GreenDelta
sustainability consulting + software

Regionalized LCIA – new software implementation and agricultural case study

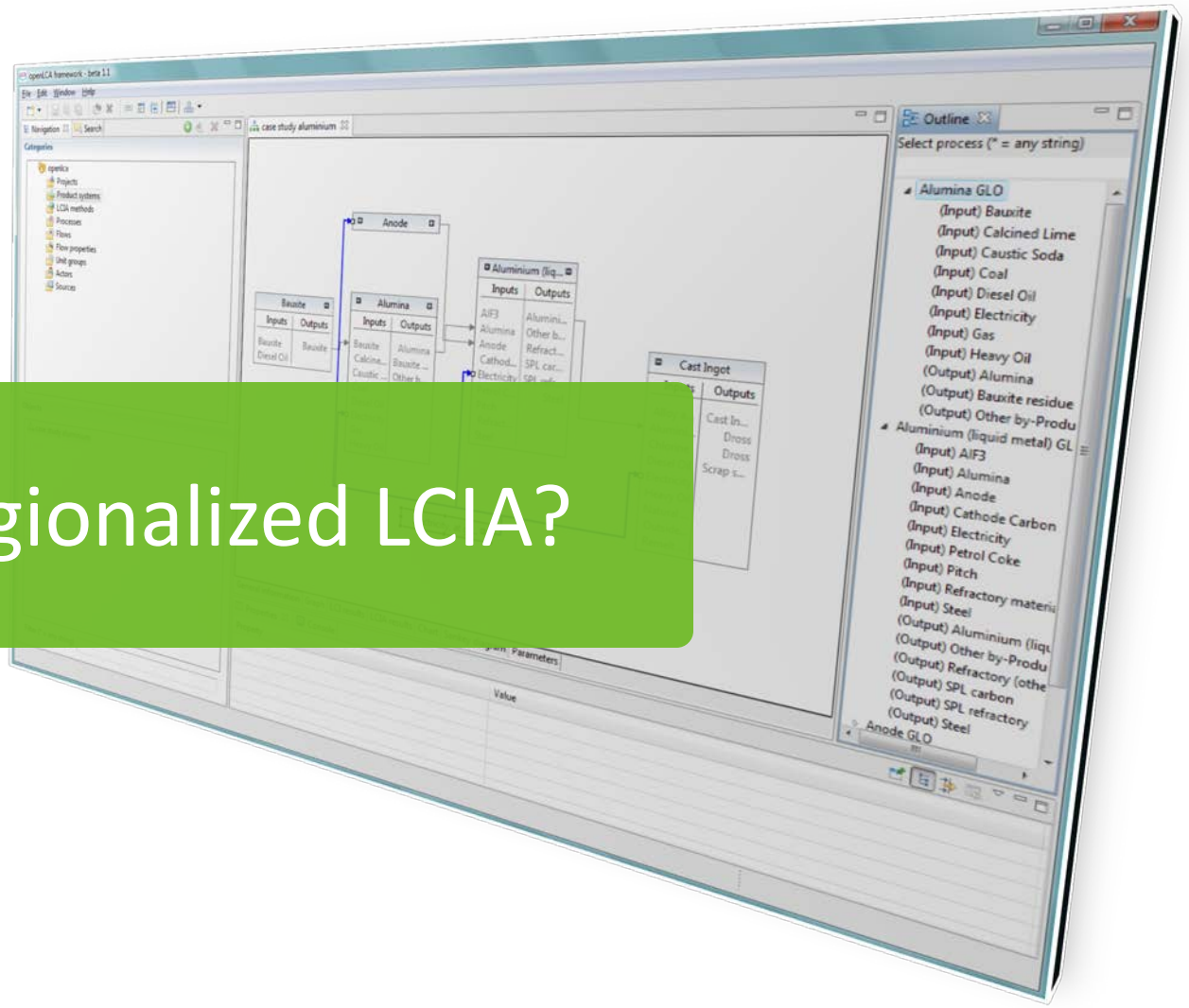
Cristina Rodríguez, Andreas Ciroth, Michael Srocka
GreenDelta GmbH

October 8, 2014
San Francisco, USA

Content

- Importance of regionalized LCIA in agriculture
- Software enhancement:
  - Process locations extension
  - New approach for LCIA methods
  - Calculation framework
- Case study: corn production in USA
- Conclusions
- Outlook

Why regionalized LCIA?



GreenDeLTa

Importance of regionalized LCA in agriculture

LCI:

- Wide variety of farming systems

  e.g. USDA crop database

LCIA:

- Commonly analysed impact categories: land use, abiotic resource depletion, eutrophication, climate change, etc.

  → Characterization factors (CFs) depend on site-specific characteristics:

  - Climate, soil type, water availability, soil erosion, etc.

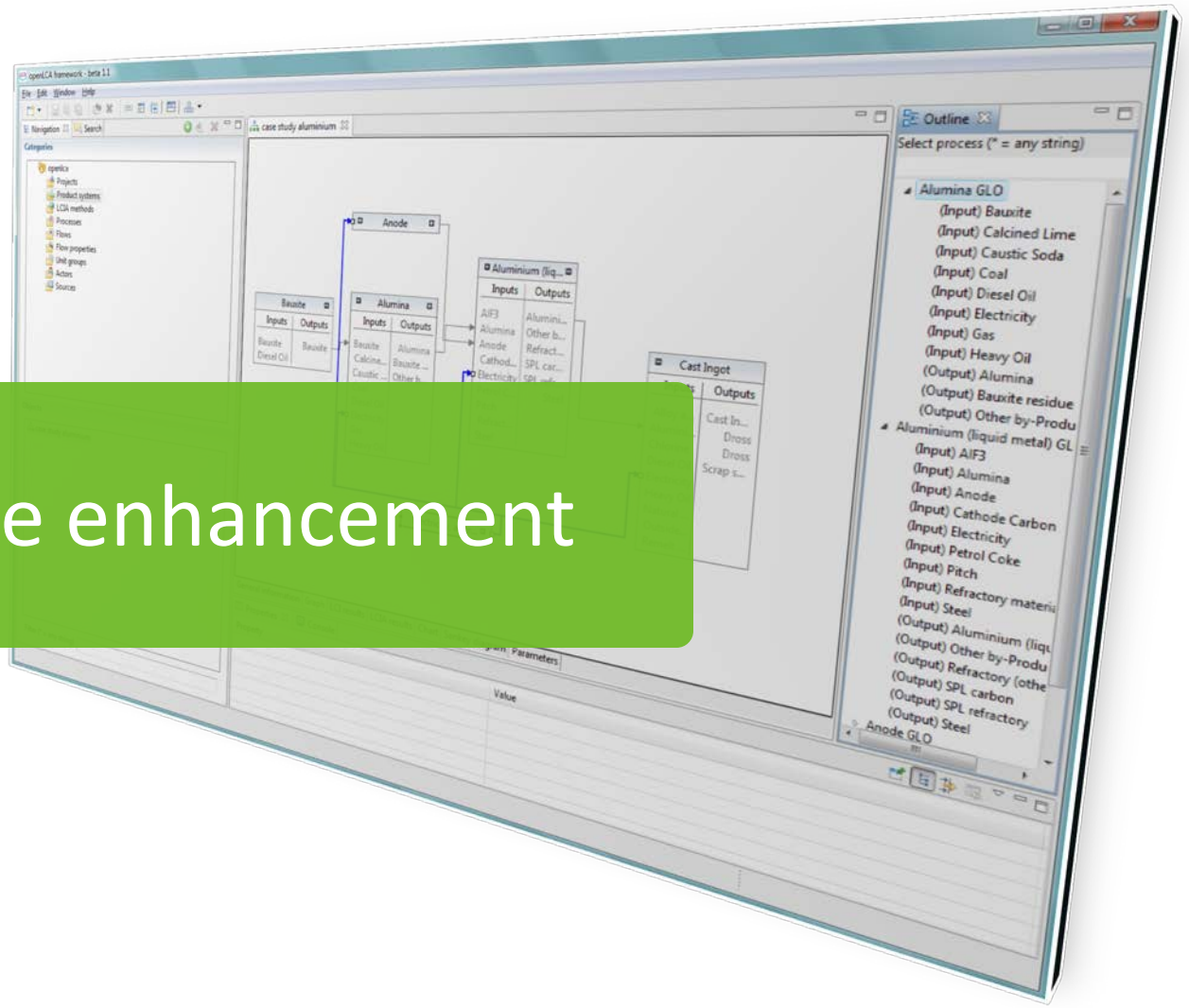
Regional variation in impact assessment

- Withdrawal of 1l of water for agriculture

source: dennis140, aloe vera plantage, Fuerteventura (left); Gario, cows meadow, Texel (right)

