ETH zürich

Quantifying biodiversity impacts of land use change

Discussion Forum LCA, Zürich, 3 November 2017

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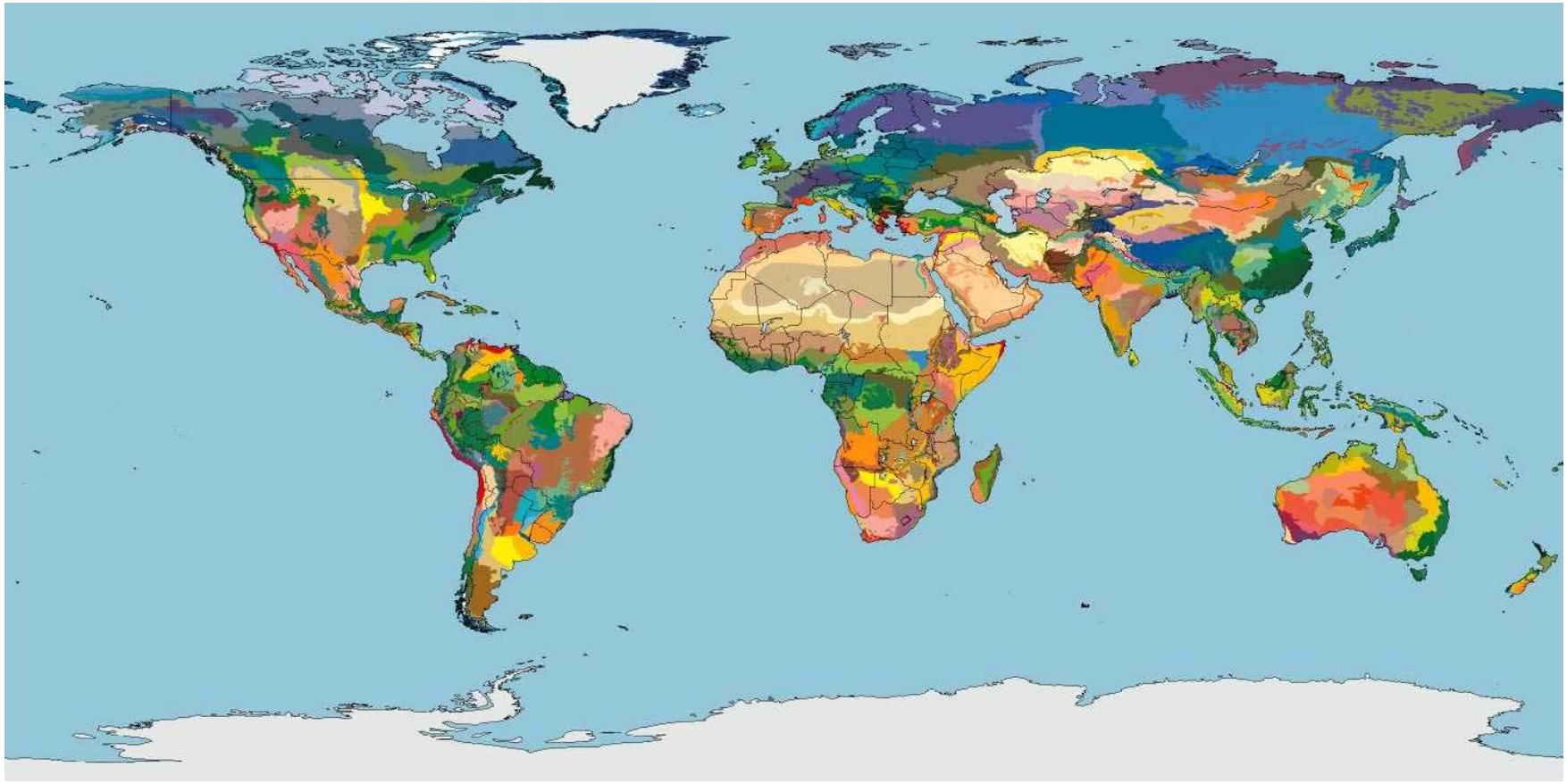
Starting situation

- UNEP-SETAC recommended Chaudhary et al. 2015 as best practice (with restrictions)
  - Provides characterization factors for land use for >800 ecoregions, 4 animal taxa and vascular plants (global coverage)
  - Quantifies regional and global extinctions.
  - Assesses land occupation and transformation.

