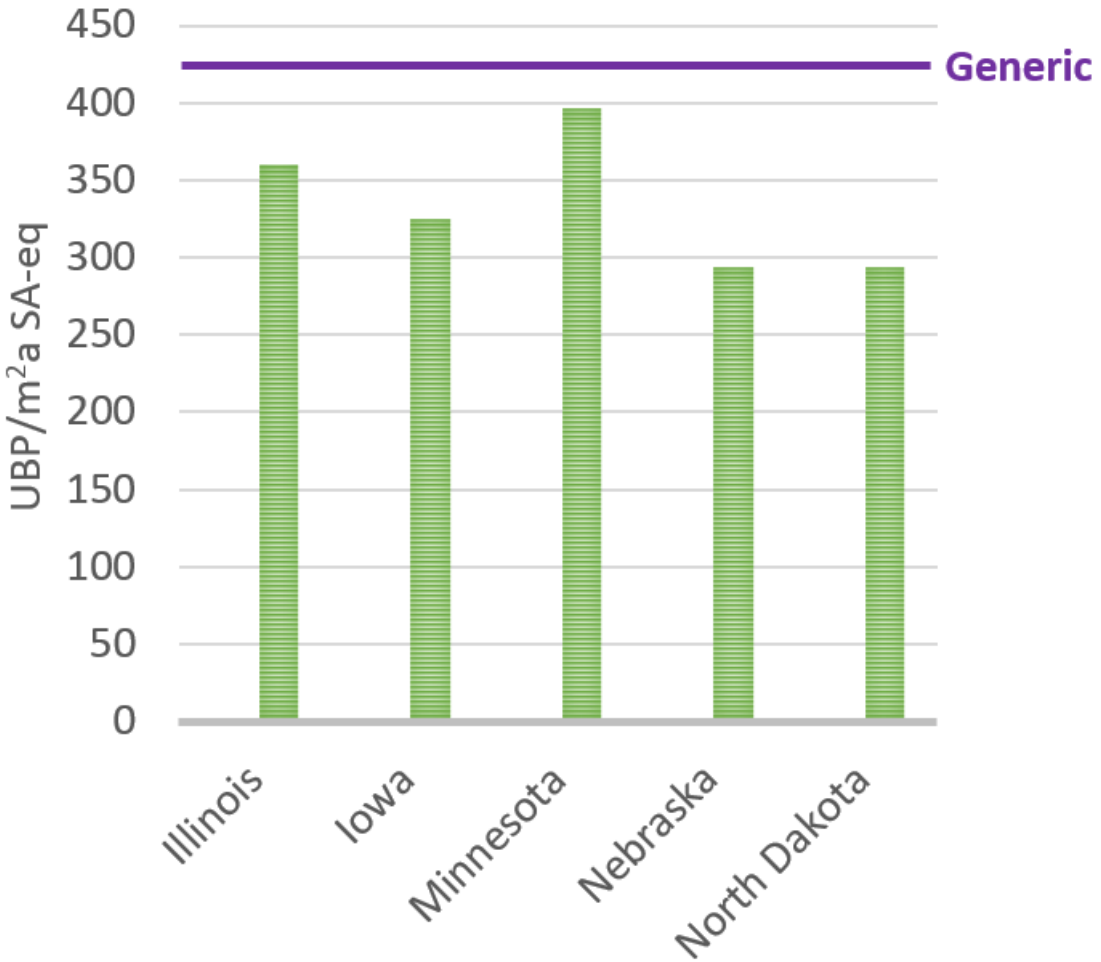
Global parameters

Input parameters

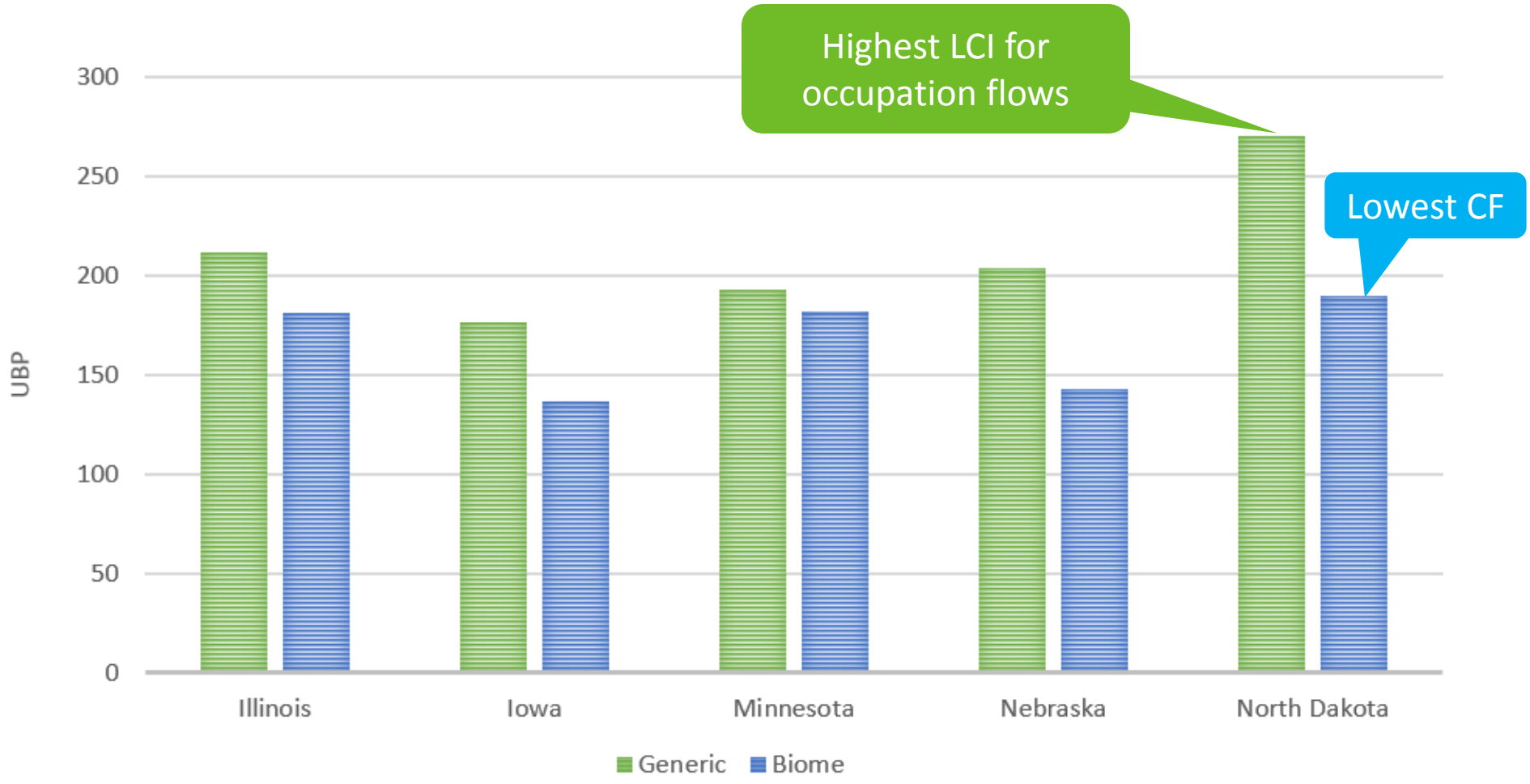
Name	Value	Uncertainty	Description
ratio_biom	1.0	uniform: min=0.21 max=1.97	from shapefile: ecoregions_with_biome_ratio
SA_CF	0.44	none	Settlement Area Characterization Factor
SA_EF	300.0	none	Settlement Area Ecofactor

Regionalized characterization factors

- Eco-factor for land use (Occupation, arable)