GreenDelta

Software enhancement



GreenDeLTa

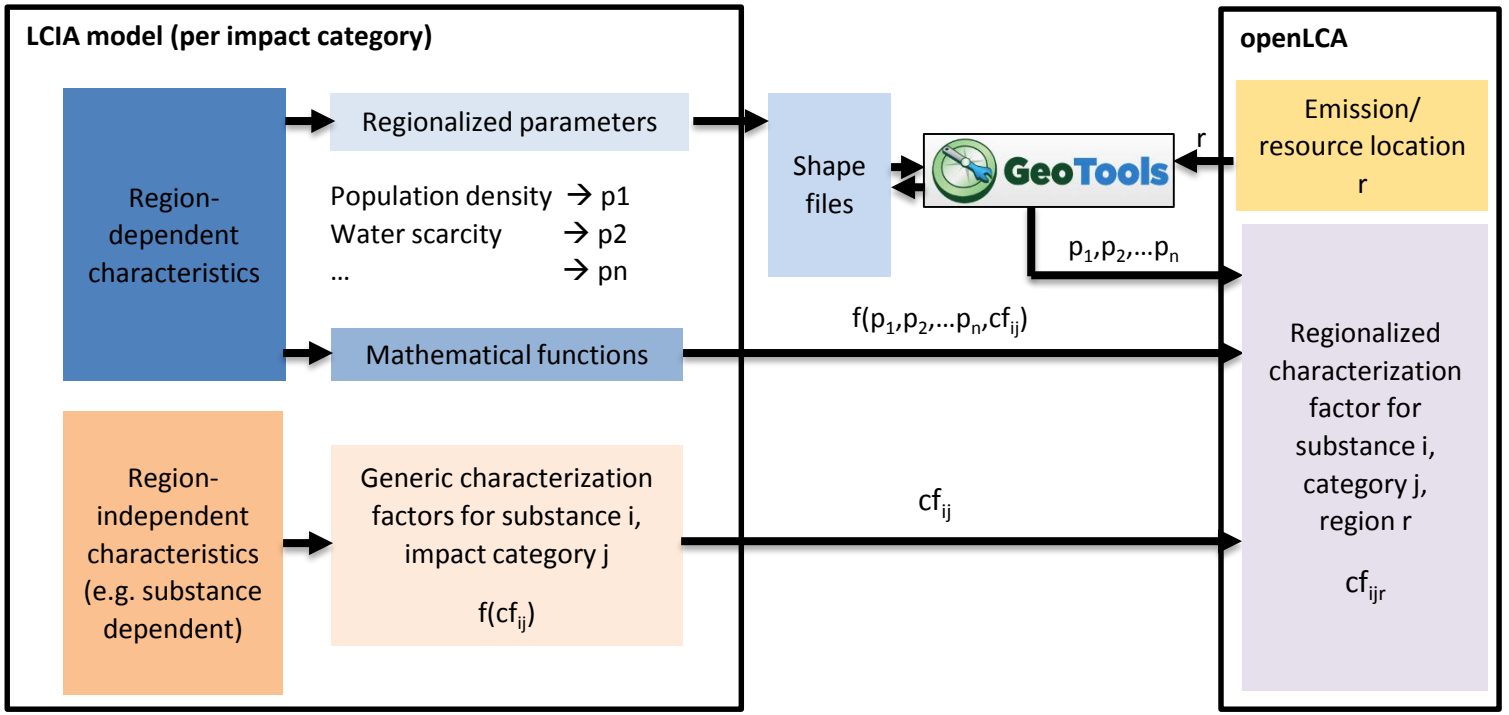
Software: openLCA

- 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

Regionalised LCIA methods in openLCA

- Idea:

  → Parameterization of LCIA methods



Parameterization of LCIA methods

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

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

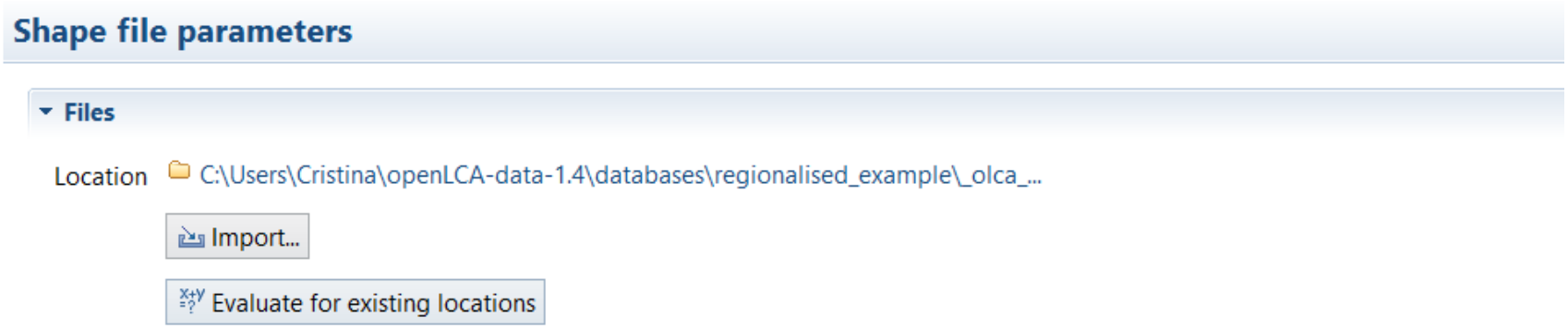
Name	Value	Uncertainty	Description
ratio_biom	1.0	uniform: min=0.21 max=1.97	from shapefile: ecoregions_with_biome_ratio
SA_CF	0.44	none	Settlement Area Characterization Factor
SA_EF	300.0	none	Settlement Area Ecofactor

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
- Shapefiles are stored in the database

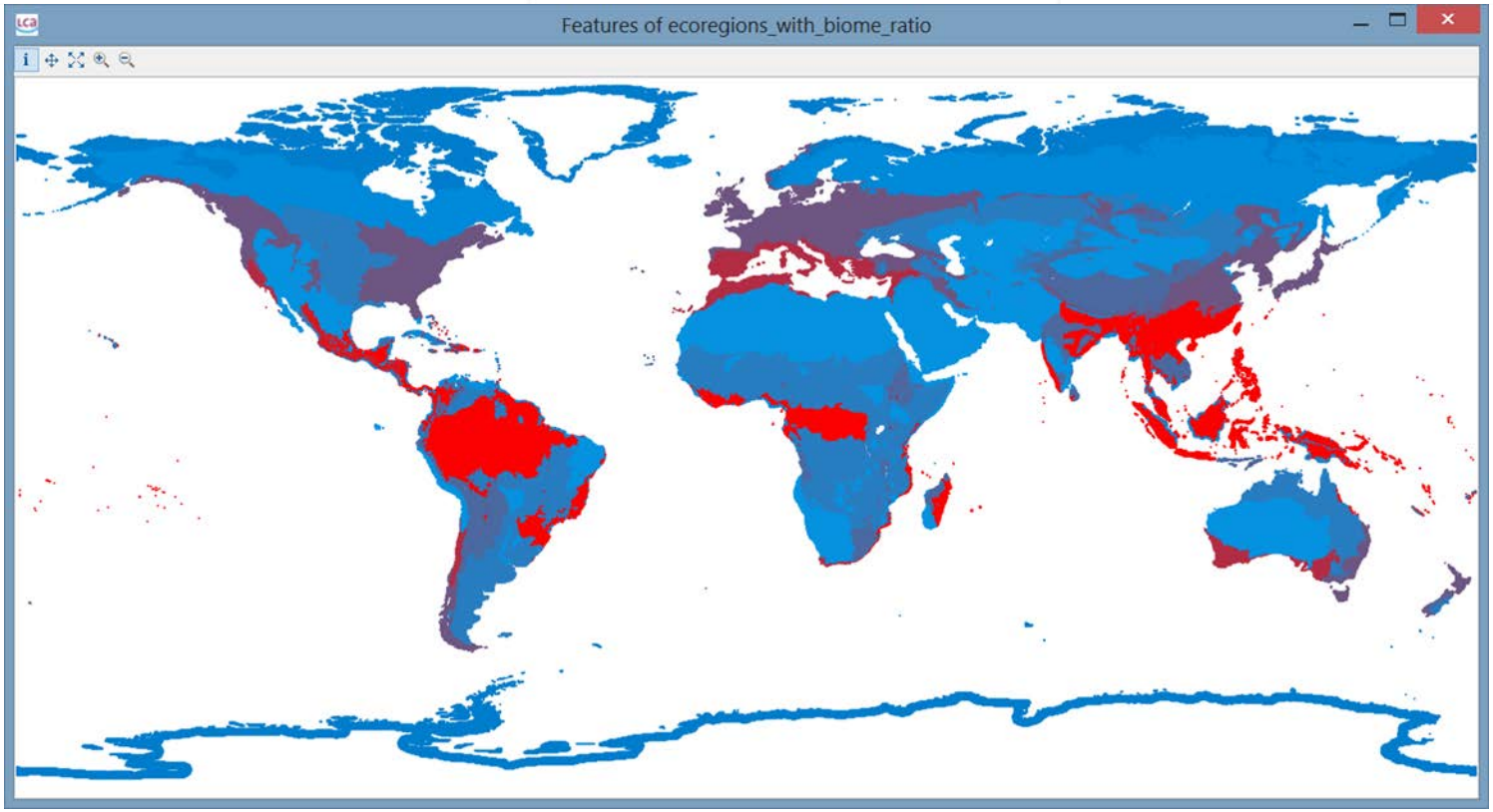


GreenDeLTa

Shapefiles containing regional characteristics

Parameters of ecoregions_with_biome_ratio

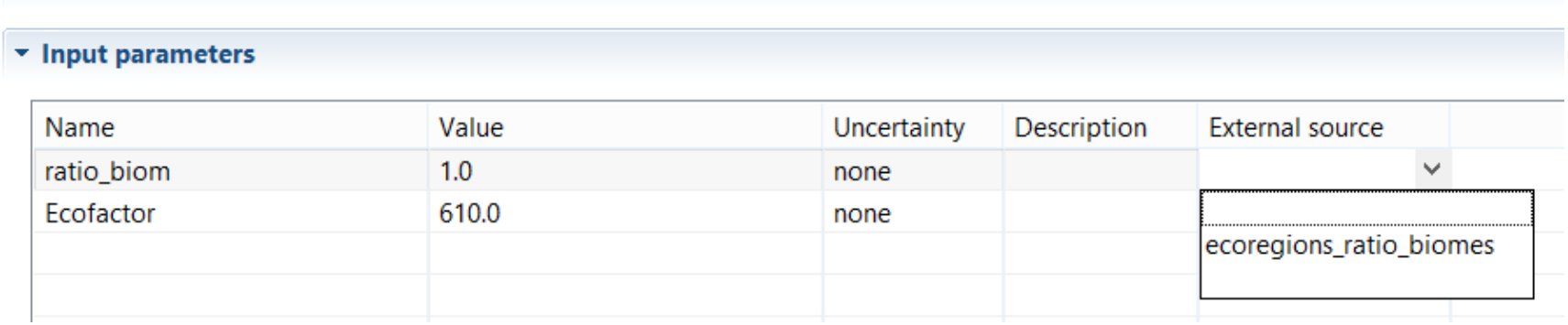
Name	Minimum	Maximum
CLS_CODE	0.0	1144.0
ECO_ID_U	10000.0	17109.0
ECO_NUM	1.0	99.0
ratio_biom	0.20929077	1.96750671



GreenDelta

Binding shapefiles and LCIA method parameters

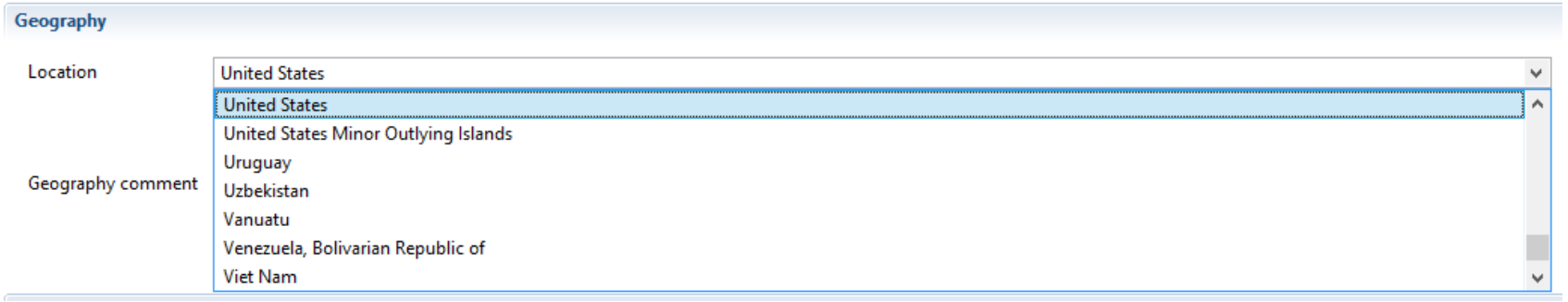
- Parameters of shapefiles can be bound to input parameters
- Default value of parameters is used for normal calculations and formula evaluation
- In regionalized assessment the parameter value derived from the shapefile is used for the formula evaluation



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 countries (e.g. UCTE, EU, etc.)