Ecoregion spatial resolution



http://www.eoearth.org/view/article/151948/

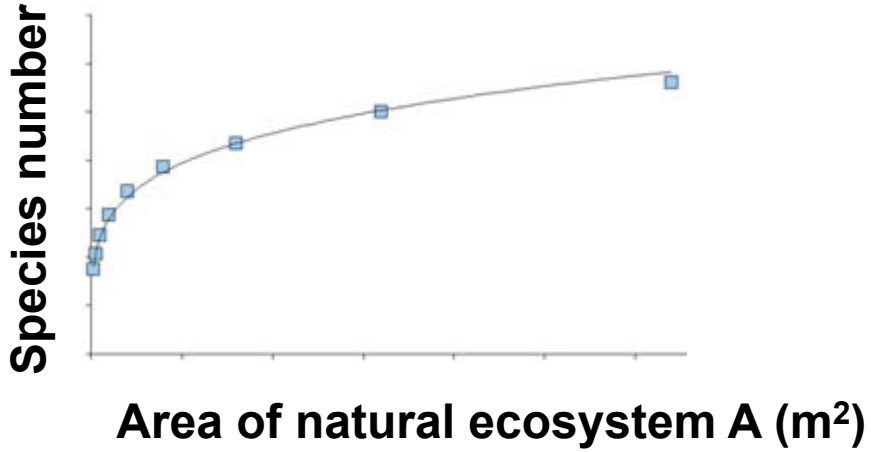
Ecoregions contain similar species compositions and similar environmental conditions.

Modeling regional species loss: Species-Area Relationships

Classical «island» Species-Area Relationship

$$S = c_j A^{z_j}$$

- S *Species richness (number of species)*
- c *Species richness factor*
- A *Area*
- Z *Species accumuliation (0.2-0.5)*
- j *Index for ecoregion j*



Arrhenius 1921

$$S_{lost} = S_{org} \cdot \left(1 - \left(\frac{A_{new}}{A_{org}}\right)^{z_j}\right)$$

→ **criticized because also new land use harbors some biodiversity**

Regional species loss: Countryside Species-Area Relationship

$$S_{lost,j}^{countryside} = S_{org,j} \cdot \left(1 - \left(\frac{A_{new,j} + \sum_{i=1}^{n} h_{i,j} \cdot A_{i,j}}{A_{org,j}}\right)^{z_j}\right)$$

$$h_{i,j} = \left(\frac{s_{i,j}}{s_{ref,j}}\right)^{1/z}$$

Pereira et al. 2014

$S_{lost,j}$ number of species lost in ecoregion j
S_{org} number of species occurring in the original habitat area
A_{new} remaining natural habitat area
A_{org} original habitat area
h_i habitat affinity (land use i);
$s_{i,j}$ empirical plot-scale species richness of land use I in region j

→ **Calculated for each ecoregion and allocated to land use types**

Chaudhary A, Verones F, de Baan L, Hellweg S, Quantifying Land Use Impacts on Biodiversity: Combining Species-Area Models and Vulnerability Indicators, Environmental Science and Technology 49 (16), 9987–9995, 2015

How to estimate global extincitions?

Weigh characterization factors (*CF*) with a factor *VS* for ecoregion j:

$$CF_{global,j} = CF_{regional,j} \times VS_j$$

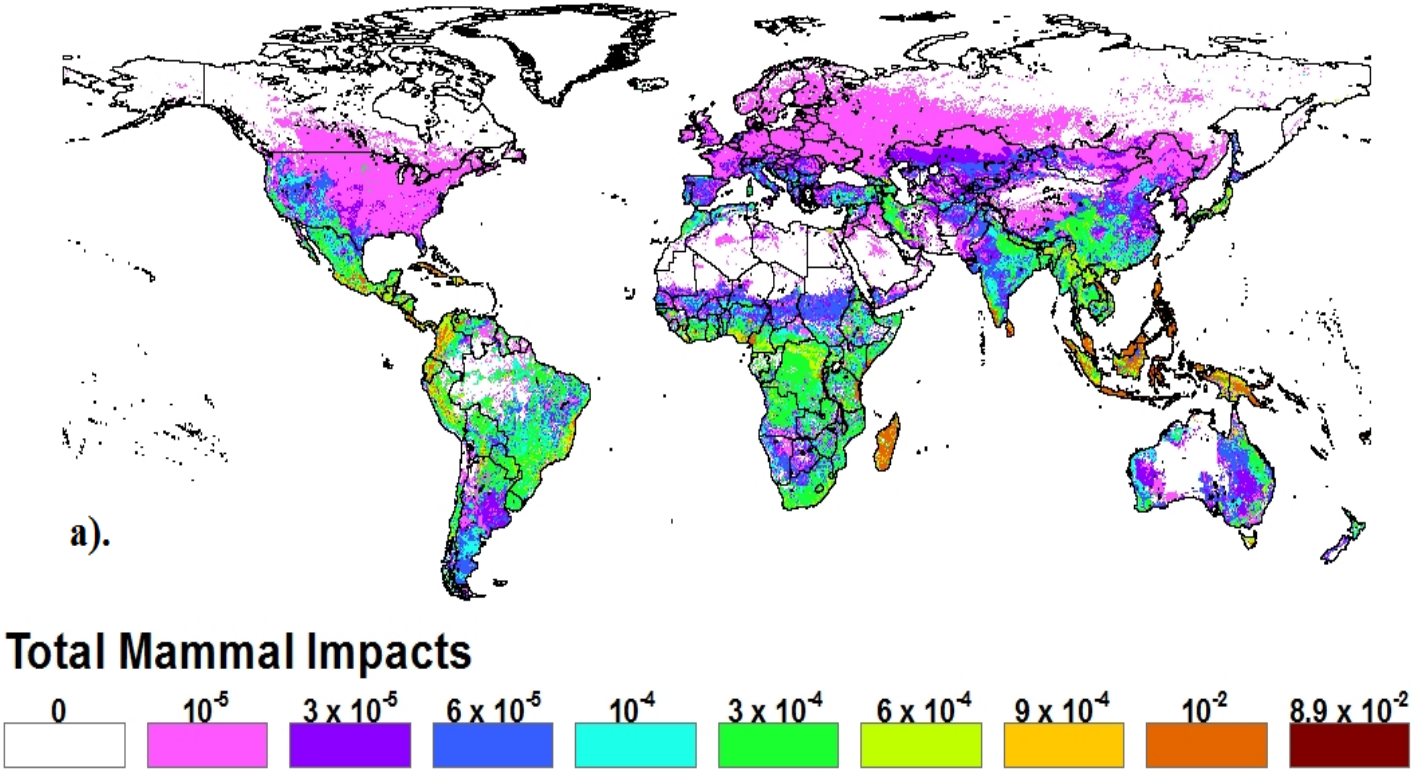
$$VS_j = \sum_{p,j} \frac{\sum_{k=1}^{m} \frac{TL_k \cdot RA_{k,p}}{\sum_p RA_{k,p}}}{m}$$

$RA_{kg,p}$: habitat range area (*RA*) of species k
TL_k: IUCN threat level of species k
m: number of species
p: cell/pixel

→ **ecoregions which host endemic and threatened species have a high weighting factor VS; land use those ecoregions lead to a higher risk of global species loss.**

Chaudhary A, Verones F, de Baan L, Hellweg S, Quantifying Land Use Impacts on Biodiversity: Combining Species-Area Models and Vulnerability Indicators, Environmental Science and Technology 49 (16), 9987–9995, 2015

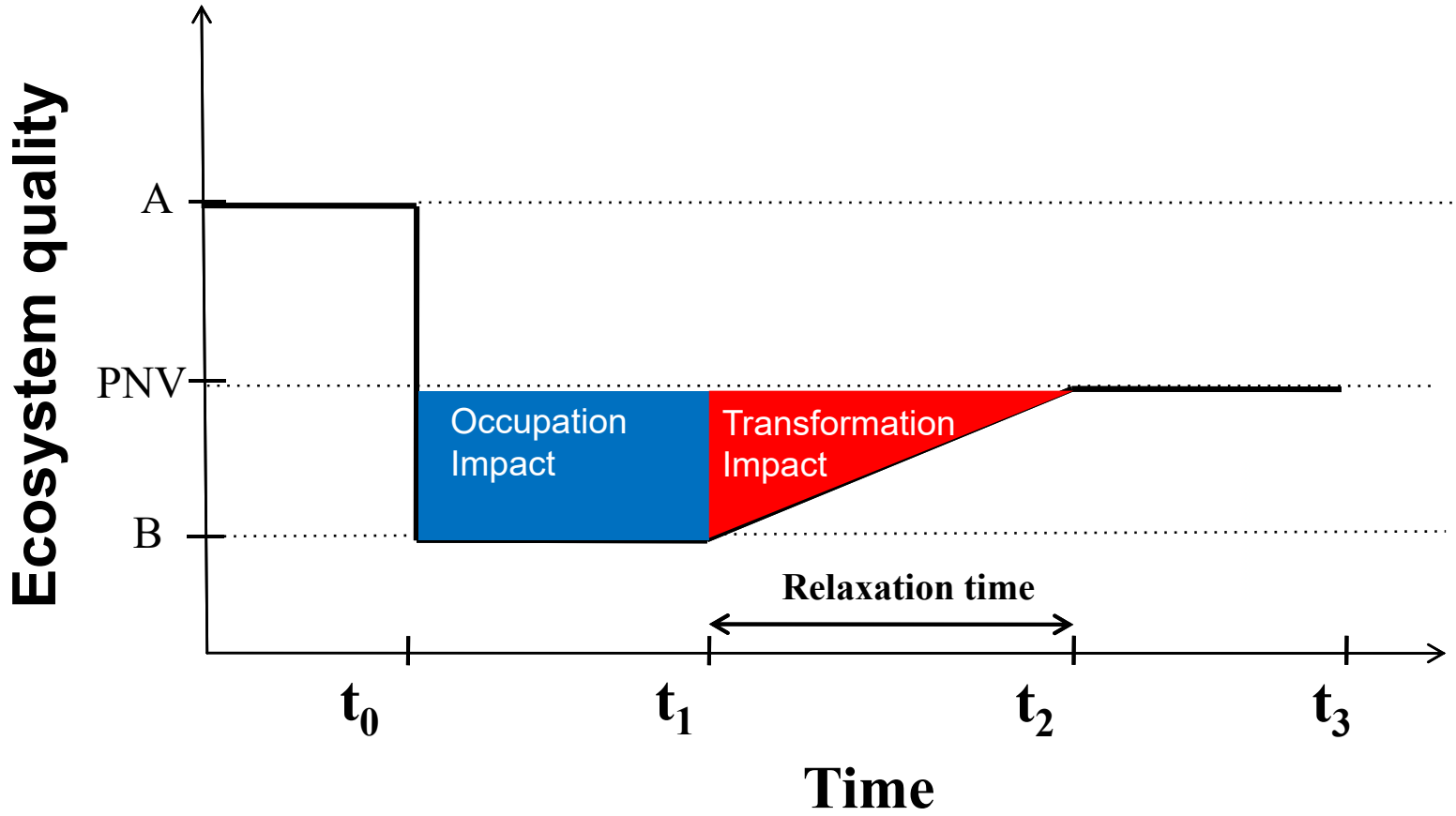
Application: Case study of global agriculture, pasture and forestry (example: mammals)