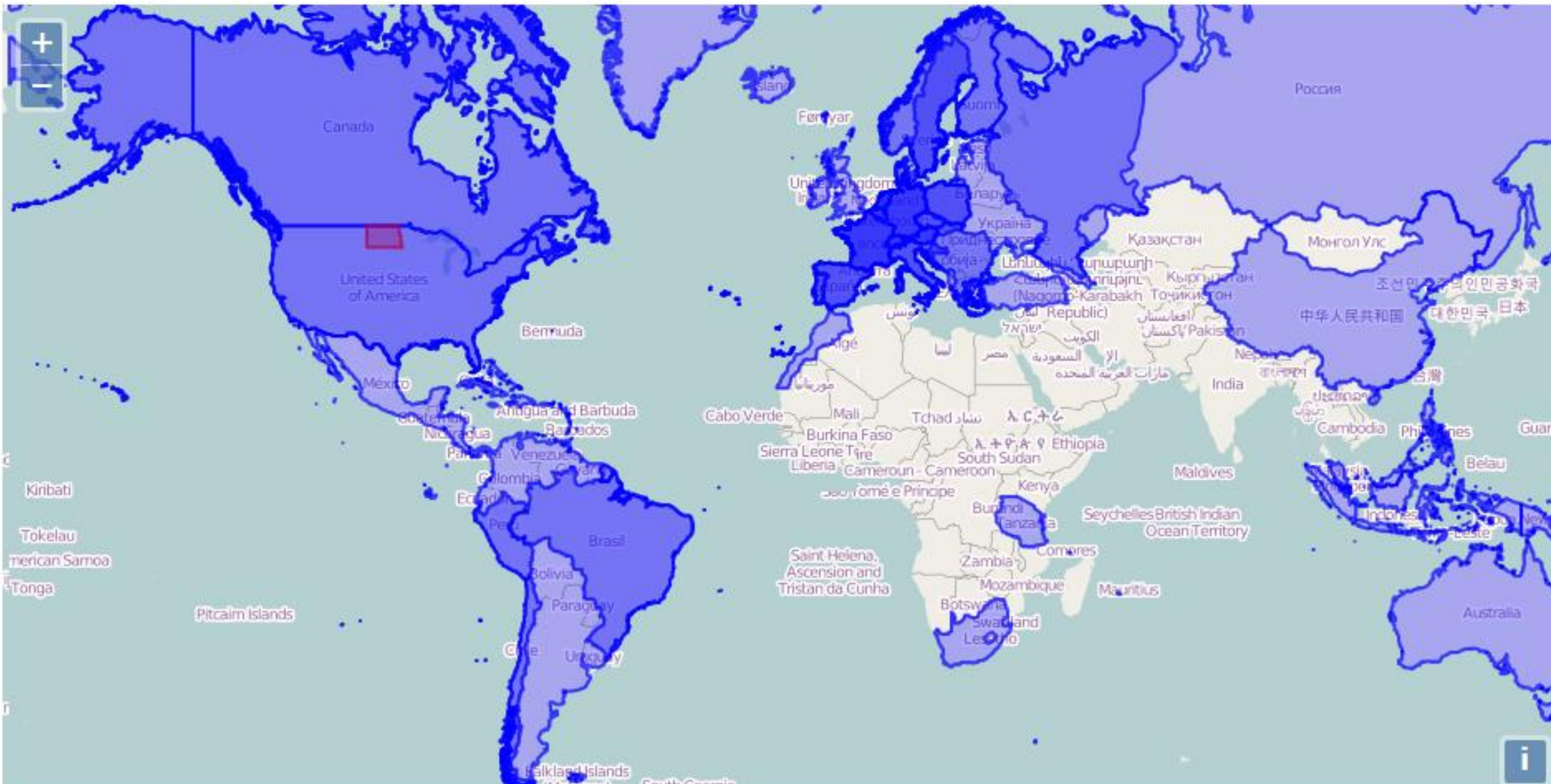


LCIA results: land use



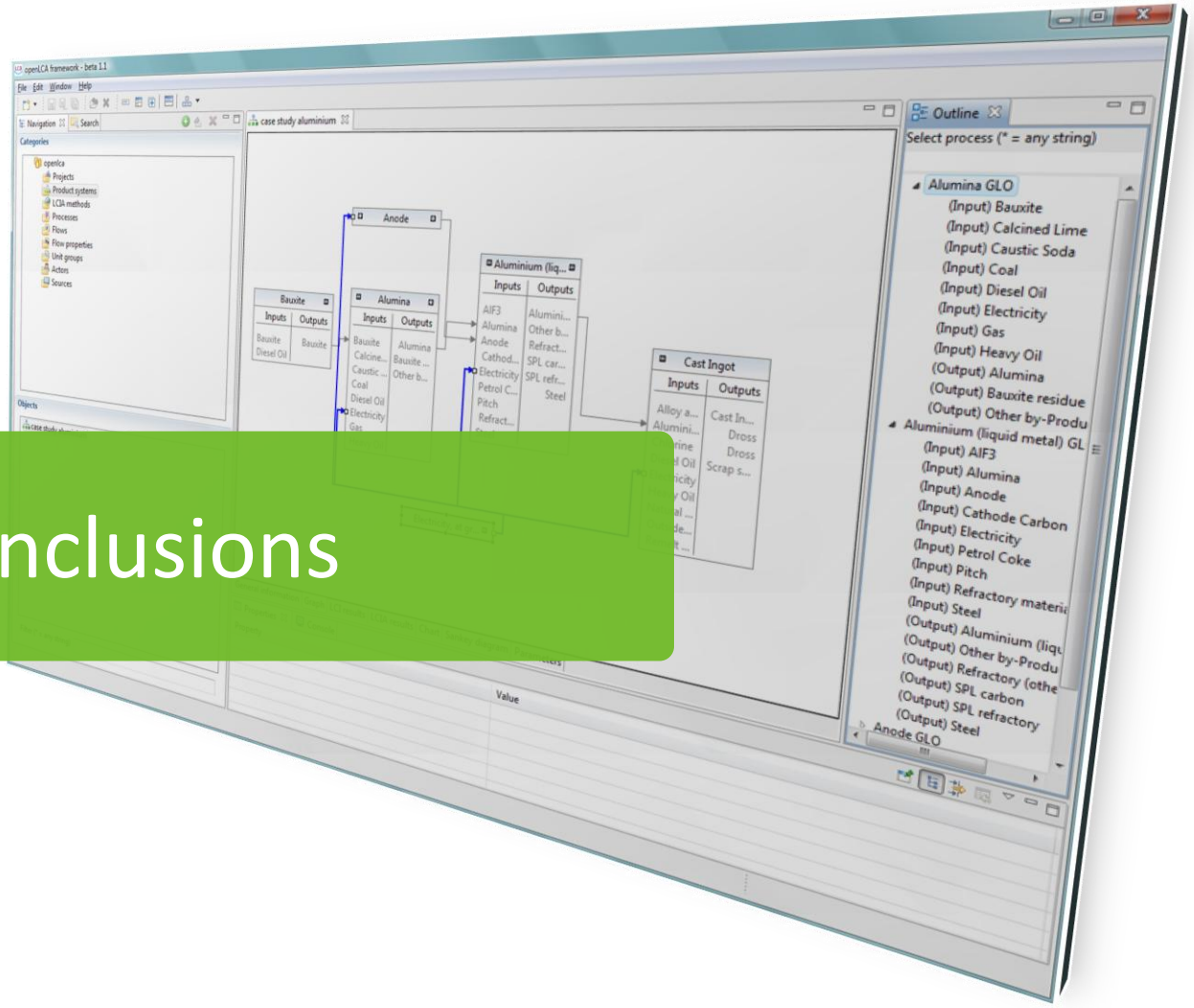
LCIA results: land use

Impact categories — total - Land use



Results for North Dakota

Conclusions



GreenDelta

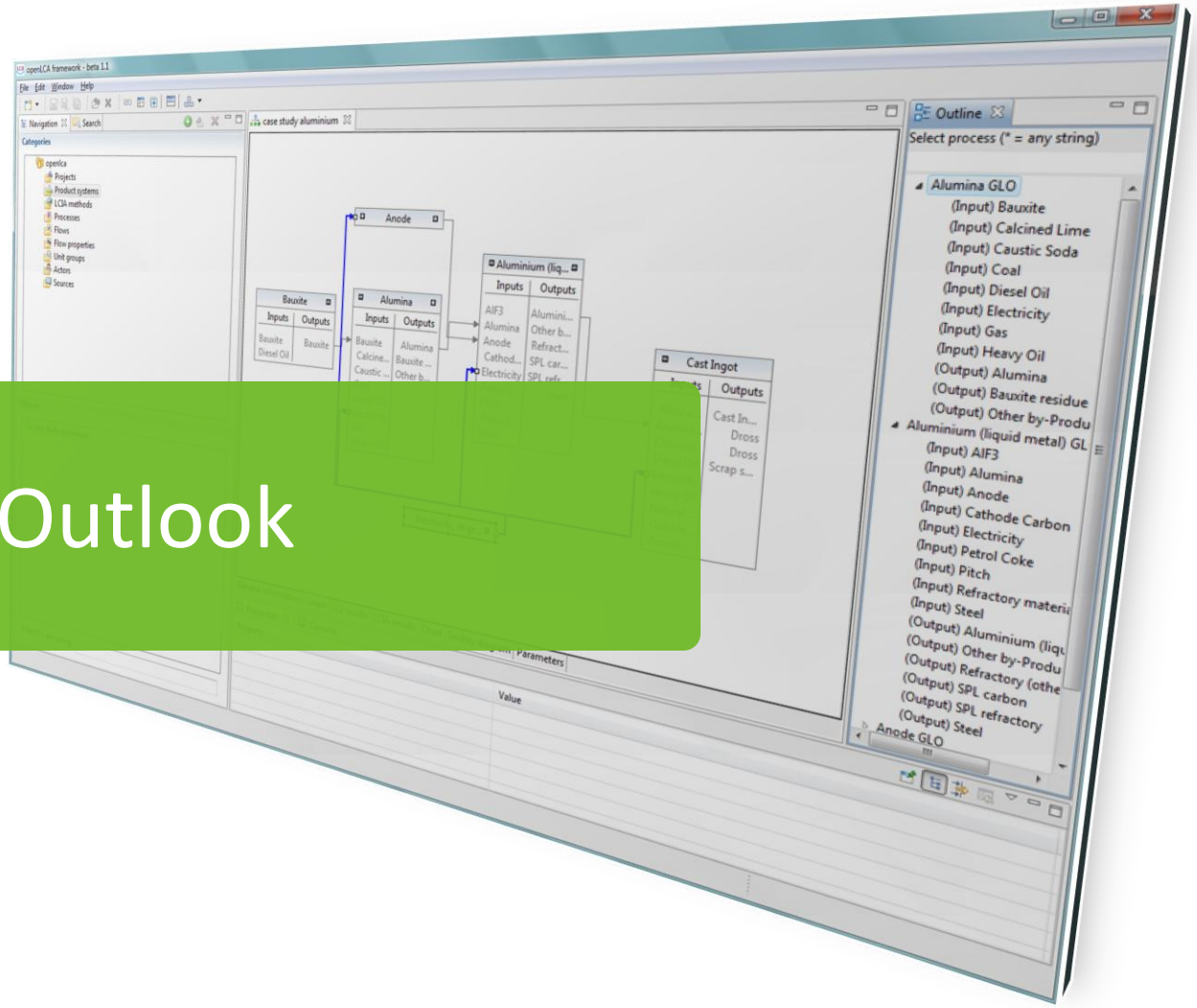
Conclusions

- Regionalized LCIA in openLCA works successfully without affecting significantly the calculation time required
- High variations in results due to different inventory and different characterization factors between locations

  → Added complexity to results interpretation
- The most suitable spatial resolution per parameter should be defined
- Weighted aggregations might be useful for avoiding misleading values (e.g. emission proxies)

GreenDelta

Outlook



GreenDelta

Future software development

- Regionalized LCIA implementation in the Project level (i.e. comparative analysis)
- Further results views (e.g. contributions per location, etc.)
- Background processes tag: avoid data sets from generic databases when performing a regionalized LCIA

Other ideas

- Geographic distributions of the processes when determining the location of each activity
- Consider geographic uncertainty per data set exchange and LCIA CF
- Include transport pathways of emissions
- Seasonal variations of regional parameters

Thank you!

GreenDelta
sustainability consulting + software

Cristina Rodríguez
GreenDelta GmbH
Muellerstrasse 135, 13349 Berlin
rodriguez@greendelta.com
www.greendelta.com