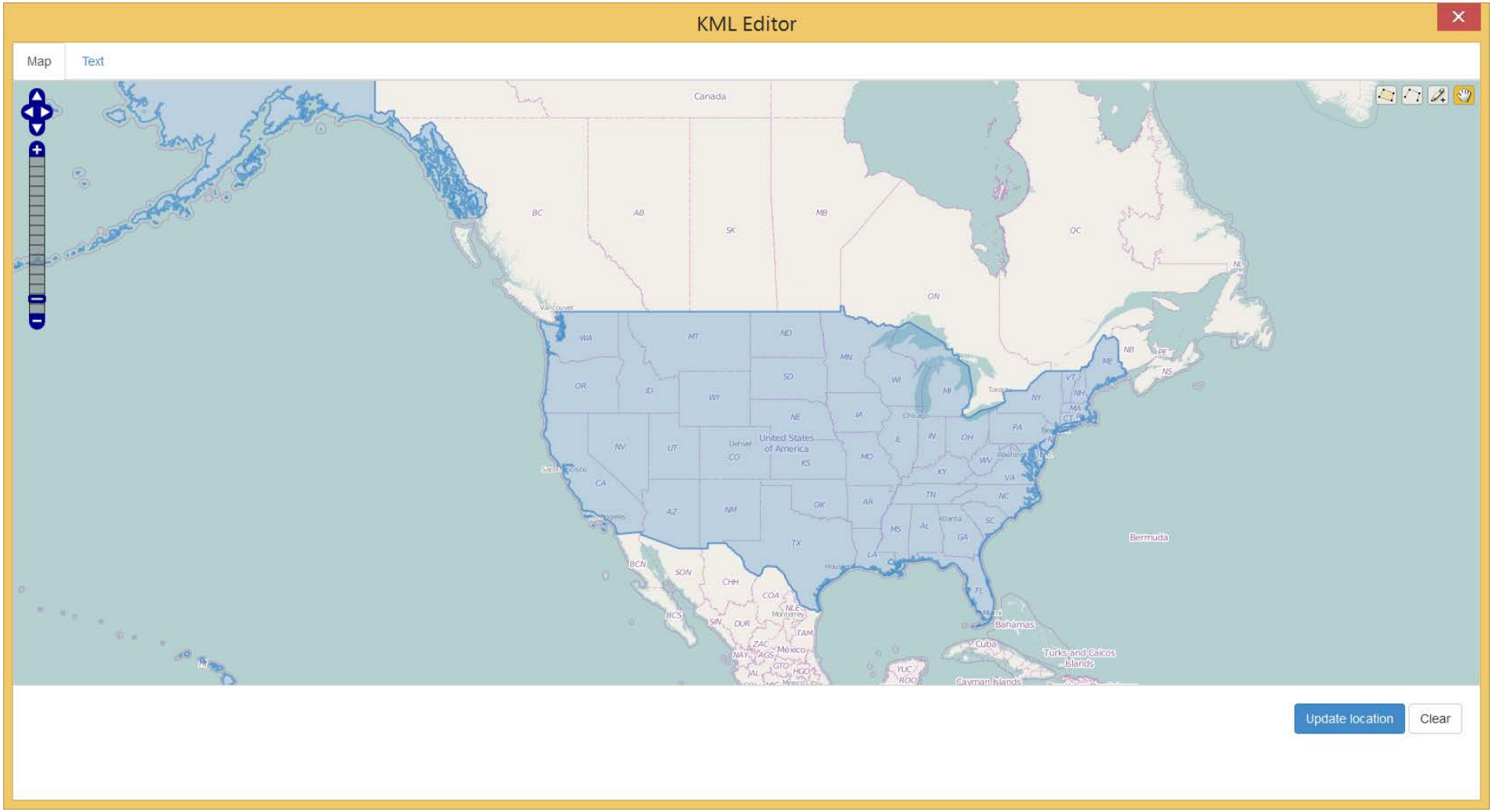


Extension of locations in openLCA (II)

New approach:

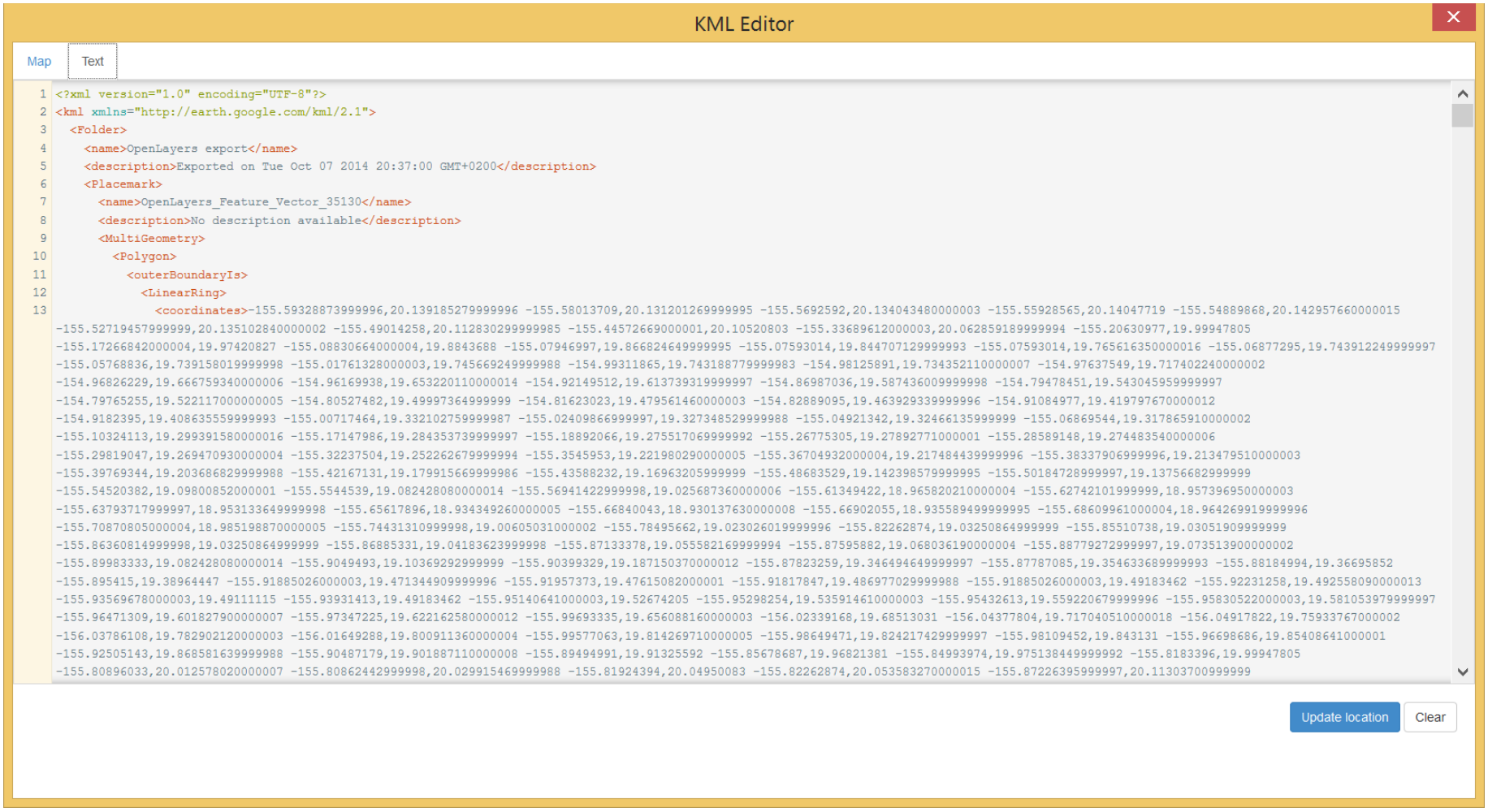
- KML data can be added to each location (polygons, lines, points):
  - Import of kmz/xml files with geographic data.
  - Write coordinates in the "Text editor".
  - Draw the polygons, lines or points in the KML editor.
- New locations can be defined in the process editor.

Extension of locations: KML editor (map)



GreenDelta

Extension of locations: KML editor (text)



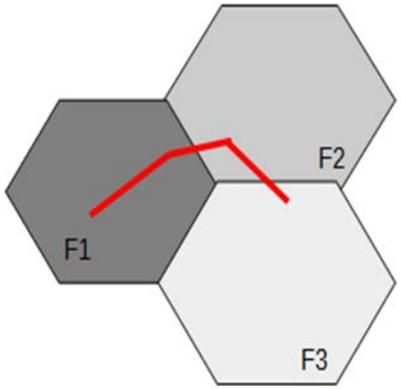
GreenDelta

Calculation framework

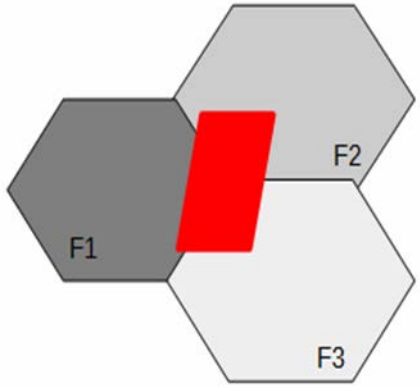
Linking of process locations and LCIA methods spatial units

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

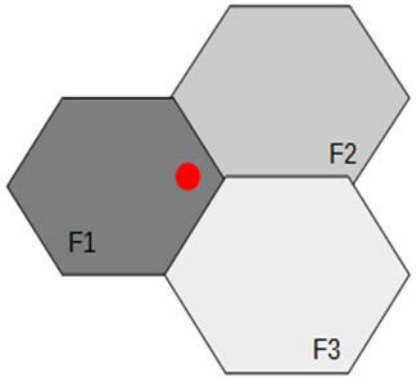
→A weighted mean calculated for each regional parameter