Chaudhary A et al., Spatially Explicit Analysis of Biodiversity Loss due to Global Agriculture, Pasture and Forest Land Use from a Producer and Consumer Perspective, Environmental Science & Technology 50, 3928–3936, 2016

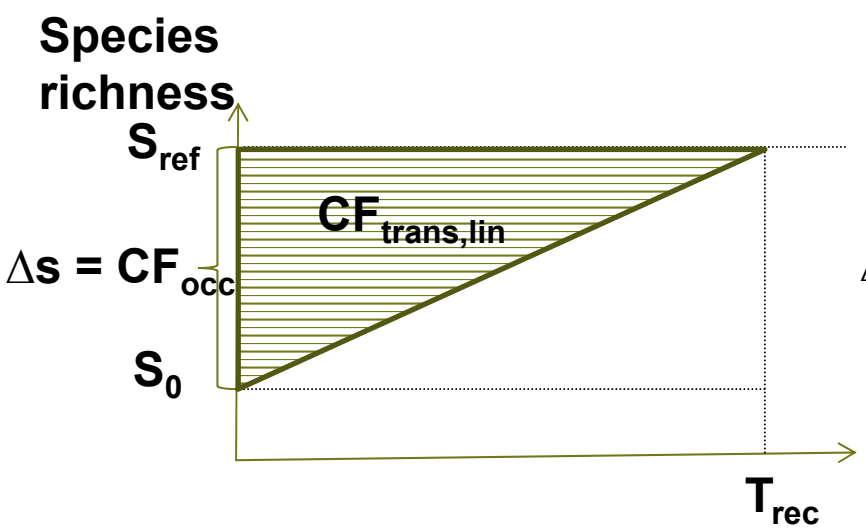
- Global characterization factors (CFs) give a measure of global (permanent, irreversible) species loss.
- CFs available for mammals, birds, amphibians, reptiles, and vascular plants
- Currently 6 land use types: annual, permanent crops, pasture, urban, extensive and intensive forestry.
- In theory the indicator can be directly used for addressing land use change, comparing the steady-state species number before and after LUC; LCA conventions suggest a different procedure though…

LCA land use assessment framework



PNV: potential natural vegetation

LCA land use assessment framework



Pezzati et al., in preparation

$$CF_{trans,\,lin,\,j} = \frac{1}{2} Cf_{occ,j} * T_{rec,j}$$

- Use-, taxon and region-specific recovery times calculated by de Baan et al. 2013, based on *Curran et al 2014*

Specific conclusions land-use change

- Characterization factors following the “convention” of LCA of distinguishing between occupation and transformation are available.
- Those CF are still an indicator of permanent global extinctions, but the units do not carry a meaning any more.
- The temporal recovery trajectory is in reality not linear; this leads to an overestimation of transformation impacts.

Thank you

- Abhishek Chaudhary
- Laura de Baan
- Michael Curran
- Koen Kuipers
- Francesca Verones