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



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



$$p_{Fi} = p$$

GreenDeLTa

Calculation framework

Regionalised LCIA calculation

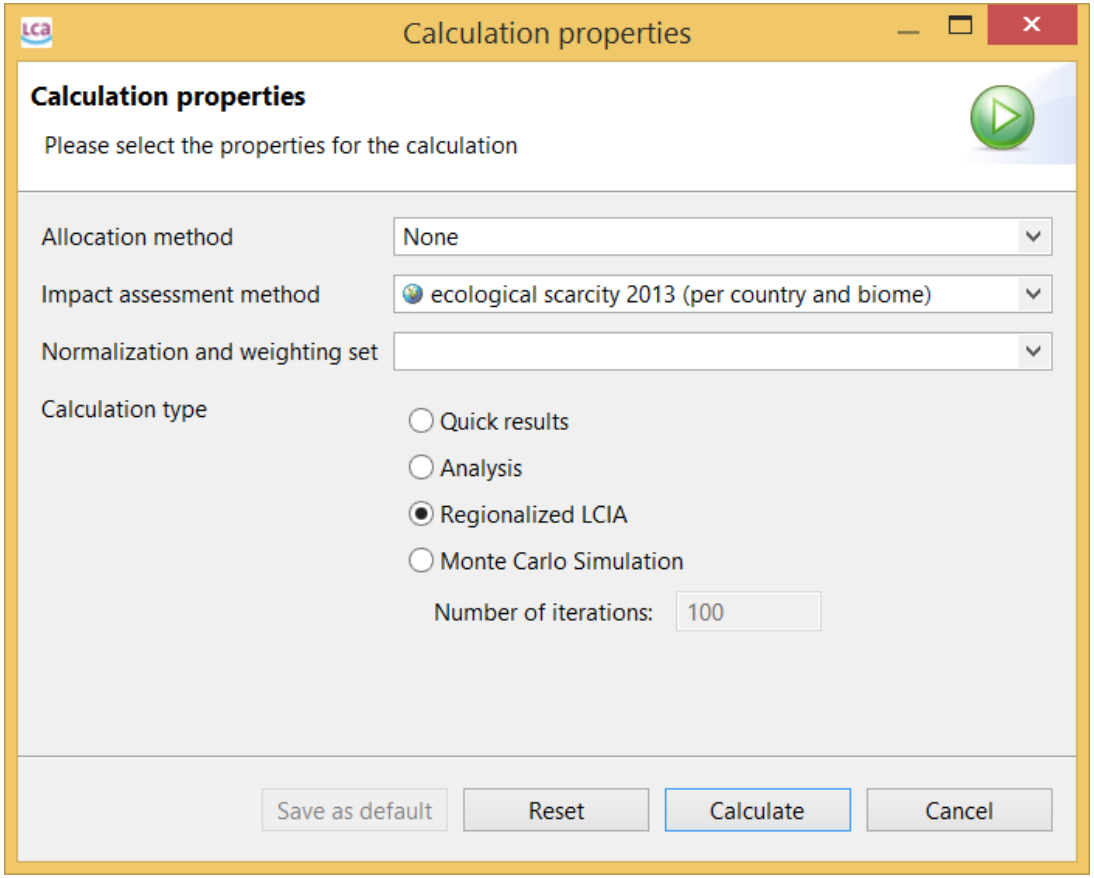
- Creation of a regionalised result matrix for the inventory (GR)
- Creation of a regionalised LCIA matrix (CR)
- Creation of the regionalised LCIA result (RR)

$$RR = CR * GR$$

Regionalised LCIA: Calculation procedure

- Select the "Regionalized LCIA" option in the calculation properties window:

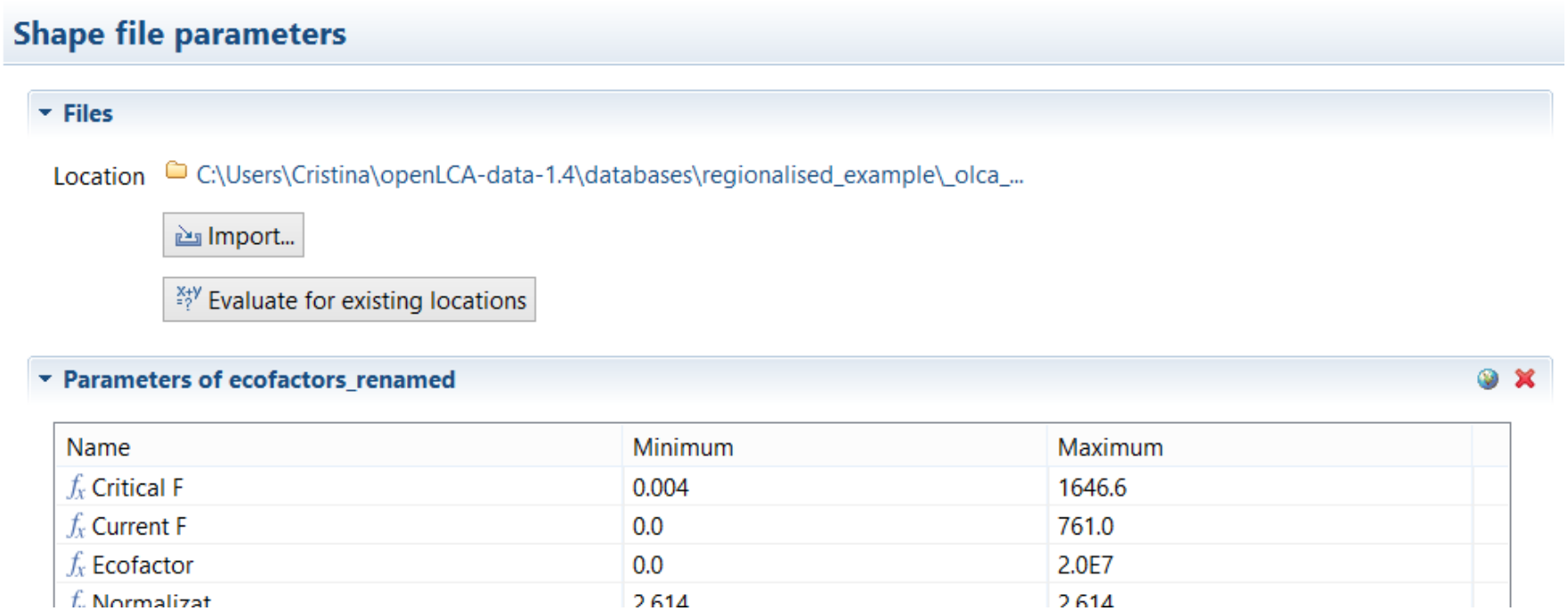
→ The impact method select must contain regionalised impact factors



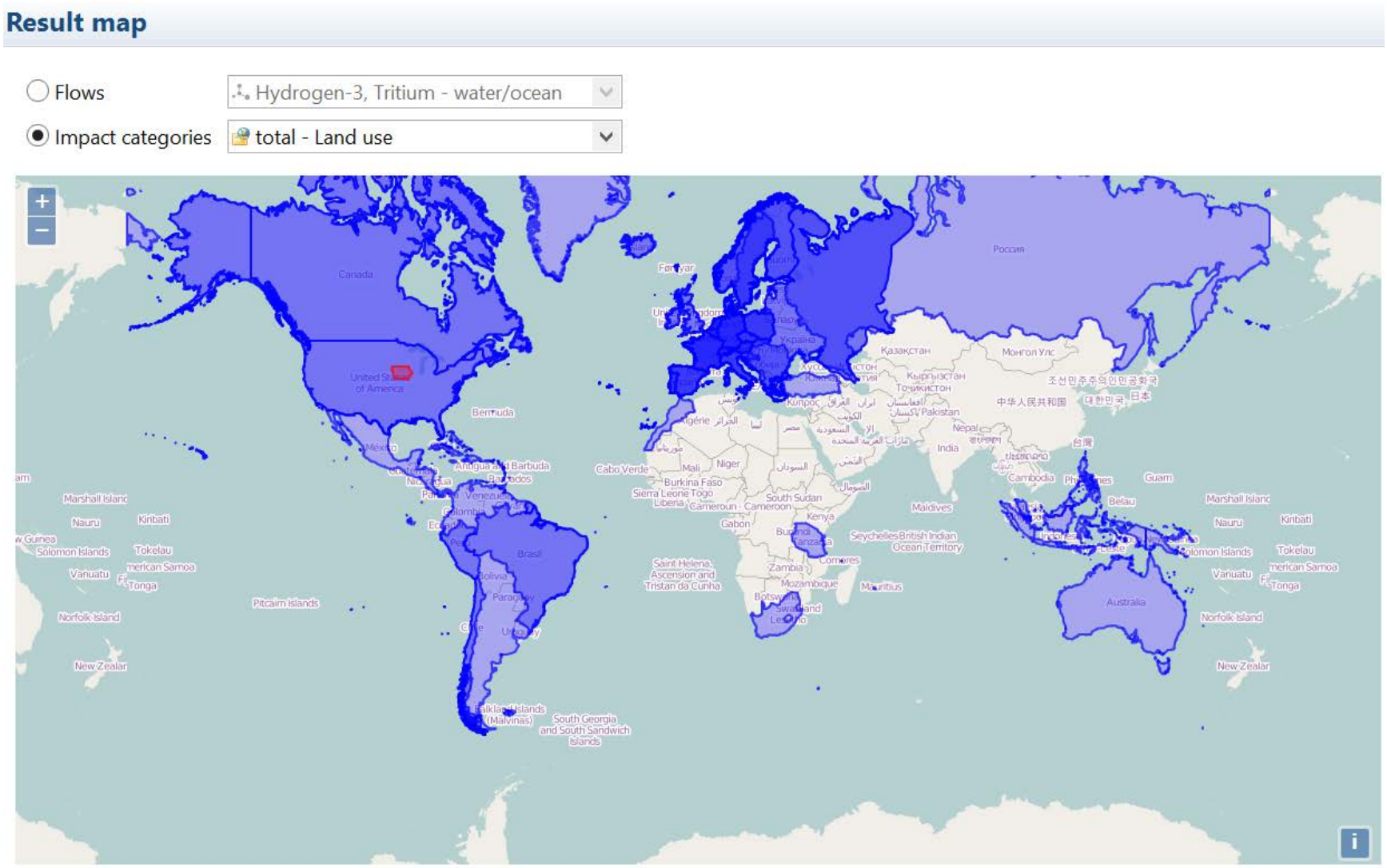
GreenDelta

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



GreenDelta

Case study: corn production in USA

GreenDeLTa

Scope

- 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 categories

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

  Parameter: Ratio of species densities of biomes 1 to 4 to species density in biome 5

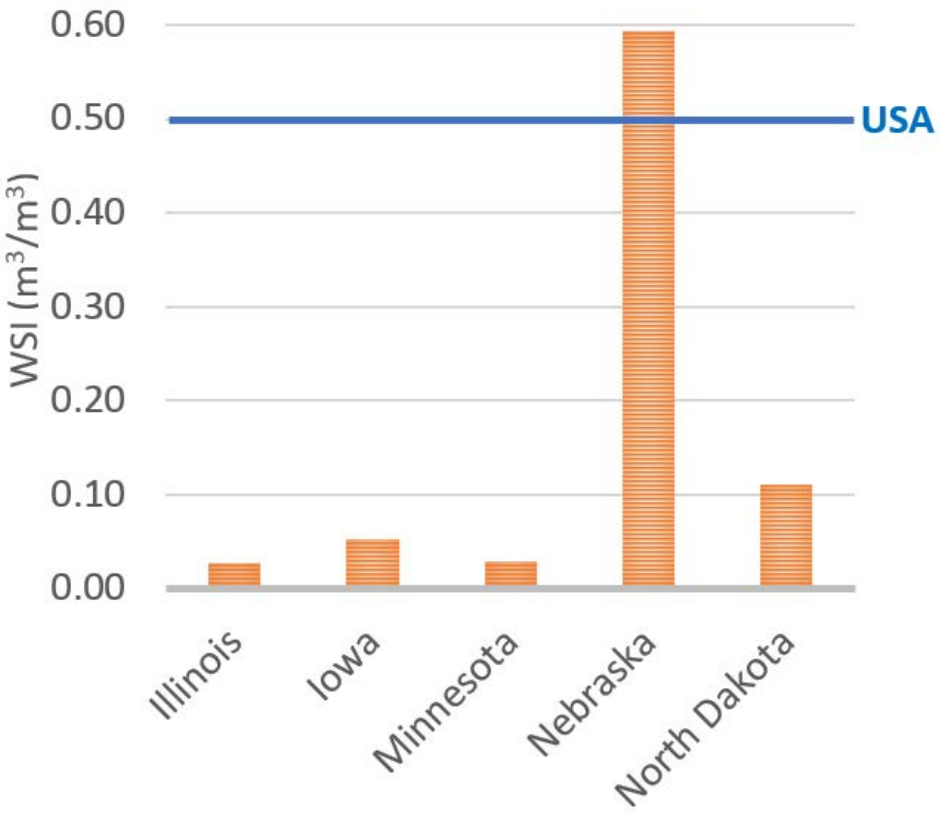
  → Generic: biome 5 values

- **Freshwater consumption:**
  - Ecological Scarcity 2013 (Frischknecht and Büsser Knöpfel 2013)
  - Pfister et al. (2009), as implemented in Enhanced Eco-Indicator 99:

  Parameter: Water stress index (WSI). Data per country and watershed

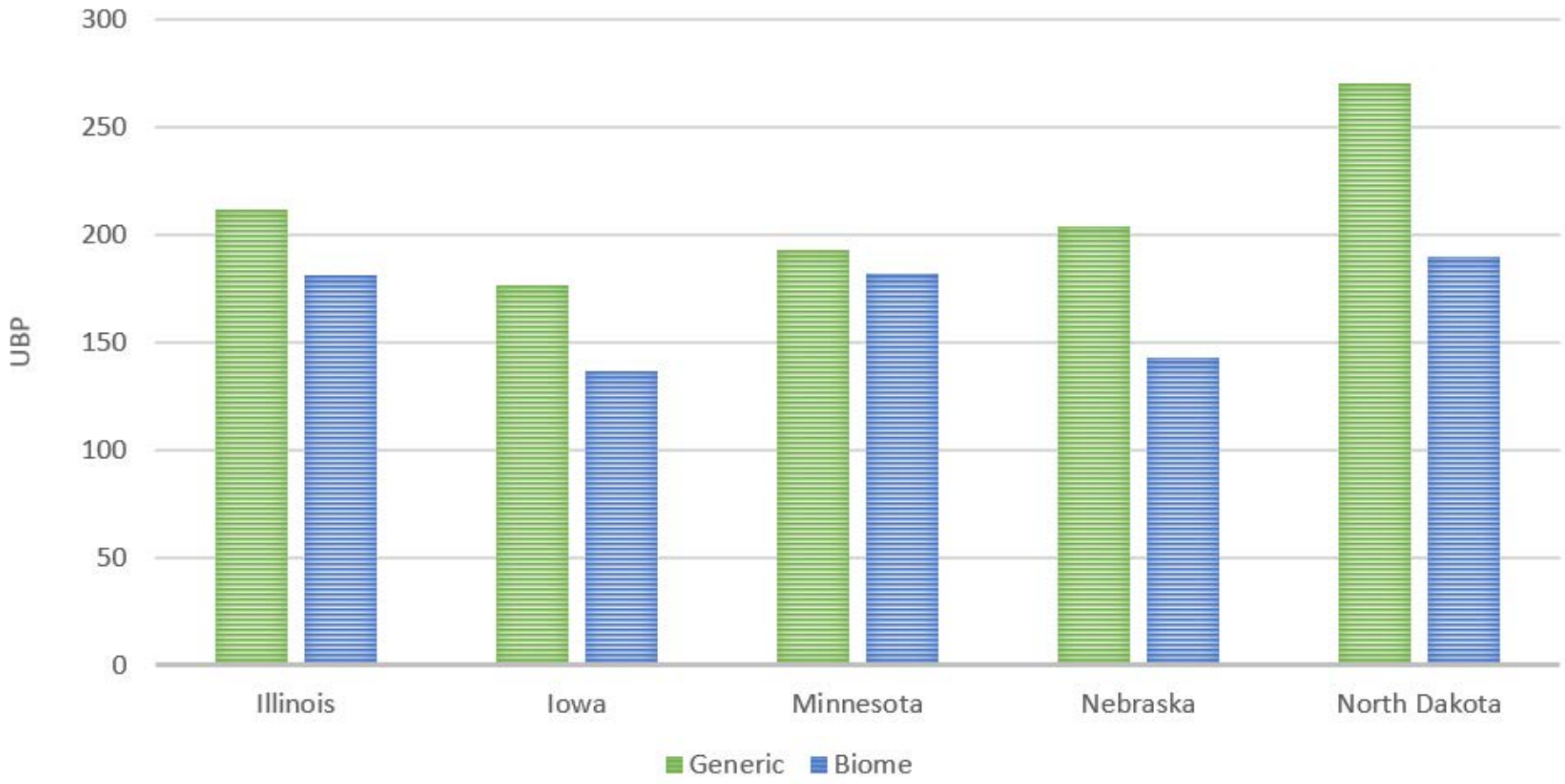
Regionalized characterization factors

- WSI from Pfister et al. (2009)

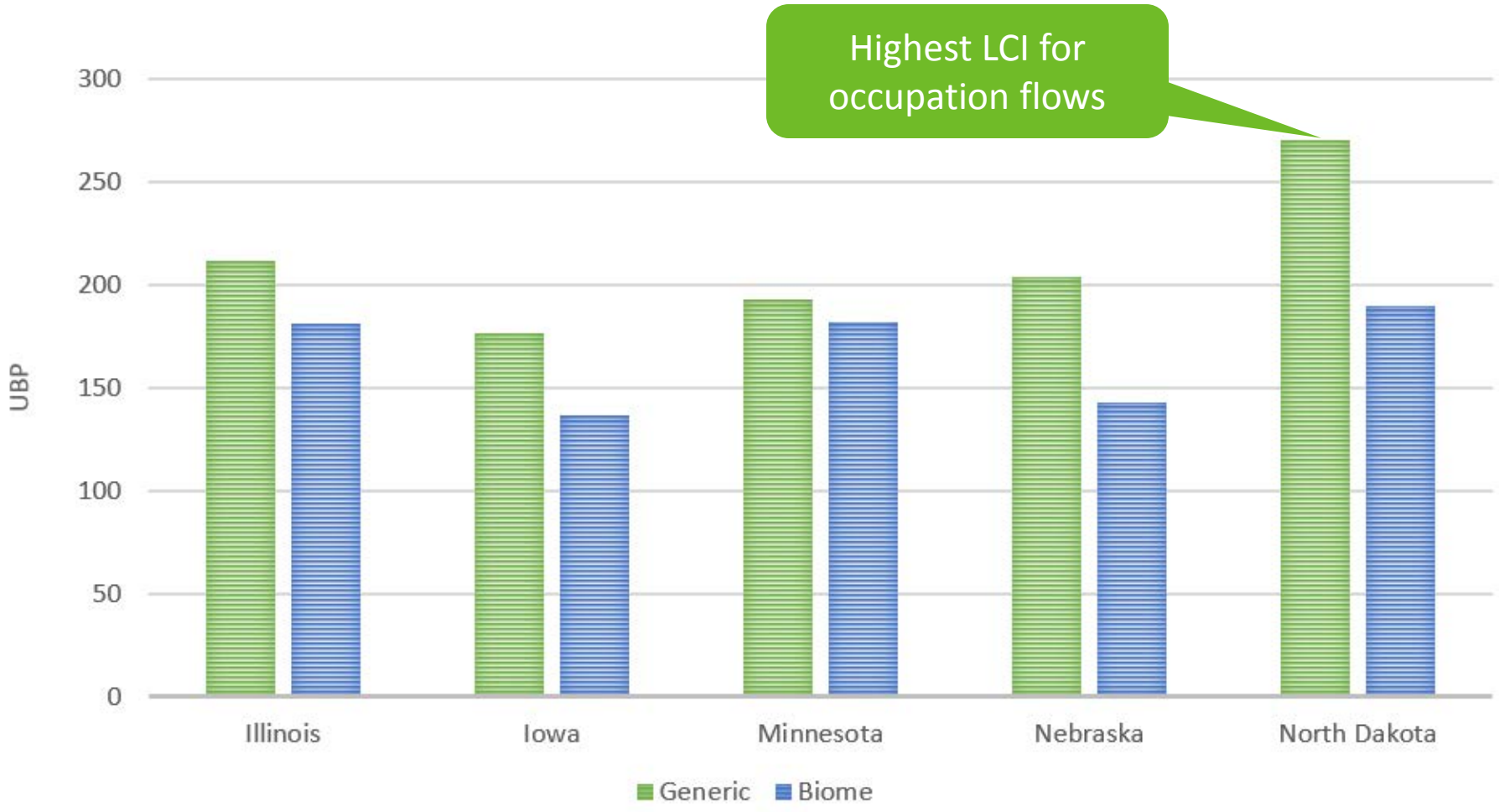


- Eco-factor for land use (arable)

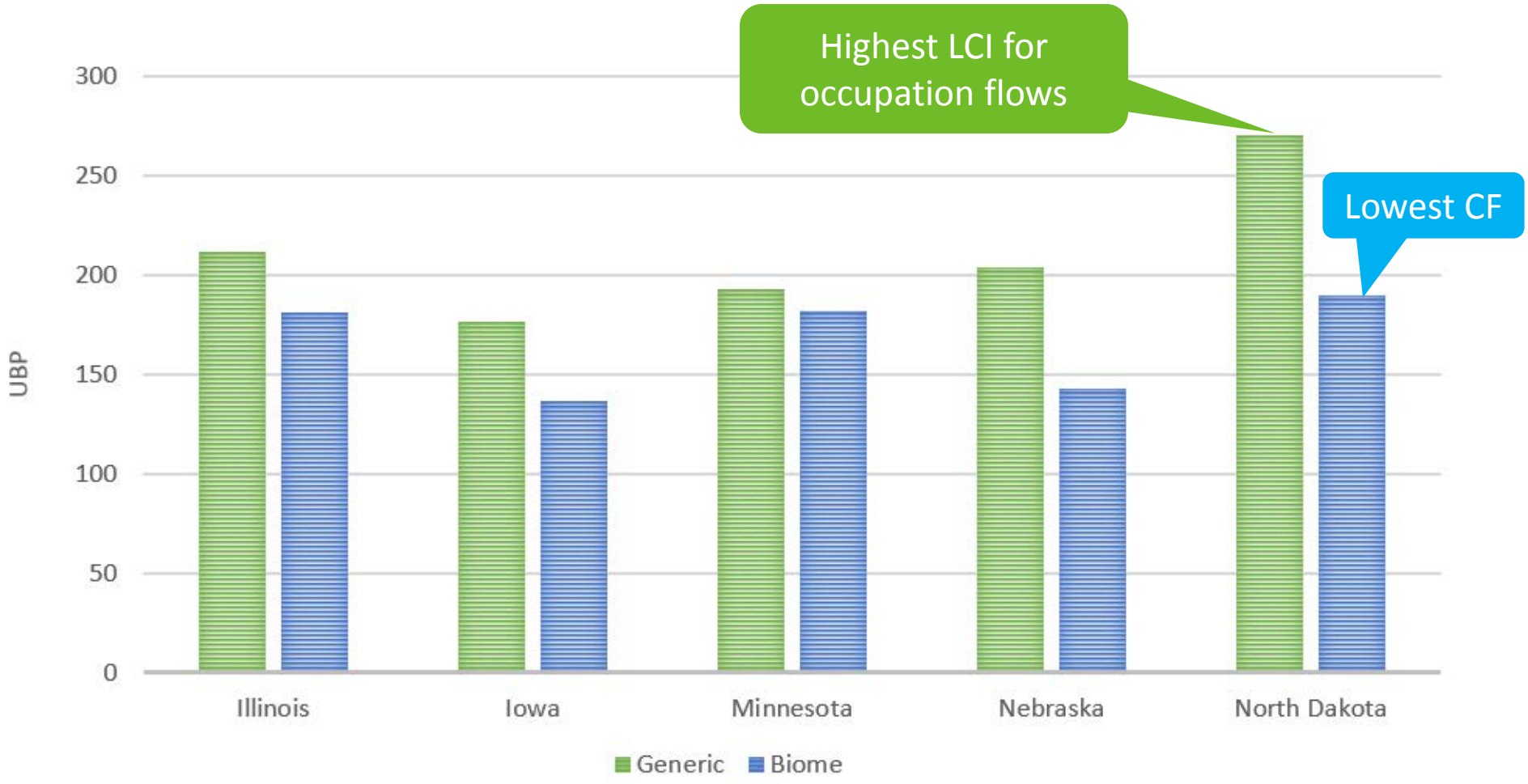
LCIA results: land use



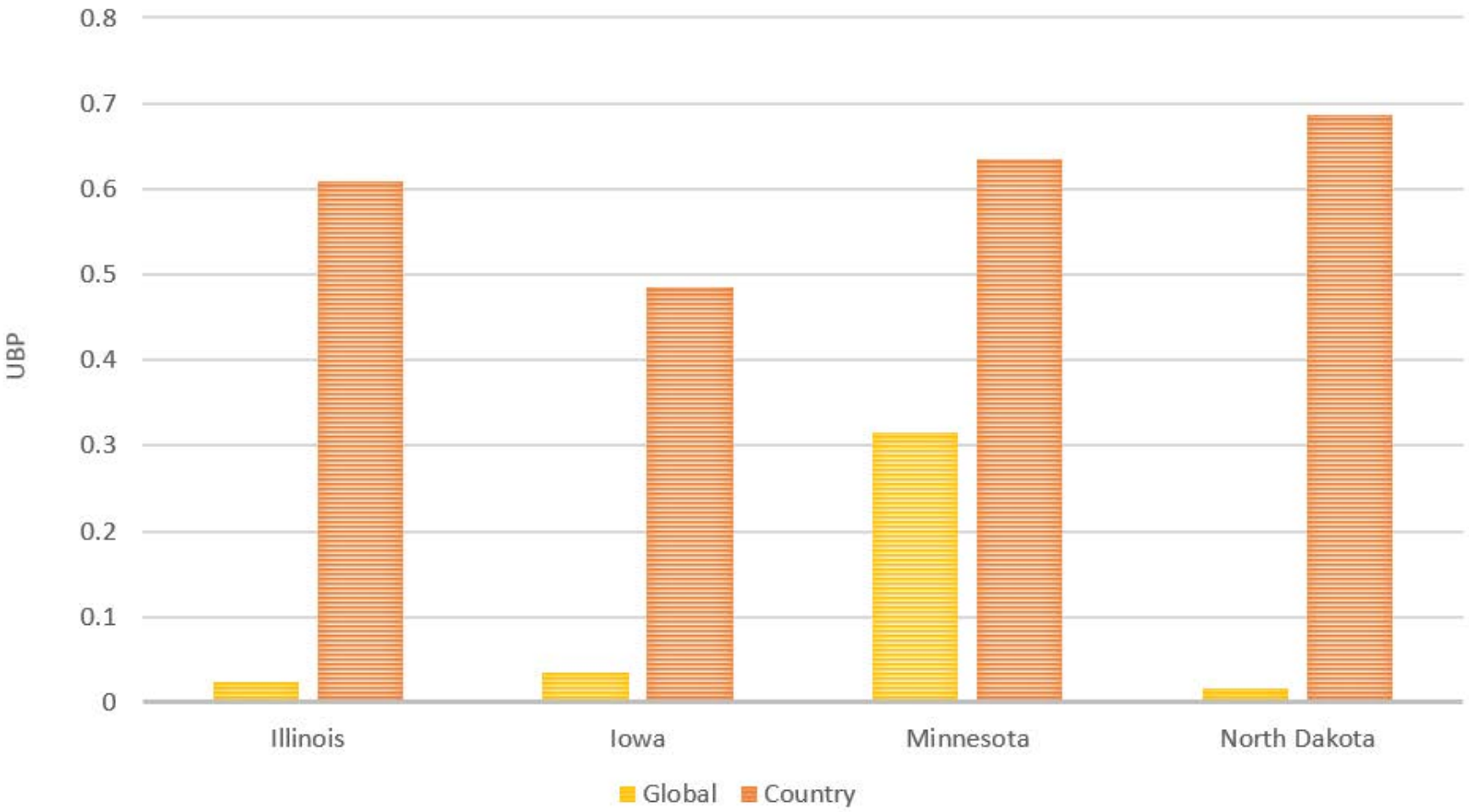
LCIA results: land use



LCIA results: land use

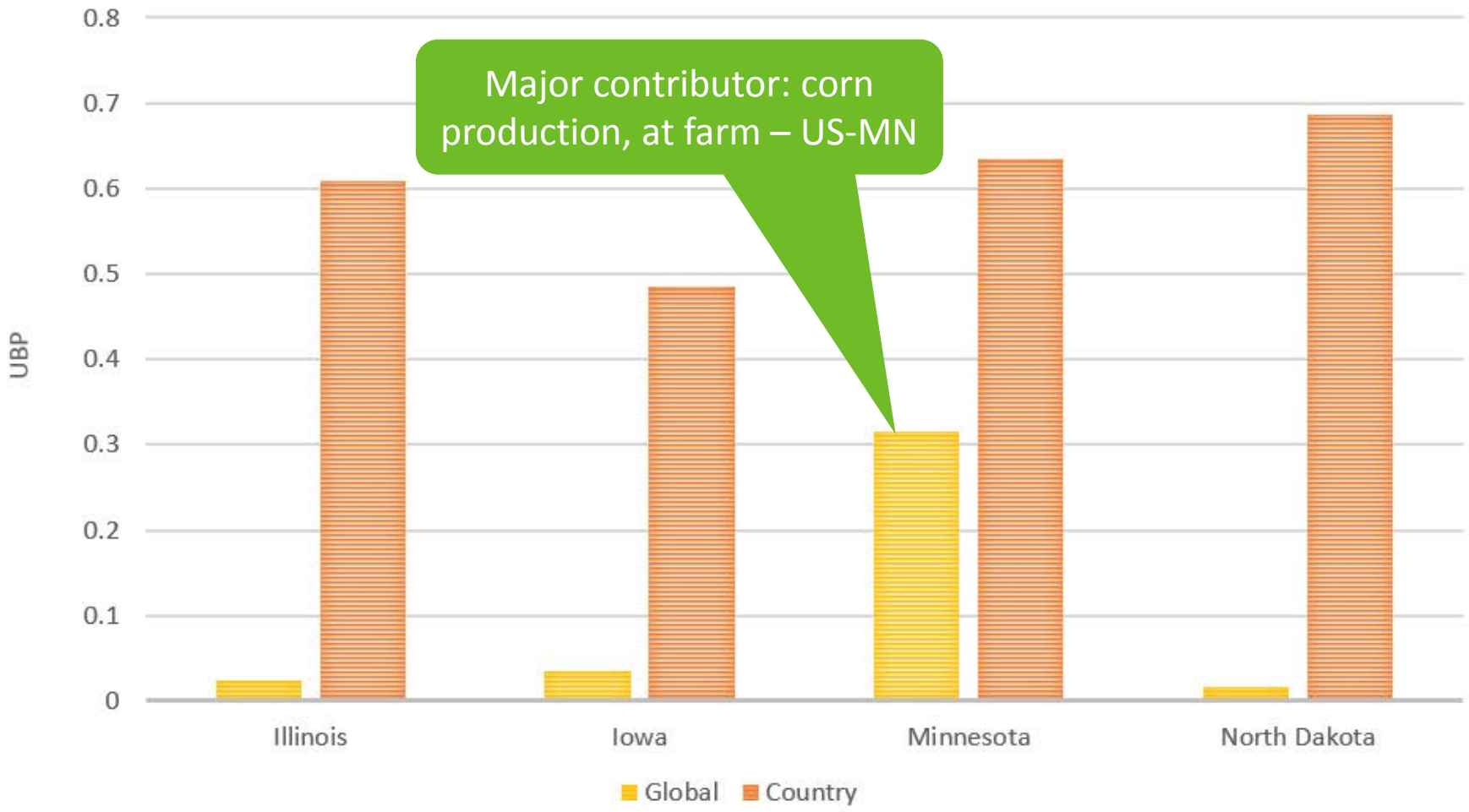


LCIA results: freshwater consumption



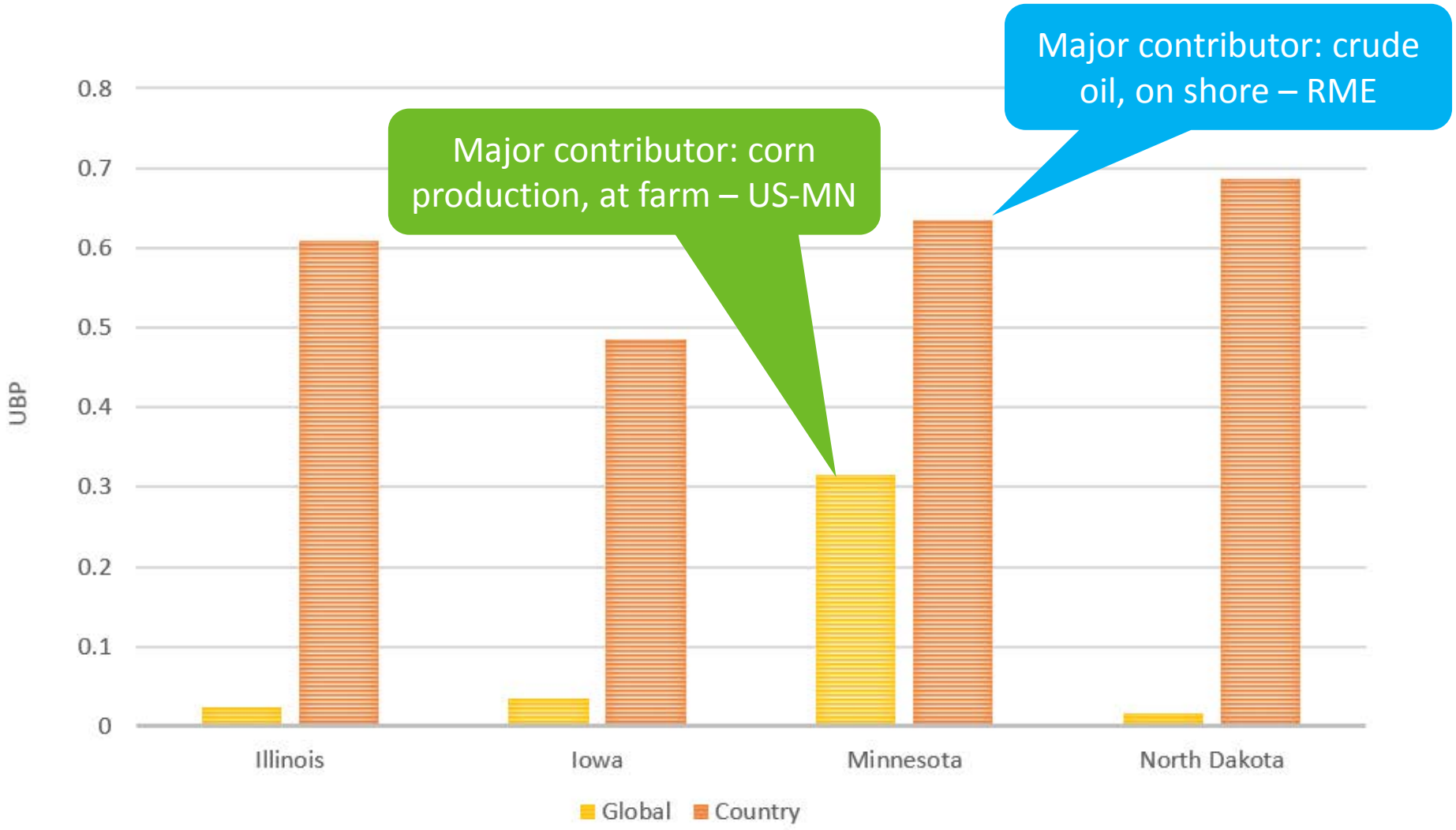
GreenDelta

LCIA results: freshwater consumption

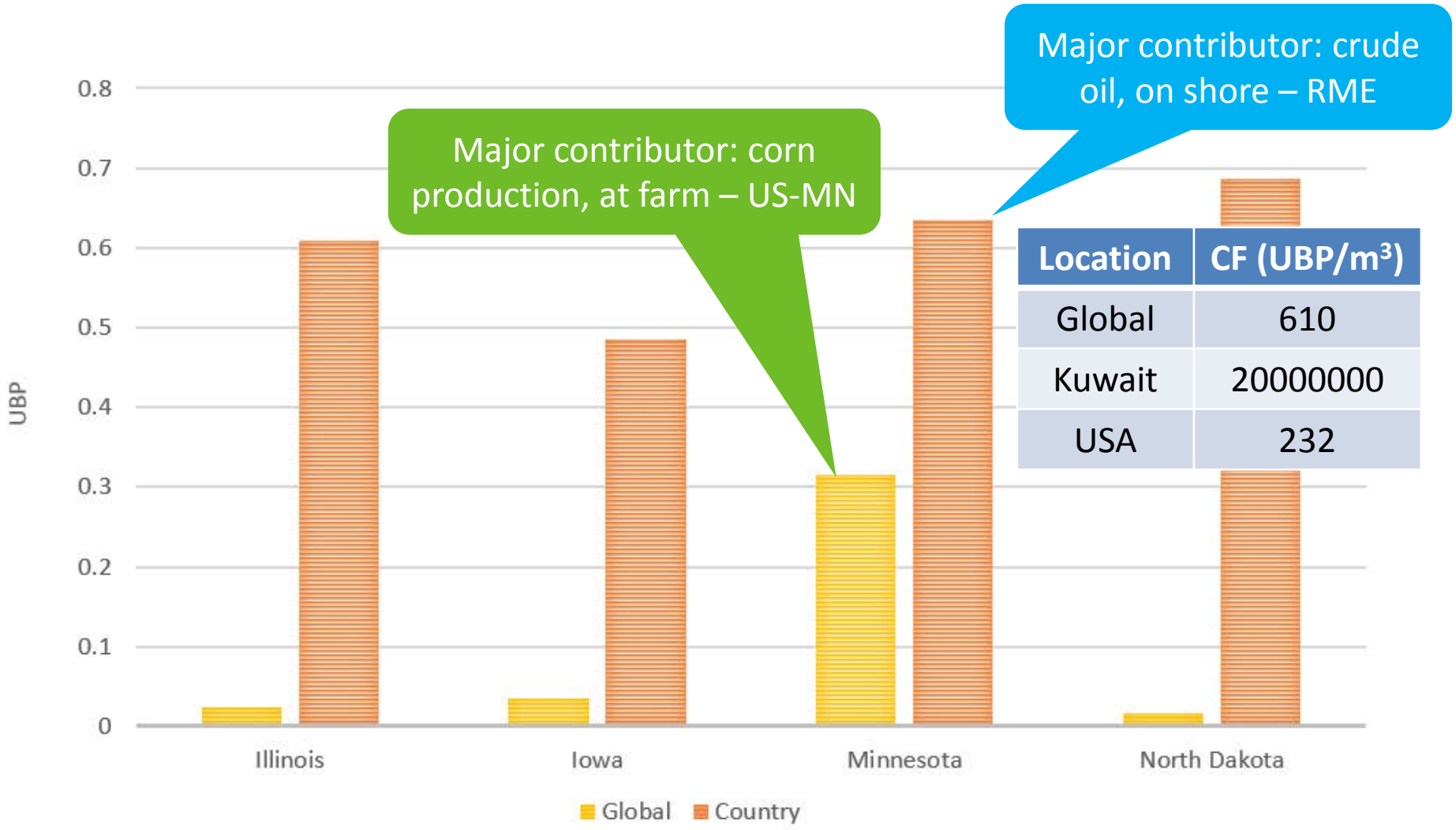


GreenDelta

LCIA results: freshwater consumption

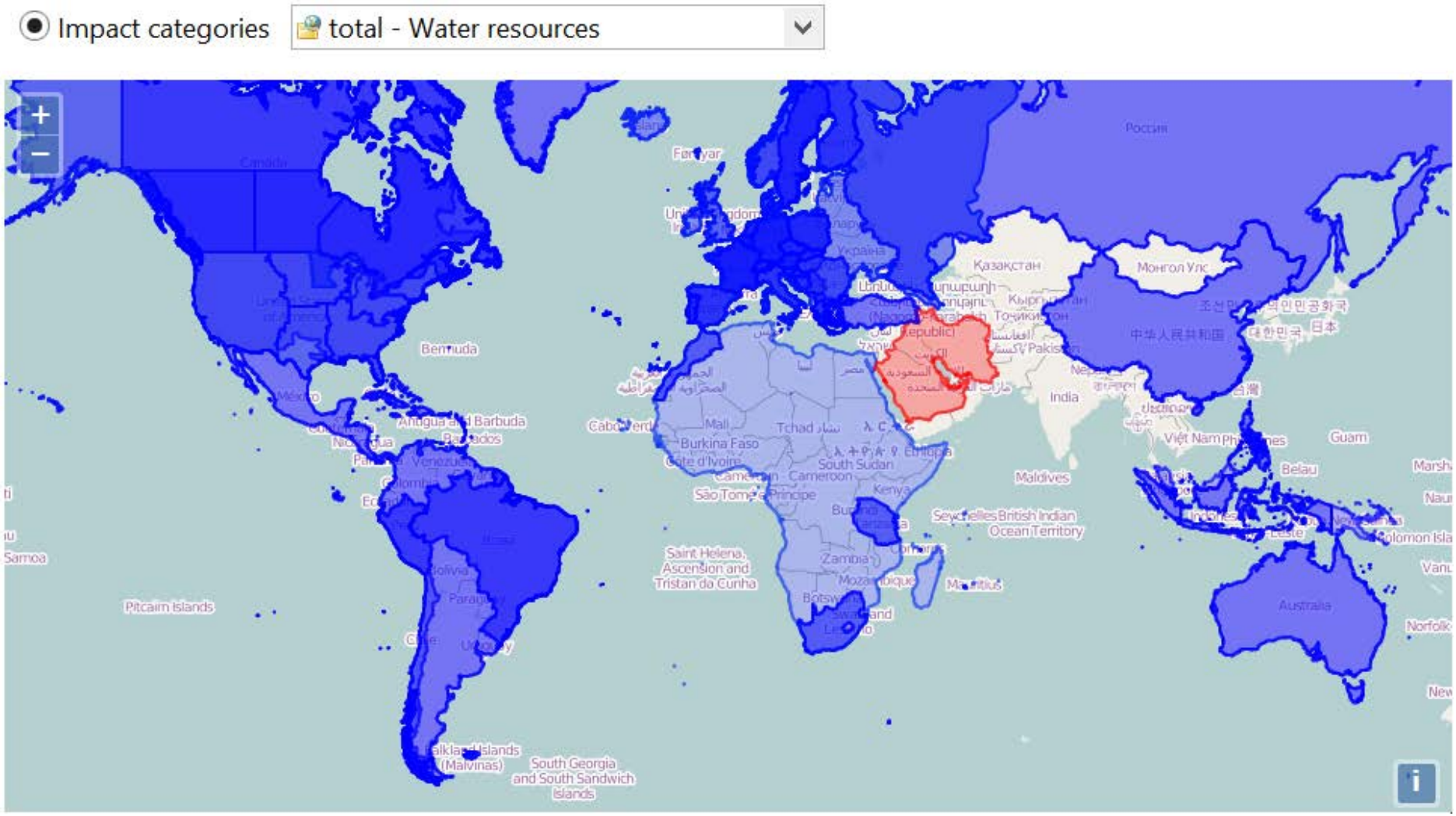


LCIA results: freshwater consumption



Location	CF (UBP/m³)
Global	610
Kuwait	20000000
USA	232

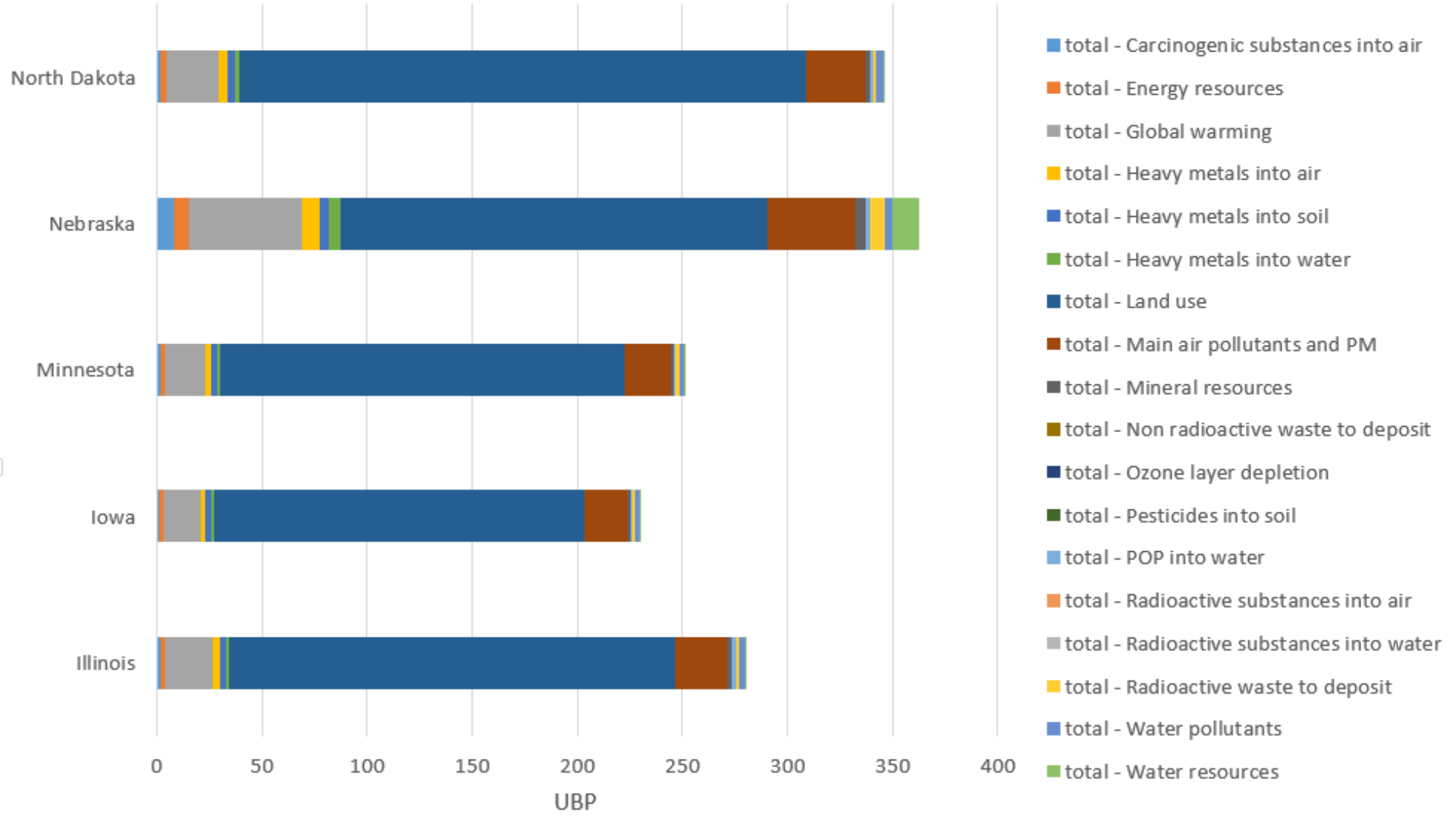
LCIA results: freshwater consumption



GreenDelta

Results for Minnesota. Regionalized data per country

LCIA results: Ecological Scarcity 2013



Conclusions

- Regionalized LCIA in openLCA works successfully without affecting significantly the calculation time required

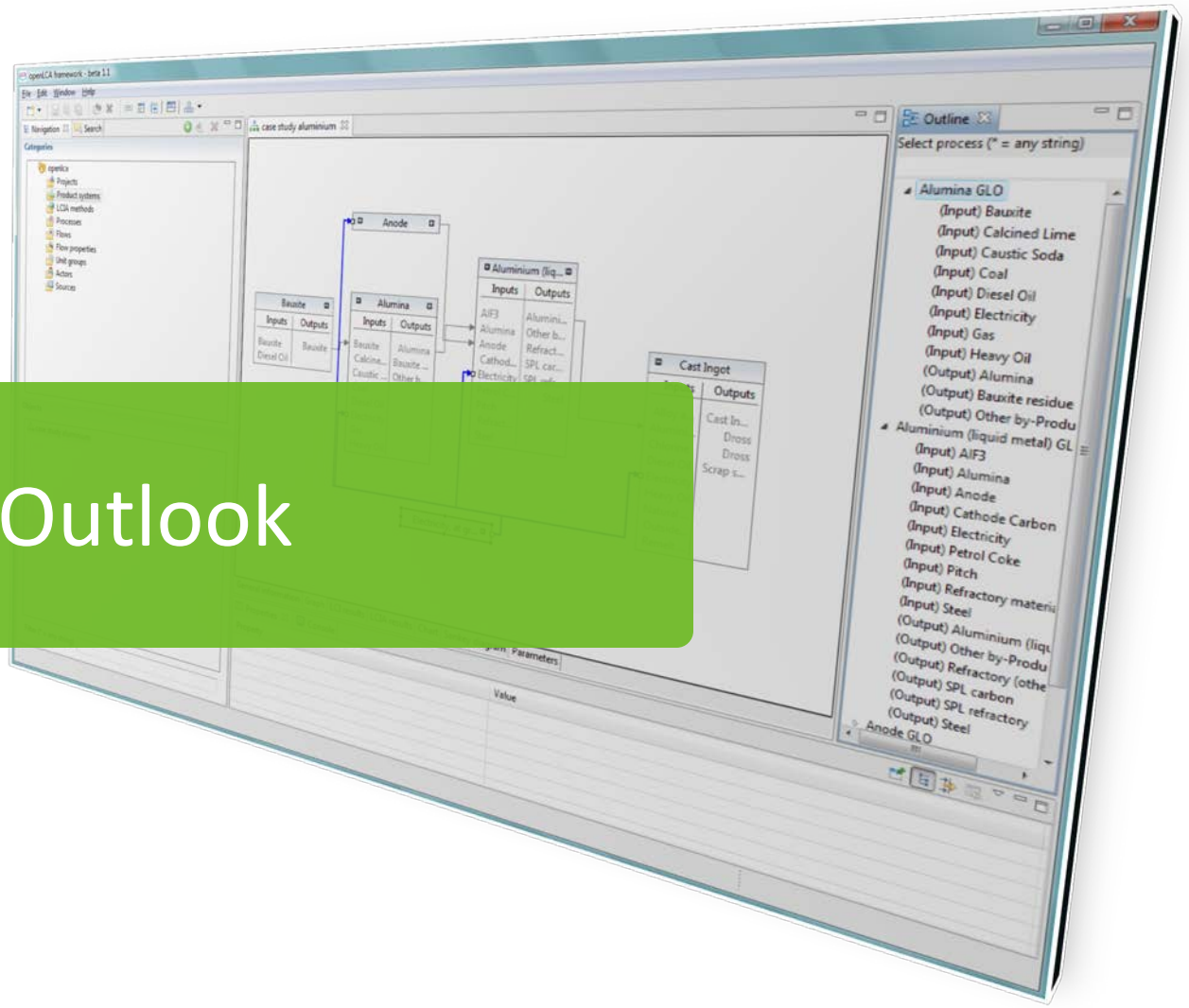
- High variations in results due to different inventory and different characterization factors between locations

  → 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)

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
- Transport pathways of emissions: does the impact occur in the process location?
- 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